EXPLORING THE USE OF AUGMENTED REALITY MODULE AS AN ASSISTIVE LEARNING TOOL FOR DYSLEXIC STUDENTS IN PHYSICAL EDUCATION SUBJECT

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by

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ABSTRAK

Pelajar disleksia adalah mereka yang mengalami kesukaran membaca, membezakan huruf dan lain-lain. Secara praktikalnya, pelajar disleksia masih menggunakan atau bergantung pada buku teks dalam kelas Pendidikan Jasmani (PE). Ini menimbulkan persoalan mendalam tentang keadaan ini. Berdasarkan jurang ini, penyelidikan ini bertujuan untuk meneroka penggunaan modul tambahan sebagai alat bantuan untuk kanak-kanak disleksia dalam kelas PE, untuk memberi mereka demonstrasi visual gambar dalam buku teks, supaya pelajar tidak terlalu terbeban untuk membaca banyak teks dan memprosesnya. Maklumat yang mereka perolehi daripada pelbagai sumber yang berbeza. Kajian ini merupakan kajian kes kualitatif, melibatkan dua kelas di salah sebuah sekolah pendidikan khas di Pulau Pinang, Malaysia, di mana jumlah peserta adalah dua orang guru PE, dan 20 orang pelajar disleksia. Kaedah persampelan yang digunakan ialah persampelan bertujuan, kerana mengikut tujuan yang dinyatakan iaitu untuk pelajar disleksia. Antara instrumen yang digunakan ialah temu bual, jurnal reflektif, pemerhatian dan rubrik kebolehan pergerakan untuk pelajar, manakala bagi guru pula adalah temu bual. Selepas pengumpulan data, analisis tematik digunakan untuk menganalisis data dan triangulasi data juga digunakan untuk mengukuhkan dapatan sedia ada. Penyelidikan ini membangunkan modul tambahan, iaitu modul yang disepadukan dengan teknologi berasaskan pembuat AR, yang membolehkan pelajar mengimbas imej

dalam modul, untuk menghasilkan animasi 3D yang akan membantu mereka menunjukkan pergerakan dalam imej. Dalam mereka bentuk modul, Teori Beban Kognitif (CLT) dan prinsip pembelajaran multimedia Mayer turut diaplikasikan untuk menghasilkan aktiviti dan alatan pembelajaran yang berkesan untuk pelajar. Selain itu, dalam mereka bentuk modul, pengkaji turut menggunakan model ADDIE sebagai garis panduan peringkat dalam mereka bentuk modul. Hasil kajian ini menunjukkan bahawa penggunaan modul tambahan sebagai alat bantu dalam kelas PE sangat membantu pelajar disleksia untuk menggambarkan imej dalam modul. Pelajar sangat dibantu oleh ciri animasi 3D, yang membolehkan mereka mendapatkan demonstrasi langsung dengan mudah dan cepat. Pelajar sangat berminat menggunakan alat bantuan ini dan ia juga benar-benar menarik perhatian mereka. Seterusnya, guru juga merasakan ianya amat membantu kerana dengan adanya alat ini, ia memudahkan pelajar menjalankan pembelajaran kendiri, sehingga guru tidak perlu menerangkan berulang kali kepada pelajar tentang pergerakan yang sedang dipelajari. Penggunaan CLT dan prinsip pembelajaran multimedia juga sangat membantu dalam mewujudkan aktiviti dan modul pembelajaran yang sangat mudah digunakan dan difahami oleh pelajar. Ini telah terbukti dapat membantu mengelakkan pelajar menjadi terbeban apabila belajar menggunakan teknologi dan alatan baharu. Cadangan untuk penyelidikan lanjut adalah untuk menjalankan intervensi yang lebih lama untuk melihat sama ada minat pelajar terhadap pembelajaran dan motivasi akan stabil seperti kali pertama mereka menggunakan teknologi atau alatan baharu atau sama ada sebarang perubahan berlaku. yang kedua ialah membangunkan aplikasi agar lebih baik lagi supaya tiada masalah apabila digunakan oleh pelajar. Pembangun juga dinasihatkan membina aplikasi serupa yang boleh diaplikasikan kepada mata pelajaran lain di sekolah.

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ABSTRACT

Dyslexia students are those primarily facing difficulty in reading, distinguishing letters and others. In practice, students with dyslexia still use or depend on textbooks in Physical Education (PE) classes, which raises critical questions about this condition. Based on this gap, this research aims to explore the use of augmented modules as assistive tools for dyslexic children in PE classes and give them visual demonstrations of the pictures in textbooks so that they would not be too burdened to read much text and process it. Currently, the information they receive comes from a variety of different sources. This research is a qualitative case study involving two classes at one of the special education schools in Penang, Malaysia. The total of participants included two physical education teachers and 20 dyslexia students. The sampling method used is purposive sampling, as it follows the stated purpose, which is for dyslexic students. The instruments used in this study involved interviews, reflective journals, observations and movement ability rubrics for students, while the interview was also used for teachers. After data collection, thematic analysis was used to analyze the data, along with data triangulation to strengthen the existing findings. This research developed an augmented module, a module integrated with AR maker-based technology, which allows students to scan the images in the module and produce 3D animations that will help them demonstrate the movements in the images. In designing the module, Cognitive Load Theory (CLT) and Mayer's principles of multimedia learning were also implemented to produce effective learning activities and tools for students. Apart from that, the ADDIE model was employed as a guideline for the stages of designing the module. Findings revealed that the use of augmented modules as assisting tools in PE classes really helped dyslexic students visualize images in the module. Students were greatly helped by the 3D animation feature, which allowed them to gain live demonstrations easily and quickly. The students were very interested in using this assisting tool, and it also really attracted their attention. In addition, the teachers also felt that it was very helpful since this tool facilitated students to carry out independent learning so that teachers do not need to repeatedly explain to students about the movements being taught. The implementation of CLT and principles of multimedia learning is also very helpful in creating learning activities with modules that are very easy to use and understand by students. Furthermore, it has been proven to help prevent students from becoming overwhelmed when learning to use new technology and tools. Suggestions for further research are to carry out longer interventions to see whether students' interest in learning and motivation will be as stable as the first time they use new technology or learning tools. The second is to develop the application to be even better so that there is no lag when used by students. Developers are also advised to build similar applications that can be applied to other subjects at school.

CHAPTER 1

INTRODUCTION

1.1 Introduction

In today's Industrial Era 4.0, technology is ubiquitous and integral to various fields (Asmiatun, Wakhidah, & Putri, 2020). This technological advancement has opened up new educational opportunities (Tulgar, 2019). Integrating technology into education can create new educational experiences for students, one of which is immersive learning. Immersive learning provides experiences in the actual context within a genuine three-dimensional physical environment (Mike, 2019). Such interventions help stimulate episodic memory, improve retention, and facilitate deep, meaningful learning (Mystakidis, Berki, & Valtanen, 2021). Episodic memory is the capacity for long-term storage of fully realized individual experiences in their multimodal temporal-spatial context (sight, sound, place, smell, etc.) (Sauzéon et al., 2012). Episodic memory plays a significant role in learning because it allows individuals to remember detailed personal experiences, which can be drawn upon to make connections with new information (Tulving, 2002; Prebble et al., 2013). This is particularly relevant for dyslexic students who often struggle with traditional text-based learning methods (Shaywitz, 2003; Siegel, 2019). The merging of virtual reality, augmented reality, mixed reality, and immersive videos is known as immersive technology (Calvet, Bourdin, & Prados, 2019; Mike, 2019). By using immersive and multisensory learning tools, such as AR, these students can form richer, more detailed memories of their learning experiences (Dale & Dale, 2019; Bujak et al., 2013).

Augmented Reality (AR) technology has significantly grown in various fields, especially in education, over the last five years, from 2016 to 2020 (Garzón, 2021). AR is one of the immersive technologies now being employed worldwide in educational technology to enhance teaching and learning processes and support independent learning (Akçayır & Akçayır, 2017; Garzón, 2021). According to Samala et al. (2023), the education sector ranks second in dominating publications on AR technology, indicating active discussions and developments in this area. The impact of AR technology on Sustainable Development Goal (SDG) number 4, "Quality Education," is also highlighted, aiming to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. Numerous articles examine AR technology to enhance learning and education, promoting the accomplishment of other SDG objectives and raising the human development index. In addition to SDG 4, AR technology also contributes to SDG 3, "Good Health and Well-being," and SDG 9, "Industry, Innovation, and Infrastructure.".

SDG 3 focuses on ensuring healthy lives and promoting well-being for all at all ages. In the context of education, AR can help reduce stress and anxiety for dyslexic students by providing an engaging and supportive learning environment. This improved learning experience can contribute to better mental health and overall well-being for students (World Health Organization, 2020). SDG 4 emphasizes the need for inclusive and equitable quality education. By integrating AR technology into the classroom, this study aims to create a more inclusive learning environment for dyslexic students. AR can help these students visualize complex concepts and engage with the material in a more interactive and meaningful way, thus promoting lifelong learning opportunities (United Nations, 2020). SDG 9 highlights the importance of building resilient infrastructure, promoting inclusive and sustainable industrialization, and fostering innovation. The use of AR in education exemplifies how innovative technologies can be incorporated into traditional learning methods to enhance educational outcomes. By fostering an environment of technological advancement and innovation, this study contributes to building a resilient and modern educational infrastructure that benefits both students and educators (United Nations, 2020). By addressing these SDGs, this study not only aims to improve the learning experiences of dyslexic students but also contributes to the broader global objectives of promoting health, education, and innovation. Numerous articles examine the use of AR technology to enhance learning and education; this will promote accomplishing other SDG objectives while raising the human development index.

AR is defined as a technique that combines digital and physical information in real-time using technological equipment (Barroso, 2018; Maas & Hughes, 2020). It integrates real-world and virtual-world elements, allowing users to mix and combine these environments in real-time using smartphones and tablets (Cabero-Almenara and Roig-Vila, 2019). Specifically, AR refers to loading and merging virtual elements into real-world perspectives, such as video, sound, photographs, text, and 3D models (Tekedere & Göker, 2016). Unlike Virtual Reality (VR), which creates a new simulated environment, AR aims to embellish existing reality with image elements, sound effects, video, or text, presenting topics to students in an interesting, interactive, and experiential way (Fitria, 2023). The selection of immersive technology should be considered based on research needs.

The number of studies on how AR is applied to education is limited but growing (Alkhattabi, 2017). AR technology and educational strategies help students absorb information more quickly by providing unique learning experiences (Tan & Tay, 2021). Research by Ziden, Ziden, and Ifedayo (2022) found that students felt their learning activities were more interactive, fun, and motivating when using AR technology through mobile learning. AR can be readily integrated into classrooms with mobile devices that students already own, making it suitable for active learning when supplemented by proper teaching approaches (Pantelić & Plantak Vukovac, 2017). AR is also increasingly popular in training, particularly in education, where various tools and methods are being developed to help students and teachers learn and teach more effectively (Chen, Liu, Cheng, & Huang, 2017). Most common uses of AR technology in education are in biology, engineering, and medical training, whereas its use in Physical Education (PE) is still lacking (Calabuig-Moreno, González-Serrano, Fombona, & García-Tascón, 2020; Fitria, 2023; Sirkaya & Alsancak Sirkaya, 2018).

However, in recent years, experts have begun to see research potential in this area. PE is essential for children in school, it will help support the physical activity they need (Cheung, 2019). Meanwhile, high-quality PE can help students develop physical fitness, movement, critical thinking, social, analytical, emotional, and overall health (Rekaa, Hanisch, & Ytterhus, 2019). It shows that PE subjects play an essential role in health and fitness. PE is another field where AR technology can be employed as a classroom learning aid. The most recent research by Garzón (2021), in which he investigates the evolution of AR in education over the last 25 years, indicates that the number of publications on the subject of AR in education is increasing and gaining popularity. More specifically, Belmonte, Moreno-Guerrero, Núñez, & Sánchez (2019) showed an increasing interest in researching the usage of AR in higher education settings. Garzón, Pavón, & Baldiris

(2019) back up these findings, where higher education and primary school are two educational levels for which more AR research were accomplished.

AR is one of the assistive technology that usually used to help disabilities. Dyslexia is a common learning difficulty that primarily affects reading and writing skills. Students with dyslexia often struggle with traditional text-based learning, which can hinder their academic performance and confidence. Assistive learning tools, particularly those leveraging technology, have shown promise in supporting dyslexic students by providing alternative ways to access and engage with learning materials. Tools such as text-to-speech software, audiobooks, and interactive apps help these students overcome reading difficulties and improve comprehension. AR technology presents a unique opportunity to enhance assistive learning tools for dyslexic students. By transforming static images and text in textbooks into interactive 3D animations, AR can make learning more engaging and accessible. This visual and interactive approach aligns well with the needs of dyslexic students, who often benefit from multisensory learning experiences. Research has demonstrated that multisensory approaches can significantly improve reading skills and overall learning outcomes for dyslexic students (Fletcher et al., 2007).

This study aims to address the gap in research on the application of AR in PE, specifically for dyslexic students. Dyslexic students often face significant challenges in traditional learning environments due to difficulties in processing written information. These challenges can be particularly pronounced in subjects like Physical Education (PE), where understanding and executing physical movements based on textual descriptions can be difficult. By exploring the use of an augmented module as an assistive learning tool, this research seeks to provide a more inclusive and effective learning experience for dyslexic students. The augmented module will help students visualize and understand movements better through 3D animations, enhancing their engagement, motivation, and overall learning outcomes in PE.

1.2 Background of Study

PE provides learners of all abilities, including those with special needs (Forestry, Kristiyanto, & Legowo, 2019). Physical activity (PA) is an essential component of overall health; most students learn about it during PE classes (Cheung, 2019). PA plays a significant role in children with disabilities developing normally, yet, selecting the correct type of physical activity for them can be difficult. Students with special needs are children experiencing abnormalities or irregularities in their growth or development (physical, mental, intellectual, social, or emotional) and require special education programs (Riadin & Usop, 2017). According to Úbeda-Colomer, Devís-Devís, and Sit (2019), across all levels of society, due to their health status and related difficulties such as discomfort, exhaustion, and a lack of energy, people with disabilities are frequently prevented from participating in physical activities. This condition proves that physical barriers, intellectual ability, and psychological can all impact the physical activity of children with special needs (Forestry et al., 2019), and also the assumption appears to be based on a lack of knowledge and resources in providing physical education to a broad set of children (Rekaa et al., 2019). Educators should think critically and creatively to make physical education a fun topic for special needs students.

Individuals with learning disabilities should be taught using various approaches so they can use their strengths to compensate for their limitations. This is one of the reasons why it is critical to include hands-on activities or objects that can be touched and utilized while learning (Kemp, Smith, & Segal, 2022). According to the Malaysian Welfare Department (2023), there are six types of learning disability (LD) which are Global Developmental Delay (GDD), Down Syndrome (DS), Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorder (ASD), Intellectual, and Specific Learning Disability (SpLD). Furthermore, the SpLD is divided into three types which are dyslexia, dysgraphia, and dyscalculia. More than 90,000 children in Malaysia, or 50 percent of the population, have learning disabilities starting at age 5 or 6. This is because of dyslexia problems (Omar & Ahmad, 2022). Dyslexia is a type of SpLD that causes difficulties with reading, writing, understanding, spelling, and counting due to differences in the way the brain connects visual symbols and sounds (Malaysian Welfare Department, 2023).

Dyslexia are usually defined as a language-based learning disability that manifests as differences in spelling, word identification, decoding skills, and overall low phonological awareness (Adlof & Hogan, 2018). It is important to remember that a person can have multiple behavioral or learning disabilities. For instance, according to several studies, up to 30% of people with reading or learning differences also have ADHD, despite the possibility of co-occurring disabilities, one does not cause the other (International Dyslexia Association, 2017). Several studies show that children with dyslexia or other learning disabilities have lower motor ability than is predicted for their age (Soares & Marco, 1997). According to the literature, at least 50% of students with cognitive disabilities have developmental issues linked to motor coordination, notably bimanual coordination, manual skills, and fine motor abilities (Capellini, Coppede, & Valle, 2010). Research by Abu-Hamour (2014) on the percentages of behavioral and learning disabilities among students at public and private schools who have learning disabilities, show that the biggest problem faced by the students is on orthographical processing which is the ability to understand and recognize the writing conventions as well as recognizing when words contain correct and incorrect spellings (Westwood, 2020), and thinking with images which student usually faced when learning using the textbook in the classrooms.

Dyslexic children have been indicated to be less motorically proficient than their normally developing classmates; nevertheless, results have been contradictory between research, in part due to methodological discrepancies (Marchand-Krynski, Morin-Moncet, Bélanger, Beauchamp, & Leonard, 2017). Deficits in gross motor abilities, notably balance and postural activities, are more commonly documented in children with dyslexia (Ramus, Pidgeon, & Frith, 2003; Westendorp, Hartman, Houwen, Smith, & Visscher, 2011). Students with dyslexia frequently struggle with spatial awareness, visual processing, timing, and rhythm (Portwood, 2012; Soares & De Marco, 2014). Dyslexia, is characterized by difficulties in accurate or fluent word recognition, poor decoding, and poor spelling abilities (Lyon, Shaywitz, & Shaywitz, 2003). These challenges can extend to other cognitive processes such as working memory and attention, making traditional text-based learning methods particularly difficult for dyslexic students (Swanson, Harris, & Graham, 2013). While dyslexia affect a student's ability to engage with any subject that relies heavily on text, Physical Education (PE) presents unique challenges and opportunities for intervention.

Visual processing issues are difficulties in recognizing and analyzing visual information, which can interfere with reading and comprehension of text. Dyslexic students may struggle to follow lines of writing, distinguish between similar characters, or comprehend complex schematics and images (Miller, 2016; Schneider, 2016). These impairments can exacerbate dyslexia's current challenges, making it considerably more difficult for these students to effectively use textbooks and other written resources in the classroom. Visual processing issues may limit a student's ability to accurately follow and carry out physical activities indicated in physical education (PE) textbooks, which typically use diagrams and illustrations to illustrate exercise. As a result, addressing these visual processing difficulties is crucial for developing successful teaching strategies and learning tools for dyslexic students in physical education settings (Ried, 2009).

In Malaysia, due to uncertain laws, a lack of human resources, and inadequate special education facilities, it has been discovered that children with disabilities do not entirely get their constitutional right to an education. As a result, children with disabilities cannot exercise their right to an equal education on an equivalent level to other children (Othman, Rahmat, Abdul Aziz, Abdul Hak, 2022). Abdul Nasir & Erman Efendi (2016) highlighted in their study of Special Education in Malaysia that these programs (special education) confront several difficulties, including a lack of facilities, readiness, resources, and instructional materials. As a result, it will inhibit disabled students from having the same access to education as other students have. PE is a subject that must be taught in all primary and secondary schools in Malaysia. The Ministry of Education views physical education as crucial to advancing the contemporary idea of education. This idea focuses on raising "whole children," or well-rounded children (Wee, 2013).

Students with special needs can solve challenges in their physical activity with the aid of adaptive physical education. According to PE Central (2016), adapted physical education is physical education that can be adjusted or adapted to meet the specific requirements of children and adolescents with developmental delays in their gross motor skills (Wilkins, 2016). In order to ensure that children with disabilities may fully engage in and benefit from physical education activities, adaptive physical education frequently entails making adjustments or adaptations to the curriculum, devices, or instructional strategies (Heryati & Ratnengsih, 2017). However, since students might be challenging to explain and communicate with, teaching children with learning disabilities can be challenging for teachers (Norazlina et al., 2018). Teachers typically find it challenging to teach the learning material, perform sports, and interact socially with them (Saputra, 2015). The teacher needs to build a lesson plan for teaching PE subjects to children with learning disabilities that involve all the students' requirements, like adjusting the class materials to be user-friendly and simple to use. This is because every student's need is unique, and their issues must be resolved with the appropriate approaches (Anggraini & Prasetyo, 2015).

Integration of information technology into instruction has become a trend that may help students learn more successfully due to its convenience and mobility (Chang, Zhang, Huang, Liu, & Sung, 2020). AR technology allows individuals to access and distribute information about their environment through the simple use of a mobile device (Gómez-García, Trujillo-Torres, Aznar-Díaz, & Cáceres-Reche, 2018). Due to its promising benefits, this technology has become contentious in the educational field, notably in physical education (PE) classrooms Casey, Goodyear, & Armour, 2017). Nevertheless, little research has been conducted on the use of AR technologies in PE (Moreno, Serrano, Fombana, & Tascon, 2020; Krause, 2017), although these technologies can be easily integrated into PE classes to assist students in learning more about physical activity (Calabuig-Moreno et al., 2020), and have the opportunities for digital technologies to shape PE in new and positive ways (Casey et al., 2017; Wyant & Baek, 2019).

Nevertheless, little research has been conducted on the use of AR technologies in PE. The concept that AR's potential benefits in PE had been overlooked or underrated may be to blame for the lack of research. Traditional methods of teaching physical education, which emphasis direct instruction and physical interaction, are seen to be the most effective. These approaches have proven to be successful and well-established. Furthermore, issues such as ensuring that technology supports active involvement rather than replacing it, as well as addressing logistical and safety concerns, may discourage academics from investigating AR uses in PE. More research is needed to determine how AR can improve PE instruction and learning outcomes. The integration of AR can be used to develop the learning strategies in PE classes since it was discovered that students felt PE sessions were monotonous and bored due to lack of lessons variety of instructional strategies (Lye & Kawabata, 2021). To reduce monotony and boredom in PE lessons, numerous strategies have been proposed, including differentiated instruction, which entails modifying tasks and delivering instructions to match diverse learners' requirements (Tomlinson, 1999). The use of multiple instructional approaches enables students of varying ability levels to attain success based on intrapersonal standards of learning (Deci & Ryan, 1985).

One of the objectives of Malaysia's National Education Policy is to provide equal access to quality education for all students (Ministry of Education Malaysia, 2013). For students with special needs, this objective translates into providing educational opportunities tailored to their unique learning requirements (UNESCO, 2015). The integration of AR into the curriculum aligns with this objective by offering an inclusive learning experience that can cater to diverse learners, including those with dyslexia (Kamaruddin & Ibrahim, 2010). Malaysia's commitment to digital education, as outlined in the Malaysia Education Blueprint 2013-2025, further supports the integration of AR in classrooms (Ministry of Education Malaysia, 2013). The blueprint emphasizes leveraging ICT to improve the quality of education and ensure that students are equipped with the necessary skills to thrive in a digital world (World Bank, 2017).

This strategic document underscores the importance of integrating advanced technologies, such as AR, to create more dynamic and engaging learning environments (Aziz, 2016). The implementation of AR in education is consistent with the Malaysian government's broader goals of fostering innovation, creativity, and critical thinking among students (Khairuddin et al., 2016). It also aligns with global trends in educational technology, where AR is increasingly recognized as a powerful tool to enhance learning outcomes and student engagement (Bacca et al., 2014). Research has shown that AR can significantly improve students' understanding and retention of information by providing multisensory learning experiences (Di Serio, Ibáñez, & Kloos, 2013). The integration of AR into the Malaysian education system is a strategic move that aligns with both national and global educational objectives. By leveraging AR, Malaysia can enhance the inclusivity and quality of education, ensuring that all students, including those with special needs, have access to effective and engaging learning experiences. The implementation of AR in education not only meets the goals set forth in the Malaysia Education Blueprint but also positions Malaysia at the forefront of educational innovation, fostering a generation of students equipped with the skills necessary to succeed in a digital world.

The International Dyslexia Association (2017) suggested that several material accommodations that can be implemented by teachers in the classrooms to enhance the learning of diverse dyslexic students, one of it is by using assistive technology. Any tool that can assist a learner with a disability in carrying out a daily task and helps a child with a disability maintain or increase their functionality is considered an assistive technology or AT (Wilkins, 2016). A complicated or customized tool may be used (Adebisi, Liman, & Longpoe, 2015). The WIPO Technology Trends (2021) categorize AR as one of the assistive technologies that can help to assist people with disability from their vision. When working with people who have dyslexia, augmented reality technology (ART) can be extensively utilized. According to Zainab, Bhatti, Shabir, Ali, & Jawaid, (2020) here are the example of field of work with dyslexics that supported by AR: AR technology in diagnosing dyslexia; AR technology in treating people with dyslexia; and AR technology in instructing people with dyslexia.

Dyslexia is often categorized under Specific Learning Disabilities (SpLD), characterized by difficulties with accurate or fluent word recognition, poor decoding, and poor spelling abilities (Lyon, Shaywitz, & Shaywitz, 2003). Dyslexia can also affect other cognitive processes such as working memory and attention, making traditional learning methods challenging (Swanson, Harris, & Graham, 2013). AR can potentially address these issues by providing multisensory learning experiences that engage multiple cognitive processes simultaneously (Digiovanni, 2017). By presenting information in a visually rich and interactive manner, AR can help students with dyslexia better understand and retain information (Beacham & Alty, 2006). For example, AR can convert text into speech, provide visual aids, and offer interactive exercises that reinforce learning in a more accessible way (Wilkins & Wright, 2021). The use of AR in the classroom aligns with Cognitive Load Theory (CLT) and multisensory learning principles, which advocate for reducing cognitive load and engaging multiple senses to enhance learning (Mayer, 2009). By offering content in various formats and allowing students to interact with the material in different ways, AR can help dyslexic students overcome some of the barriers they face in traditional learning environments (Evmenova, 2018).

Based on Walker, McMahon, Rosenblatt, & Arner, (2017) research, it is explained that AR can help dyslexic students with reading by adding the text labels to the physical items that AR can read. When using an AR application, users can receive prompts to assist independent living, receive video instructions and information about impending processes when undertaking a multistep activity, and have difficult words read aloud and shown on an academic topic. Karamanoli, Persefoni, & Tsinakos (2016) use AR to teach Greece language to students with dyslexia. It was found that AR helps the inclusion of children with dyslexia in the educational process by developing supplementary materials based on the prescribed school textbooks; AR enhance their educational experiences; Teachers believed that there is a favorable attitude towards using AR in the education of dyslexic children - if the app does not require the Internet, it would be great, and teachers can use it in the classroom.

According to a study of the literature, Quintero, Baldiris, Rubira, Cerón, & Velez (2019) found that the following effects of AR on inclusive education have been verified by research: enables students with disabilities to communicate better; increases the students' interest, focus, motivation, and academic achievement; allows the teacher to personalize the student's content; increases the students' subject knowledge; and enhances the teaching of work and career skills; encourages pupils with impairments to engage in physical activity; increases access to remote learning; enhances navigation using digital maps; improves the physical and emotional health of seniors; lessens the workload for teachers of people with impairments. According to Garzón, (2021) research, using AR in learning environments populated by students with special needs is the future path of AR research in education. That result shows good research potential in this field because few studies still focus on AR implementation in special education. Karamanoli et al. (2016) also suggested that creating supplemental materials for history and other school subjects taught to students may be the subject of future research.

Referring to the United Nations Sustainable Development Goals (SDGs), which aim to make the world a more hospitable and habitable environment for human beings, the 17 SDGs were formed from the desire to solve common human concerns (Morton, Pencheon, & Squires, 2017). As a result, the function of research becomes critical in positively promoting the processes and procedures required to make it a reality (Fayomi, Okokpujie, & Udo, 2018). In this research, AR technology will be used as an assistive tool for dyslexic students in learning physical education in the classroom as an effort to improve the quality of education and education equity for all circles to support the 3rd, 4th and 9th goal in the SGD's, which the Good health and well-being, Quality education, and Industry, innovation and infrastructure.

On the other side, evidence suggests that children with special educational needs and disabilities have fewer opportunities to participate in sports than their classmates in conventional schools (Toptaş Demirci & Tzarova, 2021). Also, the physical activity that children get during physical education classes is the basis needed to manage a healthier life, teamwork, good competitiveness, games, and personal and social responsibility to develop active and healthy life skills can all be taught in PE classes (Mamak, Temel, & Kangalgil , 2020). Furthermore, existing studies focus on short-term outcomes, lacking evaluation of the long-term effects of AR on students' physical activity, social skills, and overall health. This study aims to address these gaps by exploring the use of AR in PE classroom for dyslexic students, providing insights into creating more inclusive and effective educational practices.

This research specifically focuses on dyslexic students due to the unique challenges they face in traditional learning environments. Dyslexia, a common specific learning disability, affects a significant portion of the student population and is characterized by difficulties with accurate or fluent word recognition, poor decoding, and poor spelling abilities (Lyon, Shaywitz, & Shaywitz, 2003). These challenges can extend to other cognitive processes such as working memory and attention, making it difficult for dyslexic students to thrive in conventional text-based learning settings (Swanson, Harris, & Graham, 2013). Despite being a practical subject, Physical Education (PE) still relies on textual instructions and descriptions, especially in modules that cover the theory of physical activities, techniques, and health education. This reliance on text presents significant barriers for dyslexic students. Previous studies have largely focused on dyslexia in text-heavy subjects like language arts and mathematics, leaving a research gap in understanding how dyslexia impact learning in non-traditional, less text-intensive subjects like PE (Reid, 2016; Rose, 2009). Addressing this gap is crucial because PE not only contributes to physical development but also to cognitive and social skills, making it an integral part of the overall education curriculum (Kirk, 2010).

Despite the promising results, research in AR applications for education is still in its early stages and gaps exist, particularly in understanding the long-term effects and best practices for integrating AR into the curriculum (Bacca et al., 2014). From all the related data and previous research, it can be seen that a gap exists which could impact physical education classes, as in the actual situation, students in traditional classrooms still learn using textbooks, followed by the teacher's explanation and demonstration in front of the class (Bacca et al., 2014; Ennis, 2014; Radu, 2014). This will also be a problem in the future because dyslexic students have problems with understanding a complex instruction, it is challenging for them to comprehend (Tırıl & Okumuş, 2022). Most research and interventions for dyslexic students focus on core academic subjects like reading, mathematics, and science, where the primary mode of instruction is through text (Beacham & Alty, 2006; Reid, 2011). However, there is a lack of research addressing how dyslexia impact learning in non-traditional, less text-intensive subjects like PE (Mortimore, 2008). Despite being a practical subject, PE still relies on textual instructions and descriptions, especially in modules that cover the theory of physical activities, techniques, and health education (Smith & Green, 2004).

This research gap is significant because PE, unlike other subjects, combines physical movement with cognitive learning. Dyslexic students may struggle to understand written instructions and descriptions in PE textbooks, leading to difficulties in grasping the correct techniques and concepts (Joffe et al., 2007). This struggle not only affects their academic performance but also their physical development and engagement in physical activities. Augmented Reality (AR) offers a promising solution to this problem by providing multisensory learning experiences that can engage multiple cognitive processes simultaneously (Digiovanni, 2017). AR can convert text into speech, provide visual aids, and offer interactive exercises, making information more accessible to dyslexic students (Wilkins & Wright, 2021). By presenting information in a visually rich and interactive manner, AR aligns with Cognitive Load Theory (CLT) and multisensory learning principles, which advocate for reducing cognitive load and engaging multiple senses to enhance learning (Mayer, 2009).

This study aims to explore the use of augmented modules as a learning aid for dyslexic students in PE. The study explores how AR can help dyslexic students overcome the challenges posed by traditional text-based PE education, improve their understanding of physical activity, and enhance their overall learning experience, or conversely, it will also explore how the use of these aids may hinder students' learning. By addressing this research gap, this study seeks to provide insight into the benefits of integrating AR into PE education and offers practical recommendations for educators to support dyslexic students more effectively.

1.2.1 Preliminary Study

Smith, Morrow, & Ross (2017) explained that the goals of preliminary study are to develop various trial procedures or to gather information that will make the trial's design and execution easier. Meanwhile, the pilot studies are tests of the entire trial's procedures conducted in the interim on a small sample of potential participants to ensure, to the extent possible, that any issues with the trial's conduct will be discovered and that protocols can be adjusted before the whole trial begins. In almost every situation, a pilot study might be regarded as one of the preliminary investigations; the opposite is not true (not all preliminary studies might be regarded as a pilot studies) (In, 2017).

To lay a robust foundation for this research, two preliminary studies were conducted: a systematic literature review and a field study. Field studies are conducted to collect direct data and understand phenomena in their natural context in schools, while systematic literature reviews are conducted to gain a broad understanding of existing research and identify trends and gaps in literature. The first preliminary study done is in the field study involving an observation on the PE classrooms and some interviews. The second is done through the systematic literature review of the use of AR technology in physical education with learning disability students. As for objective research in the preliminary study is to a) Explore current teaching methods and tools, to identify the challenges and limitations faced by dyslexic students in the current PE class. b) Evaluate AR technology integration into the classroom to explore the potential benefits of integrating AR technology into PE classes to enhance the learning experience of dyslexic students. c) Understand teachers' perspectives to explore the use of AR on students' understanding of exercises movements, and overall learning outcomes.

a) Field Study

To ascertain the current problems faced by students and teachers in the PE classrooms, the researcher conducted a preliminary study by observing PE classroom and interviews sessions with one principal, two PE teachers, and five students. The interview was conducted for approximately 5 to 10 minutes. The interview with the teacher contained questions about the class conditions and the teacher's current teaching methods. In addition, the difficulties that teachers face in class when teaching dyslexic students with existing learning tools were also asked. Overall, the interview questions contained questions about the teacher's experience of teaching PE class with dyslexic students at this time. Meanwhile, interviews with students contain basic questions about students' interest in learning PE subjects, then what difficulties they face when learning PE in class, and also what makes students enjoy learning in PE classes. Interviews with the principal were conducted to see the problem from a broader perspective, interviews were conducted to find out the current technology used in schools, especially in PE classes, and the availability of devices to then see whether the AR application could be used or not. After the data was collected, a thematic analysis was carried out from the interview results.

From the interview with the principal, it was found that there is currently not many people doing research involving Students with Spesific Learning Disability (SpLD), especially those that apply technology in learning in his school, also there is presently very little technology used by the school as a teaching and learning tool for students. He said, "currently, the technology used for teaching and learning aids is only the computer in the lab. In this lab, students will be taught how to type with MS. Word, recognize shapes and try to draw themselves using Corel draw, and for some students who cannot focus on learning, we invite them to play light games on the computer". Then, the first teacher argued that he usually faced difficulties in teaching SpLDs using textbooks because they have interpretation problems with their visuals on seeing 2D image. He said, "They sometimes have problems interpreting 2D images that show slightly complicated exercise movements or ambiguous images. They will find it difficult to follow the exercise movements in the image". Then the second teacher also said that not all students understand the pictures in the textbook, and some of them need repeated explanations on how to do the exercise. "Most of the students need to see the teacher demonstrate the movements repeatedly, then they will try to follow. Even though the teacher has previously demonstrated the movement."

According to preliminary study results, students prefer physical education (PE) when it is conducted on the field because they can directly play sports such as basketball, soccer, jogging, and throwing a ball. Due to its interactive characteristics and the friendly personality of the PE teacher, this field-based approach is preferred over activities conducted in the classroom. However, students also mentioned that they feel tired of repetitive PE activities and do not want to play if they cannot understand the instructions. This study uses augmented reality (AR) technology to explore the physical education experiences of dyslexic children and also helps visualize to address students who have difficulty understanding instructions. AR will present a variety of interesting PE activities, offer interactive and clear instructions, and promote inclusive learning by making the materials available to all students.

b) Systematic Literature Review

A systematic literature review (SLR) is a thorough and exacting approach for finding, analyzing, and synthesizing prior research that is pertinent to a certain research question or area of study (Torres-Carrion, Gonzalez-Gonzalez, Aciar, & Rodriguez-Morales, 2018). It is crucial to conduct a thorough evaluation of the scientific literature in a particular field in order to formulate research questions and to support additional study in that field (Swartz, 2011). Systematic literature review is done in this research to see the gap on the current topic which is the implementation of AR technology in PE subject with learning disability students.

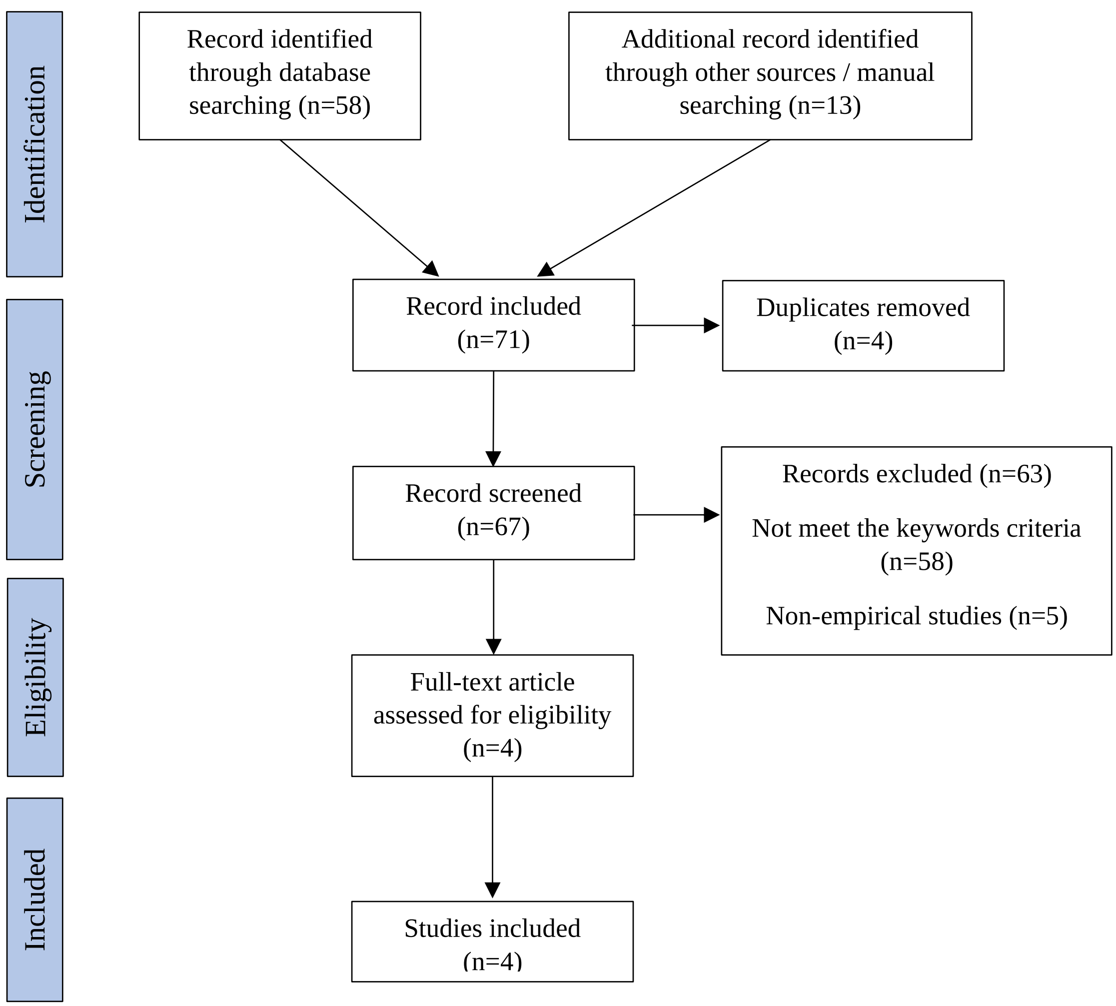


Figure 1. 1

Prisma Selection Process

A systematic search was conducted to identify empirical studies on the use of augmented reality in physical education for students with learning disabilities. The selected studies, published between 2015 and 2021, were identified using a variety of databases including ERIC, PubMed, ScienceDirect, PsychINFO, Google Scholar, Elsevier, EBSCOhost, Routledge (Taylor & Francis), SAGE, IEEExplore, and Springer. The search employed specific keywords: ('Augmented Reality' OR 'Augmented Reality Technology' OR 'Augmented Reality system') combined with ('Physical Education' OR 'Sports' OR 'Sports Education') and ('Disabilities' OR 'Disability' OR 'Disabled' OR 'Disorder' OR 'Special needs') students. Each selected study was reviewed based on its title, abstract, methodology, and results to ensure its relevance to the research topic. As for the exclusion and inclusion criteria are as follows:

Table 1. 1

Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Full-text article, and from an international peer-reviewed journal.	Conference, proceedings, book chapters, reports, letters, or research papers with simple summaries.
Used AR as a primary technology.	AR technology is not the leading technology used in the study.
Used AR technology in the physical education/sports field.	AR is implemented in another educational field (chemistry, physics, biology, etc.).
Included participants with special needs	The study uses more than one technology (virtual reality, mixed reality, etc.)
Published between 2015 and 2021.	
Written in English.	

Inclusion criteria are established to determine what data or sources should be included in the analysis based on certain characteristics or relevance to the research question. These criteria help narrow the data to what is most relevant, ensuring that the analysis focuses on information that directly addresses the purpose of the study. Exclusion criteria are established to outline what should be excluded from the analysis, such as irrelevant data or sources that do not meet certain standards. This helps avoid including data that could skew the results or dilute the focus of the analysis.

A total of 71 articles were found, with 13 articles based on additional records found through manual or other searches or other sources. The next step is, following the scanning procedure, a PRISMA-based selection procedure was carried out. The screening was done on the 71 articles that were discovered. From the initial screening it was found that four articles were duplicates and then removed. Next is continuing the second screening process with 67 articles found that as many as 63 articles were excluded because 58 of then did not meet the criteria, and five of them are non-empirical studies. After going through the screening stage, it was found that four articles that met the criteria were included in this study.

The result shows that there is a lack of research on this topic and cannot find articles with the exact topics which implementing AR in PE with learning disability students. The research found is about how AR technology is implemented for physical activity for children with disabilities. There were found as many as four research on that topic. The first article is the use of AR body motion interactive games to enhance the body strength of children with developmental disabilities. The second article is an AR floor projection system designed to enable people with mobility disabilities to compete on par with, and in the same physical environment as, their peers without disabilities on playing exergames adaptive sports. The third article is a technical discussion of the player detection and tracking features of the iGYM system by evaluating two adaptive filtering-based tracking methods, Kalman Filter (KF), and Particle Filter (PF), to quantify the performance of each scheme for player tracking. The last is the use of AR to prove that this technology can improve learning in track and field sports coaching and instructional processes. From the results of this systematic literature review, it can be seen that research on the use of AR in PE classes and involving children with learning disabilities is still difficult to find.

From the results of the preliminary study, the gap that can be found in the field is the unsuitability of learning materials and tools used to teach students with specific learning disabilities, the focus is on the use of textbooks in the PE subject, where there is too much text contained in the textbook which makes it difficult for dyslexic students to understand the material studied. Then on the teacher's side, because students have different comprehension abilities, this forces the teacher to repeat the demonstration of the movements in the textbook repeatedly to each student who needs repetition. This is considered less effective considering the duration of the class which only lasts 1 to 1.5 hours. It can be concluded that field study highlights the current challenges faced by students and teachers in PE classrooms, particularly in teaching SpLD students using traditional textbooks. The lack of adequate technology and the difficulties in interpreting 2D images necessitate the exploration of new teaching aids.

The systematic literature review reveals a significant research gap in the use of AR technology specifically for PE education involving students with learning disabilities.

Existing studies focus on AR for physical activities and sports but do not address its potential for enhancing understanding and engagement in PE classes for students with SpLD specially dyslexia. However, research on the use of AR to help children with disabilities in learning and training has begun to develop. These findings motivate the current research to explore the integration of AR technology in PE textbooks, aiming to provide a more inclusive and effective learning experience for dyslexic students.

1.3 Problem Statement

Another increasingly prevalent phenomenon is learning disabilities. A category of disorders known as SpLD or most known as learning disability is characterized by difficulties in learning and using cognitive skills such as speaking, listening, reading, writing, thinking, and math (Mona et al., 2015). According to Rogers (2010), SpLD students will have deficiencies in their motor or perceptual skills, affecting their performance in various domains (visual, auditory, kinesthetic, tactile). These challenges can pose obstacles for physical activities. Dyslexia, a common learning disability under the SpLD category, is associated with poor reading abilities and low self-concept, which can result in worse academic outcomes (Battle, 2002; Riddick, 2009; McArthur et al., 2016). Another instance demonstrates how the co-occurrence of ADHD and dyslexia can lessen the focus and engagement required for learning and practice. Dyspraxia is a neurological disorder that can accompany dyslexia and negatively affects one's capacity to process motor skills, movements, thoughts, and perceptions (Pavlovic, Simonton, & Casey, 2022). As a result, it is critical to recognize and understand the fact that dyslexia can coexist with a variety of other learning disabilities, leading to physical developmental coordination deficits (Cermak & Larkin, 2002).

Although dyslexia is not frequently highlighted as a concern in Physical Education (PE), research supports links between physical development, motor learning, and academic learning (Pavlovic et al., 2022). While some dyslexic individuals can improve basic reading and spelling skills with exceptional training, they often face significant challenges with more advanced language skills like grammar and essay writing (International Dyslexia Association, 2017). Preliminary study shows that dyslexic students are still using textbooks on learning PE in the classrooms. This is one of the visible gaps, where we already realize that dyslexia have difficulties in reading, but textbooks are still used. On the other hand, the textbook in the PE subject used contains a lot of text that describes a demonstration picture, this is certainly less effective for dyslexic students. Coupled with conditions where in one class there is only one teacher, then the teacher must demonstrate the movements in the book to students. The second gap arise is that teacher lacks of time in teaching (Ghani, Mohamad, & Bakar, 2013). As we know that dyslexic students have different understanding abilities, this makes the teacher does not enough time to repeat the demonstration movement only once, and must be repeated many times. This is less effective when it happens in class because PE class hours only last between 1-1.5 hours.

Physical activities in school PE classes are crucial for fitness, mental well-being, and social relationships, benefiting all students, including those with disabilities (Kentiba, 2015). However, children with special needs often face obstacles such as a lack of specific learning materials and low motivation due to inadequate support (Alias & Salleh, 2017; Kentiba, 2015). However, the impacts of dyslexia can be minimized by implementing an effective teaching and learning practices that will reduce reading barriers and enable students to succeed academically (Sehic, 2017). Implementing effective teaching strategies, such as those recommended by the International Dyslexia Association, (2017) can mitigate these challenges. Suggested strategies include simplifying written instructions, providing a manageable amount of work, reducing extraneous stimuli, emphasizing critical information, and utilizing assistive technology.

To address these issues, the Orton-Gillingham (OG) approach, known for its multisensory, structured methodology, is proposed. This approach emphasizes direct, corrective training and supports neurodiversity by valuing different learning methods (Gillingham & Stillman, 2012). Additionally, assistive technologies such as Augmented Reality (AR) can play a significant role. According to WIPO Technology Trends (2021), AR is a promising assistive technology that can support independent learning and enhance teaching efficiency. AR provides environments where physical and digital objects interact in real-time (Speicher, Hall, & Nebeling, 2019). It aligns with Cognitive Load Theory (CLT) by reducing extraneous stimuli and focusing on essential learning content, making it an effective tool for visualizing PE movements and improving learning outcomes for dyslexic students. In this study, CLT contributes to addressing these challenges by guiding the development of AR-based learning materials that are suited to dyslexic students' cognitive needs. This study intends to improve learning efficiency by using augmented reality (AR) to display physical motions. Furthermore, AR reduces irrelevant cognitive load by eliminating extraneous distractions, ensuring that students’ cognitive resources are focused on processing essential information. This method not only enhances comprehension and retention, but it also makes learning more enjoyable and accessible, particularly for children with learning difficulties such as dyslexia.

This research will explore the use of Augmented Reality (AR) technology in PE subject. AR can give dynamic, interactive visualizations of physical movements, decreasing the need for text-heavy resources and improving the learning experience for dyslexic students. This study uses augmented reality (AR) to bridge the gap between the traditional, text-based approach and the demand for more engaging, multisensory learning approaches. The use of AR is consistent with the Cognitive Load Theory (CLT) and the Orton-Gillingham (OG) approach, which advocate for minimizing extraneous cognitive load and applying multimodal methods to enhance learning. This strategy promises to increase dyslexic students' interest, comprehension, and involvement in PE programs, making them more accessible and successful.

1.4 Research Objectives

The primary goal of this research is to explore the use of AR technology as an assistive tool in the classroom with dyslexic students as a new learning strategy in learning PE. This purpose leads to the following research objectives:

RO 1 To explore the implementation of Cognitive Load Theory (CLT) and Mayer's Principles of Multimedia Learning on designing PE learning and augmented modules for dyslexic students.

RO 2 To explore dyslexic students learning experiences when using augmented module as an assistive learning tool in learning PE subject.

RO 3 To identify the AR app and module learning content that supports the dyslexic students learning process and barriers to using AR technology in PE subjects.

RO 4 To explore teachers’ perspectives on using augmented module for assisting dyslexic students in their PE classrooms.

1.5 Research Questions

This study attempts to answer the following research questions:

RQ 1 How is the Cognitive Load Theory (CLT) and Mayer’s Principles of Multimedia Learning applied in the design PE learning and the augmented module for dyslexic students?

RQ 2 How are the dyslexic students learning experiences when using augmented module as an assistive learning tool in PE classrooms?

RQ 3
a. How does the AR technology and augmented module learning content support the learning process of dyslexic students in PE classrooms?
b. What are the barriers on using AR technology and augmented module in PE classrooms for dyslexic students?

RQ 4 What are the teachers’ perspectives on the use of augmented module as an assistive learning tool for dyslexic students in the PE classrooms?

1.6 Significance of Study

The focus of this research is to help dyslexic students visualize 2D exercise images in the textbook that are used in PE classrooms by using AR technology as an assistive learning tool. It is known that dyslexic students encounter several challenges in the learning process such as reading difficulties; spelling, and writing; working memory limitations; slow processing speed, and low self-esteem and motivation. This is inversely proportional to the fact that they still learn by using textbooks with a lot of use of letters and long descriptions in them. This is one of the gaps encountered, considering that dyslexic students have reading problems and yet textbooks are still often used. Altough, some studies have used assistive technology in the form of reading and writing tools for dyslexic students (using sound and flashcards) (Adebisi et al., 2015; Courtad & Bouck, 2013; Samuel, 2020) the assistive tools for dyslexic students to help them in understanding images in PE textbooks by visualizing them into animation are still difficult to find. In line with that condition, this research also tries to see from teacher's perspectives on using AR as an assistive learning tool for dyslexic students in their PE classrooms.

As mentioned in the beginning, school teachers faced significant obstacles in providing excellent education and assisting students with dyslexia in overcoming learning disabilities (Tam & Leung, 2019). There are several obstacles on teaching dyslexic students which they do not have insufficient time in teaching (Thwala, Ugwuanyi, Okeke, & Gama, 2020), as dyslexic students have different understanding abilities, this forces the teacher to repeat the demonstration of movement exercises who have not understood by the students, resulting the teaching and learning process less effective, and also lack of efficient teaching approaches in an inclusive classroom (Ahmad, & Salehuddin, 2018). Based on that problem, this research will design and develop an AR module for learning PE that adapts to dyslexic students' ability and needs. This assistive technology will support dyslexic students to learn independently.

Furthermore, this research supports the special needs curriculum in Malaysia, aligning with the nation's commitment to providing equitable education for all students.

The Ministry of Education Malaysia's policies emphasize inclusive education and the integration of technology to enhance learning outcomes. This research will provide educators with ideas and suggestions for new learning strategies that can be applied in the classroom, ensuring that PE teaching methods evolve alongside technological advancements and according to students' needs. This is crucial, as research indicates that there is a lack of teacher responsibility in supporting students with special needs in PE (Priyono, 2016). Lastly, this research is expected to provide important insights into the needs of children with disabilities, particularly dyslexic students in the context of PE classrooms. These insights can be used as evaluation materials and as a basis for further research by various groups, including researchers and educators in this field.

1.7 Theoretical Framework

The teaching and learning process involves planning, delivering, engaging, assessing, and adapting instructional methods to facilitate student understanding and achievement (Brown, Roediger, & McDaniel, 2014). Teaching effectiveness is measured by students' comprehension, engagement, achievement of learning goals, and the adaptability of methods to diverse needs (Hattie, 2009). In this study, AR technology enhances this process by applying Cognitive Load Theory (CLT), which helps reduce cognitive overload by presenting complex information in interactive, visually rich formats (Sweller, 2011). Mayer’s Multimedia Learning Principles are utilized to integrate verbal and visual information, improving comprehension and retention through multisensory input (Mayer, 2009). Additionally, the Orton-Gillingham approach’s multisensory methods are incorporated, providing visual and interactive elements that support dyslexic students' learning needs (Gillingham & Stillman, 1997). By aligning these theories with

AR technology, the study aims to create an adaptive learning environment for dyslexic students in physical education, addressing traditional limitations of text-heavy materials and enhancing overall educational outcomes (Slavin, 2014).

An adaptive environment means that the learning materials and tools used for learning and teaching are adapted to their needs and ability because, as explained earlier, teachers are often unaware of this situation and that students' abilities differ from one another. Hence, the learning and teaching process becomes less effective because some students will not be able to follow the learning process due to their ability. Several theories will be used to achieve this goal as a guideline in building learning materials and implementing classroom learning.

In the design phase for the AR module as the learning materials, this research uses Cognitive Load Theory (CLT) to provide guidance for planning and executing technology-enhanced learning experiences, and Mayer’s Principles of Multimedia Learning as guidelines for the effective use of multimedia in learning environments.Then, during the teaching and learning process, this research will use Multisensory Approach by Orton-Gillingham as a reference for using more than one sense to bring about more effective communication that emphasizes student engagement through the multi-sensory instruction effective PE learning.

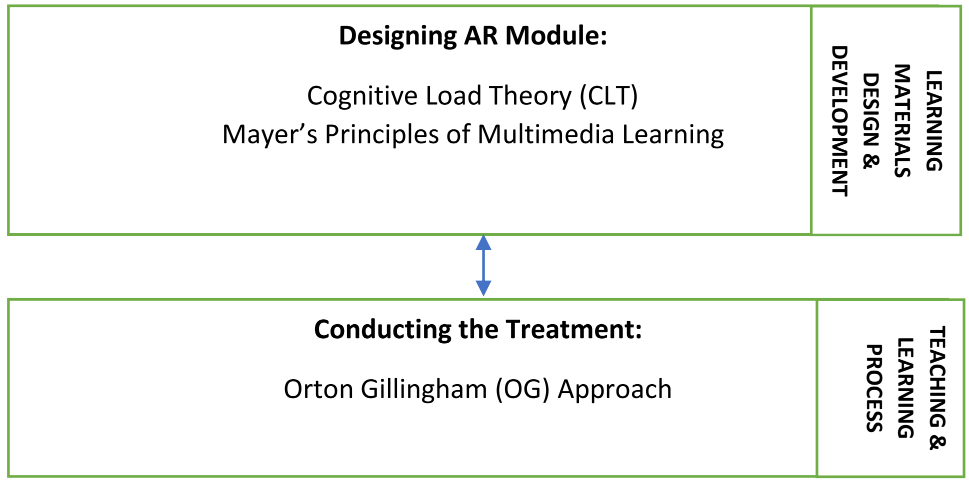


Figure 1. 2

Theoretical Framework

Figure 1.2 depicts the theoretical framework for this study. There are two implementations of the theories or model used. The first is in the creation of modules and learning materials, where at this stage there are two theories implemented: CLT and Mayer's Principles of Multimedia Learning which are used as guidelines for designing effective modules for dyslexic students. The second is in the teaching and learning process, Orton Gillingham's multisensory approach will be used as a teacher's guide when teaching and interacting with students also in providing the learning materials. So that the learning process becomes more effective.

1.7.1 Cognitive Load Theory (CLT)

The subject of cognitive load theory is the way that cognitive resources are concentrated and applied during learning and problem-solving (Sweller, 1988). Many of the learning and problem-solving techniques supported by instructional models lead to students engaged in cognitive activity unrelated to the task's stated objectives. The cognitive strain brought on by these pointless tasks may make it more difficult to learn new skills. A limited working memory and partially independent visual and auditory information processing units work in conjunction with an unlimited long-term memory to produce cognitive architecture. In order to ease the changes in long-term memory associated with schema acquisition, cognitive load theory is concerned with strategies for reducing working memory load (Sweller, 1994).

Cognitive Load Theory (CLT) and Cognitive Theory of Multimedia Learning (CTML) are closely related because they both aim to optimize the cognitive processes involved in learning. CLT emphasizes controlling learners' cognitive load to enhance comprehension and retention of information. The theory distinguishes three categories of cognitive load: intrinsic (complexity of material), extrinsic (unnecessary knowledge), and germane (effortful processing that enhances learning) (Sweller, 2010). CTML, created by Richard Mayer, refined CLT by applying these principles to multimedia learning environments. Effective multimedia training, according to this theory, should integrate text, images, and audio in a way that matches the way the brain processes information to minimize extrinsic load, control intrinsic load, and enhance relevant processing (Mayer, 2005).

Cognitive Load Theory (CLT) by Sweller (1994) is concerned with regulating cognitive load when learning. It implies that learners have limited working memory capacity, and that learning materials and technology should be designed to reduce unnecessary cognitive load while optimizing pertinent cognitive load. Technology should be developed to display information to minimize cognitive load and promote effective learning. In this study, Cognitive Load Theory (CLT) is implemented to address the learning challenges faced by dyslexic students in physical education (PE). CLT posits that cognitive resources are limited and that instructional methods should be designed to minimize unnecessary cognitive load to facilitate learning (Sweller, 2011). Dyslexic students often experience high cognitive load due to difficulties with reading and interpreting text, which can hinder their ability to process and retain information effectively (Swanson et al., 2013).

To implement CLT, this study uses Augmented Reality (AR) technology to present exercise instructions in a visually interactive manner. This approach aims to reduce intrinsic cognitive load by replacing text-heavy descriptions with dynamic, multimedia representations of exercises. By converting complex 2D images into 3D animations, AR helps dyslexic students understand and follow physical movements more easily. This method aligns with the CLT principle of reducing the cognitive burden associated with processing textual information, thus allowing students to focus on the learning task rather than struggling with reading difficulties (Mayer, 2009).

Additionally, AR technology supports the CLT principle of segmenting information into manageable chunks. It breaks down exercise instructions into visual and interactive segments, preventing cognitive overload and enabling students to process each component of the task incrementally. This segmentation is crucial for dyslexic students, who may benefit from clear, step-by-step guidance rather than lengthy textual explanations (Sweller, 2011). Overall, the integration of CLT through AR technology aims to enhance learning efficiency by making information more accessible and reducing cognitive strain, thereby improving the educational experience for dyslexic students in PE (Swanson et al., 2013; Mayer, 2009).

These theories are especially significant for dyslexic students, who frequently struggle with written text and information organization. Dyslexic students often benefit from instructional approaches that reduce cognitive load while offering unambiguous, multimodal information representations (Sehic, 2017). Educators can use CLT and CTML concepts to create instructional materials that address the unique cognitive needs of dyslexic pupils, making learning more accessible and successful for them. Using multimedia techniques like augmented reality in physical education, for example, can assist dyslexic kids better grasp and retain complicated motions by lowering reliance on text and improving visual and kinesthetic learning pathways (Pavlovic, Simonton, & Casey, 2022). CLT theory is used in this study to create instruction and give support that meets the cognitive demands of dyslexic students. Based on this theory and its relationship with dyslexic students, researchers can facilitate dyslexic students to optimize their learning potential and improve their overall educational experience by reducing extraneous cognitive load, scaffolding learning experiences, incorporating visuals, and leveraging effective instructional techniques. In this study, CLT was used as a guide in developing AR modules to reduce the working memory load that might appear on students while learning.

1.7.2 Mayer’s Principles of Multimedia Learning

Richard Mayer's (2001) significant research in his book entitled "Multimedia Learning" explains his considerable study on successfully arranging multimedia resources to maximize learning. Mayer (2005), defining multimedia learning as a type of computer-assisted training employs two concurrent modalities. This entails learning through combined audio and visuals, such as images, animations, text, and videos (through narrated voiceover). He divides his findings from several studies into 12 principles that comprise (in part) what he refers to as the "cognitive theory of multimedia learning." This theory and its ideas outline how to construct excellent multimedia learning presentations. The 12 principles of multimedia learning by Mayer's are: Coherence Principle; Signaling Principle; Redundancy Principle; Spatial Contiguity Principle; Temporal Contiguity Principle; Segmenting Principle; Pre-training Principle; Modality Principle; Multimedia Principle; Personalization Principle; Voice Principle; and Image Principle.

Based on International Dyslexia Association (2017) suggestion to implement a learning strategy for teaching dyslexic students that mentioned before, we can see that several suggestions can be achieved by using Mayer's principles of multimedia learning which are to: a) clarify or make written instructions simpler; b) provide a little quantity of work; c) remove extraneous stimuli; and d) emphasize critical information. In this study, the use of Mayer's principles of Multimedia Learning aims to guide researcher in the development of AR module learning content to create an adapted learning content and materials for dyslexic students.

The implementation of Mayer's Principles of Multimedia Learning is crucial for enhancing the learning experience of dyslexic students in physical education (PE) through Augmented Reality (AR) technology. These principles guide the design of AR modules to ensure they are effective and accessible for students with specific learning disabilities. By integrating these principles, the AR modules are tailored to the cognitive and learning needs of dyslexic students, making PE learning more effective and accessible. This alignment with Mayer's principles ensures that the AR-enhanced PE curriculum is designed to support and enhance the educational outcomes for students with dyslexia (Mayer, 2009; Wilkins & Wright, 2021).

1.7.3 Orton Gillingham (OG) Approach

The Orton-Gillingham (OG) Approach is a designed, multisensory teaching strategy created especially for people with dyslexia (Sayeski et al., 2019). It places a strong emphasis on the systematic and direct instruction of phonetics, phonology, and language abilities. They created instructional exercises intended to encourage the mastery and automaticity of those abilities for students with dyslexia as part of their approach to teaching reading, which was centered on breaking down the elements of language into distinct and overlapping skills (Uhry & Clark, 2005). An OG strategy is language-based, multisensory, adaptable, cognitive, systematic, explicit, and cumulative (Davis, 2011; Sheffield, 1991). However, this is distinct from applying the visual-auditory-kinesthetic (VAK) learning styles hypothesis since OG does not use multisensory strategies in learning. According to the VAK learning styles theory, students must learn their preferred modality and that learning is aided by teaching in that modality (Willingham et al., 2015). An OG method, on the other hand, utilizes all modalities to support repetitive practice, diversified instruction, and numerous conceptual representations. Brown, Roediger, & McDaniel (2014) research supports these instructional elements. A similar study has shown that other reading programs with a multimodal focus are effective (Kilpatrick, 2015). With the help of this strategy's auditory, visual, and kinesthetic components, dyslexic students can interact with the material in several ways. Every time a student receives information, communication is necessary to assist their learning. Multisensory education techniques have been developed to help kids with speech and hearing impairments communicate verbally and in writing (Gillingham & Stillman, 1997; Kotler, 2018). In multisensory teaching, students acquire information and learn by creating connections between their auditory, visual, and kinesthetic senses. According to Kelly and Phillips (2016), teaching with a multisensory approach is recommended since it builds neural pathways in the brain for more automatic information retrieval. Not only in children with speech disorders, but this technique can also be used for SLDs to improve communication with teachers and also the process of receiving material and visual processing.

The Theory of Multisensory Integration explores how the brain integrates data from several sensory modalities, including vision, hearing, touch, and proprioception, to produce a unified and coherent perception of the outside world (Stein, & Stanford, 2008). Based on the theory, multisensory integration happens at several neural system levels, from the earliest stages of sensory processing to more advanced cognitive functions. The integration of sensory input, according to the multisensory integration theory, has a number of advantages, including enhanced perception, attention, and memory. It also has a significant impact on how much emphasis and weight are given to various sensory inputs, and it can assist the brain in resolving conflicts between sensory modalities. The multisensory approach comes based on the principle of Multisensory Integration Theory. On his research, Pavlovic et al., (2022) applies OG Approach Modification Strategies into practice for PE subjects. Like any other quality teaching and learning environment, the instructor must be fully prepared and organized (with quality lesson planning in terms of equipment, facility, progressions, grouping, and modifications).

In relation to CLT, the OG approach efficiently reduces intrinsic cognitive load by presenting material in a structured and sequential manner, making complex activities more manageable for dyslexic learners. This technique increases appropriate cognitive load by combining auditory and visual elements, thereby promoting deeper processing and comprehension. Furthermore, this technique reduces irrelevant cognitive load by focusing only on relevant information and eliminating unnecessary distractions, which is especially important for dyslexic learners who may have difficulty processing and remembering large amounts of information at once (Sweller, 2010; Stillman, 2012). In the context of CTML, the OG approach is closely related to the theory's emphasis on the use of multimedia elements to enhance learning. OG's use of a multimodal approach is consistent with CTML's notions of dual encoding (using visual and verbal information) and continuity (aligning text with related images), all of which are important in helping dyslexic learn and retain knowledge more successfully (Mayer, 2005). The OG approach harnesses the power of multimedia learning by engaging multiple senses, making it easier for dyslexic children to encode, store, and retrieve information, thereby improving overall learning outcomes (Gillingham & Stillman, 2012).

In this study, the OG approach is used as a guide for teachers in teaching and creating learning activities that will be carried out by students that focus on connecting their visual, auditory, and kinesthetic to build maximum learning outcomes and help their visual perception on learning with AR technology. By integrating the OG approach into the AR-enhanced PE curriculum, this study aims to provide a comprehensive and effective learning experience for dyslexic students. The multisensory, structured, and adaptive nature of the OG approach, combined with the immersive capabilities of AR, creates an inclusive and supportive educational environment that addresses the specific needs of students with dyslexia (Moats & Farrell, 2005; Samuel, 2020).

1.8 Operational Definitions

The following operational definition aims to define and focus the terms related to this study.

1.8.1 Augmented Module

In this study, an "augmented module" refers to a module where there are lesson plan or instructional resource inside that uses AR components to improve the learning process. To give students a more interesting and dynamic learning experience, such modules can include interactive 3D models, animations, or digital overlays on real-world items. Augmented module is used as a term of module that uses AR technology which will be used in this research. In this study what is being developed is a module with PE learning material for dyslexic students, not an AR application, therefore the researcher calls the module to be developed an augmented module.

1.8.2 Assistive Technology

The International Classification of Functioning, Disability, and Health (ICF) defines assistive products and technology as any product, instrument, equipment, or technology that has been specially designed or adapted to improve the functioning of a person with a disability (Ellis, 2016). Assistive technology is a general term. According to Lancioni et al. (2013), AT are a variety of tools designed to improve everyday functioning and quality of life for the disabled and people with specific educational or rehabilitation requirements. In education, AT provides a variety of options for meeting the needs of students in the educational process (McKnight and Davies, 2012). In this study, AT refers to the use of technology to assist dyslexic students in learning PE subjects in the classrooms.

The Assistive Technology Act of 2004 defines Assistive Technology (AT) as any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve the functional capabilities of individuals with disabilities. AT can be anything that helps a student with a disability perform a task that he or she would otherwise be unable to perform or that increases the efficiency with which the task is performed, even common place stuff may be AT (Coleman, 2011). In this study AT refers to the technology used to assist students in learning PE in the classrooms.

1.8.3 Augmented Reality (AR)

AR is a technology that blends virtual objects with the physical world. Its guiding principle is to simulate the real world before applying computer-generated virtual information such as text, photographs, 3D models, music, and video to it (Chen et al., 2019). In other terms, AR (AR) is a technique that combines real reality with virtual additions (Rebbani, 2021). In this study, AR technology is used as an assistive technology in physical education classrooms to assist dyslexic students in learning.

1.8.4 Students with Specific Learning Disabilities (SpLD)

The Individuals with Disabilities Education Act (IDEA) defines a specific learning disability as a disorder in one or more of the fundamental psychological processes necessary to comprehend or use language, whether spoken or written, which manifests itself in the inability to listen, think, speak, read, write, spell, or perform mathematical calculations (Muktamath et al., 2022). Malaysian Social Welfare Department (2023) categorizes special learning disabilities into three categories which are dyslexia, dysgraphia, and dyscalculia. In this study, students with specific learning disabilities (dyslexia) will experience AR technology by being the research participants where the researcher will integrate AR technology into their PE in class.

1.8.5 Dyslexia

According to International Dyslexia Association (2017), dyslexia is a term given to a group of symptoms that make it difficult for some individuals to read and other specialized language skills. Other language abilities, like spelling, writing, and word pronunciation, are typically difficult for dyslexic students to learn. The main challenges are with word recognition, reading fluency, spelling, and writing. Some dyslexic people can learn basic reading and spelling with outstanding instruction, but when they need to employ more sophisticated language skills, like grammar, to understand textbook material or to write essays, they later experience their most severe challenges. Malaysian Social Welfare Department (2023) define dyslexia as the differences in the way the brain thinks in connecting visual symbols and sounds subsequently experience difficulties in reading, writing, understanding, spelling, and counting. This study will focus on dyslexic students as the participants and following their needs and ability in developing the learning materials and activity. The dyslexia group who will be participants are secondary school students at level 5 in one of the schools in Malaysia. A total of two physical education classes (12 students) will participate in this research. Students are selected based on conditions set by the researcher. The level of dyslexia that students in the class have is a mixture of mild-moderate following the standards set by the school in selecting students to register.

1.8.6 Physical Education

According to Oxford references (2023) Physical Education is a process whereby fairly intense action leads to and promotes beneficial adaptation and learning (organic, neuromuscular, intellectual, social, cultural, emotional, and aesthetic). In an official context, physical education (PE) is an educational activity that takes place in a learning environment and emphasizes physical movement. In this study, PE is a context of the study which being the environment of the study will take place.

1.8.7 Learning Experiences

Learning experiences are crucial in the constant and lifelong learning process, which tries to modify, alter, or innovate behavior. The most essential method toward achieving this objective is learning. Learning results in positive behavior change. When people have an experience, they learn. Learning requires understanding and accumulating knowledge, talents, skills, and attitudes (Inamdar & Rathod, 2012). In this study, learning experiences refer to the experiences that students get during the learning process in physical education classroom using AR applications.

1.8.8 Learning Content

International Bureau of Education (2023) defines learning content as the subjects, themes, ideas, behaviors, concepts, and facts that are supposed to be acquired and serve as the foundation of teaching and learning are frequently categorized within each subject or learning area under knowledge, skills, values, and attitudes. In this study learning content refers to the learning materials used in the AR module (the use of exercises activity, image, text, colors, etc).

1.9 Limitation of Study

There are some limitations in this study that need to be addressed in future research. First, this research will be conducted in one of vocational special education high schools in Penang, Malaysia, focusing on students who enrolled in Physical Education subject. The students involved will be first-year students in their senior high school. This research will focus on dyslexic students as one category of students with special learning disabilities (SpLD) characterized by difficulties in reading. As for the dyslexic students who will be selected is students who do not have physical limitations, meaning that they are not constrained by physical activity, and then students who do not have vision problems. These criteria selected because this research involves 3D objects and AR modules, so students must see first then just do the movements in the module, students are also selected who have no speaking problems and are fluent in Malay, because this research will be conducted in Malaysia.

Second, this study involved dyslexic students often struggle with reading due to difficulties in decoding and phonological processing, which are essential for accurate and fluent reading (Kızılaslan & Tunagür, 2021). To avoid overload in their working memory, this study will follow the instructional strategies of Cognitive Load Theory by focusing on applying one set of exercises activity per week. As mentioned before, this study will have three activities in the module, each activity has four exercises included, so at each meeting, students will learn only four exercises movements. Teachers will explain and demonstrate it, followed by the students that will learn independently using augmented module with their peers.

Third, the augmented module used as markers to bring up AR technology will be adapted to the teaching material taught at the time this research is carried out so that it remains integrated with the PE curriculum in schools, and will focus on flexibility, muscle strength and muscle endurance learning materials. Lastly, the use of augmented module that integrated with AR technology in this research, play a role as an assistive technology for assisting students learning process in the classroom.

1.10 Summary

Dyslexia is a specific learning disability that primarily affects reading and spelling abilities. Characterized by difficulties with accurate and fluent word identification, dyslexia impair decoding skills and reading comprehension. This neurodevelopmental condition is not related to IQ or effort, manifesting through several challenges: difficulties with phonological processing, reading fluency, spelling and writing, reading comprehension, phonological awareness, and sometimes working memory. Despite its lifelong nature, dyslexia is often under-addressed in educational settings, particularly in physical education (PE) classrooms. Traditional instructional methods, such as the use of textbooks, present significant barriers for students with dyslexia. They struggle with reading difficulties, visual processing issues, organizational challenges, vocabulary comprehension, and reading fatigue. These barriers hinder their ability to effectively engage with and benefit from physical education content.

To address these challenges, this study explores the application of the Orton-Gillingham (OG) approach, which uses multisensory instructional strategies tailored to the needs of students with dyslexia. By combining multisensory methods—such as visual aids, hands-on demonstrations, and interactive technology—the approach aims to enhance learning and retention. Additionally, Mayer's Multimedia Learning Principles are applied to simplify and clarify textbook material, breaking down complex information into more digestible segments. The study also integrates assistive technology, specifically Augmented Reality (AR), to provide 3D animations of physical exercises. These visual supports aim to complement traditional textbook content, making it more accessible and engaging for dyslexic students.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In the previous chapter, it was explained that the research problem encountered and will be addressed in this study is the use of instructional materials that are not suitable for dyslexic children in PE classrooms. From the existing problems, this research seeks to help facilitate dyslexic students while learning in PE classrooms by providing AR technology as an assistive tool to help assisting students when learning and understanding the materials in PE textbooks. This chapter explains the theoretical basis, models, and ideas related to this research. It is also equipped with a review of literature from relevant previous researchers to support the basis of this research.

This chapter begins with an explanation and theoretical basis regarding students with learning disability (SLD), that has subtopics about SpLD and dyslexic students. Next will be providing an information about special schools in Malaysia, also an explanation of adaptive physical education. Next, this chapter also provides an explanation on technology used in physical education, and assistive technology that has subtopics about AR, AR in education, and AR in adaptive physical education. This chapter also has literature about the related research which has subtopics on: technology applied for specific learning disability (SpLD) students, technology used in adaptive physical education, and AR for disability students. Lastly this chapter has explanations on the learning theories and design model involving the Cognitive Load Theory (CLT), Mayer's Principles of Multimedia Learning, OG Approach, and ADDIE Model as the instructional design model used in this study.

2.2 Students with Learning Disability (SLD)

There are many definitions of learning disability (LD), children with learning disabilities have intelligence that is much lower than the average for their age and are also unable to adapt their behavior, which appears during the developmental stage (Winarsih, Hendra, Idris, & Adnan, 2013). Kirk, Gallagher, Coleman, & Anastasiow (2012) also defined learning disability as a neurological condition affecting a person's brain and impairing their thought and memory capacity. It shows difficulties with thinking, reading, writing, spelling, or math. Despite possessing specific intellectual abilities, these are unrelated to medical, emotional, or environmental causes (Weyandt, 2006). According to Muktamath et al., (2022) LD is a neurodevelopmental disorder not caused by hearing or vision issues, socioeconomic issues, cultural or linguistic differences, a lack of motivation, or insufficient instruction. This is caused by the brain's ability to receive and/or process verbal and nonverbal information effectively and accurately is affected by the interaction of genetic, epigenetic, and environmental factors of biological origin.

Nowadays, up to 50% of all students receiving special education have learning disabilities (Namkung & Peng, 2018). Although the exact cause of a learning disability is unknown, LD can be brought on by a variety of factors, such as physiological factors (such as genetics, brain damage, metabolic imbalance, maturational delays, and unexplained nervous system disorders) and environmental variables are among the potential causes (e.g., poor nutrition and exposure to environmental toxins, such as lead, and injuries sustained at birth or in the first few years of life) (Namkung & Peng, 2018). LD can also be inherited by premature babies and kids who experience health issues immediately after birth (Manghirmalani, Panthaky, & Jain, 2011).

Children with learning disabilities often receive different lessons than they need at school. For the development of these children, SLDs need to learn more about life than theories or academic subjects, such as how to interact with others and live independently based on the needs of each child. According to Astuti (2014), there are seven aspects of the main objectives of education for SLD, which are; developing essential learning skills in school, healthy living habits, socialization skills, emotional abilities, and a sense of security, both at school and home, use the ability to use spare time, develop skills through vocational training, and develop the ability to push themself in productive activities. Malaysian Social Welfare Department (2023) categorizes learning disability into six types which include: Global Developmental Delay (GDD), Down Syndrome (DS), Attention Deficit Hyperactivity Disorder (ADHD), Autism (Autism Spectrum Disorder), Intellectual, and Specific Learning Disability (SpLD). This research will focus on disabilities that cause problems faced by students when participating in learning activities, one of which is learning disabilities.

2.2.1 Students with Specific Learning Disability (SpLD)

American Psychiatric Association (2021) defines Specific learning disorders as neurodevelopmental diseases commonly identified in preschool-aged children but may not be recognized until adulthood. They are distinguished by persistent deficits in at least one of three major areas: reading, written expression, and/or math’s. The term "specific learning disability" under the Individuals with Disabilities Education Act (IDEA) is defined as a specific disorder in one or more areas of psychological processes involved in understanding and using spoken or written language, which results in deficits in the ability to listen, think, speak, read, write, spell, or do mathematics, but excludes learning issues caused by sensory disorders, emotional disturbance, intellectual dissonance, or other conditions (Muktamath et al., 2022). It proves unequivocally that specific learning disabilities are not the result of visual, hearing, or motor deficiencies, mental retardation, emotional disturbance, environmental, cultural, or economic disadvantage (DOE, 1995). According to American Psychiatric Association (2021), a specific learning condition will be identified in a person who meets all four criteria listed below:

1. Children with SpLD may be having problems in at least one of the following areas for at least six months despite focused assistance: 1) difficulty in reading (i.e., inaccurate, slow, and requires a lot of effort); 2) having trouble in comprehending what is read; 3) spelling difficulties; 4) compositional difficulties, such as issues with grammar, punctuation, or organization; 5) having trouble with calculations, number facts, or number ideas; and 6) difficulty using mathematic principles or figuring out mathematical difficulties.
2. Have academic abilities that are significantly below what is normal for the child's age and cause issues in learning, employment, or daily activities.
3. Even though some people do not suffer serious issues until maturity (when academic, employment, and daily responsibilities are heavier), challenges often begin when a person is still in school.
4. Learning disabilities are not brought on by other conditions, such as intellectual disabilities, vision or hearing issues, neurological disorders (such as paediatric strokes), unfavourable environmental or economic circumstances, a lack of instruction, or issues with speaking or understanding the language.

Meanwhile, some problems may be experienced by students who have SPLD, such as:

1. Neurological Basis: SPLD often have a neurological basis, meaning that they are linked to brain function and structure. For instance, dyslexia is associated with differences in the brain areas involved in language processing (Shaywitz, 2003). Dysgraphia may involve issues with motor control and spatial processing, while dyscalculia is linked to difficulties with numerical and spatial reasoning (Geary, 2011).
2. Impact on Academic Performance: SPLD can significantly impact academic performance and learning. For instance, students with dyslexia may read slowly and with difficulty, which affects their ability to comprehend and retain information. Similarly, students with dysgraphia may struggle with written assignments, affecting their overall academic achievement (Berninger & Wolf, 2009).
3. Intervention and Support: Understanding SPLD is crucial for developing effective interventions. Tailored instructional strategies, accommodations, and assistive technologies can help individuals with SPLD manage their difficulties and achieve academic success. For example, specialized reading programs, speech-to-text software, and math tutoring can provide significant support (Snowling, 2000; Shaywitz, 2003).
4. Educational and Social Implications: SPLD can also affect social and emotional well-being. Individuals with SPLD may experience frustration, low self-esteem, and social difficulties due to their learning challenges. Addressing SPLD with appropriate support can help mitigate these issues and improve overall quality of life (British Dyslexia Association, n.d.).

A learning disability affects 5 to 15% of school-aged children, according to the American Psychiatric Association (2013). In instance, reading is thought to be impaired in 80% of people with learning disabilities (often referred to as dyslexia). According to Shaywitz et al. (2002), 20% of the population has dyslexia. Both sexes are equally affected by dyslexia. According to the American Psychiatric Association (2013), there is a substantial comorbidity between learning disabilities and other neurodevelopmental disorders (such ADHD) and anxiety. Special learning disability are categorized into three types which is dyslexia, dysgraphia, and dyscalculia (Malaysian Social Welfare Department, 2023; American Psychiatric Association, 2013).

a) *Dyslexia*

Dyslexia is a word used to describe problems learning and processing language, which are frequently exhibited by difficulties with reading, spelling, and writing. Dyslexics have trouble relating the sounds of letters to the letters they see on a page. As a result, reading for them becomes laborious and tedious, rather than being a fluid experience.

b) *Dysgraphia*

Dysgraphia is the term used to describe problems with writing down one's thoughts. Writing issues might include challenges with handwriting, spelling, grammar, and punctuation.

c) *Dyscalculia*

The term "dyscalculia" refers to problems understanding concepts relating to numbers or employing the symbols and functions necessary to carry out mathematical operations. Mathematical challenges can include issues with number sense, memorization of arithmetic information, calculations, reasoning, and problem solving.

As explained earlier, students with SpLD can be helped to improve their abilities with the help of appropriate learning strategies and learning materials. In this research, students with SpLD problems will be the focus of research more specifically students with dyslexia.

2.2.2 Students with Dyslexia

According to Muktamath et al., (2022) in the most common type of LD, accounting for at least 80% of all LDs, is dyslexia (also known as reading difficulty), a specific learning disability that impacts reading and related language-based cognitive abilities. It can coexist with other associated problems and have an impact on reading fluency, decoding, comprehension, recall, writing, spelling, and occasionally speech. However, each person's level of severity can vary, and dyslexia is occasionally referred to as a language-based learning disability. According to the Malaysian Ministry of Education, approximately 5% of Malaysian students have some form of learning disability, including dyslexia. However, specific statistics for dyslexia alone may not always be distinctly reported (Ministry of Education Malaysia, 2022). Meanwhile, The Malaysian Dyslexia Association (Persatuan Dyslexia Malaysia) estimates that about 10% of Malaysian students may experience some form of dyslexia, though this figure can vary based on the data source and study. The Malaysian government has been actively implementing special education programs and training for teachers to better support students with dyslexia and other learning disabilities. Initiatives include specialized training for educators and the development of tailored educational materials (Ministry of Education Malaysia, 2022).

Malaysian Social Welfare Department (2023) define dyslexia as characterised by abnormalities in the way the brain thinks about connecting visual symbols and sounds, resulting in difficulty with reading, writing, comprehension, spelling, and counting. Meanwhile, International Dyslexia Association (2017) stated that dyslexia is referred to as a learning disability since it can make it difficult for a student to succeed academically in the regular instructional setting, and in its more severe forms, a student will qualify for special education, special accommodations, and/or extra support services. According to American Psychiatric Association (2013), reading difficulties begin even before learning to read. Children, for example, may struggle to break down spoken words into syllables and recognise words that rhyme. Kindergartners may not be able to recognise and write letters as well as their peers. People with dyslexia may struggle with accuracy and spelling. People with dyslexia, including adolescents and adults, frequently try to avoid reading-related activities (reading for pleasure, reading instructions). They frequently prefer other mediums such as photos, video, or audio (American Psychiatric Association, 2013). Dyslexia is not associated with IQ, but it can make learning more challenging for them (The Dyslexia Association, 2023).

Dyslexia can vary in severity, which is often classified into different levels to describe the impact on reading and related skills. While there is not a universally standardized system for categorizing these levels, common classifications include:

a) Mild Dyslexia: Individuals with mild dyslexia face reading difficulties that are less severe and might be managed effectively with appropriate support and interventions (Snowling, 2000).

b) Moderate Dyslexia: Those with moderate dyslexia experience more pronounced difficulties with reading and writing, requiring targeted interventions and accommodations (Snowling, 2000; Shaywitz, 2003).

c) Severe Dyslexia: Severe dyslexia involves significant reading and writing challenges that necessitate extensive specialized support and accommodations (Shaywitz, 2003; British Dyslexia Association, n.d.).

These levels help guide educational planning and intervention strategies. The severity is typically assessed based on a range of factors including reading fluency, comprehension, spelling, and writing skills. In this study, the students who participated had a range of categories between mild and moderate following the standards at school.

Table 2. 1

Dyslexic Reader (U. Muktamath et al., 2022)

	Word level	Sentence level
Normal reader	Reading	It is easy to read this sentence
Dyslexic reader	Reabing	If is easy to reab fhis senfence

Table 2.1 explains condition that dyslexic reader faced while reading. According to Muktamath et al., (2022) these are following symptoms most commonly encountered in senior grade of dyslexic students:

a) When writing, dyslexic students frequently make mistakes in letters such as 'd' and 'b' or 'm' with 'w' as shown in the Table 2.1

b) The majority of the time, writes words backwards, such as writing 'pit' when the word 'tip' was intended.
c) Grammar concerns, such as the acquisition of prefixes and suffixes.
d) Avoids reading aloud in class and participating in reading-related activities.
e) Reading single words and related text takes a lot of work.
f) Has difficulty pronouncing multi-syllable words
g) Requires frequent reading to understand it.

According to International Dyslexia Association (2017), to help dyslexic students succeed, schools might employ academic adjustments and changes. For instance, a student with dyslexia can be given more time to finish tasks, assistance with taking notes, and appropriately adapted assignments. Here are some of the following suggestions for modifications present for assisting learners with disabilities in regular and special education classrooms:

a) *Simplify or clarify written instructions*. Some instructions are provided in the form of paragraphs and include numerous informational components. These may be too much for some students to handle. The teacher might assist by emphasising or underlining the key phrases in the instructions. Rewriting the instructions is frequently beneficial.
b) *Offer just a small amount of work*. The teacher can remove pages from workbooks and other materials to give students concerned about the quantity of work required little assignments. This method keeps students from going through a workbook, manual, or other source of information and getting overwhelmed by the amount of work. In the PE textbooks used by students, in one learning topic usualy there are

several exercises to do, for example push ups. The provision of materials in the book will have a description of push ups, a picture showing the position of push ups, a description of how to do push ups and there is also a calculation of the recommended time to do the push ups. In this study, the learning materials that will be made in the AR module will eliminate descriptions of each exercise movement and will only focus on important information such as the name of the movement and also the repetition guide that must be performed.

c) *Keep out distracting stimuli*. If the student is easily distracted by visual cues on a complete worksheet or page, the unworked portions of the page can be covered with a blank sheet of paper. Referring to this point, to minimize disturbing stimuli when learning using the AR module, this study will minimize the use of colors, symbols, icons and only use two images on each page.

d) *Emphasise the most important details*. If a teenager can read a standard textbook but has trouble identifying the crucial material, the instructor can emphasise this information. This is linked to the first point which in the AR module used, this study will only highlight the important information of the exercises that student will learn.

e) *Include more practise exercises*. Some products do not offer enough practise exercises for learners to become proficient in a particular ability. Then, teachers must add practise exercises to the lesson plan. Instructional games, peer teaching activities, self-correcting materials, computer software, and supplementary worksheets are all suggested practise activities. By using the AR app and module in learning, students will have the opportunity to learn independently by themselves after the teacher has demonstrated the exercises in front of the class. If students have problem in understanding the demonstration then they can learn it by themselves at their chair.

f) *The utilisation of assistive technology*. Tablets, electronic readers, dictionaries, and spell checkers, text to voice software, audio books, and other assistive technology goods can all be highly practical aids. In this study, the use of AR app and module aim to help assist the students in learning as one of the assistive technologies used.

2.3 Special Schools in Malaysia

Special School is a formal educational institution that serves education for children with special needs (CSN). As a special education institution, it is formed by many elements that are directed to achieve educational goals, and the core process is learning adapted to the needs of each student (Pramartha, 2015). Only a small number of special schools are available and have not been able to support the overall number of CSNs, although this number is quite large. Due to several problems faced, many CSNs still lack access to education due to this condition; in addition, most of their parents are uneducated and from underprivileged socioeconomic backgrounds (Noviandari & Huda, 2018). Despite the difficulties that persons with impairments experience, Malaysia is on the right track in helping students with disabilities (Yusof et al., 2020).

Malaysia's commitment at the national and international levels, such as ratifying the Incheon Strategies to Make the Rights of Persons with Disabilities (United Nations Economic and Social Commission for Asia and the Pacific, 2012) and committing to various agendas concerning people with disabilities, is evidence of the movement itself. The "Malaysia Education Blueprint for 2013-2025" was announced in 2012 in order to make significant changes and improvements in Malaysia's education system (MOE, 2013). According to the strategy, the ministry is dedicated to implementing an inclusive education model and enrolling more children with special educational needs. According to the report, between 2021 and 2025, 75% of students with special educational needs will be chosen for the inclusive plan, all teachers will have the requisite knowledge and knowledge of special educational needs, and every child with special needs will receive a high-quality education (Ozel et al., 2017).

Since its introduction, special education has increased steadily in Malaysia. Malaysia has made remarkable progress in special education in recent years. According to the Malaysian Education Blueprint 2013–2025, there are three options for education for children with special needs in Malaysia: Special Education Schools, Special Education Integration Programmes, and Inclusive Education Programmes. In Malaysia, there are 97 220 students enrolled in the Special Education Programme as of October 2021. According to Buku Data Pendidikan Khas 2021, Special Education Integration Programme has 78,030 students, more than Inclusive Education Programme (16,504 students), and Special Education School (2,686 students), and each of these three programmes stands apart from the others. Special Education Schools primarily provide learning and education to children with one form of disability, such as hearing, vision, or learning disabilities (Kurniati & Widyastono, 2021). There are 34 Special Education Schools in Malaysia, with 28 for primary schools and 6 for senior high schools (Buku Data Pendidikan Khas, 2021).

According to Ministry of Education Malaysia, in Malaysia, special education schools are designed to cater to students with diverse learning needs, including those with various disabilities. The curriculum in these schools is tailored to provide an inclusive and supportive learning environment, focusing on the individual needs and abilities of each student. Special education schools in Malaysia often use Individualized Education Plans (IEPs) to address the unique needs of each student. IEPs are customized plans that outline specific educational goals and the methods to achieve them. They are developed based on assessments of the student's abilities and needs, ensuring that the educational approach is personalized and effective. The curriculum in special schools is adapted from the standard national curriculum to accommodate different learning needs. Key adaptations may include:

1. Modified Content: Adjustments to the content and difficulty level to match the student's abilities and learning pace.
2. Flexible Teaching Methods: Use of varied teaching strategies, such as hands-on activities, visual aids, and technology, to cater to different learning styles.
3. Additional Support: Provision of additional support such as one-on-one instruction, assistive technology, and resource materials to enhance learning.

The curriculum typically includes a focus on core areas such as:

1. Basic Literacy and Numeracy: Emphasis on fundamental reading, writing, and arithmetic skills, often tailored to the student's level.
2. Life Skills: Instruction in practical skills necessary for daily living, including personal hygiene, money management, and social skills.

3. Communication Skills: Support for developing effective communication, including speech therapy and alternative communication methods if needed.
4. Physical and Occupational Therapy: Integration of therapies to improve motor skills, coordination, and overall physical development.

Special schools in Malaysia often adopt inclusive education practices, which aim to integrate students with special needs into mainstream educational activities wherever possible. This can involve:

1. Collaborative Learning: Opportunities for students to interact with their peers in regular classrooms or activities.
2. Supportive Environment: Creating an environment that promotes understanding and acceptance among all students.

According to Othman et al., (2022) special Education for Visual Impairments is assigned to children who have visual difficulties such as reduced vision or the inability to see straight. Their teaching and learning methods are customised to meet their educational needs, such as adopting a braille system to increase their academic progress (Othman & Rahmat, 2020). Deaf and half-deaf kids with hearing impairments are assigned to Special Education for Hearing Impairments. According to Omar and Sulaiman (2018), means of communication such as sign language, speech, acting, and visual language differ and are dependent on the talents and requirements of the students. Lastly, children with autism, down syndrome, slow learning, attention deficit hyperactivity disorder, mental retardation, and dyslexia are assigned to Special Education for Learning Disabilities. Special Education Curriculum and Alternative Curriculum are utilised in this special education programme to educate students with learning disabilities. Special curriculum, skill training curriculum, basic reading and writing, manipulation skills, and others are used (Othman & Rahmat 2020). As explained previously, dyslexia is included in the category of special schools, and for higher education there are only six special schools, six including schools for the blind, learning disabilities, visual impairments etc. This research will be conducted in one of the six special schools that have been mentioned and only in special schools for learning disabilities.

However, some numerous problems and quandaries require undivided attention and careful effort to achieve inclusive education for all Malaysian residents. According to Abdul Nasir and Erman Efendi (2016) there are six main themes regarding today's challenges faced in Malaysia's special education sector, which are facilities, readiness, resources, lack of provision of appropriate teaching materials, early intervention programs and equivalent accreditation exams for students with learning disabilities. Based on the background of the problem, this research will focus on helping to facilitate dyslexic students while learning in PE classrooms from the technology and assistive devices side. Where there is still much to be done to enable children and young people with disabilities to facilitate their learning process at school, assistive technology play an important role in the education of people with disabilities, as well as in other aspects of their daily lives (e.g. work, socializing, etc) (Abdul Nasir & Erman Efendi, 2016). Furthermore, this research also will be focusing on solving the insufficient provision of teaching materials, where the subject matter taught is not adapted to children's needs, rendering it less effective.

Meanwhile, the study by Abdul Nasir and Erman Efendi (2016) on the implementation of special education needs in Malaysia faces several limitations. These include a potentially non-representative sample size, which may affect the generalizability of the findings across all regions and schools in Malaysia. The reliance on specific data collection methods, such as surveys or interviews, may introduce biases or inaccuracies in the data. Additionally, the study's focus on particular aspects or regions of special education may limit its applicability to the broader national context. Changes in educational policies since the study's publication could also impact the relevance of the findings, and the lack of longitudinal data restricts the ability to assess long-term effects. Furthermore, the study may not fully address contextual factors or the direct experiences of students and educators, which are crucial for a comprehensive understanding of special education implementation.

2.4 Adaptive Physical Education (APE)

A person can develop physically to a certain extent through PE, but this requires the best coordination of unique pedagogical processes. Adaptive physical education is PE that is customized to the needs of the students; it is intended to do more than only help people with various medical issues improve their physical qualities and abilities (Adyrkhaiev & Adyrkhaieva, 2017). The emphasis on children with special needs in terms of physical health and physical activity levels has not been fully met by the system of accrediting teachers that is in line with their academic fields which is Adaptive PE (Mahendra et al., 2020). The lack of specialist adaptive PE teachers has resulted in most general sports teachers being obliged to teach children with disabilities in special schools. They consider that including children with disabilities in PE classes is a challenge because changes are needed in activities, implementation, and evaluation that must be adapted to the needs of children, as they also lack knowledge about disability conditions and experiences and in teaching children with disabilities (Martin, 2014).

However, using a variety of adaptive physical education tools and techniques is the most effective strategy to treat physical diseases, promote crucial compensatory behaviors, put preventative plans into place, and integrate children with disabilities into society (Adyrkhaiev & Adyrkhaieva, 2017). In this study, adaptive PE refer to the PE for disability student that the learning matrials and activity has been adapted to their ability and needs.

2.4 Theoretical Background of PE Education

Physical Education (PE) education is grounded in several key theoretical frameworks that emphasize the holistic development of students. These frameworks guide educators in designing effective curricula and instructional strategies to promote physical, cognitive, and social growth. Below are some of the primary theories that underpin PE education (Usher et al., 2015):

a) Constructivist Theory: This theory, based on the works of Piaget and Vygotsky, posits that learners construct their own understanding and knowledge of the world through experiences and reflection on those experiences. In PE, this means students learn best through active participation and by connecting new physical skills with their prior knowledge and experiences (Brooks, 1999).

b) Guided Discovery: Developed by Mosston and Ashworth, this approach encourages students to discover solutions to movement problems through guided questioning and exploration. It promotes critical thinking and problem-solving skills, as students are not merely passive recipients of information but active participants in their learning process (Mosston & Ashworth, 2002).

c) Teaching Games for Understanding (TGfU): TGfU is a learner-centered approach that focuses on teaching the tactical and strategic aspects of games rather than just the technical skills. This approach helps students understand the 'why' behind movements and decisions in games, making learning more meaningful and engaging (Webb & Pearson, 2008).

d) Inquiry-Based Learning: This approach fosters a sense of curiosity and encourages students to ask questions, conduct investigations, and build new understandings. In PE, inquiry-based learning helps students explore different physical activities, understand the importance of physical fitness, and develop lifelong learning habits (Harris & Alexander, 1998).

The theoretical models mentioned, support effective PE pedagogy by promoting active, engaging, and student-centered learning environments. These approaches help students develop not only physical skills but also cognitive and social abilities, making PE an integral part of their overall education. While the educational theories of constructivism, guided discovery, TGfU, and inquiry-based learning significantly contribute to effective PE pedagogy, the multisensory approach offers unique advantages, particularly for students with learning disabilities like dyslexia. The multisensory approach integrates visual, auditory, and kinesthetic-tactile pathways to enhance learning and memory. This method is particularly effective in physical education because it engages multiple senses, aiding in the development of motor skills and physical literacy (Dell’Olio & Donk, 2007). By incorporating AR technology, this study aims to create an inclusive and supportive learning environment that addresses the unique needs of dyslexic students, thereby enhancing their learning experience and outcomes in physical education.

2.5 Technology Used in Physical Education

Technology integration in PE can enhance learning and engagement among students. Technology can offer innovative, creative methods for instructing students in movement and physical fitness while also improving their overall learning experience. Physical literacy learning processes follow a sequential, interdependent stage development model and are crucial components of quality PE teaching (Schmidt & Wrisberg, 2000). According to Fiorentino and Castelli (2005) Students are motivated by the use of technology in physical education subject. It helps to track students development to spot gaps in their repertoire of motor abilities and to boost their perception of their physical self-efficacy. Physical educators today have access to various tools thanks to technology, especially mobile technology, to assess and enhance their students' physical skills. In their research Suriya and Arumugam (2020) identified several technologies that can be implemented into the PE classrooms involving video analysis, wearable technology, fitness apps, gaming systems, virtual classrooms, monitors and trackers. A sistematic literature review on the use of tecnology in physical education to enhance learning conducted by Sargent & Calderón (2021) found that the most technology used in PE learning is video followed with mobile app and website.

Table 2. 2

Technology in Physical Education

Technology Used in PE	Number of Study
Video	10
Mobile App (AR, game)	8
Website	5
AR location based	4
Ipad and tablet apps	4
Smart watch	3
Messaging app	1

The results of the literature review in this study found that the most widely used technology in PE learning is video-based learning. Video has been widely used as a teaching aid used by teachers in the classroom. One of the instruments for qualitative assessment is video analysis. It helps students feel more competent and is a useful tool for tracking learning levels (Anderson & Martinez, 2001). According to Palao, Hastie, Cruz, & Ortega (2015) with statistically substantial increases in skill execution, technique, and informal learning, together with the highest degree of practice, the videos and teacher feedback condition produced the most favorable overall outcomes. Despite this, the teacher felt overburdened by the demands of the technology on both his time commitments and his technological proficiency, despite appreciating the value of video feedback as an instructional tool. The second popular technology is occupied by mobile apps, where the use of mobile apps is very easy to access and supported by conditions where most students have smartphones. Then the most use is also found in AR based location, where the application used makes the location a marker and this application is used for students exercising.

In the context of Physical Education (PE), technology integration is becoming increasingly essential for enhancing learning experiences and addressing the diverse needs of students. While video and traditional mobile apps are commonly used technologies, Augmented Reality (AR) offers distinct advantages, particularly for dyslexic students.

d) Interactivity and Engagement: AR provides an interactive and immersive experience by overlaying digital content onto the physical world, which significantly enhances student engagement (Mayer, 2009). This is especially beneficial for dyslexic students who may struggle with traditional text-based or video content. In contrast, videos are primarily passive, limiting interaction and engagement (Sherrill, 2003).

e) Multisensory Learning: AR aligns well with the Orton-Gillingham approach, a multisensory method proven effective for dyslexic students. By providing visual, auditory, and kinesthetic inputs simultaneously, AR supports multiple senses, which is crucial for reinforcing learning (Lieberman & Houston-Wilson, 2018). Videos, however, engage primarily visual and auditory senses, lacking the tactile component that AR offers (Winnick & Porretta, 2016).

f) Real-Time Feedback and Adaptation: AR allows for real-time feedback during physical activities, helping dyslexic students with immediate corrections and guidance (Mayer, 2009). This feedback loop is vital for learning and improving physical movements. Conversely, videos do not provide real-time interaction, which can limit their effectiveness (Sherrill, 2003).

g) Enhanced Visualization: AR enhances visualization by overlaying 3D animations onto real-world images, aiding dyslexic students in understanding complex physical movements more clearly (Lieberman & Houston-Wilson, 2018). Traditional mobile apps may not offer the same level of enhanced visualization or contextual learning (Winnick & Porretta, 2016).

h) Contextual Learning: AR situates digital content within the students' immediate physical environment, fostering deeper understanding and retention (Mayer, 2009). This contextualization helps dyslexic students make connections between digital instructions and physical actions, which is often lacking in traditional mobile apps (Lieberman & Houston-Wilson, 2018).

i) Engagement and Novelty: The novelty of AR technology can increase motivation and participation among dyslexic students, who may find AR more engaging than traditional mobile apps (Winnick & Porretta, 2016). This excitement can lead to improved learning outcomes and engagement.

In summary, AR's interactive, support multisensory learning, and engaging features make it a best choice over video and traditional mobile apps for dyslexic students in PE classrooms. Other than that, AR was chosen to be used as a technology that students will use when studying in PE classes compared to video because the use of AR can be customized according to student needs, the selected content can also be customized and the most important thing is not using the internet.

2.6 Assistive Technology (AT)

Based on to the Assistive Technology Act of 2004, any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customised, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities falls under the definition of assistive technology. Coleman (2011) states that assistive technology (AT) can be anything that enables a student with a disability to carry out a task that they would not otherwise be able to carry out or that improves the effectiveness of the task. Even commonplace objects can be AT. Individuals with disabilities utilize assistive technology to carry out tasks that would be difficult or impossible without it. Hardware, software, and accessories that make it easier for persons with disabilities to use computers and other information technologies, such as walkers and wheelchairs, are examples of assistive technology (Islim & Cagiltay, 2014). When it is suitable for the user and the environment, assistive technology can be a valuable tool for boosting independence and enhancing the involvement of students (Funk, 2012). It enables special needs students to become independent and engage in classroom activities alongside their peers (Viner et al., 2020). To succeed in the inclusive classroom, children with special needs must have their many specialized challenges addressed. For students with disabilities to be successful in their academic activities, selecting the right assistive technology tool is crucial.

According to Brown et al., (2011), the usage of assistive technology devices by students with impairments has improved how well they are able to carry out daily tasks. According to The WIPO Technology Trends (2021), AR is one of the assistive technologies that are being utilized more frequently to improve vision. A user's surroundings can be observed by an AR device, which can then identify nearby objects and inform the user by displaying the information on a smartphone, or the visual scenery can be improved to compensate for certain visual impairments, such as color blindness. In this study, AR technology is used as an assistive technology to help students learn in PE classes by visualizing images in textbooks into 3D animations that will show exercises movement to the user.

2.6.1 Augmented Reality (AR)

Many experts define AR as in short, the implementation of AR was described by Azuma (1997) and other researchers (Kaufmann, 2003; Zhou, Duh, & Billinghurst, 2008) into three characteristics: (a) the combination of the real world and virtual elements, (b) interactive in real-time, and (c) which are registered as 3D. (i.e., virtual objects or information display is intrinsically tied to real-world loci and orientation). Between the real world and the virtual world, Milgram and Kishino (1994) identified four different types of environments. First is the real world or real environment, which we are all familiar with. On the other end of the spectrum are virtual worlds, or virtual environments (commonly referred to as virtual reality), where the user can only observe computer-generated data without connecting to any actual places, things, or activities.

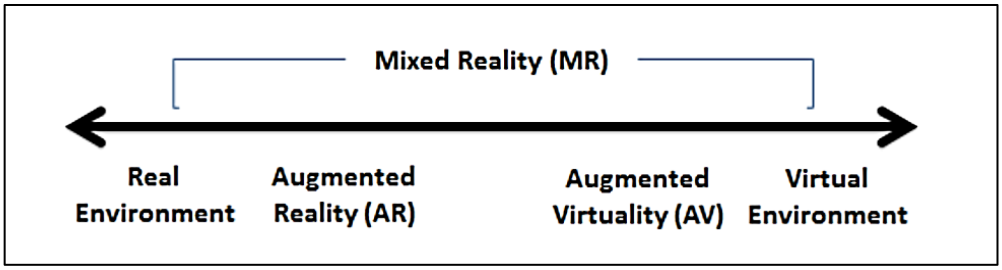


Figure 2. 1

Reality – Virtuality Continuum

From Milgram, and Kishino (1994) A Taxonomy of Mixed Reality Visual Displays. *IEICE Transactions on Informations Systems, 77 (12).*

The Reality-Virtuality (RV) Continuum, as proposed by Milgram et al. (1994), is illustrated in Figure 2.1 as the mixed reality (MR) spectrum. Edwards-Stewart, Hoyt, & Reger, (2017) indicate six different types of AR as shown in Figure 2.2, which fall into two broad categories; view-based and triggered augmentation. The stimuli or characteristics known as triggers are what start or "trigger" the augmentation. Paper or object markers, GPS position, dynamic object augmentations, and a complex augmentation that combines dynamic object recognition with GPS location are all examples of triggers. View-based AR is another type of AR. Other AR forms are view-based, such as digitized augmentations that do not consider what is shown or augmentation of a stored/static view.

Category	Type	Examples	Characteristics
Triggered	1a. Marker-based: Paper	String (string.co) Blippar (blippar.com)	Paper marker activates stimuli.
	1b. Marker-based: Object	Aurasma (aurasma.com)	Most objects can be made into markers.
	2. Location-based	Yelp (yelp.com) PAJ (t2health.dcoe.mil/ positiveactivityjackpot) Instagram (instagram.com)	Overlay of digital information on a map or live camera view. GPS may activate stimuli.
	3. Dynamic Augmentation	Video Painter (itunes.apple.com/us/app/video-painter/id581539953?mt=8) Swivel (Motion; facecake.com)	Meaningful, interactive augmentation with possible object recognition and/or motion tracking.
	4. Complex Augmentation	Google Glass (google.com/glass)	Augment dynamic view and pull internet information based on location, markers, or object recognition.
View-Based	5. Indirect Augmentation	Wall Painter (itunes.apple.com/us/app/wall-painter/id396799182?my=8)	Image of the real world augmented intelligently.
	6. Non-specific Digital Augmentation	Swat the Fly (inengy.com/swatthefly) Bubbles (virtualpopgames.com)	Augmentation of any camera view regardless of location.

Figure 2. 2

Types of AR Technology

From Edwards-Stewart, Hoyt, & Reger (2017). Classifying different types of augmented reality technology. Annual Review of CyberTherapy and Telemedicine, 14(January), 199–202.

According to Edwards-Stewart et al., (2017) AR technology are difided into two categories: Triggered and View based. There are four different types of triggered AR technology exist. The first form of AR is marker-based; a marker is needed to activate an augmentation in this type. These markers can be made of paper or real-world materials. Although some marker-related augmentations just serve as a way to access digital content, others improve the image or object. The second trigger type is location. Location-based AR uses the device's GPS location as a trigger to match a dynamic location with points of interest in order to give pertinent facts or information (for example, eateries in Yelp's monocle view). The third option is dynamic augmentation, which adapts to the object's changing point of view. Scaling the augmentation to fit the recognised item is another option for dynamic augmentation with motion tracking. For instance, Swivel is a shopping software that enables users to virtually try on apparel and accessories. A Complex Augmentation comes last. This type of AR combines a dynamic, real-world perspective with digital data that is generally accessed online. It mixes dynamic augmentation and marker/location-based AR. This is evident in Google Glass' original design, which allowed users to view information about nearby locations depending on their GPS location. Another type of AR are view based AR. This study will be using AR maker based paper because the aims of AR technology in this study as an assistive tools for dyslexic students while learning in PE classrooms. This AR will assist student to understand the learning material in the textbook, so the textbook that students usually used in the classroom will be represented by AR module.

2.6.2 Augmented Reality and Virtual Reality

Technology and education are now interconnected, and technological progress offers many educational possibilities. It was crucial in the Industrial Revolution 4.0 since it was the main capital in the global marketplace. Utilising technology as a tool for teaching and learning is one of its functions in the educational system (Samala et al., 2023). VR and AR are both referred to as immersive technologies (Fitria, 2023). Immersive technologies put people into a computer-generated or digitally enhanced environment by creating a sensation of presence and participation (Calvet et al., 2019). These tools are designed to give users the impression that they are physically there and engaged in the augmented or virtual environment. In AR, users interact directly with other users, the surrounding physical environment, and computer-simulated virtual items, meanwhile in virtual reality, users interact with a fully immersive visual environment (Saju, Babu, Kumar, John, & Varghese, 2022). Both AR and VR technologies attempt to fully immerse consumers in their respective experiences, but they do it in unique and varying ways. While VR totally replaces the actual world with a virtual one, allowing users to interact with simulated locations and activities, AR augments the real world with digital features (Fitria, 2023). Table 2.3 shows the differences between AR and VR (Elmqaddem, 2019; Mulders et al., 2020).

Table 2. 3

Differences Between AR and VR

	Augmented Reality (AR)	**Virtual Reality (VR)**
Definition	AR is a technology that augments the real world with additional information such as text, photos, animations, videos, or moving 3D objects. This technology incorporates digital features while highlighting that these aspects exist in the real world.	Virtual reality is a technology that allows users to engage with a computer-simulated virtual world. Users who use virtual reality equipment, such as gloves, can experience the sensation of being in a virtual world.
Objectives	Technology enhances and augments the real-world environment.	The technology entirely replaces reality and simulates the virtual environment.
Immersivity	Offer an immersive experience that is 25% virtual and 75% real.	Offer an immersive experience that is 75% virtual and 25% real.
Experiences	Users can interact with nearby virtual objects while	Users feel completely involved in the virtual world and

	maintaining a connection to the actual world.	disconnected from the actual world.
Tools	The technology can be accessible using a phone's camera, and the screen of the device can be used to view the virtual content display.	Users require a tool, such as a VR headset, gloves, console, to experience this technology.
Utilization	The usage of AR technology is popular across several industries, including games, entertainment, science, and education.	Virtual reality technology is widely employed in several commercial sectors as well as for entertainment, education, science, and games.

In educational settings, AR is frequently utilized to supplement conventional teaching techniques and offer engaging learning opportunities in the classrooms (Liarokapis & Anderson, 2010). Meanwhile, VR most used for providing demonstrations, "edutainment," museums, and training (Christou, 2010). In the context of assisting dyslexic students in Physical Education (PE) classes, Augmented Reality (AR) is a more suitable choice compared to Virtual Reality (VR) due to its practicality, cost-effectiveness, and ease of integration into classroom settings. AR enhances the real-world environment with digital elements, making it easier to implement in traditional classrooms without requiring costly equipment or extensive training (Fitria, 2023; Elmqaddem, 2019). This integration allows for immediate, context-sensitive support and interactive learning experiences that are well-suited for PE activities, where maintaining connection with the physical environment is essential (Calvet et al., 2019). In contrast, VR creates a fully immersive digital environment that can be less practical and more expensive, requiring specialized equipment and potentially limiting students' engagement with real-world physical activities (Christou, 2010; Samala et al., 2023). Thus, AR provides an accessible and effective means of enhancing learning for dyslexic students in PE, aligning well with the educational goals and practical constraints of classroom settings. In this study AR will be used as a technology that will assist students when studying in PE classes. AR was chosen because it is more suitable for classroom contexts that do not require high immersiveness and also uses tools that are easy and inexpensive.

2.6.3 Augmented Reality in Education

A new generation of mobile technologies called AR allows users to simultaneously watch computer-generated media that enhances real-world items or environments (Garrett, Anthony, & Jackson, 2018). AR employs image recognition technology to recognize locations, images, markers, or objects projected in the real world using smartphones or eye devices (Mokmin & Rassy, 2022). The usage of AR in educational settings has become popular (Godoy, 2020). AR is utilized as a learning tool in education to make the material more interesting (Adami & Budihartanti, 2016). This is one of the conveniences found in the use of AR in the field of education because of its easy use, only by installing it on a smartphone the user can directly use this technology. During its use, there is a lot of potential for AR technology as a learning tool, and it has already started to affect education (Brown et al., 2020). Researchers feel that AR has potential implications and various benefits for the improvement of teaching and learning environments, given the exciting advances and the obvious functioning of AR as an upgraded user interface technology (Billinghurst, 2002; Cooperstock, 2001; Klopfer & Squire, 2008; Shelton & Hedley, 2002). The summary of the AR ability, according to

Yuen et al. (2011), is to: (a) engage, stimulate, and motivate students to examine course topics from many perspectives (Kerawalla, Luckin, Selijefot, & Woolard, 2006); (b) assist in teaching subjects like geography and astronomy where students could not realistically obtain first-hand experience in the real world (Shelton & Hedley, 2002); (c) improve student-student and student-teacher collaboration (Billinghurst, 2002); (d) enhance students' imagination and creativity (Klopfer & Yoon, 2004); (e) assist students in taking charge of their education by letting them choose their speed and route (Hamilton & Olenewa, 2010). (f) establish an authentic learning environment that accommodates different learning preferences.

Table 2. 4

Summary of AR Research in the Educational Field

Educational Field	**Total**
Mathematics and statistics	39
Biology	18
Engineering education, Manufacturing and Construction	14
Medical education and medical training	13
Physics	13
Arts and humanities	10
Chemistry education	8
Social sciences, journalism and information	7
Natural sciences and Sciences	6
Informal Education	6
Astronomy	5
Information and communication technologies	5
Language Education	5
Health and welfare	4
Special Education	4
History	3
Preschool Education	3
Education	1

Based on research conducted by Ajit, Lucas, and Kanyan (2020); Garzón, Pavón, and Baldiris (2019); Saidin, Halim, and Yahaya (2015); Sirkaya and Sirkaya (2018) regarding research trends about the use of AR in education, it was found that a total of 174 studies implemented AR technology into the field of education. The summary results of these studies can be seen in the Table 2.4, which shows that the highest use of AR in education is applied to mathematics and statistics. The second is biology and the third is Engineering Education, Manufacturing, and Construction. Based on the Table 2.4, the impelentation of AR in PE subject are still lacking. According to Liu et al., (2022), PE in schools has rarely used applied coaching in AR. Physical activity have also used visual coaching, but it does not incorporate immersive practice or equally embody academic learning and athletic abilities. Based on the previous research, it can be seen that AR technology is one of the technologies that can be implemented into the field of education, especially in the classroom. Previous research also supports the availability of AR for use in education which supports AR as one of the technologies that can be used for assisting students when learning.

2.6.4 Augmented Reality in Adaptive Physical Education

PE is a program that combines athletic skills and experience (Liu et al., 2022), while APE is physical education that has been adapted to the material that disability students needs. Its activities are based on the needs of the students, usually referring to PE for children with disabilities. A difference in how a person's brain is "wired" is typically the root cause of a learning disability (Rachamalla & Rafi, 2016). Specialized teaching methods are necessary for students with a learning disability who commonly struggle to understand and develop new skills due to communication, behavioral, or developmental challenges (Cifuentes et al., 2016). Yenioglu et al. (2021) believe that using AR as a teaching tool can help students with special needs enhance their social, physical, and cognitive capacities, conversational skills, and learning outcomes. One learning strategy that can be utilized to assist children with learning impairments is by integrating AR into the PE classroom. In his research, Yenioglu et al. (2021) uses AR technology to help children learn PE in the classroom. According to Chang et al., (2020) in their research, which applying AR in PE classrooms. students will study in groups and then in one group a mobile phone will be provided. Students will scan the images in the module and then study the movements shown in the exercises. In other words, the use of AR in the classroom is not accompanied directly by demonstrations of movements together, but students will learn these movements first and then only do these movements together, in which the use of AR is to facilitate and support independent learning for students.

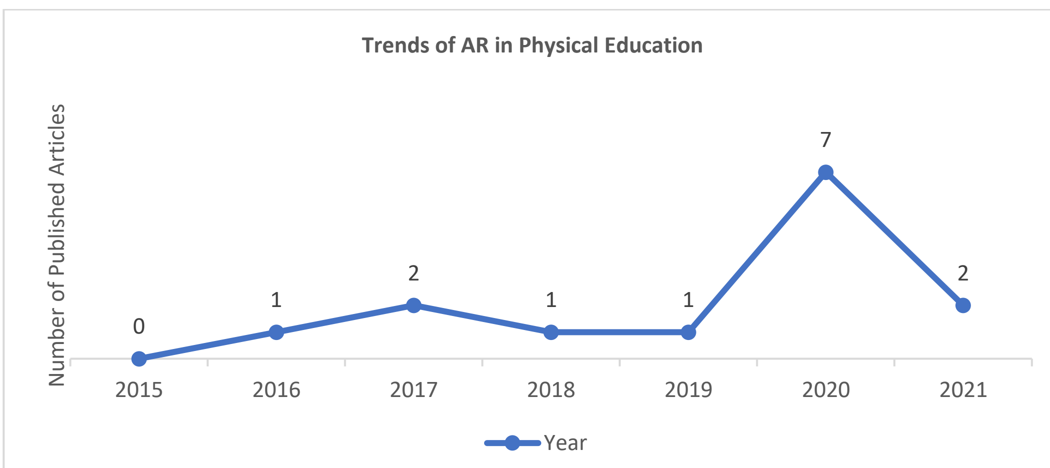


Figure 2. 3

Trends of AR in Physical Education

However, the study by Mokmin & Rassy, (2022) demonstrates how little research has been done on using this technology in PE subject from 2015-2021. A systematic review on learning PE using AR technology discovered that there are 14 publications related to the application of AR in the PE subject that can be seen on the Figure 2.3, it shows that the trends increased in 2020. This also demonstrates that few researchers are still aware of the significant benefits of integrating technologies, particularly AR, into PE subjects for a more modern and effective teaching and learning process. Of all the articles found, when filtered again based on the topic which the use of using AR in adaptive PE classes, related research was not found. Four articles found out of the 14 articles were regarding the use of AR for children with disabilities in physical activities area. Three of the articles looked at sports, and one investigated a simple physical exercise. From the research it was found that there are lack of research development on the application of AR technology in the PE area involving SpLDs as participants (Mokmin & Rassy, 2022). From the previous section it has been explained how the positive impact of AR can be produced when using it in the classroom, and how easy and inexpensive it is to use. However, there is a gap from the research results that the use of this technology as an assistive tool for adaptive PE (PE class for children with disabilities) is still difficult to find. Therefore, this research will try to implement AR as a learning strategy to use assistive technology in learning which can be used as an effort to facilitate dyslexic children learning in PE class.

2.7 Related Research

A systematic review was conducted to provide an in-depth understanding and views of the implementation of AR with dyslexic students. A systematic literature review is a rigorous, methodical approach to reviewing research literature on a specific topic to synthesize findings, identify trends, and highlight gaps in current knowledge. In this study, the process of systematic literature review involves several key steps (Kunz, 2003):

1. Define the Research Question: Clearly articulate the research question or objective that the review aims to address, ensuring it is specific, relevant, and answerable.
2. Develop a Protocol: Create a detailed protocol that outlines the methodology for the review, including criteria for inclusion and exclusion, search strategies, and plans for data extraction and synthesis.
3. Conduct the Search: Systematically search for relevant literature across multiple databases and sources using predefined search terms and criteria.
4. Screen and Select Studies: Review the search results to select studies that meet the inclusion criteria, typically through a two-stage process involving title and abstract screening followed by a full-text review.
5. Extract and Synthesize Data: Extract data from the selected studies and synthesize the findings using appropriate methods, such as qualitative or quantitative analysis, to provide a comprehensive overview of the evidence.

To gain a clear idea of what has been done and what has not been done in the application of AR for dyslexic children, this study highlights both the inclusion and exclusion criteria used during the selection of prior research. The following are the primary factors considered when choosing past studies:

a) Randomized peer-reviewed sources that were primarily published from 2016 to 2023 in the English language.
b) The topic focuses on implementing AR technology for dyslexic students, the use of technology in adaptive PE, and the use of AR for physical activity.

c) Context in the school / classroom

The systematic review was divided into three sub points: i) AR for dyslexic students, ii) technology used in adaptive physical education, and iii) AR for physical activity. The details of systematic review can be found on section 1.2.1 preliminary study.

2.7.1 Augmented Reality for Dyslexic Students

Table 2. 5

The use of Augmented Reality for Dyslexic Students

Author	Subject	Ease	Difficulty
(Karamanoli et al., 2016)	Language Course (Greece)	• AR helps the inclusion of children with dyslexia in the educational process by the development of supplementary materials based on the prescribed school textbooks. • The use of an AR app might impact on how dyslexic students are taught in the classroom and enhance their educational experiences. • Teachers believed that there is a favorable attitude towards the use of AR in the education of dyslexic children. • The creation of supplemental materials for history and other school subjects taught to students may be the subject of future research (suggestion). • If the app does not require internet, then it would be great and teachers can use it in class, cause internet in school sometimes very low (suggestion).	• The AR program takes too long to load. • The video story duration is too long. • May be not suitable for children aged 6 years due to limited ability to operate tablets/smartphones. • Neet clearer instructions on writing some letters.
(Bjekić et al., 2020)		• The use of AR technologies in the learning and instruction of dyslexic pupils supports the efficacy of AR as a tool for inclusive education.	• The study of AR's educational applications is still in its early stages. It is especially crucial to explore the potential uses of AR in education for students with dyslexia. • The organization of specialized teaching staff training is also required for the use of AR educational technology.
(Lazo-Amado & Andrade-Arenas, 2023)	Reading Comprehension and spelling	• This dyslexia-specific mobile design concept with AR suggests enhancing spelling and reading comprehension so that children can communicate without having trouble speaking. In such a way, its solution focuses on creating cognitive games for children; to support this, it is enhanced with the application of the Design Thinking methodology.	• Due to the methodology's concentration on creating mobile or web prototypes, the biggest drawback is that the generated product cannot be displayed (prototype).

The first research discussed the use of AR as a classroom learning aid for dyslexic children aged 6 years. The first research uses AR for the Greece language subject. This application focuses on helping dyslexic students to read, spell and recognize letters as well as words in Greece. The results of the study show that the development of teaching materials tailored to school textbooks using AR helps the inclusion of dyslexic students in the learning process. The research also shows from the teacher's perspective, they argue that the use of AR in the instruction of dyslexic students is seen favorably. While the disadvantages contained in the application are long loading on the application, this application also has videos in it that require internet, due to inadequate internet access this has an impact on loading videos to be slow. Then the use of AR for 6-year-old children is seen favorably. Then the use of AR for children aged 6 years is deemed inappropriate because they have limits to using gadgets, and there are also instructions and writing that are less clear. As for the suggestions in this study, if the AR application does not require internet, then this will be better, and also the development of AR technology for other subjects is highly recommended.

The second research discusses the use of AR technology in education for dyslexic children. In this study, it was not stated in detail which technology was applied to which subjects. Overall, the study states that the use of AR technology to teach and learn to dyslexic students is evidence of AR's effectiveness as a tool for inclusive education. However, the use of AR for education is still in its infancy. Exploration of the potential uses of AR in education for students with dyslexia still needs to be done, and training for staff and teaching staff is needed if integration of the use of this technology is to be carried out in the classroom.

The last research uses AR to teach reading comprehension and spelling for dyslexia students, which aims to improve spelling and reading skills so that this helps dyslexic students to be able to communicate without facing communication problems. This research also focuses on making cognitive games to improve students' abilities. The drawback of this research is that the design is still in the form of a prototype, so the product from the AR application is not yet available. This study suggests further research to build AR applications for dyslexia students that students can use, not just in the form of prototypes. From this study it can be seen that the use of AR to assist dyslexic students in learning has good potential and overall, there are no problems for dyslexic students with the use of this technology. Some researchers suggest that AR technology that will be implemented in class be integrated or adapted to the school curriculum. development of AR technology for other subjects is also suggested to be made. When referring to the weaknesses of previous studies, AR is not recommended for use in early childhood, the use of the internet for AR content is also recommended not to be used and also AR content instructions must be made as clear as possible.

Compared with related research, all studies recognize AR's potential in enhancing education for dyslexic students, albeit in different contexts. This study aligns with the general positive outlook on AR’s effectiveness but focuses specifically on its application in PE, a relatively under-explored area compared to language and cognitive skills. AR is used to supplement PE classes, offering interactive and engaging experiences tailored to dyslexic students. The focus is on practical classroom integration and real-world application. The studies by Karamanoli et al. (2016) and Lazo-Amado & Andrade-Arenas (2023) focus on language skills and reading comprehension, while Bjekić et al. (2020)

addresses the broader need for further exploration and training in AR for education. This study distinguishes itself by addressing AR's role in physical education, highlighting practical classroom integration and real-world applicability, and potentially facing similar challenges related to technology use and effectiveness.

From all these perspectives, in this study the use of AR will follow suggestions from previous research and integration of AR will also be carried out on subjects that are still less implemented in classrooms for dyslexic children, which is the PE subject,

2.7.2 Technology Used in Adaptive Physical Education

As previously explained, AT is a technology that is used to assist people with disabilities in their daily lives. The use of AT tools helps students achieve their goals of improved learning, independence, self-esteem, and quality of life (Reed, 2007). According to Laughlin, Murata, Gonnelli, & Larranaga (2018) research, the use of technology in adaptive PE can be divided into certain categories based on their intended use:

1. Communication. If students with disabilities are to demonstrate literacy in personal and social behavior (Standard 4) and recognize the value of physical activity (Standard 5), teachers will likely need to communicate effectively with students and vice versa.
2. Fitness. To promote personal fitness, allowing students to set personal goals and organize performance across topics such as yoga, aerobics, motor coordination, and cardiovascular fitness.
3. Developmental Motor Skills. Occasionally, physical educators will need to create unique AT devices to meet the needs of their students. When teaching the skill of

striking to a large, inclusive physical education class, teachers must consider issues of safety and student ability, all while finding ways to maximize time on task.

4. Sport, Recreation and Leisure. There are a host of AT devices designed to promote functional capability across sport, recreational and leisure pursuits. The Rio 2016 Paralympics, for instance, featured several sporting events (which could be enjoyed competitively or recreationally by athletes with disabilities) where AT devices were used to support athlete performance. Examples include a mouth tab for one-arm or mechanical release in archery, straps used to stabilize the body into a wheelchair or weight-lifting bench, and noise-making balls during goalball and five-a-side soccer.

Table 2.6 depicts several studies related to the use of assistive technology in the PE subject.

Table 2. 6

Assistive Technology Used in Adaptive Physical Education

Author	AT Category	Sample	Purposes	Technology	Results
Kang & Kang, (2019)	Sports	Disability Students	To investigate the virtual reality contents for impaired people's sports activities, as well as cases of virtual reality application in the disability and sports domains.	Virtual Reality (VR)	VR sports that integrate withs virtual reality technology allow disabled persons who are physically and cognitively limited to build up appropriate levels and obtain repeating experience in a virtual setting that is similar to reality.
Mokmin & Ridzuan, (2022)	Fitness	Learning Disability Students	To help engage and motivate LD students to learn physical exercise (parcourse training).	Virtual Reality (VR)	Users successfully learned the fitness activity and had positive results in their activities by applying immersive technology.
Darmawan et al., (2022)	Fitness	Intellectual Disability / Mental Retardation Students	To investigate the effects of a smart cube as a physical activity aid for children with mild mental retardation	Mobile app (Smart cube)	There is a significant difference between the results of the final test of basic movement skills between the experimental group and the control group.
Erianti et al., (2022)	Sports	Children with disabilities	To create the E-Practicum Module through the use of digitalization-based adaptive	Flipbook E-Module	The student responds to the E-Practicum courses received an average score in an interesting area.

	(mentally disabled children, deaf children, and autistic children)	physical education courses as well as the use of Information and Communication Technology (ICT) in problem solving		The study's findings have positively motivated students to enrol in online classes, notably in adaptive physical education.

From the Table 2.6, it can be seen that the use of AT for PE is mostly used for fitness and also sports. The first study used VR to help students with various disabilities (physical and cognitive) to experience sports activities, which without the use of this technology might be difficult for them to do, due to their limitations. Similar to the first study, this second study uses VR as an assistive technology for training course topics to learning disability students who do not have physical impairments. This research was conducted to see students' understanding and motor performance scores. The next research is the use of mobile app applications to support physical activities for students with intellectual disabilities / mental retardation, and the last is the use of e-module flipbooks for disabled students as practicum teaching materials when online classes take place. From this research it can be seen that the use of AT can be in the form of a variety of technologies and tools as long as it aims to help people with disabilities perform in daily life. So, the use of AT can be adjusted according to the research that is being or will be carried out. in this study AR will be used as a representation of AT which will be used by dyslexic students when learning PE in the classroom.

2.7.3 Augmented Reality for Physical Activity

Caspersen, Powell, & Christenson (1985) define physical activity as any movement made by the skeletal muscles of the body that causes an energy expenditure above the resting state is considered to be engaging in physical activity. Meanwhile Kruk (2014) defines physical activity as any body motion requiring an energy expenditure is referred to as physical activity. It involves exercises or movement such as walking, jogging, swimming, playing sports, dancing, and other activities. The majority of children learn about physical activity during their PE classes, which is an important part of overall health (Cheung, 2019). In conclusion, PE and exercise are linked elements of healthy living. While physical education offers a formal educational setting within schools to teach students about the benefits of physical activity and equip them with the necessary skills and knowledge for a physically active life, regular physical activity outside of school is crucial for overall health.

Table 2.7 highlights four articles that are relevant to this topic. The first article uses AR in education aimed at increasing body strength for children with developmental disabilities. The results of the study showed positive results on physical activity and students' motivation to do so. The second research is the use of AR based floor projection to help students with mobility disabilities to compete with their peers to play exergames. The results show that the use of this technology helps students experience playing exergames with friends with all disabilities, even with normal friends, even though this is very difficult to do in normal conditions (not using technological assistance). The last is the use of AR to help improve learning in students with hearing problems in track fields and sports coaching. The results show that by using AR, it helps students with hearing problems to understand instructions clearly and in detail with pinpoint accuracy. When compared to activities without technology this may be difficult to do. From some of these studies, it can be seen that the use of AR for physical activities of children with disabilities can be used and can help them. However, the selection of the AR type and also the learning materials used must be in accordance with the objectives and research objectives because they must be adapted to the students' needs and abilities. In this study, the use of AR marker-based paper will be used to assist students with dyslexia when learning PE in the classroom when understanding the lessons conveyed by the teacher.

Table 2. 7

Augmented Reality for Physical Activity

Authors (year)	Research Purpose	Results	Limitation
Lin & Chang, (2015)	To enhance the body strength of children with developmental disabilities. Using AR body motion interactive game.	The results of this study indicate that the use of real-time technology to create a flexible, low-cost interactive basic program investigated for individuals diagnosed with developmental disabilities yielded significant results. This application has a positive effect on children's physical activity and motivation to carry out the physical activities they need for their body health.	Because the application is free and flexible, the content of this application has been changed (image and sound) to suit the disabilities experienced by the participants. So, three participants received different content.
Graf et al., (2019)	Creating an interactive floor projection system designed to enable people with mobility disabilities to compete on par with, and in the same physical environment as, their peers without disabilities on playing exergames adaptive sports.	The results showed that most of the participants that had previous experience with adaptive sports stated that iGYM is not like other adaptive sports that require special equipment to be played adaptively. iGYM is adapted for everyone, even people without physical disabilities. Players love iGYM which allows them to play	Since this research takes the form of exergames 1 on 1 matches, there are uncontrollable factors that impact the players' gameplay, including personal preferences, social factors, the impact of some players' internal balancing to ensure fairness, and spectators' support for players who are playing against friends or family.

		with people with different abilities. Most of the players said that they did not often engage in physical activity with people with different mobility prior to this study.	After the treatment session without reducing the number of players on the field or increasing the pressure of observation, participants were given more time to play. The gameplay seems to change as a result. It prompted multiplayer matches, participation using mobility aids other than wheelchairs (such as crutches), and the children players playing alongside their parents.
Nebytova et al., (2021)	Proving that AR technology can improve learning in track and field sports coaching and instructional processes.	The findings show that AR technology has a significant impact on how well children are trained in the movement approach since AR can demonstrate it at any level of detail. Athletes who are hearing impaired can see the reference components of various exercises in full detail with an equal degree of accuracy. They are able to compare techniques, recognize their mistakes, and get insight into all aspects, which in actual practice would be extremely difficult to achieve.	The sports training of children with hearing impairment has been found to benefit from the usage of AR technology. However, The technology of AR hasn't been used as much as it should, though, so far. In particular, it relates to sports training.

2.8 Learning Theories and Design Model

There are many types of learning theories, one of which is cognitive learning theories. When addressing dyslexic students' learning needs in Physical Education (PE) through the use of Augmented Reality (AR), Cognitive Learning Theories offer specific advantages over other learning theories. Cognitive learning theories, such as Cognitive Load Theory (CLT) and Dual Coding Theory, emphasize the internal mental processes involved in learning, such as memory, information processing, and problem-solving. These theories are particularly relevant for dyslexic students because they address how to optimize cognitive resources and reduce mental overload, which can be crucial given dyslexic students' difficulties with reading and processing text-based information (Sweller, 2011; Mayer, 2020). For instance, CLT helps in designing AR interventions that manage cognitive load effectively, preventing overwhelm and supporting better learning outcomes (Sweller et al., 2011).

Compared with others learning theories such as behaviorism theories that focus on observable behaviors and reinforcement, which may not adequately address the internal cognitive processes and challenges faced by dyslexic students (Skinner, 1953). They lack the emphasis on mental strategies and cognitive support that are crucial for dyslexia. Humanistic Theories emphasize personal growth and self-actualization, which are valuable but may not provide the specific cognitive strategies needed for addressing reading difficulties and learning disabilities (Rogers, 1961), and lastly Social Learning Theories focus on learning through observation and imitation, which are important but may not directly address the cognitive processing issues related to dyslexia (Bandura, 1977). From the comparative results, cognitive learning theory is very suitable for designing AR-based educational interventions for students with dyslexia in PE because the theory focuses on optimizing cognitive processes, integrating multimodal information, and overcoming specific learning challenges. It provides a framework for creating effective learning experiences that support the unique needs of students with dyslexia and improve their educational outcomes.

Meanwhile, there are two theories, under cognitive learning theory, which is Cognitive Load Theory (CLT) and Dual Coding Theory that related into this study. Cognitive Load Theory (CLT) focuses on optimizing the amount of cognitive effort required to process information. For dyslexic students, who often struggle with processing text and decoding information, CLT is particularly relevant because it aims to reduce extraneous cognitive load and enhance working memory efficiency. By using CLT, AR modules can be designed to minimize unnecessary complexity and present information in a way that supports cognitive efficiency, crucial for dyslexic students who may be overwhelmed by excessive or poorly structured information (Sweller, 1988).

Dual Coding Theory, while also valuable, emphasizes the use of both verbal and visual channels to enhance learning. Although this theory supports the integration of multimodal information, it does not specifically address how to manage cognitive load or how to structure content to avoid overloading working memory. For dyslexic students, who may struggle with processing text, CLT's focus on managing cognitive load ensures that the information is presented in an optimized manner, directly addressing their needs for clarity and reduced cognitive strain (Paivio, 1986).

As discussed in Chapter 1, this study uses four related learning theories. Its use is divided into two conditions; The first is to develop the AR module with the implementation of CLT and Mayer's Principles of Multimedia Learning. The design and development process will be following the ADDIE Model as an instructional design as a guideline for creating the AR module to be adapted to learning materials for dyslexic students. This ADDIE model consists of several phase, which Analysis, Design, Development, Implementation, and Evaluation (Aldoobie, 2015). In the design phase of the AR module, this study implemented Cognitive Load Theory (CLT) as a guide for designing the module to be more focused and in line with learner needs. In the development phase and completing the sample design for the module, an evaluation was carried out. It was found that there are several designs that were still less effective. Then, in the module development, Mayer's Principles of Multimedia Learning was implemented to make the design more effective for learners. Next, the second implementation of the following theory is implemented when learning occurs. The use of OG- approach where involving multisensory approach in teaching will be used, where this theory is one theory that can be used for more effective communication to improve learners participation.

2.8.1 Cognitive Load Theory (CLT)

The Cognitive Load Theory (CLT) is a psychological and educational theory that addresses the constraints of human cognitive processing during learning (Sweller, 1998). Since its initial formulation by John Sweller in the late 1980s, the theory has played a key role in educational psychology and instructional design. The foundation of CLT, which Sweller originally studied in the late 1980s, is the notion that our working memory, which processes what we are doing at the moment, can only handle a finite quantity of information at once (Sweller, 1998). Based on the CLT, learning and problem-solving need the focus and application of specific cognitive resources (Sweller, 1988, 1989).

Many of the learning and problem-solving techniques supported by instructional models lead to students engaged in cognitive activity unrelated to the task's stated objectives. The cognitive strain brought on by these pointless tasks may make it more challenging to learn new skills.

As explained before, dyslexic students frequently have significant difficulties acquiring and processing information, making CLT more pertinent and advantageous. Reading, spelling, and writing skills are all impacted by dyslexia, which categorizes as a specific learning condition. Students who are dyslexic may have trouble decoding and understanding words, which can result in increased cognitive load during reading and studying tasks. In this study, by considering the principles of CLT and applying appropriate learning strategies, it is hoped that it can help facilitate and create an adaptive learning environment that supports the unique learning needs of dyslexic students and enhances their learning experience without feeling burdened with a lot of information when studying. CLT focuses on optimizing cognitive processing by managing the load placed on working memory during learning. It identifies three types of cognitive load: intrinsic (related to the complexity of the material), extraneous (related to the way information is presented), and germane (related to the cognitive effort invested in learning):

- Intrinsic cognitive load refers to the material's inherent difficulty, which can be affected by a past understanding of the subject. CLT helps manage intrinsic load by simplifying complex information and breaking it into manageable parts. For dyslexic students, who may struggle with reading and text processing, CLT principles suggest using clear, concise instructions and visual aids to reduce the cognitive burden associated with understanding complex texts.

- Extraneous cognitive load is the load brought on by the presentation of the material and is not helpful for learning. By reducing extraneous load, CLT emphasizes the importance of presenting information in a way that minimizes unnecessary cognitive effort. This includes using multimedia elements (e.g., animations, graphics) and clear, organized content to facilitate comprehension. For dyslexic students, this can mean integrating visual and auditory information to support their reading difficulties and improve overall understanding.
- Germane cognitive load refers to the factors that facilitate information processing and aid in building "schemas." CLT promotes the enhancement of germane load by designing materials that encourage active engagement and meaningful learning. For dyslexic students, this might involve interactive elements and hands-on activities that help them integrate new knowledge effectively.

CLT shows that people will have trouble finishing an activity successfully if the cognitive load exceeds their ability to process it. This theory asserts that learning is impaired when working memory capacity is exceeded in a learning task (De Jong, 2010). From the explanation, even though this research refers to CLT theory, the AR module design will try to reduce cognitive load. According to Shibli and West (2020), there are several ways to reduce cognitive load, including decomposing the subject matter into smaller chunks and delivering the information in a sequential manner, the intrinsic cognitive load can be lowered. When introducing new work, the goal is to avoid overburdening a student too soon. On the other hand, how instructions are given can lessen the extraneous cognitive load. Due to unclear instructions, place an undue burden on the working memory, too much time is spent deciphering the instructions rather than creating a new schema.

Meanwhile, Richard Mayer's (1992) Cognitive Multimedia Theory gives a framework for understanding how multimedia might help students learn by integrating visual and linguistic information. The hypothesis is based on three basic assumptions:

1. According to Mayer's theory, humans process information using two distinct channels: visual and auditory. The dual channel assumption implies that these channels can work together, allowing learners to receive visual and verbal information separately but concurrently. This split improves cognitive load management by reducing the pressure on a single channel and leveraging the brain's ability to accommodate numerous types of input (Mayer, 1992).
2. The Limited Capacity Assumption states that each channel has a limited capacity for processing information. Both visual and auditory channels have restricted cognitive resources, so too much information presented at once might overload them and impair learning. Effective multimedia learning entails delivering information without surpassing the capability of either channel, so optimizing cognitive resources and improving comprehension (Mayer, 1992).
3. Mayer's Active Processing Assumption: Learners actively organize information into coherent mental representations. This active processing entails picking important information, organizing it into meaningful structures, and combining it with past knowledge. Effective multimedia training should facilitate active participation by clearly presenting material, employing visual and verbal aspects

to enhance comprehension, and encouraging learners to create connections between new and existing knowledge (Mayer, 1992).

These assumptions are critical in this study, which combines the Orton-Gillingham (OG) method with augmented reality (AR) for dyslexic students. The dual channel assumption allows for the incorporation of both visual and audio aspects in the AR module to engage students' various cognitive channels. The concept of limited capacity emphasizes the significance of creating AR content so that pupils are not overwhelmed with too much information all at once. Finally, the active processing assumption emphasizes the importance of the AR module facilitating meaningful content engagement, assisting students in successfully organizing and integrating new knowledge.

The use of CLT is suitable for addressing the challenges faced by dyslexic students in Physical Education (PE) when using Augmented Reality (AR) due to its focus on optimizing information processing and managing cognitive load. Dyslexic students often struggle with reading and comprehension, which can overwhelm their cognitive capacities when engaging with traditional text-based resources. CLT helps mitigate these difficulties by structuring learning experiences to reduce unnecessary cognitive demands and enhance the processing of essential information. AR complements CLT by providing dynamic, visual representations of physical movements, aligning with principles such as Spatial Contiguity and Signaling to improve understanding and retention. Theoretically, Mayer's Multimedia Learning Principles, when applied together with Cognitive Load Theory, can create a comprehensive framework for developing additional modules that address the cognitive and sensory needs of students with dyslexia. This approach ensures that the module is engaging, clear and supports their learning process. In this study, to support the

CLT, it will implement multimedia principles by Mayer as a strategy that can be used to reduce the cognitive load of dyslexic students.

2.8.2 Multimedia Learning Principles

Multimedia Learning Principles are a type of instructional design theory. Mayer's principles are grounded in extensive empirical research, making them reliable and effective. It is designed to optimize learning by addressing how people process and integrate visual and auditory information (Mayer, 2001), which is crucial for dyslexic students who may struggle with traditional text-based learning. It provides guidelines for creating educational materials that enhance learning by effectively using multimedia (e.g., text, images, audio, video) to align with how people process information (Mayer, 2009). These principles are rooted in cognitive psychology and aim to optimize the cognitive processing of learners by managing cognitive load and promoting meaningful learning. This is related to the concept of CLT. Dyslexic students typically face challenges in reading and interpreting textual information due to deficits in phonological processing and visual-perceptual skills. In a PE context, where understanding movement and physical activities is essential, traditional learning materials like textbooks can be particularly ineffective. This is where Multimedia Learning Principles, rooted in cognitive psychology, come into play.

Table 2. 8

Comparison between instructional design theory with Mayer's learning principles

	Strengths	**Limitations**	**Comparison**
Paivio's Dual Coding	Emphasizes the use of both verbal	Less detailed guidance on	Mayer's principles build on the idea of dual coding but

Theory (Paivio,1986)	and non-verbal systems for learning.	how to design multimedia materials.	offer more concrete strategies for integrating text, images, and animations in a way that reduces cognitive load and enhances learning. The integration of CLT further ensures that these multimedia elements are presented in a manner that optimizes cognitive processing.
Constructivist Principles (Piaget, 1970; Vygotsky, 1978)	Focus on active learning and building knowledge through experience.	It can be less structured, potentially leading to cognitive overload without careful design.	Mayer's principles provide structured guidelines that can be used within a constructivist framework to ensure that multimedia content is effective and does not overwhelm dyslexic students. CLT supports this by emphasizing the importance of managing cognitive load during the learning process.
Gagné's Nine Events of Instruction (Gagné, 1985)	Comprehensive model for instructional design.	Not specifically focused on multimedia.	While Gagné's model is effective for general instructional design, Mayer's principles offer targeted strategies for multimedia learning, making them more suitable for creating AR modules. The inclusion of CLT ensures that the design

			of these modules effectively supports cognitive processing.

A comparison of the use of Mayer's learning principles in this research compared to others instructional design theory can be seen in table 2.8. It can be seen that the choice of Mayer's multimedia learning principles is more suitable for the needs of this research and also these principles are very close and support CLT. Compared to other theories and principles, Mayer's framework offers practical and specific guidelines that can be directly applied to multimedia-rich environments used in AR-based education. This integration of CLT and multimedia learning principles creates a strong foundation for developing educational interventions that meet the cognitive and sensory needs of students with dyslexia, which is expected to improve their learning experiences and outcomes in physical education.

Multimedia learning is a type of computer-assisted learning that employs two concurrent modalities. This entails learning via audio and visuals (such as images, animations, texts, and videos) (through narrated voiceover). This assertion "People learn more deeply when exposed to both words and images" is known as the multimedia principle. It serves as the foundation for using multimedia instruction, instruction that includes words (such as spoken text or printed text) and graphics (such as illustrations, charts, photos, animation, or video) and is intended to promote learning (Mayer, 2009). In his book, Mayer (2001) describes twelve principles for structuring and constructing multimedia learning, such as presentations that function better as course materials to aid student learning.

In the fields of educational psychology and instructional design, CLT and Mayer's Principles of Multimedia Learning are closely connected and complementary concepts. Applying CLT enables educators and instructional designers to understand better the factors that affect cognitive load and how to manage it to maximize learning (Asma & Dallel, 2020). By considering how learners process information and how to deliver information in a way that maximizes learning efficiency, both theories seek to optimize learning (Greer, Crutchfield, & Woods, 2013). To support CLT theory on reducing the cognitive load on students, some of Mayer’s principles of multimedia learning will be used in this research as a guide to produce more effective learning modules for dyslexic students.

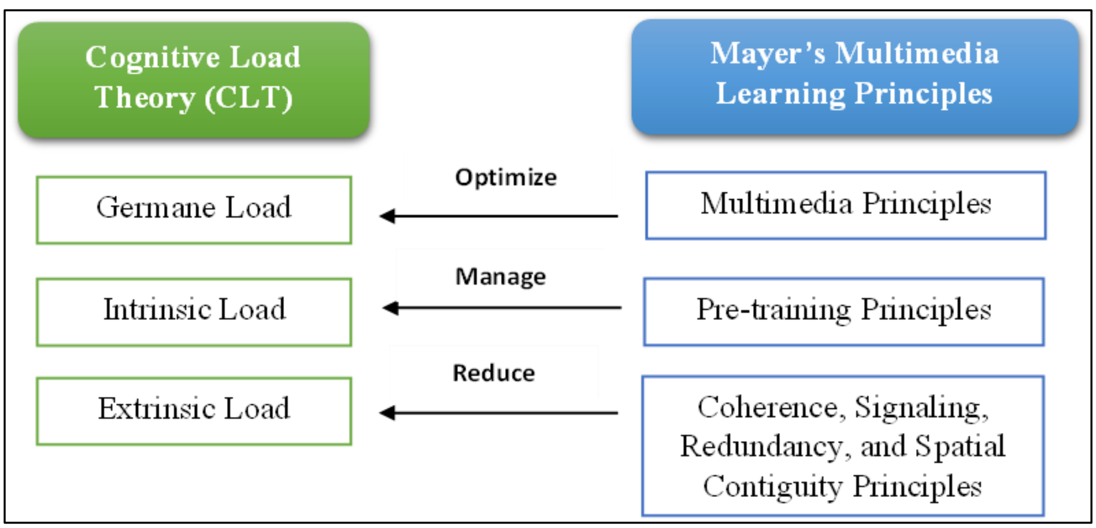


Figure 2. 4

Relation between CLT and Multimedia Learning Principles

Figure 2.4 depicts the relationship between CLT and Multimedia Learning Principles used in this study. In this study, to design an AR module for dyslexic students to make it more effective and adapted to the needs of students, CLT and multimedia learning principles will be used. The relationship between these two theories is that they have the same goal, namely maximizing learning efficiency by considering how students process information and deliver information that is also related to working memory. As is well known, students with dyslexia have problems in communication which ultimately affect their learning process, especially reading, writing, and processing information related to written and spoken words.

Therefore, this research will use six principles of multimedia learning from Table 2.9. Each of the principles applied has its own purposes. For reducing extraneous load, this study will implement coherence, signaling, redundancy, and spatial contiguity principles, then to optimize germane load this study will implement multimedia principles, and the last one is for managing intrinsic load will be using pre-training principles. All of these principles will be applied in the AR module. The six principles chosen are particularly effective in supporting dyslexic students by providing a structured, clear, and multimodal learning experience. Although there are additional principles that could be considered, these six address the most critical aspects of cognitive load management and multimedia integration for dyslexic learners specifically in this study.

The main goal of this study is to reduce unnecessary cognitive load. The needless mental effort needed to understand information that does not directly aid in learning is referred to as extraneous cognitive load (Sweller et al., 2011). Students can allocate more cognitive resources to comprehending the content by reducing unnecessary cognitive load. The Orton-Gillingham (OG) approach's structured, sequential, and multimodal teaching approaches are naturally intended to reduce cognitive load, especially extraneous cognitive load. The OG approach eases the way dyslexic students process information by involving multiple senses and offering simple, step-by-step guidance. Because OG lessons are structured, students are less likely to have to mentally arrange and interpret the information on their own, which lowers unnecessary cognitive load (Joshi et al., 2002; Hook & Jones, 2002).

This study employs multimedia learning principles to improve the AR module's effectiveness. These approaches, such as the use of both text and graphics, can assist with lessening cognitive load by presenting information in a more digestible fashion. Dual coding, which presents verbal and visual information together, is one example of a principle that can improve understanding and recall. Richard Mayer's study supports the adoption of Multimedia Learning Principles, demonstrating that learners absorb and remember knowledge better when it is provided in both verbal and visual modes. Mayer's multimedia learning principles, which include coherence, signaling, redundancy, spatial contiguity, and temporal contiguity, are intended to reduce superfluous cognitive burden while supporting the pertinent cognitive load required for learning (Mayer 2009).

The focus of this study on lowering unnecessary cognitive burden is consistent with recognized cognitive load theory methodologies (Sweller, Ayres, & Kalyuga, 2011). By implementing this theories, the goal is to improve the learning process for dyslexic students in physical education by combining the Orton-Gillingham (OG) approach with multimedia learning concepts. The OG approach, with its structured, sequential, and multisensory methodologies, naturally decreases superfluous cognitive load by delivering clear, step-by-step instructions and engaging many senses. This technique is supplemented by multimedia learning concepts, which convey knowledge in both verbal and visual modes to avoid cognitive overload (Mayer, 2009). The study improved students' overall learning experience by reducing unnecessary cognitive load.

Table 2. 9

Mayer's Multimedia Learning Principles

Principle	Description	How to Address	Cognitive Load Effect
Multimedia	People learn better from words and pictures than from words alone.	• Use pictures to highlight important ideas. • Ensure that each image contributes to or clarifies the meaning. • Prefer static pictures than animations (with some exceptions).	Optimizes germane load
Coherence	People learn better when you exclude extraneous material	• Only use narrative, images, and text that further the intended learning objectives. • Avoid using music as a background. • Employ basic visuals.	
Signaling	People learn more effectively when there are cues that emphasize the structure of the essential materials.	• highlight significant information, use arrows, underline, and other signals. • Include a slide that details how your presentation is structured. • Whenever you go on to a new section, refer back to it.	Reduces extraneous load
Redundancy	Compared to some pictures, narration, and printed text, people learn more effectively from graphics and narration.	• Don't combine text and images when providing a narrated presentation. • When giving a narrated presentation, utilize text as little as possible.	

Spatial Contiguity	People learn better when corresponding words and pictures are presented near rather than far from each other on the page or screen.	• Put text and the graphics it references side by side. • Place the feedback in close proximity to the queries or responses it addresses. • Display instructions with an activity on the same screen. • Read any words to the audience before introducing an animated visual.	
Temporal Contiguity	People learn better when corresponding words and pictures are presented simultaneously rather than successively	• The narration should be timed to match the animations.	
Segmenting	People learn better from a multimedia lesson that is presented in user-paced segments rather than as a continuous unit	• Give users the option of setting the lesson's pace. • Cut up lengthy passages of text into manageable chunks.	
Pre-Training	People learn better from a multimedia lesson when they know the names and characteristics of the main concepts	• Before starting a process-based presentation, define key terminology (such as names, definitions, locations, and features), either in a separate presentation, handout, or similar material.	Manages intrinsic load
Modality	People learn more deeply from pictures and spoken words	Avoid using on-screen text unless it:	

	than from pictures and printed words	• List of crucial tasks • Provides directions. • Provides references. • Presents important information to non-native English users during a narrated presentation with graphics	
Personalization	People learn better from multimedia presentations when you use conversational language (rather than formal)	When presenting important information to non-native English speakers during a narrated presentation with graphics, avoid utilizing on-screen text unless it: • Lists of important tasks. • Provides directions. • Provides references.	
Voice	People learn better when narration is spoken in a human voice rather than in a machine voice.	Including narration that is performed by a human rather than a computer.	Optimizes germane load
Image	People do not necessarily learn better when the speaker's image is added on the screen	• When making an asynchronous multimedia presentation with photos and words, avoid including a video of yourself. • When there are neither words nor images, consider including your face. • You want to develop a social or academic presence.	

2.8.3 ADDIE Model

Creating an augmented module for dyslexic students requires a robust, flexible, and iterative instructional design model that can accommodate their unique learning needs. Among the various instructional design models, the ADDIE model stands out as particularly effective for this purpose. Here's a comparison to illustrate why the ADDIE model is the best choice:

a) ADDIE model

ADDIE Model consists of five phases: Analysis, Design, Development, Implementation, and Evaluation. This model is highly systematic and iterative, ensuring that each phase informs and refines the next (Clark, 2015).

Advantages:

- Structured and Systematic: The step-by-step approach ensures thorough planning and execution, which is crucial for addressing the specific needs of dyslexic students (Clark, 2015).
- Flexibility: The iterative nature allows for continuous refinement based on feedback, making it adaptable to the evolving needs of students (Molenda, 2003).
- Comprehensive Evaluation: The built-in evaluation phase ensures that the effectiveness of the module is assessed and improved continuously.

b) Gagné's Nine Events of Instruction

Gagné's model is a detailed instructional strategy that outlines specific steps to enhance learning. However, it is more focused on the micro-level of instruction rather than the macro-level design process (Gagné, 1985).

Limitations:

- Micro-Level Focus: Concentrates on individual lessons rather than the entire instructional design process.
- Less Iterative: Does not emphasize continuous feedback and iteration as strongly as ADDIE (Gagné, 1985).

c) Dick and Carey Model

The Dick and Carey model is a systematic approach to instructional design that views instruction as an entire system, focusing on the interrelationship between context, content, learning, and instruction (Dick, Carey, & Carey, 2015).

Limitations:

- Complexity: The model is highly detailed and can be complex to implement, especially for those without extensive training in instructional design.
- Rigidity: While comprehensive, the steps can be seen as rigid, making it harder to adapt quickly to new insights or changing needs compared to the more flexible ADDIE model.

In conclusion, all of the instructional design models provide systematic approaches to instructional design, but the ADDIE model's simplicity, flexibility, and iterative nature make it particularly well-suited for creating an augmented module for dyslexic students. The straightforward phases of ADDIE allow for easy understanding and adaptation, while the comprehensive evaluation ensures continuous improvement tailored to the unique needs of dyslexic learners.

ADDIE is one of the instructional methods that aims to facilitate effective learning. The instructional design strives for a learner-centered rather than a conventional teacher-centered approach to instruction (Steven, 2000). This implies that the learning outcomes, established after carefully examining the learners' requirements, dominate every aspect of training. According to Dick, Carey, and Carey (2009), effective teaching and learning design should involve a systematic procedure for creating, developing, putting into practice, and assessing the teaching itself; that is why this research uses the ADDIE model as one of the guidelines because this model has several stages. The ADDIE Model is an iterative instructional design method in which the instructional designer may return to any earlier phase based on each phase's formative evaluation findings (Yoong, 2022). The starting product for the following step is the final product of the previous phase (Steven, 2000). This is also in accordance with this study, where from each stage, it is possible to make changes according to the results of the evaluation carried out; considering that the sample of this study was students with special needs, the teaching materials must adapt to their needs.

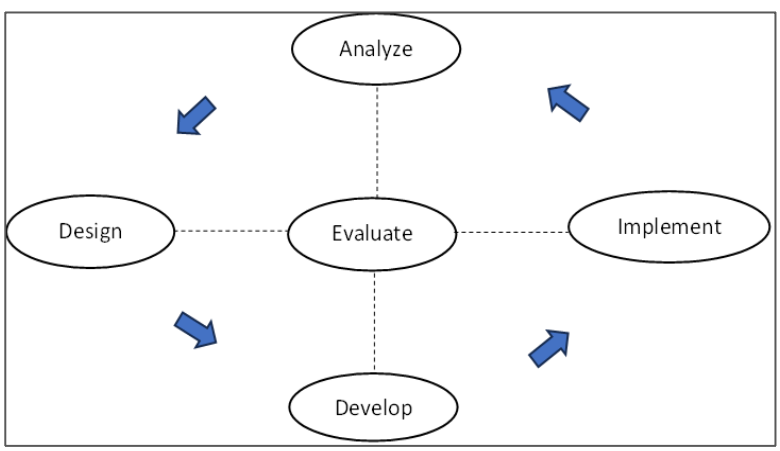


Figure 2. 5

Augmented Module Design Process Based on ADDIE Model (Branch, 2009)

Figure 2.5 depicts the steps in the creating an instructional material using ADDIE Model. ADDIE stands for Analysis, Design, Development, Implementation, and Evaluation. Each phase corresponds to a different stage of the instructional design process. According to Aldoobie (2015), The summary of each phase is:

a. *Analyzing* phase is the foundation for all subsequent phases of instructional design. During this step, the instructional designer must characterize the problem, identify the source of the problem, and determine possible solutions. The phase may contain particular research approaches such as needs, job, and task analysis. This phase's output frequently contains the instructional goals and a list of actions to be instructed. These results will be used as inputs in the Design phase.
b. *Design* phase is all about putting the teaching into action. In this step, the instructional designer considers how design instruction may help people learn and interact with the resources develop and supplied. Furthermore, during the design process, the instructional designer will concentrate on designing assessments topic, deciding on a course format, and developing their instructional strategy.
c. *Development* phase is dependent on the prior two phases, which are analysis and design. That suggests that if we completed these steps correctly, development would be easier. The instructional designers integrate technology into the educational setting and process during the third phase.
d. *Implementation* phase is all about putting the plan into action. To complete this phase, instructional designers must consider three important steps: training instructors, preparing learners, and organizing the learning environment. The

designer can display our course in extremely engaging and authentic ways using these three processes to reach the implementation phase.

e. *Evaluation* phase is the final process in the ADDIE model. It is critical to evaluate each phase to ensure that the design developed achieves the aims by utilizing instructional design and resources to satisfy the needs of the learners.

In this study, step by step ADDIE model implementation will be discussed further in Chapter Four.

2.8.4 Orton Gillingham Approach

Dyslexia is commonly described as a language-based learning disability characterized by differences in spelling, word identification, decoding skills, and overall phonological awareness (Adlof & Hogan, 2018). According to research, poor reading abilities caused by dyslexia and low self-concept are linked (Battle, 2002; Riddick, 2009); hence, students with dyslexia are more likely to have worse academic success and overall self-concept (McArthur et al., 2016). These theoretical and clinical findings call for caution while working with dyslexic students in cognitive development settings. In addition, evidence suggests that learning disorders, such as dyslexia, might have a negative impact on physical abilities and development, such as coordination, perceptual motor skills, and motion control (Salend et al., 1985; Soares & Marco, 1997). Students with dyslexia frequently struggle with visual processing, spatial awareness, timing, and rhythm (Portwood, 2012; Soares & De Marco, 2014). This, in turn, directly impacts abilities like catching a ball or just the main training orientation for balance (Tore et al., 2016; Willows et al., 1993). Although dyslexia is not commonly mentioned as an issue for PE students, the data show links between physical development, motor learning, and academic learning (Pavlovic et al., 2022).

Creating or teaching instructions to dyslexic students requires an approach that addresses their unique learning needs and challenges. Meanwhile, there are several approaches to teaching or creating specific instructions for dyslexic students as explained below.

a) The Orton-Gillingham approach, a well-known multisensory method, is designed specifically for individuals with dyslexia (Ritchey & Goeke, 2006). Multisensory teaching methods are highly recommended because they engage multiple senses simultaneously, which can reinforce learning and improve memory and understanding.
b) Structured literacy approaches, which are explicit, systematic, and sequential, focus on the structure of language and provide the scaffolding necessary to build foundational skills, critical for students who struggle with phonological processing (Moats, 2020).
c) The use of technology (assistive technology), such as text-to-speech, speech-to-text, and augmented reality (AR) applications, can support dyslexic students by providing alternative ways to access and engage with content (International Dyslexia Association, 2018). Technology can reduce the barriers posed by dyslexia, making learning materials more accessible and interactive.
d) Differentiated instruction tailors teaching methods and materials to accommodate diverse learning needs, ensuring that each student learns in a way that suits them (Tomlinson, 2001).

e) Scaffolded instruction provides temporary supports that are gradually removed as the student becomes more proficient, helping dyslexic students manage complex tasks (Reiser & Dempsey, 2018).

f) Lastly, explicit instruction involves direct teaching of concepts and skills in a clear, straightforward manner, benefiting dyslexic students who require clear and direct guidance (Smith & Ragan, 2005). By combining these methods, educators can create a comprehensive and supportive learning environment that addresses the unique needs of dyslexic students in physical education.

When considering the best approach to create or teach instructions to dyslexic students, especially in the context of Physical Education using augmented reality (AR), the multisensory approach stands out as the most effective compared to other methods. This approach is rooted in the principle that engaging multiple senses simultaneously can significantly enhance learning and memory retention, which is particularly beneficial for dyslexic students who often face challenges with traditional learning methods that rely heavily on text. According to Ritchey and Goeke (2006), the Orton-Gillingham approach, a prominent multisensory method, is designed specifically to address the needs of dyslexic individuals, making it highly effective in improving their reading and comprehension skills.

In contrast to structured literacy or differentiated instruction, which primarily focus on linguistic and cognitive aspects, the multisensory approach integrates visual, auditory, kinesthetic, and tactile elements. This integration helps dyslexic students by reinforcing neural pathways through multiple channels, making it easier for them to process and retain information. For instance, when using AR in Physical Education, students can see, hear, and interact with 3D models of physical movements, providing a comprehensive understanding that purely visual or auditory methods might not achieve.

Furthermore, while technology-based approaches like text-to-speech and speech-to-text offer significant benefits, they might not fully address the kinesthetic and tactile learning needs that are crucial in Physical Education. The multisensory approach, however, encompasses these aspects, ensuring a more holistic learning experience. By engaging students in a hands-on, interactive manner, the multisensory approach not only addresses their cognitive needs but also caters to their physical learning preferences. (Moats, 2020; International Dyslexia Association, 2018).

The Orton-Gillingham (OG) approach is a highly organized, multisensory, and individualized method for teaching reading, writing, and spelling abilities, especially for people with dyslexia or other language-based learning issues. It was created in the early 20th century by Samuel Torrey Orton and Anna Gillingham and is based on the concept that people with dyslexia have issues with language processing, phonological awareness, and decoding skills (Sayeski et al., 2019). The OG approach emphasizes remedial training for apparent weaknesses while also urging beliefs in neurodiversity (Gillingham & Stillman, 2012). It is directed at a multisensory, direct, and structured system. Overall, the effective communication strategies used in the successful OG approach strategies emphasize getting students involved through multiple sensory (i.e., auditory, visual, and kinesthetic) instructional approaches as well as focusing on individual modification strategies that are most appropriate for each student (Sayeski et al., 2019).

The key component of the OG approach is multisensory instruction that offers the student different pathways through which to process information (Morgan, 2019). Overall, teachers' use of specific, straightforward, and instructional language and various communication techniques, such as audio, visual, and kinesthetic, is especially crucial for children with dyslexia (Pavlovic et al., 2022). Although the OG approach focuses on students with speech and language problems in language education, all students in an inclusive PE setting can benefit from the strategies and concepts. For instance, a typical OG classroom teaching strategy involves having kids view a letter or word, say its name, hear it out, and then write it with their fingers on the desk. Similar principles can be used in physical education classes, where students are taught using a variety of auditory, visual, and kinesthetic communication channels (teacher speaking, presenting or displaying, and asking students to apply), as well as by being physically assisted while they apply or integrate new skills (Pavlovic et al., 2022).

PE teachers may disregard disabilities that are "hidden," like dyslexia in their planning and expectations in favor of those that are more physically and/or visually obvious (Gilbert, 2019). In order to increase comprehension and memorization for students with dyslexia, the teacher may be required to format class notes into "mind maps," complete with colors, arrows, drawings, and humor (Sayeski et al., 2019). In the PE class for dyslexic students, the use of AR technology will be used as an assistive tool which aims to help students visualize the pictures in the textbooks and allow students not to be distracted and fulfill their working memory by reading written explanations in the books. Besides that, the use of a multisensory approach will also be implemented to produce effective communication and ways of learning. Multisensory refers to having multiple senses, which are among the five senses (sight, hearing, smell, touch, and teach) that allow a person to be aware of their surroundings (Oxford Advanced Dictionary, 1986). Ginder (2010) asserts that humans learn naturally through a variety of senses; most of us learn best through touch and sight, and least effectively through hearing alone. According to Albrecht and Plass (2015), the multisensory approach is founded on multisensory integration theory, which contends that information is presented through various sensory channels, such as visual and auditory, and kinesthetic (tactile) inputs, to maximize learning effectiveness. By presenting different representations of the same information and engaging numerous senses in the learning process, the multisensory approach aims to improve the likelihood that the knowledge will be efficiently processed, retained, and recalled.

Syahputri (2019) stated that regardless of age, the multisensory teaching method is incredibly effective, but it is especially crucial for children with learning disabilities. It is crucial to understand that students will grasp information with their senses easily and effectively if they are grasping according to their learning style, whether they are seeing, hearing, or grasping anything moving when they are learning that information during the teaching and learning process. This is important because these disorders cause varying degrees of deficits in the way the brain processes information gathered by the senses. Reading, writing, and speech are all made possible for kids with speech and hearing impairments because of multisensory teaching techniques (Gillingham & Stillman, 1997; Kotler, 2018; McGinnis, 1939). According to Amstrong (2008), the learning style provides the answer to many particular demands. The use of multiple senses during instruction improves student learning through the multisensory method. The goal of multisensory teaching is to create a strong connection between what students see in written instructions and demonstrations (visual), what they hear in instructions (auditory), and what they feel while performing the skill and making the sounds of the words (kinesthetic) (Gillingham & Stillman, 1997). The Language Triangle shown in Figure 2.6, commonly referred to as multisensory instruction, illustrates the three associations—visual, auditory, and kinesthetic—that are required to help children develop their language skills.

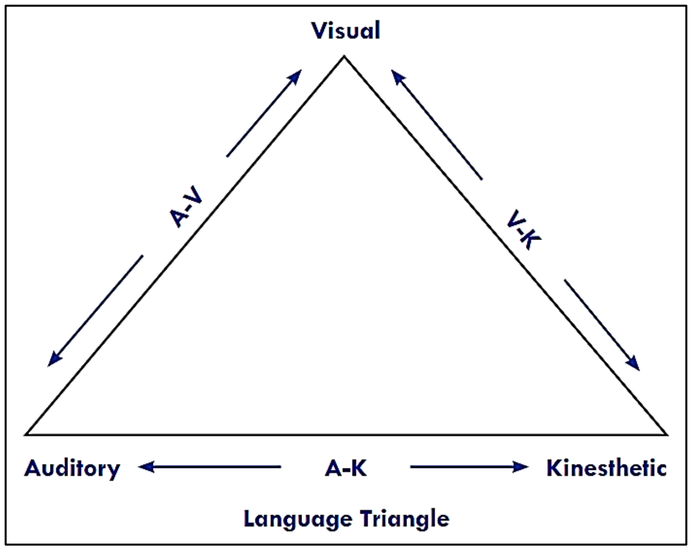


Figure 2. 6

Language Triangle

The Language Triangle from "The Gillingham Manual," by Gillingham and Stillman, (1997). Cambridge, MA. Educators Publishing Service

2.8.5 Multisensory Approach in PE

Motor skills can be taught using a variety of communication methods through multisensory teaching (Morgan, 2019). In PE, communication is visible at three different points, (a) before practice when the task is presented; (b) during practice when feedback is given; and (c) after practice when a review is given (Silverman, 1994). For efficient communication with all students—those with and without language disabilities—

multisensory teaching could be incorporated into physical education. Since PE differs from a classroom context in that students move around, a wider area is used, equipment is used, and there is a higher teacher to student ratio (Rink & Hall, 2008). Based on the Language Triangle, the purpose is to create connections between language learning and the visual, auditory, and kinesthetic senses. To learn motor skills, this Language Triangle could be applied in physical education by connecting the senses of visual, auditory, and kinesthetic (Morgan, 2019).

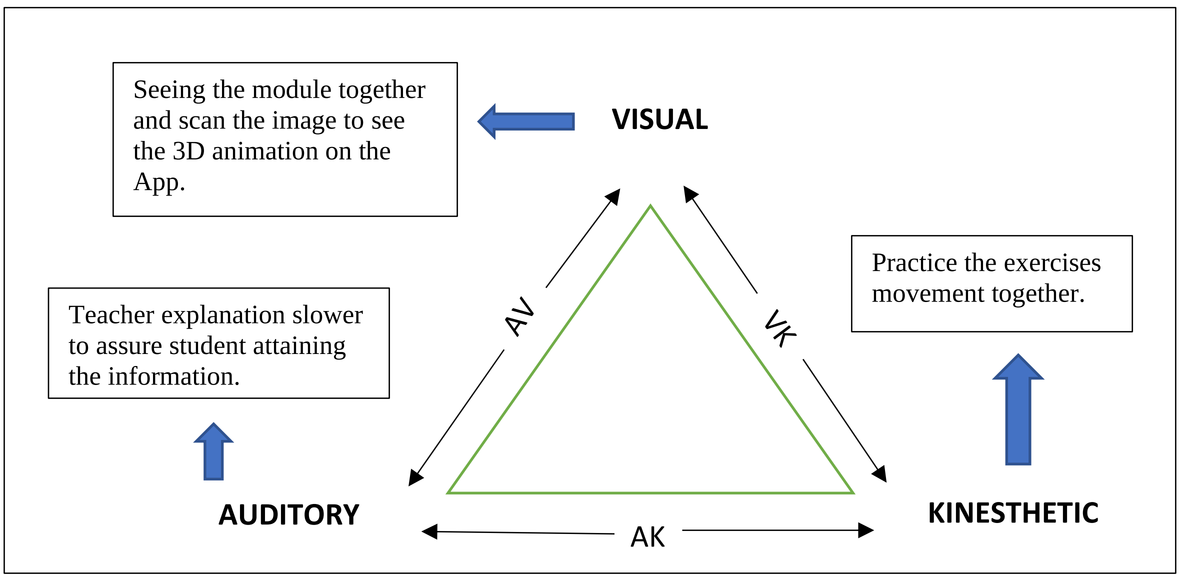


Figure 2. 7

Implementation of Multisensory Approach in PE Classrooms Settings

Figure 2.7 explains how the use of the multisensory approach applied into the PE classrooms. The first is on the visual component, what is done is that students will see the AR module and find the image that shows exercises movement which then they will scan the image using the AR application, then the 3D animation will appear on the phone screen. Then proceed with Auditory, in this component, the teacher will help explain the purpose of the exercises movement that they learn in the AR module slowly, which aims to ensure students are attaining the information, and the last component is the kinesthetic component, where students will perform the movements exemplified in the tutorial in AR applications and modules. This method of learning by applying multisensory approach will continue to be repeated and reviewed by the teacher, with a duration of one hour for learning and understanding one activity each meeting, in which there will be four movements in each activity. The repetition and review are done to help students improve their movement, confidence, and skill.

2.8.6 OG Approach in Teaching Dyslexic Students

The Orton-Gillingham (OG) approach is a well-known and effective method for teaching dyslexic students. Developed in the early twentieth century by neuropsychiatrist Samuel Orton and educator Anna Gillingham, this strategy has proved helpful in assisting dyslexic pupils in overcoming their reading issues through a multimodal, systematic, and tailored teaching methodology (Peavler 2019). The OG approach emphasizes using various senses to promote learning. Students use visual, aural, and kinesthetic-tactile activities to improve their knowledge and memory of reading and spelling skills. This multimodal involvement helps to bridge brain circuit gaps that dyslexic students frequently encounter (Birsh, 2018).

The instructions are meticulously designed, sequential, and cumulative. It starts with the most basic topics and gradually advances to more complicated ones, ensuring that pupils have a strong foundation before going on. This methodical approach assists dyslexic kids in developing confidence and writing skills (Henry, 2010). Numerous studies have shown that the OG approach can help dyslexic students improve their reading skills.

Table 2. 10

Review of relevant research

Author	**Participants**	**Key Components of OG Approach**	**Findings**	**Challenges/ Considerations**
Joshi et al. (2002)	Inner-city school students with dyslexia	Multisensory, structured, sequential, individualized	Significant improvements in reading accuracy, fluency, and comprehension	Resource-intensive; need for trained teachers
Hook & Jones (2002)	Students with dyslexia	Multisensory, structured literacy	Substantial gains in reading abilities	Importance of teacher training emphasized
Ritchey & Goeke (2006)	Review of various studies	Multisensory, sequential, individualized	Consistent improvement in reading skills	Variability in implementation; need for standardized practices
Campbell et al. (2008)	Students struggling with decoding	Multisensory components added to reading program	Improved decoding skills in treatment-resistant students	Need for extensive teacher training and resources
Moats & Dakin (2008)	General dyslexic student population	Structured, sequential, multisensory	Effective in diverse educational settings	Flexibility and creativity required in different environments

A review of relevant research on the Orton-Gillingham (OG) approach to teaching dyslexic students reveals some common findings and themes. The OG technique has been shown to be extremely effective in increasing reading skills such as accuracy, fluency, and comprehension. Joshi et al. (2002), Hook and Jones (2002), and Ritchey and Goeke (2006) all report considerable gains in these areas, highlighting the method's efficacy. According to Campbell et al. (2008), a key component of the OG approach is its multimodal learning strategy, which uses the visual, aural, and kinesthetic-tactile senses to improve memory and learning. This study closely follows the recognized benefits and techniques of the Orton-Gillingham (OG) approach, which focuses on employing an augmented reality (AR) module as an assistive learning tool for dyslexic children in physical education. Here, OG's shown ability to improve learning outcomes and reading comprehension is used to increase comprehension and participation in physical education. Within the AR module, the study uses an organized, multimodal, and customized teaching style that incorporates OG concepts. Similar to OG's multimodal approaches, this approach utilizes the visual, aural, and kinesthetic-tactile senses to improve learning and recall of physical motions.

2.8.7 Information Processing Theory and Dyslexic Students

Information Processing Theory (IPT) is a framework for explaining how people encode, process, store, and retrieve information. This theory compares the human mind to a computer and emphasizes the steps of information processing: encoding (input), storage (maintenance), and retrieval (output) (Anderson, 1983). It includes several crucial components:

1. Encoding is the process of converting sensory input into a format that can be stored in memory. This encompasses attention, perception, and early processing (Eysenck & Keane, 2015).
2. Storage: The preservation of encoded information across time, including both working memory (short-term storage) and long-term memory (permanent storage) (Baddeley, 2007).

3. Retrieval: The process of accessing stored knowledge, when necessary, which includes recollection and recognition (Tulving & Thomson, 1973).

Dyslexic students usually have difficulty with numerous areas of information processing, which can hamper their learning.

1. Encoding Issues
    a. Phonological Processing: Dyslexic kids usually have difficulty with phonological processing, which limits their ability to recognize and manipulate sounds within words. This issue may impair their ability to efficiently encode spoken information.
    b. Attention and Focus: Dyslexic students may fail to concentrate and efficiently absorb new material due to attention issues (Swanson, 1999).
2. Storage Issues
    a. Working Memory: Dyslexic children frequently struggle with working memory, which can impair their ability to briefly retain and manage knowledge. This problem impairs their capacity to do tasks that require them to remember knowledge while performing a cognitive task (Alloway & Alloway 2010).
    b. Long-Term Memory: Encoding difficulties can have an impact on long-term memory storage. Dyslexic students may struggle to organize and retrieve coherent memory representations of previously taught content (Snowling & Hulme, 2012).
3. Challenges in retrieval

a. Efficient Retrieval: Dyslexic students may retrieve information more slowly and inefficiently, especially if the material was poorly encoded or preserved. This can have an impact on their performance on tasks requiring quick memory or identification of previously learned knowledge (Miller & Hildreth, 2016).

Understanding these processing difficulties is essential for developing effective solutions. Instructional practices that aid in encoding, working memory, and retrieval are critical for dyslexic children. Multisensory instructionn, scaffolding, and the use of technology (e.g., AR modules) can all help to address these issues by providing additional support for encoding information, enhancing memory retention, and improving retrieval processes.

2.9 Summary

This chapter explains in detail about the literature review of previous research related to this research, as well as a clearer explanation of the theory and approach used. Previous studies have explained that dyslexia are closely related to language-based problems which directly affect a child's ability to write, read, spell etc. These limitations can then affect the way children learn and will affect their academic performance. After further investigation regarding its relationship with physical activity, previous studies also explained that dyslexia have an impact on physical abilities and development, including perceptual motor skills, motion control and coordination. In addition, in the current situation it was also found that the use of textbooks is still the main source of learning for dyslexic children in PE classes. This is one of the gaps found, because it is clear that the problems experienced by dyslexia are closely related to reading. This research will use AR technology as an assistive tool that will be used by dyslexic students when learning PE in class. The aim is to facilitate dyslexic students in the PE class in order to obtain learning materials and tools that are appropriate and adapted to their needs and abilities. Meanwhile, to achieve this goal, the implementation of CLT and multimedia learning principles will be used as a basis for creating learning materials that suit the needs and abilities of dyslexic students, besides that the use of ADDIE instructional design is also used as a guideline to produce good learning materials. On the other hand, for the effective teaching and learning results, the use of the OG Approach is also carried out, where in the PE class the use of multiple sensory approaches and repetition and review will be carried out to ensure that students can understand the material delivered in an effective way according to their needs.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The purpose of this research is to facilitate dyslexic students to study in adaptive PE classes according to the needs and abilities of these students. To create an adaptive environment, the selection of instructional materials and activities must also be adjusted to the needs of students. This study uses one of the assistive technologies which is AR to assist students when learning using textbooks in PE class. As for this research, it used existing AR applications, and the augmented modules that are used as markers and representations of textbooks that students usually use in class will be developed. This chapter presented the research methodology used in this study, the detailed explanation of the case study, how to define the case, and choosing the case study. The research population, sampling, research instruments, and the design of AR modules integrated with the school curriculum are also described. This chapter explains the research instruments used in this research, pretest, posttest, direct and participant observation, and interview. Lastly, the data analysis procedure is described.

3.2 Research Design

This study employs a qualitative case study methodology to explore the learning experiences of dyslexic students using an augmented module in their Physical Education (PE) classes. The qualitative case study approach is selected to gain an in-depth understanding of the specific challenges and benefits that the augmented module provides within the real-world context of a PE class. The qualitative case study approach is well-suited for this research as it allows for a detailed and nuanced examination of the experiences of dyslexic students interacting with the augmented module. This methodology is ideal for capturing rich, descriptive data and understanding the subjective experiences of participants (Yin, 2018). Regardless of the research project, people will act in their regular roles or will write in diaries, journals, write in their writings, or take photographs to express themselves (Yin, 2016). The nature of phenomena, including their quality, various incarnations, the environment in which they exist, or the viewpoints from which they can be observed, is studied in qualitative research. Qualitative research often involves data in words rather than statistics (Punch, 2013). Qualitative research focuses on emotions, concepts, or experiences. The main objective of data collecting, which is typically done in narrative form, is to identify insights that can lead to testable hypotheses (Ugwu & Eze Val, 2023).

As previously explained, the objective of this research is to explore the use of augmented modules as an assistive technology for dyslexic students when studying in PE classrooms. Referring to the objectives, qualitative research is suitable for this study. According to Yin (2016), although no systematic typology or inventory of the variants has been developed about qualitative research types, here are 12 types that have been widely acknowledged as action research; a) arts-based research; b) autoethnography; c) case study; d) critical theory; e) discourse analysis; f) ethnography; g) ethnomethodology; h) grounded theory; i) narrative inquiry and life history; j) oral history; and k) phenomenology.

Case study is one of the variants of qualitative study. According to Baxter and Jack, (2008) researchers can use qualitative case study methodology to analyses complex phenomena in their contexts. This qualitative case study allows for the exploration of a phenomenon in its context by utilizing a variety of data sources. This ensures that the topic is evaluated through multiple lenses, rather than just one, showing and comprehending the phenomenon's numerous facets. According to Yin (2003) case study design should be taken into consideration when: (a) the goal of the study is to provide "how" and "why" answers; (b) you are unable to control the behavior of those who will be participating in the study; (c) you want to cover contextual conditions because you think they are pertinent to the phenomenon under study; or (d) the boundaries between the phenomenon and context are unclear.

This research tries to explore the use of augmented modules for dyslexic students. The case study was chosen to carry out this research because this case is an exploration of dyslexic students when learning to use assistive technology, but the case could not be considered without the context, which is the physical education subject more specifically the classroom settings. It is in this setting that the experiences of dyslexia students are explored. It would have been impossible for this researcher to have a true picture of dyslexic students' experiences without considering the context within which it occurred.

3.3 Case Study

According to Creswell (2003), a case study is an in-depth exploration of a program, event, activity, process, or one or more individuals. In a case study, the researcher investigates a real-life, contemporary bounded system (a case) or numerous bounded systems (cases) across time, using extensive, in-depth data gathering involving multiple sources of information (Creswell 2013). The case study approach has the advantage of dealing with each individual in its genuine context, which is one of its main benefits (Yin, 2016). Case studies can get close to the subject of interest as they are able to be, in part by direct observation in natural settings and in part through their access to subjective aspects (thoughts, feelings, and desires). Variables are not the focus of the case; the case itself is. Case studies can be used for theoretical elaboration or analytic generalization, even though their primary goal is to generate knowledge of the particular. In this study, the case study approach is chosen because it allows for a detailed exploration of a specific phenomenon within its real-life context. In this case, the phenomenon is the use of the augmented module in PE classes for dyslexic students. This approach is ideal for exploring complex issues where multiple sources of data and perspectives are needed to understand the impact fully (Stake, 1995).

According to Yin (2014), there are three types of case studies: exploratory, explanatory, and descriptive. An exploratory case study is usually used when there is no predetermined outcome of getting an in-depth explanation of a social phenomenon. An exploratory case study investigates potential causal relationships that are too complicated for a survey or experiment (Yin, 2014). In this research, an exploratory case study is used to explore the use of augmented module on PE settings for dyslexic students, since intervention being evaluated has no clear, single set of outcomes (Yin, 2003).

3.3.1 Selection of the Cases

Gall et al., (2003) stated that case study is the most commonly used approach to qualitative research in education. According to Theodorson and Theodorson (1969; cited in Punch, 1998, p. 153), a case in case study research might be a person, a group, an episode, a process, a community, a society, or any other unit of social life. Yin (2012) defined a case as a constrained thing (a person, organization, behavioral condition, event, or another social phenomenon). According to Seawright and Gerring (2008), to choose the right cases, researchers should keep in mind that there are two main goals in case selection: (1) to choose a representative sample and (2) to include a useful variation on the theoretically relevant dimensions. When cases are picked, a purposive sampling method is used, which means that not every member of the population has an equal probability of being selected as a member of the sample.

Furthermore, case selection is concerned with producing diversity among the cases, implying that within the limited population, the characteristics of candidate participants are also used as the basis of selection, with the common goal of reflecting the 'diversity and breadth of the sample population' (Wilmot, 2005). The reasoning behind case sampling differs significantly from statistical sampling (Ebneyamini & Moghadam, 2018). The selection of cases is also purposeful and not random (Perry, 1998). The rationale behind case studies comprises theoretical sampling, intending to select cases most likely to replicate or extend the emergence theory or to fill theoretical categories and offer examples for polar kinds (Eisenhardt, 1989).

The primary objective in selecting cases for this study is to ensure that they provide rich, detailed, and relevant data about the use of augmented reality (AR) technology in Physical Education (PE) classes for dyslexic students. The cases should exemplify how the augmented module impacts student learning experiences within a real-world educational setting. Participants are selected based on specific criteria to ensure relevance to the study. For students, criteria include being diagnosed with dyslexia (detail criteria in Table 3.2) who are in level five of secondary school and participating in PE classes where the augmented module is used. The class involved is two PE classes. Teachers are selected based on their experience with both dyslexia and adaptive physical education and also who teach the classes involved to provide views on the use of augmented modules in PE classes (Table 3.1).

Table 3.1

Selection of cases

	Class A	**Class B**
Teacher participants	One physical education teacher specifically for special education school	One physical education teacher specifically for special education school
Student participants	6 dyslexic students who took physical education classes in 5 levels of secondary school	6 dyslexic students who took physical education classes in 5 levels of secondary school
Education institution	One special education school in Penang, Malaysia	

3.3.2 Selection of Case Study Design

A case study design focuses on in-depth analysis and understanding of a specific person, group, event, organization, or environment. There are various case study design types, and each one has unique qualities and goals. Yin (2018) states in his book that in designing a case study, there are four types of designs, which single case study which has one unit (individual or group) within one environment (context) or multiple case studies which used to explore differences within and between cases and holistic which has a single unit of analysis or embedded that has multiple units of analysis on it as can be seen in the Figure 3.1.

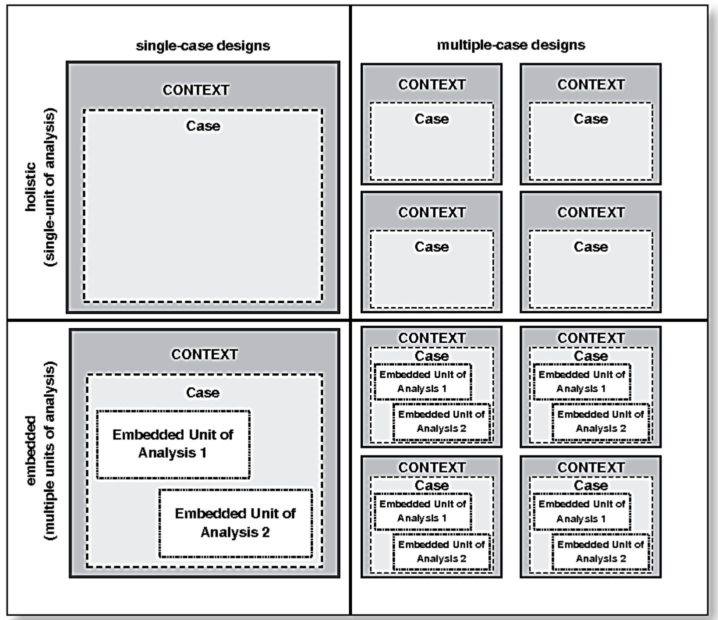


Figure 3. 1

Types of case study design

From Yin (2018). Case study research and applications: Design and methods (Sixth Edition). SAGE

Based on Figure 3.1 as can be seen that there are four types of case studies:

a) *Single Case Study*: In a single case study, the researcher carefully investigates just one person, family, group, incident, or organization. When a situation is exceptional, crucial, or exemplary, this design can be especially helpful since it can offer insightful information about more general issues.

b) *Multiple Case Study*: In a multiple case study, the researcher investigates several cases, which could be people, groups, things that happened, or organizations, or even a combination of these things. To find recurring themes and distinctive traits, the instances are compared.

c) *Embedded Case Study* is one in which the primary case of interest is included into a larger context or setting. To fully grasp the case's influences and effects, the researcher looks at it in the context of its larger environment.
d) *Holistic Case Study* approaches the case with a thorough and all-encompassing perspective. To provide a full analysis, it considers the case's many facets and dimensions.

However, researchers must decide whether it is wise to do a single case study or if it will be more beneficial to conduct numerous case studies to acquire a deeper knowledge of the phenomenon. This decision must be made in addition to choosing the "case" and the exact "type" of case study to be conducted. This study uses a single-case embedded design as it allows for an in-depth exploration of the augmented module's impact within a specific school, while also providing comparative insights from multiple units of analysis. This approach ensures a thorough understanding of the effectiveness and challenges of the augmented module in supporting dyslexic students in PE. Single case study chosen to deeply explore the implementation and impact of the augmented module within a specific school context. Focusing on a single school provides a controlled environment where variables such as school policies, teaching methods, and resources are consistent. This allows for a more detailed understanding of how the augmented module affects dyslexic students in a specific setting. Meanwhile the use of multiple units of analysis is to investigate the use and impact of the augmented module in different classes within the same school. By examining two classes, the study can compare and contrast the experiences and outcomes of the augmented module implementation, providing a richer, more nuanced understanding of its effectiveness and challenges.

3.3.3 Validity and Reliability

According to Rowley (2002) four tests are commonly used to assess the quality of empirical social research:

a) *Construct Validity*: Establishing appropriate operational measurements for the concepts being researched is known as construct validity. By tying data collection questions and measures to research questions and propositions, this seeks to reveal and diminish subjectivity.

b) *Internal Validity*: (only for causal or explanatory research; not for exploratory or descriptive research) establishing a causal relationship, as opposed to a fictitious one, whereby certain situations are proved to cause other conditions.

c) *External Validity*: Determining the area in which research discoveries can be applied broadly. Replication logic was the foundation of generalization.

d) *Reliability*: Proving that a study's processes, such as the data collection created, can be repeated, and provide the same results. This is accomplished by carefully documenting the steps and keeping suitable records.

The construct validity of a study can be improved by employing numerous sources of data that all triangulate the research questions and provide different assessments of the same occurrence (Yin, 2009). In this study, data was obtained from several resources. Student data was obtained from student interviews, observations, pre-tests, and post-tests to see students' movement abilities, researcher field notes and students reflective journal. On the other hand, teacher data is obtained through the results of interviews and researcher field notes. While in the data analysis process, the experts will be accessed, cross-checked, and reviewed the data. Before the data were clustered and the report was created, suggestions for improving the themes' descriptions and coding from the experts were taken note of and corrected.

In qualitative research, the term "external validity" refers to how far to which the results and interpretations of the study may be generalized or applied to other contexts, populations, or settings aside from the participants and conditions researched (Rowley, 2002). It evaluates the degree to which the findings are pertinent to the larger population or to circumstances like those in question. According to Rowley (2002) in case studies, the method of generalization is an analytical generalization in which a previously created theory is utilized as a template to compare the empirical data of the case study. Replication can be asserted if two or more cases support the same hypothesis. Analytic generalization considers each instance to be an experiment, not a case inside an experiment. The more case studies that demonstrate replication, the more rigorous theory has been established. In this study, data saturation will be carried out during the data collection process. Data saturation is to continue data collection until data saturation is reached, meaning that no new themes or insights emerge from the data. Data saturation ensures that the analysis is comprehensive, and all relevant aspects of the phenomenon have been captured. This is also done to get enough data for replication.

According to Seltiz et al., (1976), reliability is the ability of the investigators to gather and record information accurately, as well as the consistency, stability, and repeatability of the informant's stories. It speaks to a study method's capacity to produce the same outcomes throughout several testing intervals consistently. In other words, it mandates that a researcher must consistently produce the same or comparable results when employing the same or comparable methodologies on the same or comparable participants (Brink, 1993). Thus, constructing a case study database could increase the reliability of a case study (Yin, 2009). In this study, a shared online database was created during the data analysis process with the experts who checked and reviewed the coding during the data analysis process. The file consists of two participant sources: students and teachers. Student data will consist of recorded interviews, interview transcribed observation notes from the teacher, and pre and post-test results. Meanwhile, teachers' data are recorded interviews and transcribed interviews. In addition, the researcher's notes from interviews and observations are also included in the database for both participants. This raw data is made accessible for independent scrutiny to the new investigators.

Table 3. 2.

Validity and Reliability for Case Study Research

	Case Study Strategy	**Strategy Applied in the Research Phase**
Construct Validity	Use multiple sources of evidence (triangulation)	Data collection
External Validity	Use replication logic and data saturation	Research design, and data collection
Reliability	Develop case study database (NVivo)	Data collection

Table 3.1 shows how validity and reliability are done in case study research. First is the case study strategy for construct validity which is done by using multiple sources of evidence or triangulation and this strategy applies to data collection processes. The second is external validity which is done by using replication and data saturation, and this strategy

applies when designing the research and also in data collection processes. Lastly is a reliability strategy that is done by developing the case study database in data collection processes. The case study database serves as a comprehensive and organized collection of data and documentation related to the research. The purpose of this database is to ensure transparency, facilitate analysis, and support the reliability and validity of the study. In this study, the supervisor can view the database.

3.4 Research Site

This research was conducted at a special education high school in Penang, Malaysia. As previously explained in Chapter 2, special schools in Malaysia are divided according to the disabilities of the students. Out of six special education high schools in Malaysia, this school is specifically one of the special schools for children with learning disabilities. The disability categorization used is based on the disability card that students get from the Community Welfare Department, Ministry of Women, Family and Community Development, Malaysia.

3.4.1 Length of Study

This research will run for approximately three weeks with a total of six meetings (twice a week). Figure 3.2 depicts the length of study plan in this study. Each meeting will last 1-1.5 hours. The time is adjusted to schedule of the PE subject at school. The research aims to explore the learning experiences of dyslexic students using an augmented module in their PE class. The focus is on understanding how the augmented module impacts students learning. Given that the objective is exploratory, the six meetings provide a structured yet flexible timeframe to observe, gather data, and interact with the participants meaningfully (Creswell, 2013). Each of the six meetings is strategically planned to include specific activities and interactions that allow for comprehensive data collection. This includes observing the use of the augmented module, interviewing students and teachers, and reviewing student feedback and performance. By conducting these meetings over a six-week period, the research ensures consistent interaction with the participants, which is crucial for building trust and eliciting detailed, honest responses (Merriam & Tisdell, 2016).

In qualitative research, saturation is reached when no new information or themes emerge from the data. While it typically requires ongoing assessment, six meetings can be sufficient to reach saturation if the research is well-structured and focused (Guest, Bunce, & Johnson, 2006). The research is designed to gather data cumulatively, with each meeting building on the previous ones. This approach helps in identifying recurring themes and patterns, which can lead to saturation within the six meetings. Researcher remain open to adjusting the number of meetings if needed. The decision to conclude at six meetings is based on real-time assessment of data saturation, ensuring that additional meetings would not yield significantly new information (Fusch & Ness, 2015). On the other hand, using multiple data sources (observations, interviews, reflective journal) ensures methodological rigor and helps in reaching saturation efficiently (Patton, 2015).

Week 1	Monday	Thursday
	Introduction & training Movement Ability Test	Topic: Activity 1 *Flexibility*

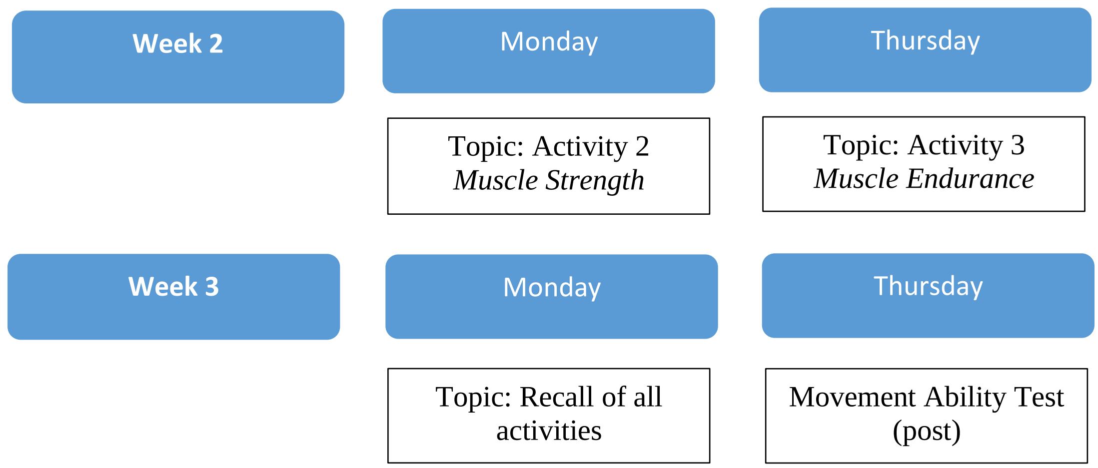


Figure 3. 2

Length of Study Plan

Each activity studied consist of four sessions or movements. So, in each meeting, students learned four movements related to the topic on that day.

3.4.2 Delivery System

Physical education classes at school are divided into two types of activities, which are sports activities in the field and learning in class. The implementation of using augmented modules in this study was carried out when students studied in class using textbooks. The use of the augmented module served as an assistive tool that helped dyslexic students visualize the images in the textbook. The setting of the place to be used is a hall which allows students to also do simple exercise. The way the teacher taught in class followed the guidelines from the OG approach applied in PE, where a multisensory approach was used as explained in Chapter 2. The Orton-Gillingham (OG) approach is a well-established instructional method, particularly effective for students with dyslexia. It is characterized by its use of a multisensory approach, explicit teaching, and individualized instruction. The guidelines for implementing the OG approach generally involve incorporating visual, auditory, and kinesthetic (VAK) learning modalities to reinforce learning through multiple sensory pathways. The implementation of the OG Approach in the Study is as follows:

1. Introduction and Explanation of Topics (Auditory)

   The teacher introduces the topics to be covered in the session and verbally explains the movements associated with the physical activities. This auditory component helps students process information through listening.

2. Visual and Auditory Demonstration

   The teacher and students review the augmented module, which provides visual representations of the movements. The teacher demonstrates each movement, combining visual (seeing the demonstration) and auditory (hearing the explanation) modalities. This dual-sensory input reinforces the learning process by engaging both sight and hearing.

3. Kinesthetic Practice

   Students are then asked to perform the movements themselves. This kinesthetic activity allows students to physically engage with the material, reinforcing the learning through movement and muscle memory. The teacher provides guidance and feedback during this practice.

4. Independent Study with Peers (Multisensory)

After the guided practice, students use the augmented module independently or with their peers. The module can include visual (animations, text), auditory (narration, instructions), and kinesthetic elements (interacting with the app, performing movements). This stage allows for reinforcement and self-directed learning.

5. Review and Reinforcement (Kinesthetic)

At the end of the lesson, the teacher conducts a review by asking students to demonstrate the movements again, either individually or as a group. This final kinesthetic activity serves as a review and assessment of the students' understanding and retention of the material.

The implementation of the Orton-Gillingham (OG) approach in this study aligns well with its core principles, particularly in providing multisensory engagement. The instructional method incorporates visual, auditory, and kinesthetic modalities, ensuring that students receive information through multiple sensory channels. This comprehensive engagement is crucial for reinforcing learning and aiding comprehension, especially for dyslexic students who benefit from such an approach. Additionally, the teaching process follows an explicit and systematic sequence, starting with an explanation of topics, followed by demonstrations, guided practice, independent practice with peers, and culminating in a review session. This structured sequence facilitates clear and methodical learning progression, allowing students to build on their knowledge incrementally. Furthermore, the inclusion of repetitive and cumulative learning experiences helps reinforce the material, promoting retention and mastery over time. This deliberate repetition and gradual development of complexity is important to strengthen students' understanding and skills, following the OG approach's emphasis on structured, multisensory learning.

3.4.3 Course Material

In this study, the topics in the module were taken from physical education and health textbooks for special education that had been adapted to students' abilities. Meanwhile, there are three topics taken from the book that were adapted into the module: flexibility, muscle strength and muscle endurance. Each of the topics has four sessions or movements as explained in Table 3.3.

Table 3. 3.

Lesson Plan

Lesson Plan

Unit 5: Physical Fitness Based on Health

Introduction: Physical fitness is the ability to perform daily tasks efficiently and vigorously without feeling excessive fatigue and having enough energy for leisure activities. In addition, a person who is physically fit should be willing to face the challenges of emergency situations that may arise.

Standard content:

3.1. Doing physical fitness exercise follows the physical fitness component based on health

3.2. Measure the level of physical fitness based on health

4.1. Apply knowledge of fitness principles and strategies to improve physical fitness based on health

4.2. Apply concepts, principles and strategies in physical fitness assessment

5.1. Adhere to and practice management and safety elements

5.2. Demonstrate confidence and self-responsibility when doing activities

5.4 Forming groups and working together in groups

Variation: Customize the activity according to the type of activity, the number of sets, the number of activities and the size of the activity area based on the student's ability.

Activity 1: Flexibility

Objectives:

Flexibility refers to the ability of muscles, joints, tendons and ligaments to allow our limbs to move at their maximum range of motion. In general, individuals who are active in physical activity have a better level of flexibility than those who are not active in exercise.

Total sessions:

Session 1: Shoulder rotation

Session 2: Side curl

Session 3: Body stretching

Session 4: Twist the body forward

Activity 2: Muscle strength

Objectives:

Muscle strength means the ability of a muscle or a group of muscles to produce force with maximum power to overcome resistance when lifting, pulling or pushing a load. Muscle strength can be increased by increasing the load through muscle strength training.

Total sessions:

Session 1: Bending

Session 2: Scissor jump

Session 3: Star jump

Session 4: Superman plank

Activity 3: Muscular endurance

Objectives:

Muscular endurance is the ability of muscles to perform repeated activities over a long period of time.

Total sessions:

Session 1: Push up

Session 2: Sit up

Session 3: Up and down the bench

Session 4: Squat jump

3.4.4 Course Assessment

In this study, the assessments carried out were in the form of pre- and post-tests regarding the movement abilities that students were to learn and had learned, which were related to the three topics or activities explained in the previous section. Students were asked to perform the movements in the module, and then the teacher assessed them according to the assessment rubric in the textbook.

3.5 Research Participants

A sample is a selection of people, groups, or things used in the study that is used for measuring a vast population (Hair et al., 2014). Thus, sampling is done to obtain accurate data. This study involved dyslexic students who were enrolled in PE subjects. Participants are selected based on specific criteria to ensure relevance to the study. For students, criteria include being diagnosed with dyslexia and participating in PE classes where the augmented module is used, they also must be in level five of secondary school. Teachers are selected based on their experience with both dyslexia and adaptive physical education. The selection of participants was based on purposive sampling. The purposive sampling is a sampling method that chooses the sample based on the purpose of the study and if the population of interest is small and specific data from a particular population subset is needed (Bhardwaj, 2019). Purposive sampling is used to identify participants who can provide rich, relevant data about the research focus. To answer the last research question, this research involved twelve students and two PE teachers who were teaching in the classroom.

Students who participated in this study were first year high school students. According to the Malaysian Ministry of Education, research involving high school students is only permitted to be conducted with students in their first year of school. Following these rules, this research will involve students in their first year of education at special high schools who take PE subjects. As for the students who will participate, they are dyslexic students in which the category of their disability is seen through their disability card from the ministry.

Table 3. 4

Criteria of Selected Participants

Inclusion Criteria	Exclusion Criteria
Dyslexic students	Others disability
Have no visual or vision problems	Have vision problems or blindness.
Have no physical problems	Have physical problems or disabilities.
Good in communication	Have communication problems.
Fluent in the Malay	Not fluent in Malay

Table 3.4 explains inclusion and exclusion criteria for dyslexic students involved in this study. As for the inclusion set, dyslexic students who enroll in PE subjects will be the participants of the study. Dyslexic students chosen are the ones who do not have vision problems or disabilities because learning activities will involve the use of modules and AR technology. Dyslexic students who participate are also selected who do not have physical problems or disabilities because this PE class will involve demonstrations of exercise movements which will then be seen whether students are able to do the movements as in the module. Students are also selected who have good communication,

meaning they can understand instructions and understand when spoken to, and the last one is fluent in Malay language because this research was conducted in Malaysia.

3.6 Research Instruments

This is an exploratory study that collects thorough information about the learning experiences of a group of dyslexic students who have various experiences in the PE classroom setting while using an assistive tool. Data is gathered from their personal experiences and environment. According to Yin (2009), in conducting a case study, data collection can be obtained through six sources: documents, archival records, interviews, direct observation, participant observation, and physical artifacts. Each source requires different data collection procedures. At the same time, gathering information about actual human events and behavior has been a key goal. Additional data were obtained from the results of students' pre- and post-tests regarding movement abilities when carrying out movements in the module. This additional data can be a complement for triangulation to be carried out later.

3.6.1 Interviews

The interview is one of the essential sources of case study information because it will guide conversations rather than set questions (Yin, 2009). This study used semi-structured interviews. Semi-structured interviews combine predefined questions with the freedom to delve deeply into issues. The researcher has a list of key questions or subjects to cover, but he or she can also ask follow-up questions or explore further to acquire more information. Semi-structured interviews strike a compromise between standardized data gathering and unstructured inquiry. Participants were given the flexibility to express themselves while keeping covering the topics necessary for data collection (Noor, 2008). In qualitative research, several types of interviews are commonly used to gather rich and detailed data:

a) Structured Interviews: These follow a strict script and set of questions, ensuring consistency and comparability across all participants (Bryman, 2016).
b) Semi-Structured Interviews: These have a predefined set of questions or topics but allow for flexibility in how and when questions are asked. This approach allows the interviewer to probe deeper based on the participant's responses (Kvale & Brinkmann, 2015).
c) Unstructured Interviews: These are very flexible and do not follow a specific set of questions. Instead, they are more like guided conversations, allowing the participant to steer the direction of the discussion (Fontana & Frey, 2005).
d) In-Depth Interviews: Usually semi-structured or unstructured, these aim to gather deep, detailed information and focus on understanding the participant's experiences, perceptions, and feelings in great depth (DiCicco-Bloom & Crabtree, 2006).
e) Focus Group Interviews: These involve a group of participants discussing a topic or set of topics. The interaction between participants can generate new insights and highlight different perspectives (Morgan, 1996).
f) Narrative Interviews: These focus on collecting stories from participants about their experiences, emphasizing the sequence and meaning of events as told by the participant (Riessman, 2008).

g) Ethnographic Interviews: Often conducted in the field as part of broader ethnographic research, these focus on understanding cultural practices and social interactions within a specific context (Hammersley & Atkinson, 2007).

In this study, the interviews were conducted in two stages: before (pre-interview) and after (In-depth interview) the treatment. The duration of the interview is estimated to be around 1-3 minutes for pre-interview and 5 minutes for in-depth interviews. The duration of the interview depends on the participant's answer. Some answer briefly, so the interview estimate will finish faster and vice versa. This approach is taken so that the researcher can explore the impact of using AR technology in PE learning in the classroom. Semi-structured interview questions also guided the interview sessions. With this strategy, the researcher can have more control over the interview's subject, and participants may feel more at ease sharing their experiences and ideas throughout the interview. In this study, the interviewees were divided into two groups: teachers and students. Both groups of participants were involved in the pre- and in-depth interviews.

3.6.2 Teacher Observation

Direct observation in qualitative research involves systematic watching and recording of behaviors, actions, and interactions in their natural settings without intervention or manipulation by the researcher. This method allows researchers to gather detailed and contextually rich data about how people act and interact in real-life situations (Merriam & Tisdell, 2016; Patton, 2015). Direct observations serve as another source of evidence in a case study because a case study should take place in the natural setting of the "case," this is the opportunity for conducting direct observations. Observational instruments can be created formally as part of the case study protocol. In a case study, direct observation entails the systematic and firsthand observation of a specific person, group, event, organization, or scenario. It is a qualitative research method in which researchers collect data by watching the subject of study in its natural setting or context. The fundamental goal of direct observation is to get a detailed and accurate understanding of the case under investigation's behaviors, interactions, and dynamics. The fieldworker can be asked to evaluate the frequency of behaviors during particular times in the field (Yin, 2009). In this study, direct observation was carried out by the PE teacher. Observations were documented in writing through teacher notes that the teacher filled in during teaching and learning in the classroom when students performed the exercise movements. In this study, observation was conducted following this steps:

a) Preparation: an observation checklist or guide was developed, outlining specific behaviors, movements, and activities to observe. This included noting students' abilities in doing the exercises movements.
b) Observation Sessions: Observations were conducted during regular PE classes where the AR module was being used and the students practice exercises movements.
c) Data recording: The observation data were analyzed using thematic analysis to identify patterns and themes related to the use of AR in the classroom. This analysis focused on the ability of the students to do movements that they have been taught using AR, aligned with the research questions and contributed to understanding the efficacy and challenges of using AR for dyslexic students in PE.

The results of these observations were then presented in Chapter 5 (Results), organized under the relevant research questions (RQ 2,3, and 4). This chapter detailed the findings from the observations, integrated with other data sources like interviews and surveys, to provide a comprehensive view of the study's outcomes.

3.6.3 Researcher Field Notes

Researcher field notes in a qualitative study refer to detailed, written accounts of observations, reflections, and contextual information gathered by the researcher during or after fieldwork. These notes are critical for capturing the nuances and complexities of the research setting, behaviors, and interactions that may not be fully conveyed through audio or video recordings alone (Emerson, Fretz, & Shaw, 2011; Saldaña, 2015). Field notes are one of the data collection tools in qualitative research, serving several key functions:

a) Descriptive Notes: These include detailed descriptions of the environment, participants, activities, and interactions observed. They provide a rich, contextual background that helps to situate the research findings within a specific setting (Emerson et al., 2011).
b) Reflective Notes: These capture the researcher's thoughts, feelings, interpretations, and insights about the observed events. Reflective notes are essential for understanding how the researcher's perspectives and potential biases may influence the data collection and analysis process (Saldaña, 2015).
c) Analytic Notes: These notes involve preliminary analyses and ideas about emerging themes, patterns, and concepts. They help the researcher to make sense of the data and to guide future data collection and analysis efforts (Wolcott, 2005).

In this study, researcher directly followed the PE classes as observers. Researcher do the descriptive and reflective notes that observed all aspects during the activities as explained previously.

3.6.4 Students' Reflective Journal

To obtain extra data, the researcher created a daily reflective journal for the students. Reflective journals are students personal notes of their learning experiences, with the goal of providing their reflection on the activities, topic, and obstacles encountered during the learning process (May-Melendez et al., 2019). Furthermore, based on the Henter and Indreica (2014) perspective, the reflective journal has a positive impact on the students' learning because it can be used to monitor metacognitive dimensions and encourage reflection on their own strengths and weaknesses while or after performing an activity. Moon's (2010) concept for language learning and reflective journaling is centered on written work of students such as video summaries, vocabulary lists, and self-reflective comments. In this case, because the research participants were dyslexic students, the researcher not asked the students to make reflective journals using notes they supposed to themselves, but instead to replace the notes with audio recordings. In analyzing the reflective journals, which in this study were replaced by audio recordings due to the participants being dyslexic students, the researcher followed a systematic process that involved several steps. The analysis focused on understanding students' learning experiences, challenges, and reflections, and was aligned with the relevant research questions. Here is some steps conducted for analyzing the reflective journal:

1. Transcriptions of audio recording

All audio recordings made by the students were transcribed verbatim. This step ensured that the content of the reflections was accurately captured and made available for detailed analysis. The transcriptions included students' descriptions of activities, their reflections on the learning process, and any challenges or obstacles they encountered.

2. Coding and categorization

The transcriptions were read multiple times to familiarize the researcher with the content. Thematic analysis was used to identify key themes and sub-themes within the data. This involved coding segments of the transcriptions that related to specific topics, such as reflections on specific AR activities, mentions of challenges faced, or insights into personal strengths and weaknesses. Codes were grouped into categories, and these categories were further refined into broader themes. For example, themes might include Engagement with AR Content, Challenges in Understanding, Perceived Benefits of AR.

3. Identification of patterns and insight

The researcher looked for recurring patterns and significant insights within the themes. This step involved comparing and contrasting reflections across different students to identify common experiences or unique perspectives. The analysis also focused on changes over time, noting if students' reflections evolved as they became more familiar with the AR technology.

4. Triangulation with other data sources

The findings from the reflective journals were triangulated with other data sources, such as teachers observations and interviews with teachers and students. This triangulation helped validate the findings and provided a more comprehensive understanding of the students' experiences. The analysis of the reflective journals primarily contributes to understanding 2^{nd}, 3^{rd} and 4^{th} research questions.

3.6.5 Pre-test

A pre-test is a test or measurement administered to participants before their exposure to a specific intervention or therapy in the context of research. A pre-test's primary goal is to collect baseline data on the participants' traits, abilities, or behavior before the intervention. In qualitative research, triangulation is a methodological strategy that entails using several data sources, methods, or perspectives to improve the findings' credibility, validity, and reliability. Triangulation allows researchers to cross-validate their findings and increase the overall reliability of the research. In this situation, pre-tests can be used to supplement other methods, such as interviews or observations, as part of data source triangulation. Researchers can get a more comprehensive picture of the research issue and evaluate the consistency of their findings by gathering pre-test data in addition to data from other sources. In this study, a pre-test collected using movement ability rubric (Appendix F) which was done before students start to learn using the augmented module. A movement ability rubric to be completed or filled in by the teacher that being used in measuring the students pre-test performance.

3.6.6 Post-test

A post-test is a test or measurement given to individuals after they have been exposed to a specific intervention or treatment. A post-test primary function is to evaluate participants' outcomes or responses following an intervention, therapy, or experimental modification. Same as the pre-test, the post-test was conducted after the treatment is done and the purpose of doing the post-test on movement ability in this study is also to support data triangulation sources. This was done so that the researcher obtained accurate data at the same time. The post-test used a movement ability rubric that was filled in by the teacher.

3.7 Pilot Study

According to In (2017), the purpose of a pilot study is to investigate whether something is possible, whether it should be pursued by the researchers, and if so, how it will be conducted. A pilot study also has a unique design element; it is carried out on a smaller size than the main or full-scale investigation, which is crucial for enhancing the effectiveness and quality of the latter. Additionally, it is carried out to examine the randomization and blinding process, evaluate recruitment potentials, increase researcher experience with the study methods or medications and interventions, and provide estimates for sample size calculation. Based on this explanation, before conducting the actual study, the researcher conducted a pilot study first to find out whether the instruments for data collection and the AR app and module were appropriate and also to get to know the participants and the environment of the study.

The pilot study was conducted in one of the special education schools at the junior high school level involving students with low and mild dyslexia. A total of 10 students participated in this pilot study where they were selected based on purposive sampling. The intervention carried out with students was to study in PE class using an augmented module and then in the next meeting students would use the AR application in their learning. At the beginning and end of the meeting, all students would do a pre- and post-test to see their movement ability and five of them would be asked to do a pre- and in-depth interview.

From the results of evaluating the learning content in the module (exercise movement) by the teachers, it was found that some of the movements were too difficult for students to do, the teacher then suggested changing these movements. After the module has been approved by the teacher, a pilot study was conducted by which it started with the students giving their information to be filled in the demographic form done by the researcher. The movements that have been removed can be seen in Figure 3.3.

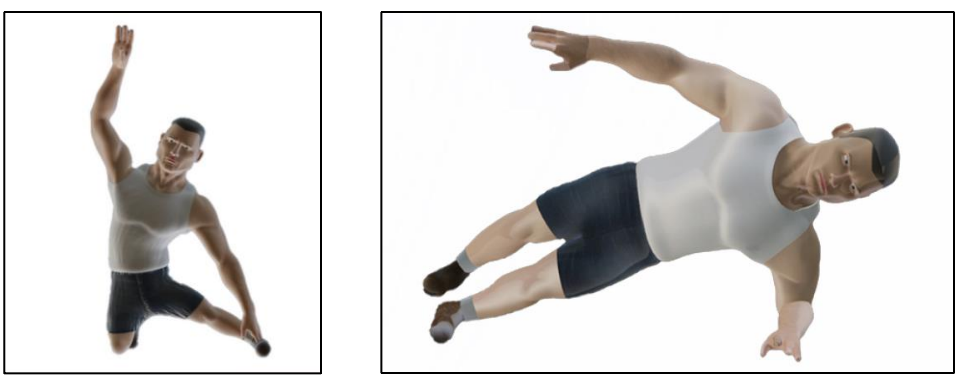


Figure 3. 3

Removed Exercises

Pilot Study Results

Before Intervention

While the term "intervention" is commonly associated with quantitative research, it is also applicable in qualitative studies when researchers introduce a specific change or new element into the participants' environment to explore its effects (Creswell & Poth, 2018). The focus was on exploring and interpreting the qualitative aspects of these experiences, rather than measuring quantitative outcomes (Merriam & Tisdell, 2015). In this qualitative research, the term "intervention" refers to the introduction and implementation of the augmented module using AR technology in the physical education (PE) class for dyslexic students. The primary goal of this intervention was to explore and understand the learning experiences of dyslexic students when using AR technology, rather than to measure specific quantitative outcomes.

a) Students results

In the first meeting, five students are asked to did the pre-interview. Students are given four questions about their background and experiences when learning physical education in the classroom. From the results of the pre-interview, no difficulties were found in the questions given, all students understood and were able to communicate well what they wanted to convey. From the results of the pre-interview, it was found that there were two main themes regarding the difficulties faced by students when learning PE in class, then the feelings of students when learning in class.

Difficulty

Students revealed in the results of their interviews that four out of the five students found it difficult to interpret the 2D images contained in physical education textbooks. They have difficulty imagining how the pictures move, and how the movements of the exercise they should make. Then four out of five students also felt that reading books and looking at the 2D image was not enough for them to understand how the actual movements had to be made. Students felt that they need to be modeled to do the movements they see in the book. Meanwhile, teachers do not have much time and opportunity to model these movements for each student.

Feelings

In the interview session, the theme of feelings was also found, four out of the five students said that they felt bored when learning PE in the classroom. They stated that when in class they are required to sit, write, and read a book. Meanwhile, they prefer to learn PE on the field. Then three of the five students felt happy and enthusiastic about learning PE because they could do any exercise. Two of the students also said that PE was good for their health and could release stress when they were tired of studying.

b) Teacher’s results

Meanwhile, one PE teacher who teaches and have responsible for the class also conducted pre- and in-depth interviews to see from the teacher perspective. The results were obtained from teacher interviews. Teachers said that the problem they face when teaching dyslexia is the difficulty of getting students to focus on learning. Moreover, teaching PE using textbooks in class is very difficult for students when they have to look at the textbook. Usually, teachers will minimize the use of textbooks, by directly giving demonstrations to students. However, other problems arise, because each student has a different level of understanding, teachers often run out of time to explain a movement to one student, in the end not all students get balanced teaching.

After Intervention

a) Students results

After conducting the pre-interview, the next stage is when the students are introduced to the AR application. Students explored and learned to use the application. There are three activities that have four moves each in them. After the students learned to use the application then students conduct in-depth interviews conducted to them. From the results of this last interview, it was found that there are three main themes which have sub-themes in them as explained below.

Learning experiences

All of the students interviewed said that this is the new learning tool for them, since this is the first time they are using AR technology in their learning. All of them like using the AR app and feel that learning to use this app is really fun because it can help them to show the animation of exercise movement on the module. Three out of five students are interested in using AR applications because now everyone is using technology, so this app really helps them to make learning easier in classrooms and still update with the latest technology. Three of the five students also said that by using this application they did not need to rely on the teacher when they had difficulty on understanding the 2D images in books, and they could also study at home. One of them also said that using this application in the classroom would make it easier for teachers to teach.

Learning Material

The five children who were interviewed said that the instructions in the module was easy to understand because it contains lots of images with less explanation. Then four of the five children said that the exercise movements shown by the 2D characters in the module were also easy to understand. The five children also claimed that it was easy to perform the overall exercise movement in the module. However, three of the five children found it difficult to do the scissor jump movement.

AR Application

The four students said that this AR application was very easy to use, because they only needed to point it at the 2D object in the module and then the 3D object would appear in the application and show the animation of the movement exercise. The five students also said that the 3D objects and animations in the AR application were very easy to understand. However, two children encountered problems when trying the application because there were several 2D objects that were difficult to detect so that the animation in the application did not appear immediately, and there were also blinking the animation.

b) Teacher results

The results of the in-depth interview, the teacher explained that the use of augmented modules really helps students to minimize the text they have to read. Students can focus on looking at the images in the module and just read the title of the image, for information about the movements shown by the image, the teacher will help explain to the students. then with the presence of 3D animation, it helps teachers to demonstrate exercise movements to students more personally because each student can access and use it. the use of this technology is considered very useful for teachers and students in PE class, the teacher suggests adding more activities so that they can be used for a fairly long period. On the other hand, in some images there are obstacles to displaying 3D animation, meaning that some images are not easy to detect the marker so that it takes some time to detect the 3D application. in addition, the availability of devices at school may also be an obstacle in the future according to the PE teacher.

Movement Ability

Pilot testing for movement ability was followed by 20 students. A pilot study is carried out to ensure that the research instrument used is appropriate, and there are no problems with its use.

Table 3. 5.

Descriptive Statistic of Movement Ability in Pilot Testing

	Movement Ability	
	Pre	Post
Sample Size	10	10
Mean	8.28	9.68

Table 3.5 depicts results of the movement ability of the students. After the students learned the movements assisted with an augmented module, the results on the movement ability test showed an increase in scores on the post-test.

3.8 Research Procedure

The research process contained the activities that were carried out to accomplish the desired goals. The procedure in this research starts from the define and design stage, which is looking for relevant theories that match the desired objectives. Then determined the case to be studied from the context that had been determined and designed the data collection protocol that was used for data retrieval. As previously explained, the expert validated the data collection instrument before it was used. Based on Figure 3.3, it can be seen that there is a dotted line. When the data collection process is being carried out, if there is different or invalid data that is not in line with the existing theory, the process can loop, and return to the stage of the select case, meaning that the case can be changed and adjusted to avoid errors in the result. Then in the next stage, i.e., prepare, collect, and analyze stage, the data collection process started by taking data on a case-by-case basis. After all data is obtained, the following process is to make individual case reports from each case. Reports are made on a case-by-case basis so that researcher can see if there are differences in the results obtained from each participants. The next stage is to analyze and conclude. At this stage, a cross-case conclusion was drawn and then the theory was modified, if necessary, to adjust to the results obtained. Finally, a report was written based on the findings. Table 3.5 indicates the research procedures that were carried out during data collection.

Table 3. 6

Research Procedure of the Actual Study

Weeks	Remarks	Place & Tools	Instruments
Week 1 Day 1	• Participants had a short briefing about the study, data collection procedure, and information confidentiality (5-10 minutes)	Physical Education Classrooms	
	• Pre-Interview (students). (1-3 minutes)		Student pre interview guideline
	• Participants were given an augmented module and asked to understand it (10 minutes).	Augmented Module	
	• Pre-test (Movement ability test) (5-10 minutes)		Movement ability rubric
	• Teacher's pre-interview (2-5 minutes)		Teachers pre interview guideline
Week 1 Day 2 - Week 2 Day 2	• Participants attended the PE classes as usual and used the augmented module as an assistive tool (1.5 hours).	Augmented module	
	• The observations were carried out during the teaching and learning process.	Physical Education Classrooms	Observation checklist & researcher field notes
	• Learning Content: a. Flexibility (week 1-day 2) b. Muscle strength (week 2-day 1) c. Muscle endurance (week 2-day 2)	Physical Education Classrooms	Observation checklist & researcher field notes
	• A reflective journal was recorded after each class (3-5 minutes).	Physical Education Classrooms	Reflective Journal
Week 3 Day 1	• Recall of all Learning Content (1 hour)	Physical Education Classrooms	Observation checklist & researcher field notes
Week 3 Day 2	• Post-test (movement ability test). (5-10 minutes)	Physical Education Classrooms	Movement ability rubric

• In depth interview (5 minutes)	Students pre interview guideline
• Teachers in-depth interview	Teachers pre interview guideline

3.9 Data Collection Process

The description of the data collection process in this study, which was carried out over three weeks (six meetings during PE classes), is depicted in Figure 3.4. Based on the PE textbook and school curriculum, explained some conditions:

- PE class lasts for 60 - 90 minutes. In the first 10 minutes, preparations were made, including activities such as praying together before starting the class, ensuring no student was sick, motivating students to create a pleasant learning atmosphere, and informing them about the benefits of exercise for their health and fitness.
- Then proceeded with 40 minutes of main activities, where warm-up movements were carried out first. The teacher briefed the students on how to use the augmented module and then began the learning process. Students learned and practiced the movements using the augmented module provided, in collaboration with their peers..
- In the last 10 minutes, a cooling movement, the teacher evaluates today's learning activities, students give their reflection and close them with a prayer together.

The data collection process explained previously is depicted in Figure 3.5.

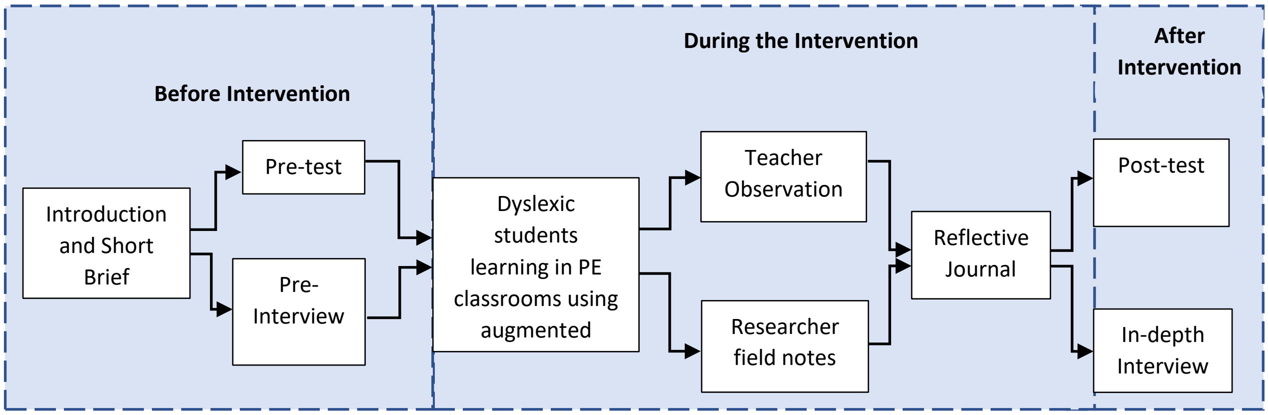


Figure 3. 4

Data Collection Process

Referring to the learning activities as described previously, the data collection in this study began with a pre-test where students were invited to try the movements exemplified by the figures in the module. This condition mirrors how students previously learned by looking at figures in textbooks and then attempting to understand and replicate them. At this stage, a pre-test assessed the students' movement abilities, which were evaluated by the teacher using the provided assessment rubric. Following the pre-test, each student was interviewed about their experiences with the PE lessons. After the pre-test and pre-interview, the next phase involved distributing the augmented module for use during the intervention. The teacher then introduced and explained the activities to be undertaken during the intervention period, including a briefing on how to use the augmented module, which contained exercises that the students were to learn. The teacher provided detailed explanations of each movement, and students were given time to practice the exercises with their peers. Observations began during this learning process, as outlined in Figure 3.6.

Figure 3. 5

Teacher Teaches How to Do Exercises Movement

On the second day, the students were introduced to AR applications, which were installed on six school-provided Android tablets. Students learned physical education as usual with the assistance of the augmented module (see Figure 3.7). At this stage, teacher observations and researcher field notes were collected. After the teaching and learning process, students recorded reflective journals to reflect on their learning that day. Learning using the application continued on the third and fourth days. On the fifth day, the teacher reviewed all the activities that had been covered to ensure that students understood the topics.

Figure 3. 6

Students Learn Using the Assistance of AR

In figure 3.7, students are seen studying in peers using AR tools that have been installed on the school tablets they use. Meanwhile, figure 3.8 shows 3D animated views when viewed from student devices, while figure 3.9 shows real 3D animations that students see on their respective tablets.

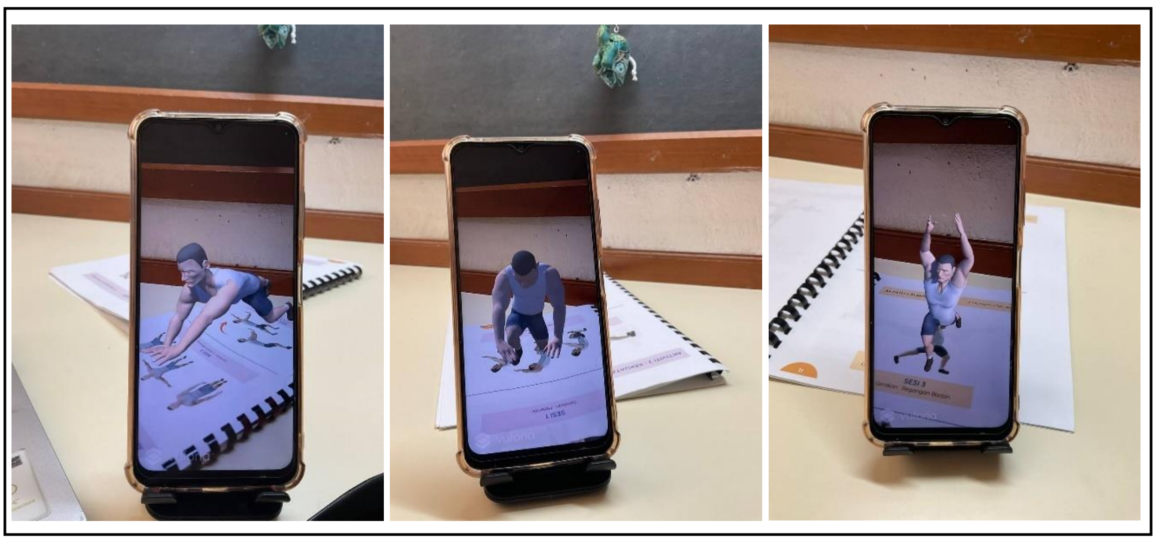


Figure 3. 7

3D Animation Viewed from Student Devices

Figure 3. 8

3D Animation Viewed from Student Screen

On the last day, the movement ability test (post-test) was conducted by asking the students to demonstrate the movements in the module without the use of any technological assistance. At this stage, the teacher assessed the students using the movement ability rubric. After each student took their turn in the post-test, they participated in in-depth interviews. The entire data collection process was estimated to take three weeks (six meetings), taking into account that pre-interviews, pre-tests, post-tests, and in-depth interviews required additional time. The researcher could not dictate the students' moods, so adjustments were made according to their current circumstances. For the teachers, pre- and in-depth interviews were conducted after the PE class.

3.10 The Roles of Researcher

In contrast to quantitative research methods, the richness of data in qualitative research is frequently tied primarily to the investigator himself/herself. Therefore, Willis et al., (2007) argues that within a qualitative research paradigm, it is critical for researchers or investigators to serve as the primary instrument or tool for data collection, because it is the researcher who makes immediate decisions and adjusts to the complex situations encountered during the investigation process (Silverman, 2016). The qualitative research paradigm emphasizes a holistic and interpretive approach to understanding human experiences. The researcher, as a key instrument, navigates the complex interplay of factors within the research setting, striving to capture the richness and diversity of participants' perspectives. This paradigm values depth over breadth, seeking to uncover the underlying meanings and contexts that shape the phenomena under investigation.

A tighter or more intimate relationship between the researcher and the cases is thus required in qualitative research (Yin, 2013). During the intervention, the researcher also entered the PE class to make observations. The researcher did not conduct any interventions, only observed. The class was completely controlled by the teacher. During the data collection, the researcher was the interviewer for both the students and the teachers. In the data analysis process, the researcher analyzed all the data gathered from both the participants and the researcher’s field notes.

3.11 Experts

In this study, the modules and instruments were validated and checked by several experts. The experts involved are:

a) *Content Expert*: The content expert in this research is one of the lectures from the Center for Instructional Technology and Multimedia, Universiti Sains Malaysia. He is a content expert because he has experience teaching PE and also experienced in the field of instructional design. The expert validated the content in the augmented module.

b) *Instructional Design Expert:* This expert is also one of the lectures from the Center for Instructional Technology and Multimedia, Universiti Sains Malaysia. She was experienced in instructional design and also served as an expert who checked the stages of developing the module using an instructional design model.

c) *Qualitative expert*: This expert is a lecturer from the School of Educational Studies, Universiti Sains Malaysia. She is one of the qualitative experts in the field of education. In this study, she validated the qualitative instruments (interview guidelines for students and teachers, and the reflective journal) before they were used.

d) *Adaptive PE expert*: This research also involves an expert in the field of special education, specifically in adaptive PE, namely the PE subject for children with disabilities. This expert teaches at a special school for learning disabilities in MalaysiaIn this study, the activities and interventions that were carried out were done through the approval and adjustments suggested by this expert to ensure the children's safety while the research was taking place.

3.12 Ethical Considerations

To make sure that research is carried out in a way that respects and protects the rights, well-being, and dignity of the participants, ethical issues are crucial in qualitative research. In qualitative research, where researcher frequently interact closely with individuals and examine delicate subjects, ethical norms are particularly important. There are four requirements for ethical considerations in qualitative research, (Lincoln & Guba, 1985). They are reliability, dependability, confirmability, and credibility. The researcher adhered to these four criteria to guarantee that this study was impartial. The researcher took all necessary precautions to reduce any potential bias from their position as an insider researcher.

3.12.1 Credibility

According to Anderson et al., (2014), credibility in qualitative research refers to how reliable and believable the results, interpretations, and conclusions are. It is one of the main standards used to assess the excellence and validity of qualitative research. Credibility is crucial to ensuring that the study effectively captures the viewpoints, feelings, and meanings of the participants and offers a solid framework for comprehending the topic being studied. Through the various triangulation methods, credibility can be increased (Yin, 2017). To put it simply, triangulation refers to the process of frequently identifying patterns using many sources of data or methods from the field. Replicability in an a priori empirical investigation differs from the recognition of similar outcomes repeatedly through numerous data sources. As previously explained, this study used triangulation of data resources to improve the findings' credibility, validity, and reliability (Noor, 2008).

This study's credibility was established by extensive data triangulation, ensuring that the conclusions accurately mirrored the participants' experiences and perceptions.

Given the participants' dyslexic nature, the researcher gathered data from a variety of sources, including detailed observations during physical education classes where the augmented module was used, semi-structured interviews with students and teachers, and audio recordings of their reflective journals. The study used these numerous qualitative methodologies to cross-check and verify the consistency of the findings across diverse data types, hence improving the dependability of the results. The constant themes and patterns found across different methodologies offered a solid foundation for the study's conclusions. Furthermore, the utilization of detailed descriptions provided a thorough view of the research background, making the findings more relevant and credible. The researcher also used reflexivity, critically reflecting on their own biases and the influence of their involvement in the study, to ensure that the results were based on the participants' real experiences rather than the researcher's assumptions. The study used these combined tactics to offer a trustworthy and credible description of employing an enhanced module as an assistive aid for dyslexic students in physical education classes.

3.12.2 Transferability

Lincoln and Guba (1985) propose transferability as a second factor for trustworthiness. Transferability in qualitative research refers to the amount to which a study's conclusions can be used or applied to situations, contexts, or groups other than the particular participants and research site. Transferability differs from generalizability, which is frequently connected to quantitative research, because it does not involve extrapolating statistical findings to a broader population (Suter, 2011). Instead, it focuses on the relevance and applicability of qualitative study's findings and conclusions in various contexts or with various individuals. This study's transferability was improved by including a detailed description and complete description of the research site, participants, and context. Thick explanations help readers comprehend the study's distinctive qualities, which can help them judge the findings' transferability. Second is reflexivity, throughout the course of the study process, the researcher was open and honest about their own prejudices, presumptions, and values. Understanding how the researcher's perspective may affect the applicability of the findings is made easier for readers by acknowledging it. Next, the sampling strategy must be carefully taken into account for transferability. The method used to choose participants should be disclosed, as well as any attempts made to include individuals from other settings and views. It is crucial to understand that transferability does not imply that the conclusions may be applied universally. Instead, it focuses on arming readers with enough knowledge to assess the degree to which the study's conclusions can be extended to other contexts or circumstances.

This study addressed transferability by providing comprehensive, thorough descriptions of the research site, participants, and context, which included the school environment, physical education (PE) class characteristics, and the backgrounds of the dyslexic students included. The study clearly demonstrated the researcher's reflexivity, recognizing potential biases and the impact of their insider status on data collection and interpretation. A defined sampling method ensured a varied range of perspectives by outlining the criteria for selecting participants and the range of experiences represented. Furthermore, the study provided contextual relevance by describing the specific obstacles and benefits of adopting augmented reality (AR) technology in this educational setting, allowing readers to assess the findings' applicability to other situations. Finally, the study acknowledged its limits, offering a balanced perspective that helps readers understand the breadth and constraints within which the findings can be applied, allowing for careful analysis and potential adaption in similar scenarios.

3.12.3 Dependability

Lincoln and Guba (1985) present dependability or trust in trustworthiness as a third viewpoint on trustworthiness. Dependability in qualitative research refers to the accuracy and consistency of the study's results and recommendations across time and under various circumstances. It is one of the factors considered while assessing the calibre and accuracy of qualitative research. By proving that the results are unaffected by chance or researcher bias, dependability is essential to establishing the stability and credibility of the research. Researcher use a variety of strategies and procedures to increase the dependability of qualitative research, including:

a. *Consistency in Data Collection:* When collecting data from participants and data collection sessions, researcher should make sure that the method is consistent. Standardizing the data collection techniques for this study can help ensure dependability. Examples include employing the same interview methods or observational checklists.
b. *Consistent Coding and Analysis*: When coding and analyzing data, researcher should be consistent. It is easier to ensure that the same data are interpreted consistently throughout time and by several researcher, if necessary, by using unambiguous coding conventions and guidelines.

c. *Saturation*: Achieving data saturation, in which additional information no longer significantly modifies the emerging themes or offers novel insights, increases the reliability of the conclusions

3.12.4 Confirmability

Confirmability in a case study describes the extent to which the study's results and conclusions are founded on the actual data gathered and not affected by the researcher's biases, viewpoints, or prejudices (Ary et al., 2013). It is a fundamental criterion for determining the validity and rigour of qualitative research, including case studies. The primary method for proving confirmability in qualitative research is the audit trail. An audit trail is a thorough record of the data collection process and the reasoning behind significant choices (Suter, 2011). The field notes, memos, and coding procedures were all documented to ensure that the "findings are grounded in the data" (Lincoln & Guba, 1985).

In this case study, confirmability refers to how closely the findings and conclusions are based on the real data obtained, rather than being impacted by the researcher's prejudices or previous beliefs. It is an important factor for determining the quality and rigor of qualitative research. To ensure confirmability, the study used an audit trail, which is a complete record of the whole research process. This comprised detailed documentation of data gathering methods, field notes, memos, and coding procedures utilized throughout data processing. By rigorously recording these features, the study attempted to establish that the conclusions are solidly anchored in data, guaranteeing that the results are reflective of the participants' experiences and not overly influenced by the researcher's viewpoints. This transparency and systematic approach to data management help in affirming the credibility and trustworthiness of the study's outcomes.

3.12.5 Data Analysis

This study has several instruments as a data collection tool as explained in the Table 3.6. The data sourced from several instruments (interviews, teachers observation and researcher field notes) is then analyzed using thematic analysis, meanwhile the pre- and post-tests were analyzed using descriptive analysis to see the mean of the movement ability test results. Thematic analysis is a method of discovering patterns or themes in qualitative data. According to Braun and Clarke (2006), it should be the first qualitative approach learned since it provides core skills that will be useful for conducting many other types of analysis. Table 3.7 explains data sources and data analysis used in this study related to each research question.

Table 3. 7

Data Sources

No	Research Questions	Data Sources	Data Analysis
RQ 1	How is the Cognitive Load Theory (CLT) and Mayer's Principles of Multimedia Learning applied in the design PE learning and the augmented module for dyslexic students?	• Student pre and in-depth interview (Appendix B and C) • Researcher field notes (sample in Appendix Q) • Student Reflective Journal (recorded) (Appendix G)	Thematic analysis
		• Movement ability rubric (pre and posttest) (Appendix F)	Descriptive analysis

RQ 2	How are the dyslexic students learning experiences when using an augmented module as an assistive learning tool in PE classrooms?	• Student pre and in-depth interview (Appendix B and C) • Researcher field notes (sample in Appendix Q) • Student Reflective Journal (recorded) (Appendix G)	Thematic analysis
RQ 3 .	a) How does the AR technology and augmented module learning content support the learning process of dyslexic students in PE classrooms? . b) What are the barriers on using AR technology and augmented module in PE classrooms for dyslexic students?	• Student pre and in-depth interview (Appendix B and C) • Researcher field notes (sample in Appendix Q) • Student Reflective Journal (recorded) (Appendix G) • Movement ability rubric (pre and posttest) (Appendix F)	Thematic analysis Descriptive analysis
RQ 4	What are the teachers' perspectives on the use of augmented module as an assistive learning tool for dyslexic students in the PE classrooms?	• Teacher pre and in depth Interviews (D and E) • Student pre and in-depth interview (Appendix B and C) • Student Reflective Journal (recorded) (Appendix G) • Researcher field notes (sample in Appendix Q) • Movement ability rubric (pre and posttest) (Appendix F)	Thematic analysis Descriptive analysis

This study used thematic analysis as the primary method for analyzing data in a qualitative approach. Thematic is a method for identifying, analyzing, and reporting data patterns (themes) in data that will systematically arrange and describe your data collection. Thematic analysis, according to Braun and Clarke (2006), is a valuable technique for assessing the perspectives of various research participants, showing parallels and differences, and producing unexpected findings. In conducting the analysis, this research followed Braun and Clarke (2006) six-phase guide for doing thematic analysis which is a very useful framework for conducting this kind of analysis. Six-phase of thematic analysis by Braun and Clarke are:

3.12.5(a) Become familiar with the data

The researcher must thoroughly ingest the data in the initial stage. This entails repeatedly reviewing the transcripts, notes, or other qualitative data sources to become familiar with the material and get a sense of the information gathered. Reading and rereading the transcript is always the starting point in any qualitative study. Before moving on, it is important to thoroughly understand the full corpus of data (i.e., all interviews and any other data that may be used) by performing re-readings. It is helpful to make notes and write down your initial thoughts at this point. In this first step, the researcher transcribed the audio recording data found during the interview process and read through the transcribed results to familiarize and recognize the data found.

3.12.5(b) Generate initial codes

Once researcher have studied and become familiar with the data and have ideas about what is in the data and what is interesting, the second phase starts (Braun & Clarke, 2006). The researcher can create initial codes after becoming familiar with the data. Coding is the application of labels or tags to pertinent data sections. This procedure entails selecting useful information units and methodically assigning descriptive codes to them. In this stage, the researcher begins meaningfully and systematically arranging the data. Coding breaks down large amounts of data into manageable meaning units. There are various coding techniques, and the one you choose will depend on your viewpoint and study objectives (Maguire & Delahunt, 2017). In this research, the interview data that had been transcribed was then coded according to the relevant information. After the codes were created, they were reviewed and compared with data from other participants, and code changes were made if the codes did not match.

3.12.5(c) Search for themes

The next stage is to start looking for themes in the data. The study topic's key components are captured through themes, which are reoccurring patterns or ideas. To find probable themes, look for links, contrasts, and parallels between the codes. A theme is a pattern that, as previously mentioned, captures something important or fascinating about the data and/or study issue. According to Braun and Clarke (2006), there are no strict guidelines as to what constitutes a theme. The significance of a theme characterizes it. When all data has been first coded, compiled, and a list of the various codes found throughout the data set has been generated, the third step starts. In this stage, all the possibly pertinent coded data extracts are sorted and organized into themes (Braun & Clarke, 2006). In this research, after all the data has been coded, the next step is to create themes and group the codes that have been made previously so that they can become a theme.

3.12.5(d) Review themes

Once a set of themes has been developed and is in need of refinement, the fourth phase starts (Braun & Clarke, 2006). Researcher evaluate the coded data extracts for each theme during this phase to see if they seem to form a logical pattern. To establish if the themes accurately reflected the meanings visible in the data set as a whole, each theme's validity was considered. In this phase, the researcher reviewed and refined the themes by collating relevant data under each theme. To ensure that the themes accurately represent the data.

3.12.5(e) Define and naming the themes

The fifth phase of the research process involves determining what part of the data each topic captures as well as what and why it is interesting (Braun & Clarke, 2006). The purpose of this last iteration of the themes is to "find the 'essence' of what each topic is about." (Braun & Clarke, 2006, pg. 92). Meanwhile, the researcher must provide clear and concise definitions for each theme.

3.12.5(f) Write-up

After the researcher had finished fully defining the themes and had reached the point of drafting a report, the final phase began. . A thematic analysis's written report should give a succinct, logical, non-repetitive, and engaging description of the data within and across themes (Braun & Clarke, 2006). On writing the report, the researcher should also present the findings and supporting quotes from the interviews. The details of data analysis are reported on chapter 5.2 Data analysis.

3.13 Summary

This chapter discusses how this research conducted and also the methodology used. This study uses a qualitative approach and uses a case study methodology with a single case design. In addition, it applied purposive sampling since this type of data collection was recommended for taking qualitative data because sampling was based on the purpose determined in the study. This study involved dyslexia students as a case and PE classroom settings as a research context. As for the learning material to be studied, it has been adapted from PE textbooks for special education that are used by schools and has also been adapted to students' needs and abilities. The students studied in the PE class as usual, except that they received the help of an augmented module as an assistive tool to help them visualize the learning material in the textbook into 3D animation.

CHAPTER 4

DESIGN AND DEVELOPMENT

4.1 Introduction

This study used an existing AR application, as described in Chapter 3, and only augmented modules were developed in this study. The Senaman AR application was chosen as the researcher did not find a similar application on the Play Store (there was no AR application for PE or sports) to be used as a comparison. This application employs an AR type that requires markers to trigger the emergence of 3D objects in the application, So the augmented module was used as the markers to bring up the 3D animation and as a representation of the textbook used in the classrooms. This chapter discusses the stages of developing the augmented module used as an assistive tool for dyslexic students when studying in the PE class. As for the development of an augmented module, it followed the steps described in the ADDIE model as one of the models for designing instruction. Then, CLT theory was implemented, as well as Mayer's learning principles being the basis for developing the module to produce learning material that adapts to the needs and abilities of students. The learning materials were taken based on the curriculum in school textbooks. Figure 4.1 depicts the textbook used by the students in the PE classrooms to be adapted, while the learning material taken was Unit 5, Physical Fitness based on Health. The chosen topic was flexibility, muscle strength and muscle endurance based on the basic knowledge and skills that are important for students to know.

Figure 4. 1

Physical Education Textbooks for Special Education

In the augmented module, three sets of activities were chosen from the PE textbook on Unit 5, as shown in Figure 4.1, which are included in the fitness and exercise movement skills category. This unit was chosen because, for students with disabilities, learning about fitness and movement exercises such as flexibility, muscle strength, and muscle endurance in physical education classes is essential because of their profound impact on overall well-being and functional ability. These exercises promote functional independence by improving the physical abilities needed for daily activities, thereby promoting greater autonomy. These exercises also play a vital role in preventing injury by improving joint support and range of motion, which is especially important for individuals with limited mobility (Rimmer & Rowland, 2008). In addition, these exercises contribute to better posture and balance, which are essential for safe movement and participation in a variety of physical activities. Next, the design, learning objectives and other details needed in the module were adjusted according to the student's needs. The module was adapted to the curriculum of physical education and health education book for special education, Level 4.

4.2 Instructional Design Model

The systematic process of converting learning and teaching ideas into plans or specifications for instructional materials or activities is known as instructional design. These strategies are built on tried-and-true foundations, namely learning theories (Molenda, Reigeluth & Nelson, 2006). Many instructional design models can be used as a guide when the researcher creates learning material, one of which is the ADDIE model. The benefit of instructional systems design (ISD) is that it leads to innovations that can convert learning issues into lesson plans, ensuring the caliber of the instruction (Molenda et al., 2006). Using the ADDIE model's approaches on any educational product, this model is a strategy that enables teachers, content developers and instructional designers to build an effective teaching design that is efficient and effective (Aldoobie, 2015). The elements of the ADDIE model include analysis of learners' problems and needs, as well as designing instructional activities and materials. The development of instructional goals is also done to meet the learners' needs, where implementation includes training and evaluation of the instruction and the learners' outcomes (Aldoobie, 2015). In short, the

ADDIE model consists of several phases: Analyze, Design, Develop, Implement, and Evaluate (Reiser & Dempsey, 2012).

The ADDIE model was used as the instructional design guideline in this study since it has an iterative construction process. Using this approach allows module designers to go back to a prior level of content development based on the outcomes of an evaluation during development and at the end. It can help the researcher design and develop the materials, as making adaptive learning material requires repeated adjustments and revisions to suit the needs of SLDs as research participants.

4.2.1 Analyze Phase

This analysis phase is the initial step in the ADDIE model instruction design before moving on to the next stage: design, development, implementation, and evaluation. There are four aspects analyzed in this phase.

4.2.1(a) Analysis of the learner

Based on the results of interviews and observations during the preliminary study with PE teachers, it was found that these students have problems understanding the material and demonstrations shown by the teacher. This observation indicates that students still use textbooks in PE class. As for the difficulties experienced by the teachers, although they demonstrated the movements in front of the class, some students still had problems understanding and performing them, resulting in the need for the teachers to repeat the demonstration. In addition, some students sit quietly and do not dare to ask. When asked to perform the movement, they were usually confused. Then, the problem encountered by the learners was that they had problems absorbing instruction, which impacted the physical activity they did. Some learners also faced limitations in doing certain physical activities. Therefore, in making this AR module, several theories were used: Cognitive Load Theory (CLT) and Mayers 12 Principles of Multimedia Learning, as guides for creating effective materials.

4.2.1(b) Analysis of the instructional goals

An analysis of the instructional objectives was carried out to save a lot of time and resources. In Unit 5, there are several topics related to physical fitness based on health. However, the basic topics that learners should understand and be able to demonstrate are flexibility, muscle strength, and muscle endurance. In each of these topics, there are exercise movements, but there are some movements that are difficult for students to perform which, if forced, will have the potential to injury. Therefore, the movements chosen to be included in the module were adjusted following the safety and ability of the students. Based on observations and interviews with the teachers, it was also discovered that using textbooks with much descriptive text in them was less helpful for students as they basically have difficulty reading and understanding the text. In this research, the use of text in the module developed was reduced, while the animation was used in the image so that the students could understand the meaning and movements shown in the image in the module. With the augmented module, the researcher attempts to provide an assistive tool as a new learning experience for the students in learning PE. The expected goal is that learners understand the instructions given through the AR application and can follow them (perform the movements as shown in the AR app).

4.2.1(c) Developing instructional analysis

To achieve the mentioned goals, some essential steps and all the details were written at this stage.

- The students learned through the augmented module during PE class.
- There are three sets of activities (flexibility, muscle strength and muscle endurance) that include four movements in each set.
- The students tried to scan the marker on the module and understand it. At the end, they needed to try to do the movement themselves.
- Each set of activities was carried out during each class meeting, so in one meeting, the students focused only on learning four movements (one activity in each class meeting).

4.2.1(d) Developing learning objectives

This stage defines what the students should be able to do after the instruction period is over. Since the objectives of each topic were already explained in Chapter 3, the overall learning objective is for the students with dyslexia to be able to understand each movement in each topic and perform it within a specific time and repetition so that they can do the movements and repeat them at home, as they need to regularly carry out physical activity to keep their bodies fit. To determine the students' behavior, skills and knowledge, the researcher identified the level of accuracy that could be achieved using the observation rubric. After completing the instruction, they are expected to perform at least two of the four movements in each class meeting.

4.2.2 Design Phase

This step focuses on effective instructional design strategies that support learners' learning and interaction with the materials provided. The design process concentrates on choosing a course format, developing the instructional method and evaluating each topic.

4.2.2(a) Assessment design

To assess outcomes while learning with the augmented module, several instruments were used. Table 4.1 explains the assessment design in this study.

Table 4. 1

Assessments Design

Assessments	Purpose
Pre-interview	Was done before giving intervention to the students. The point was to find out the current situation, needs, and problems.
Pre-test	This is also done before giving intervention to students. different from the pre-interview, the pre-test is used to determine their ability to learn without using the augmented module.
Observation (researcher and teacher)	Observations were made during the intervention. This was carried out to assess students' ability and condition that happened during learning PE using the AR application in detail, which were carried out by researcher and teachers separately.
Students reflective journal	This reflective journal was taken after students completed their class. The purpose of taking this was to obtain students reflection on the classes that they have attended.
Post-test	The post-test is the last test conducted after the students gets the intervention. This is done to assess improvement

	or changes in students' abilities and knowledge after learning using augmented module.
In-depth Interview	An in-depth interview is the last assessment to explore the students learning experiences based on their opinions and personal experiences.

4.2.2(b) Select a form for the course

PE learning by using this AR technology as an assistive tool to help dyslexic students was carried out in an offline PE classroom setting using the augmented module provided as a marker to trigger the AR app and as a representative of the school textbooks. After conducting the observation, it was found that each class in the particular school only consists of 8-10 students in one class. In this setting, the students were asked to work with peers, as many as two students in one group with two augmented modules and one Android device. Before the learning takes place, the researcher trained the teachers and students to use the application.

4.2.2(c) Creating instructional strategy

The next stage is to determine the instructional strategy by combining several methods to help students understand the topic. It can also take the form of activities that can be done by students to practice the presented ideas and skills. In this study, several strategies were applied. The first was the use of an augmented module in the classroom as an assistive tool to help students understand the material presented by the teacher, whereas, in the augmented module, AR technology was employed, which allows the pictures in the module to be animated. This was done to help the students visualize images that they must understand without having to read and understand the description text in the book. As for the development module, CLT theory and Mayer's Principles of Multimedia Learning were implemented to provide learning material according to learners' needs and abilities. Then, in the learning process, the teacher used the multisensory approach, as explained in Chapter 2. The use of these two theories is shown in Figure 2.6.

In addition, the augmented modules also implemented CLT and Principles of Multimedia Learning by Mayers to make them more effective. According to Asma and Dallel (2020), theorists believe that instructional material is most effective when all types of load do not exceed working memory capacity. Educators need to try to reduce unnecessary load while optimizing intrinsic load and increasing germane load (Van Merriënboer & Sweller, 2005). To produce good instructional materials and increase retention, the CLT was selected as a basic foundation and guideline regarding cognitive load on the human brain when processing information. This theory used in designing the augmented module by reducing the extraneous load (Asma & Dallel, 2020).

- *Worked Example Effect*: According to Sweller (1998), it is about giving students clear instructions on how to handle an issue so they may concentrate on a specific learning objective rather than using up cognitive resources. The Worked Example Effect from CLT can be used in PE to assist students in learning and developing their motor abilities and movement strategies. Students can better grasp how to perform exercises by being given examples of correct motions. This also helps to lessen the cognitive burden that comes with having to figure out the movements on one's own. In this study, the use of AR technology aimed to bring up demonstrations of movement through 3D animation that visualized the movements displayed in the image, allowing the students to conduct independent learning.

- *Split Attention Effect*: In order to comprehend the content, students sometimes need to process information from several sources at once. As a result, it happens when knowledge is acquired ineffectively (Chandler & Sweller, 1991). In a PE class, students might have to divide their attention between seeing the demonstration and listening to the directions if a teacher performs an exercise or movement while giving verbal instructions separately. Ineffective processing and integration of the information can result from this, reducing the learning process's value. In this study, when students scanned the images on the augmented module, the 3D animation that shows students the demonstration of exercise movement appeared without any sound or voice-over to explain the movement while reducing the attention-split effect that occurs.
- *Redundancy Effect:* According to Diao and Sweller (2007), students do not learn efficiently when additional information that is not directly related to learning objectives is presented to them. This is because they must process irrelevant information to balance the two incoming streams, causing their working memory to be focused on unimportant information. To avoid this from happening, this study implemented the redundancy principle from Mayer's Principles of Multimedia Learning.

- *Modality Effect:* The amount of information to be processed by working memory may depend on the modality of presentation, as the auditory and visual streams process information substantially and independently (Tindall-Ford, Chandler & Sweller, 1997). In this study, encouraging peer teaching and collaborative learning were used to support and leverage the Modality Effect. While students learned in pairs, they took turns demonstrating movements to their peers while explaining the techniques, which reinforced their learning while helping others.
- *Complexity Effect:* The Complexity Effect is a phenomenon where learners experience an increased cognitive burden when dealing with more complicated or elaborate material or tasks, according to the cognitive load theory. The Complexity Effect may affect how students learn and develop new skills in physical education. Considering this situation, learners may experience an increased cognitive load when learning complex movement patterns like advanced dance routines, gymnastics sequences, or elaborate martial arts forms. Similarly, learners may encounter the Complexity Effect when acquiring new sports skills, especially those that require several steps or phases. As a result, direct instruction is required to understand how people learn efficiently, leading to the development of the CLT model of instruction (Kirschner et al., 2006). In this study, topics adapted from textbooks were basic topics that students must understand and be able to do. It aims to strengthen the basic knowledge and skills of students, as well as not to place too much cognitive load on students when giving topics that are too difficult for them.

Then, students learned new movements at each meeting. To overcome overload, the topics studied at each meeting were limited to only one topic per meeting (four movements). The teacher was also asked to demonstrate the movements to the students before they learned in pairs and also guided them while learning.

Meanwhile six principles from Mayer's multimedia learning principles are also used.

- *Multimedia Principle*: Students retain information more effectively when combined with graphics and words. Understanding and memory can be enhanced by combining visual and audio components in a presentation. Multimedia learning principles are used to optimize germane load. In the augmented module, this principle used a combination of images, graphics, and words.
- *Pre-training principles*: Before delivering the primary topic, key terms and concepts are defined. Pre-training aids in understanding new concepts and gets students ready for the material to come. This principle is used to help manage intrinsic load. In this study, before the teaching and learning began, the teachers trained the students to use the augmented module, which needs an AR app on the tablets and images on the module to be scanned.
- *Coherence principles*: This is when unnecessary content is removed from multimedia presentations. Content that is irrelevant or unnecessary might tax cognitive abilities and prevent learning. This principle is applied to help reduce extrinsic load. When designing the module, unnecessary content was deleted,

such as the use of arrows, ambiguities of image placement, the use of long explanations, the use of extra animation or avatars, as well as the use of extra notes and colors.

- *Signaling principles:* Bring attention to crucial material by using indicators like arrows or highlighting. Signaling aids in organizing the material and keeps learners' attention on important information. This principle is applied to help reduce extrinsic load. In the module, the use of highlights aims to clarify text, differentiate between text and images, and categorize each of the four movements into an activity or topic.
- *Redundancy principles*: The same information should not be presented visually and verbally. Overloading the brain with redundant information might prevent learning. This principle is applied to help reduce extrinsic load. In this module, students were required to focus on the information given by the 3D animation to avoid redundancy; there was no sound, voice or user interface on the app.
- *Spatial contiguity principles*: On the screen or page, related words and graphics are put close together. The words and the visual image they relate to are better associated when they are close to one another. This principle is applied to help reduce extrinsic load.

Table 4.2 Highlights summary of the application of the CLT theory and the multimedia learning principles in this study.

Table 4. 2

Theory and Principles Applied

Cognitive Load Theory	
Worked example effect	Give worked examples of correct movements shown by the 3D animation on the AR app
Spilt attention effect	Minimizing split attention by presenting information with a dual mode which is from the teacher in form of verbal information and 3D animation as visual information. The 3D animation also comes with no sound or voice or any text to reduce the attention split effect
Redundancy effect	The use of text and images in the module is replaced with the use of 3D animation in AR applications to reduce extraneous cognitive load caused by unnecessarily processing of redundant information
Modality effect	Learning occurred in pairs. The students learned through the augmented module and also did it together with their peers (visual and auditory)
Complexity effect	Reduce extraneous cognitive load by focusing attention on problem conditions and useful solution steps by letting the students use the AR application and explore it. Learning topics in one class meeting was also limited to only 4 movements or one activity, this is done to reduce the possibility of students experiencing increased cognitive load when learning new movements
Multimedia Learning Principles	
Multimedia principles	Using images and words in the module for an effective information
Pre-training principles	Teacher trained the students before the intervention started, also provided AR app guidelines in the module
Coherence principles	Remove unnecessary content and elements
Signaling principles	The use of colors, font and bold effect on the text in the module as a highlight

Redundancy principles	Avoiding intervention from different sources of information in a time
Spatial Contiguity principles	Putting image or graphic close together with words

4.2.3 Development Phase

In the third phase, instructional designs are carried out by combining technology with the environment and educational methods. A backup plan is needed, which can then be used if the selected technology fails.

4.2.3(a) Create a factual sample for the instruction design

At this stage, the implementation of the instructional strategy that has been discussed in the previous point is carried out. Figure 4.2 depicts an augmented module design by applying the theories explained.

Figure 4. 2

AR Module Cover Design

The cover page was designed to represent that this module is for physical education students as the user. The impression of a bright and beautiful environment was used by adding elements of trees, green grass, flowers, and clear skies, as well as two students doing sports movements to attract the children's attention to read it. Moreover, multimedia, coherence and signaling principles were applied here.

Figure 4. 3

Table of Content Design

The table of contents page still used a cheerful nature theme with objects of children doing sports. Fonts that can be easily read were also selected, along with sequential page numbers. The page number was located at the bottom of the page and marked with an orange color that would move on each page. Multimedia, coherence and signaling principles were applied here.

Figure 4. 4

Chapter 1 Design

In the design of Chapter 1 in Figure 4.4, a cover for each chapter was added, which then continued with the contents of the chapter. In the previous module design, Chapter 1 consisted of several pages of materials about a balanced meal. In the new design, the researcher only made one page containing a balanced meal for teenagers. The researcher also included pictures representing a balanced meal and an explanation of each food component on the plate to make the information provided shorter, denser, and clearer to reduce unnecessary details. Multimedia, coherence, spatial contiguity and signaling principles were applied here.

Figure 4. 5

Chapter 2 Design

In the design of Chapter 2 (Figure 4.5), the title of the chapter and the number of children as a representation of the title of the chapter was put on the cover. Then, the next page comprised recommendations for physical activity for teenagers, as recommended by the Ministry of Health Malaysia. The last page of the chapter also illustrated pictures of the physical activity previously mentioned on page seven. Multimedia, coherence, spatial contiguity and signaling principles were applied here.

Figure 4. 6

Chapter 3 Design

The students were required to focus on Chapter 3 (Figure 4.6), which contained all the 2D markers. In Chapter 3, the researcher tried to make the image bigger and limit each page so that there are not many images to reduce distractions. The researcher also used several principles in this design. On the cover of Chapter 3, the pre-training principle was applied to the design. For the content, multimedia, coherence, redundancy, spatial contiguity and signaling principles were applied here.

4.2.3(b) Develop the materials for the course

As described earlier, using the ADDIE model can flexibly return to the initial stage or stages that require revision. After showing the module to the teacher and expert followed by conducting an evaluation, the researcher obtained some input. The researcher needs to simplify the page display and deduct unnecessary information for students, as this module only acts as a marker. There were some changes made in this phase.

a) *Redundancy Principles*

In the application or module provided, no text was included to explain the 3D motion image to avoid redundancy, the teacher explained the movement verbally.

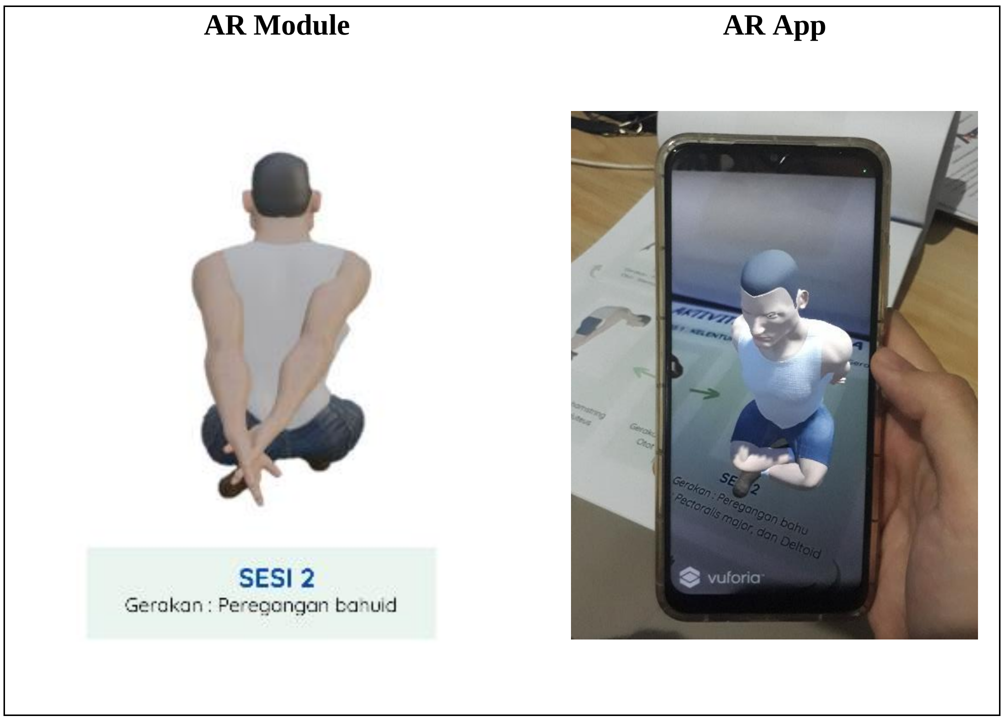


Figure 4. 7

Implementing Redundancy Principles

b) *Coherence Principles*

This principle was implemented by cutting the extras and focusing on the information that the learner needs (Figure 4.8). Since PE learning for dyslexics focuses on developing skills and understanding, the module does not require the explanation needed by the students.

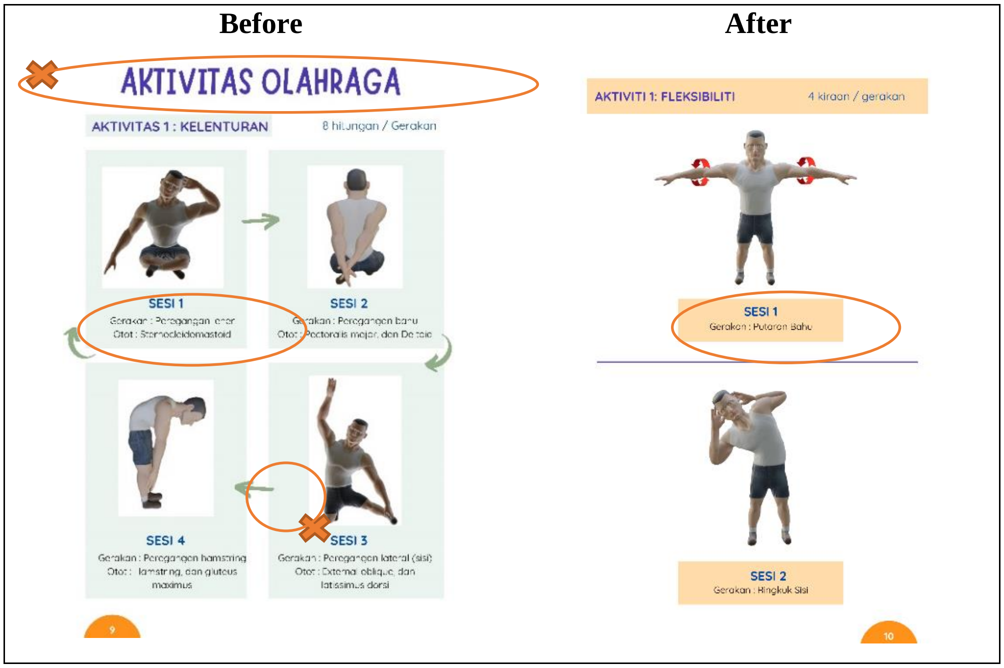


Figure 4. 8

Implementing the Coherence Principles

c) *Signaling Principles*

Just like the previous application of the theory, signaling principles were used to highlight important information that the researcher wanted the students to know (Figure 4.9) so they would focus on the important information that would not fulfill their working memory.

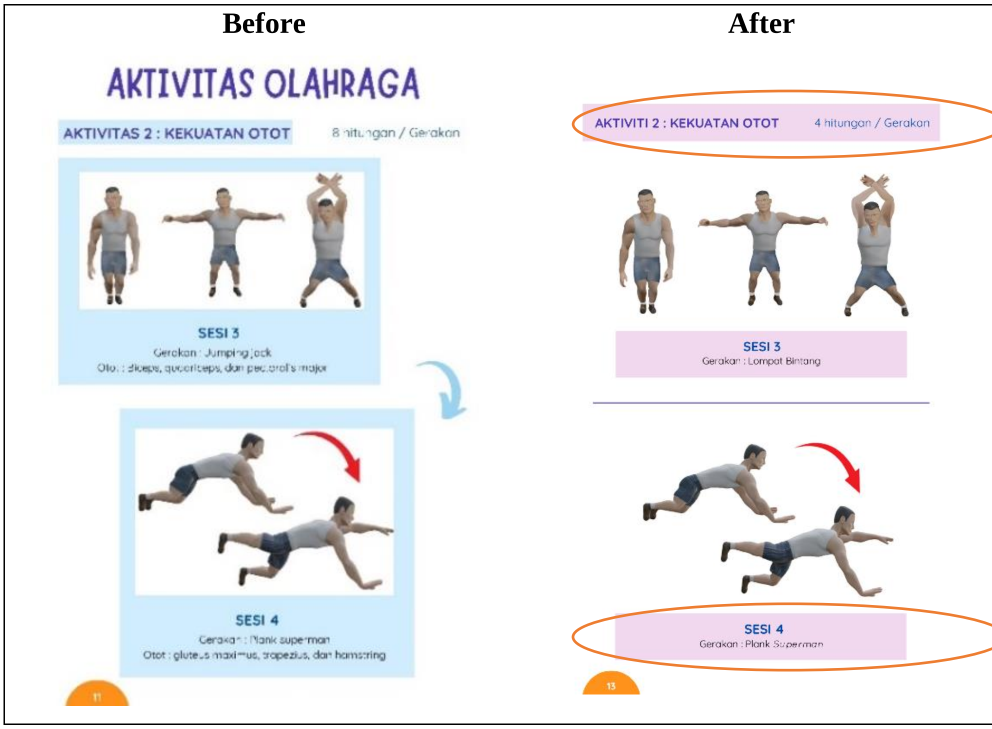


Figure 4. 9

Implementing the Signaling Principles

d) Spatial Contiguity Principle

This principle is to keep all related text and images physically close together in the frame (Figure 4.10) to make it easier for the students to understand relevant images and texts.

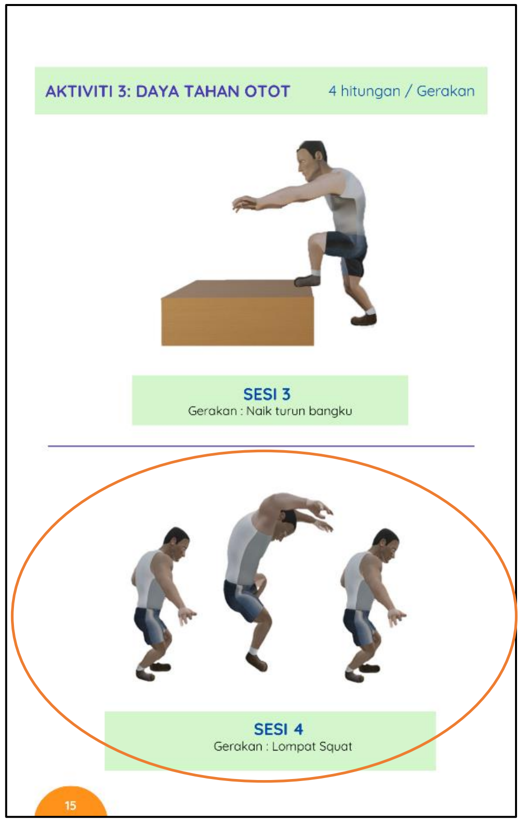


Figure 4. 10

Implementing Spatial Contiguity Principles

e) Pre-Training Principles

Instead of having learners begin the course immediately, the researcher created an introductory guide for using the app (Figure 4.11). Before the students received the intervention, the researcher introduced them to the module first so that they could be accustomed to it.

Figure 4. 11

Implementing the Pre-Training Principles

f) *Multimedia Principles*

This principle was applied using text and visuals relevant to the material to enhance the information presented.

4.2.3(c) Run through the conduction of the design

Once the development of the course material was completed, the next step was to run through the design (practice run or usability test). This step is the actual time to rehearse the course using all developed materials. In this step, the researcher can involve friends so they can treat them as real students and use the same conditions in real-time. In this phase, the augmented module was tested on five students and reviewed by the expert. After the testing, some changes were made (Figure 4.12).

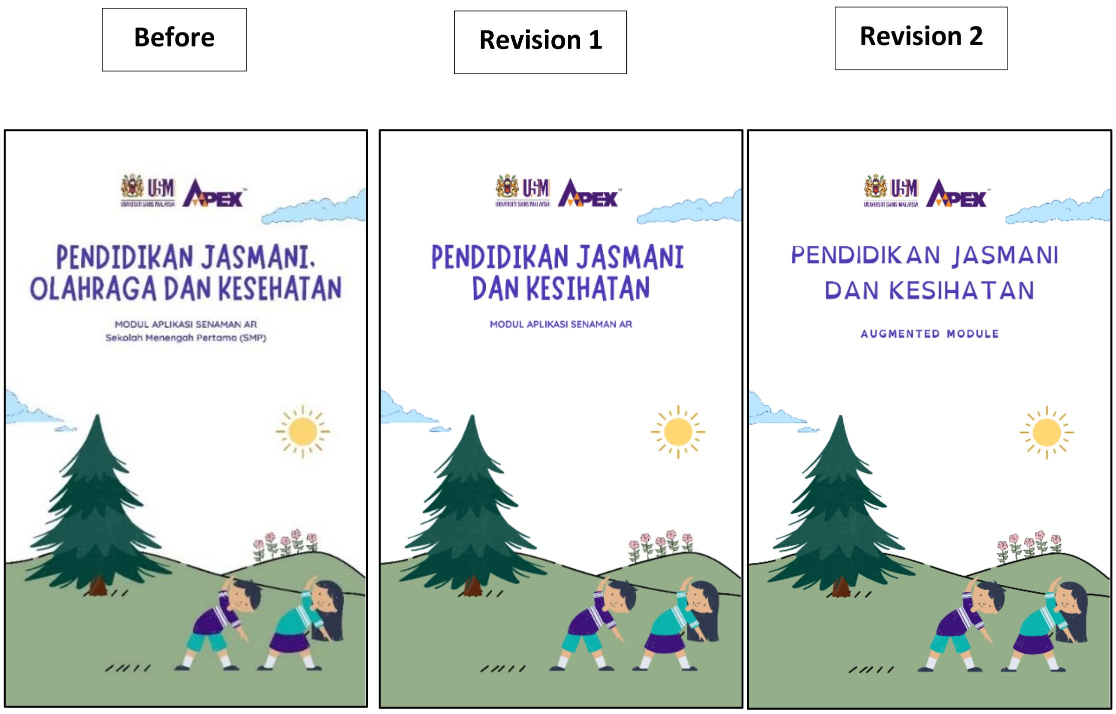


Figure 4. 12

AR Module Cover Design Revised

In the first revision, the information on the page was simplified. Unnecessary information was removed while the language was adjusted (the Indonesian language was changed to Malay language) because the module is used by students in Malaysia. Meanwhile, the font in the second revision was changed to Open Dyslexic, as suggested by Franzen et al. (2019), to improve reading comprehension among dyslexic students and make space in line spacing and letter spacing so that the spaces between one letter and another would not be too tight.

Figure 4. 13

Chapter 1 Design Revised

Similar to the first page, the researcher simplified the information on this page as the first revision. Unnecessary information was removed, the language was adjusted, and for the second revision (Figure 4.13), the font, line spacing and letter spacing were changed accordingly.

Figure 4. 14

Chapter 1 Design Revised (II)

On this page, the information on the page in the first revision was simplified. Unnecessary information was removed, language was adjusted, while important information was highlighted. As for the second revision, the font, line spacing and letter spacing were changed, whereas unnecessary information was removed (Figure 4.14).

Before

Revision 1

Revision 2

Figure 4. 15

Chapter 2 Design Revised

In this first revision, the content was altered according to the content in the textbook. The information on the page was also simplified. Unnecessary information was removed, language was adjusted, important information was highlighted, and more multimedia elements were added. For the second revision, the explanation text was combined with the example of the image directly to avoid confusion for the students. The font, line spacing and letter spacing were also changed (Figure 4.15).

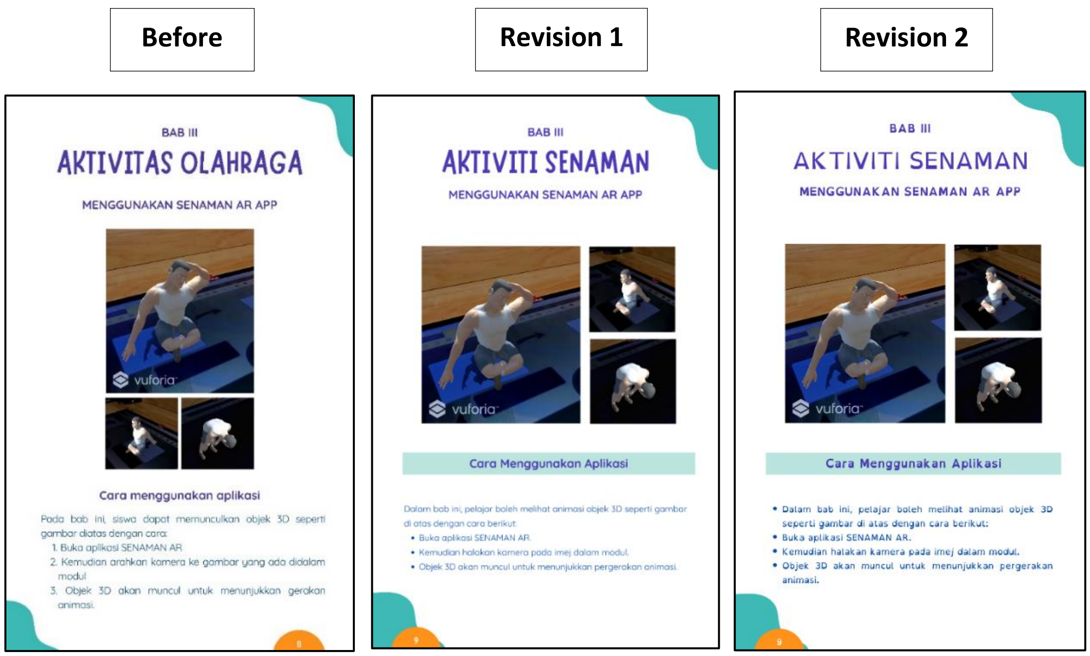


Figure 4. 16

Chapter 3 Design Revised

On this first revision, the image was re-arranged for ease of viewing. The researcher also adjusted the language, rearranged the text, and highlighted the important information. As for the second revision, the researcher changed the font and provided adequate line and letter spacing (Figure 4.16).

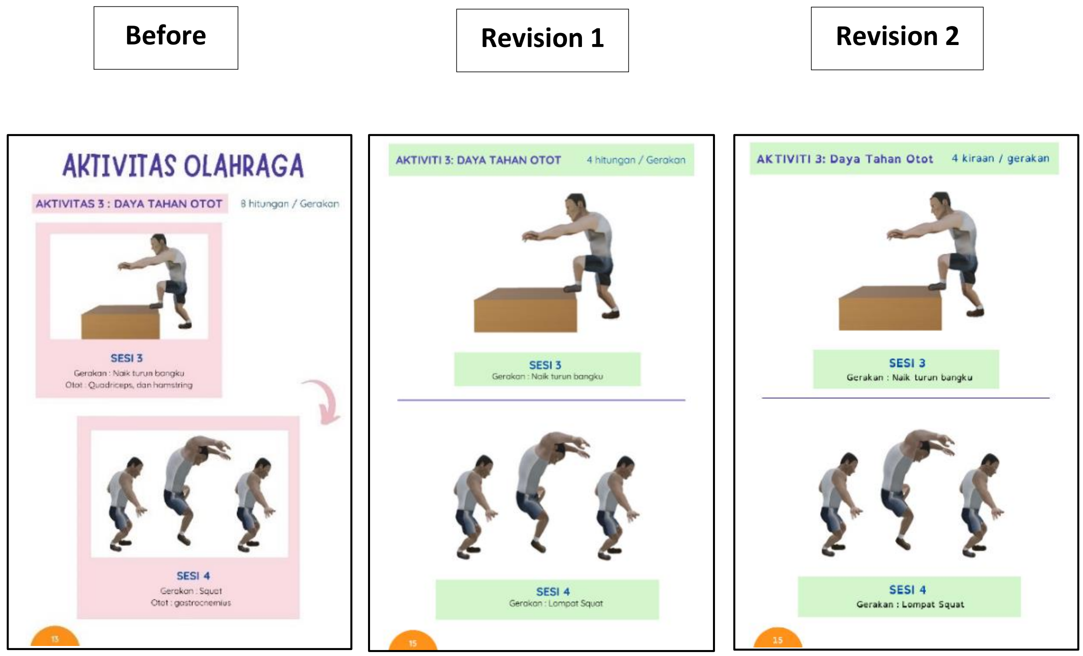


Figure 4. 17

Chapter 3 Design Revised (II)

In this first revision, the researcher simplified the use of colors as a highlighter so that it is clearer to view, and unnecessary shapes can be removed. The researcher also adjusted the language, rearranged the text, removed unused information, highlighted the important information and simplified the design. For the second revision, the researcher changed the font and provided adequate letter and line spacing.

4.2.4 Implementation Phase

After designing the augmented module, the implementation stage was carried out (Figure 4.18), where the students could use the module and its applications for learning. In this phase, the three main stages must be completed: (i) training the teachers, (ii) getting the students ready, and (iii) setting up the learning environment.

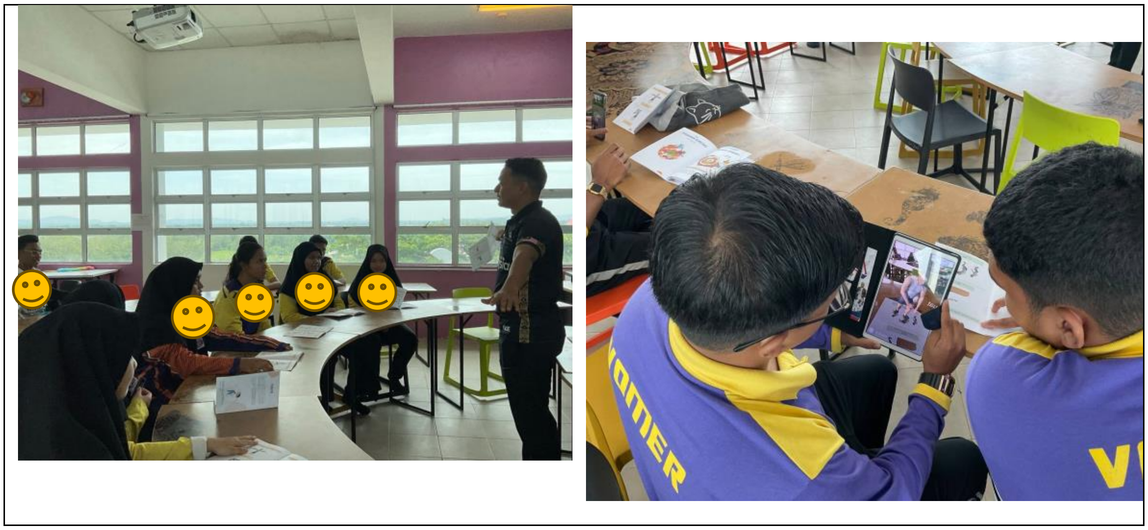


Figure 4. 18

Implementation Phase

4.2.4(a) Training the instructors

To ensure the teachers are well prepared to use the augmented module in their classes, the researcher has conducted training for them after the pre-interview and pre-test. Any problems among the teachers in using the module were solved or corrected prior to the real class sessions.

4.2.4(b) Prepare for the learners

Prior to the class session, the researcher made sure that the students were prepared and had all the necessary resources, skills, and information to participate in the class. In this study, the researcher and teachers ensured that students wore sports clothes and that they could operate the application. In addition, their health conditions were checked. Before the class began, they were also asked to find out how much they knew about the topic to be studied on that day.

4.2.4(c) Organizing the learning environment

In this study, the hall in the school was used as a classroom setting so that the students get a larger room to make it easier for them to do exercise movements during learning. At this stage, the researcher and teachers also ensured that the availability of the augmented module, Android devices and AR apps were sufficient and in working condition.

4.2.5 Evaluation Phase

After the implementation phase, the next phase of the ADDIE model was evaluation. It is crucial to assess each phase to ensure that the researcher meets the objectives while utilizing the instructional design and resources to satisfy the needs of the subjects. Summative evaluation was used in this phase. Summative evaluation is an assessment procedure used to evaluate students' overall performance or achievement after a learning session or educational program using post-tests and in-depth interviews as instruments. In this evaluation phase, the first thing to do is alpha testing. Alpha testing was conducted when the ID expert validated the content and found two images from the module that did not move (only 3D images appeared). from the evaluation results, researchers and experts decided not to use the movement exercise because there was no movement animation available in the application (the application cannot be edited, only the content in the module can be adjusted).

After that, beta testing was conducted. Beta testing was only conducted on 5 dyslexic students and one PE teacher and implemented small groups session. From the results, it was found that several exercises movements did not fit them, for the safety reasons and level of difficulties. The number of repetitions of each movement is also adjusted to the student's abilities (based on suggestions written in the textbook). From the evaluation results, researcher returned to the design phase to make several improvements based on the evaluation results.

4.3 Summary

Chapter 4 discussed the design and development of augmented modules adapted to the needs of dyslexic students using the guideline of ADDIE instructional design model. The phase included analysis, design, development, implementation, and evaluation. The use of the ADDIE model was chosen as it allows for revision at each stage. As for this study, one revision was carried out at the development stage.

CHAPTER 5

DATA ANALYSIS AND RESULTS

5.1 Introduction

This chapter discusses the results of the data analyzed in this study. First of all, this research focuses on the use of augmented modules as assisting tools in physical education subjects and dyslexic students. Although these students are having difficulty in reading and distinguishing letters and symbols, in reality, they still have to use textbooks in their learning process. The augmented modules in this research were used specifically during classroom sessions for PE subjects, which aim to help students understand the tutorial exercises as depicted in the textbook (Figure 5.1) without having to read the lengthy descriptions in the book or any description text that can overwhelm their working memory. By using the augmented module, the students can focus on understanding the movements and practicing them. In addition, this also attempts to help the teacher explain or demonstrate the movement to the students.

Figure 5. 1

Physical Education Textbook for Special Education

This chapter presents the findings from the study on the use of Augmented Reality (AR) as an assistive tool for dyslexic students in Physical Education (PE). The data were analyzed to identify key themes and sub-themes related to the research questions. The emergence and consistency of these themes throughout the data collection process indicate that the study has reached saturation. Thematic analysis was conducted on the qualitative data collected from various participants, including students and teachers. The analysis revealed several key themes and sub-themes that discussed based on each RQ. As data collection progressed, it became evident that new data did not introduce additional themes or sub-themes. For instance, participants consistently highlighted the benefits of 3D animations in aiding comprehension and noted recurring challenges, such as technical issues with the AR app. Both students and teachers repeatedly emphasized similar points, suggesting a commonality in their experiences.

Throughout the later stages of data collection, including subsequent interviews and observations, the responses became redundant. For example, every new participant confirmed the previously identified theme of 'Ease of Use,' without introducing novel aspects. The uniformity in the responses across different participants and sources, combined with the absence of new emergent themes, indicates that data saturation was achieved. The consistent emergence of these themes across the data set suggests that the key issues related to the use of AR in PE for dyslexic students have been thoroughly explored. No new information was obtained from additional data, affirming that the research has reached saturation. This saturation ensures that the findings are comprehensive and robust, providing a reliable foundation for further analysis and discussion.

5.2 Data Analysis

In this study, several instruments were used, including interviews (pre- and in-depth), observation, reflective journals (recorded audio), and movement ability tests (pre and post). After the data was collected, it was analyzed using thematic analysis. However, prior to this, data in the form of recorded audio, such as interviews and reflective journals, was transcribed into text files first. This was then followed by data analysis using NVivo software. While transcribing the data, the process of familiarizing the data began, which is the first step of doing thematic analysis. Thematic analysis is the process of data analysis that focuses on finding, characterizing, clarifying, supporting, and connecting themes. It is predicated on the assumption that every piece of information conveys meaning and that meaning can be inferred by focusing on a single thought or a group of related ideas that together provide the meaning (Zilnyk, 2011).

To make it easy to compile information from existing data, the first thing to do is generate initial codes from some of the information obtained in the existing transcript. However, the researcher needs to first categorize the existing data, referring to the existing interview guidelines and then coding each piece of information in the transcript. After creating a code for each transcript, the researcher has to group the codes to create a theme that includes these codes. After each piece of information is coded, it is then grouped into themes, where the researcher reviews and codes again to ensure that they are appropriate or whether something should be renamed, moved to another theme, or deleted. Next, the researcher gives the appropriate names to these themes.

After all data was analyzed using thematic analysis, triangulation of several data sources was carried out to obtain valid data to answer the research questions as described in the previous chapter. This has been clearly stated in the research from Noble and Heale (2019), who define research triangulation as the process of increasing the credibility and validity of research. As previously mentioned, analysis in this research followed guidelines from Braun and Clarke (2006) which have six phases of analysis.

5.2.1 Phase one: familiarization with the data

In this first phase, what the researcher done is try to become familiar with the data. The first thing to do after taking the data is to manually transcribe the audio data into a document and group it according to its source. The process of listening to audio at the transcribe stage is carried out repeatedly so that no words are left behind. Then the written data from the observation stage is rewritten to be more systematic and familiar with the data.

	Transcript
R	Is this the first time you use mobile app in learning PE?
S3	Yes
R	So, you never used it before? Usually, what tools that you use when learning PE in class?
S3	Textbook
R	What do you feel when using AR?
S3	When I use it, it can help me with certain parts that I didn't understand such as scissors jump, I can understand.
R	Do you think that this app helps you in learning?
S3	Yes, it is help
R	How is it helping you?
S3	It will show how to do the movement

Figure 5. 2

Example of Document Transcript

Figure 5.2 shows part of an audio document that has been transcribed into a text document. After completing all the audio, the next thing is to thoroughly read all the data collected several times to immerse it.

5.2.2 Phase two: generating initial codes

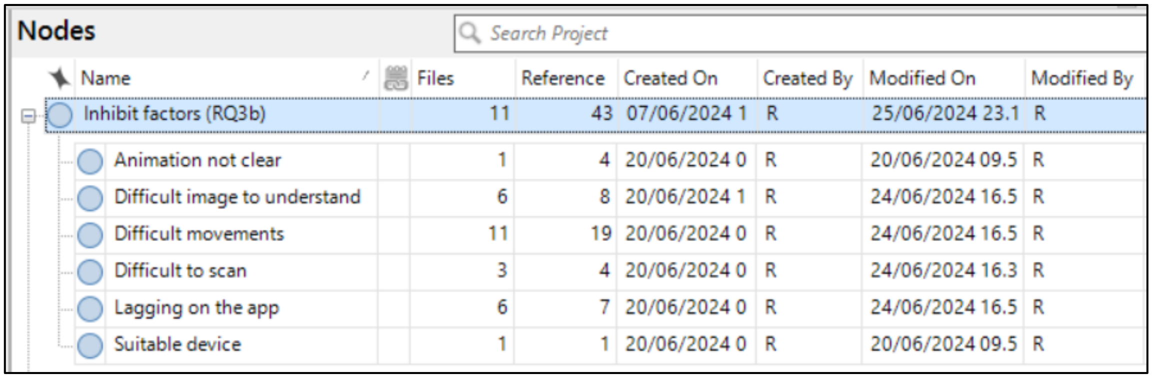
In this phase, researchers study the data set and generate initial codes in an inclusive manner and discover as many potential patterns as possible as can be seen in Figure 5.3. Then the researcher organizes the codes and compiles relevant data for each code.

	Transcript	Codes
R	Is this the first time you use mobile app in learning PE?	
S3	Yes	First Time
R	So, you never used it before? Usually, what tools that you use when learning PE in class?	
S3	Textbook	Learning tool used
R	What do you feel when using AR?	
S3	When I use it, it can help me with certain parts that I didn't understand such as scissors jump, I can understand.	AR benefits
R	Do you think that this app helps you in learning?	
S3	Yes, it is help	Animation help students in learning
R	How is it helping you?	
S3	It will show how to do the movement	Animation help students in learning

Figure 5. 3

Generating Initial Codes on the Transcript

After each initial code on the transcript is placed, then the transcripts are entered one by one into the application and the existing codes are readjusted and revised if there are codes that are not correct as can be seen in Figure 5.4.



Nodes

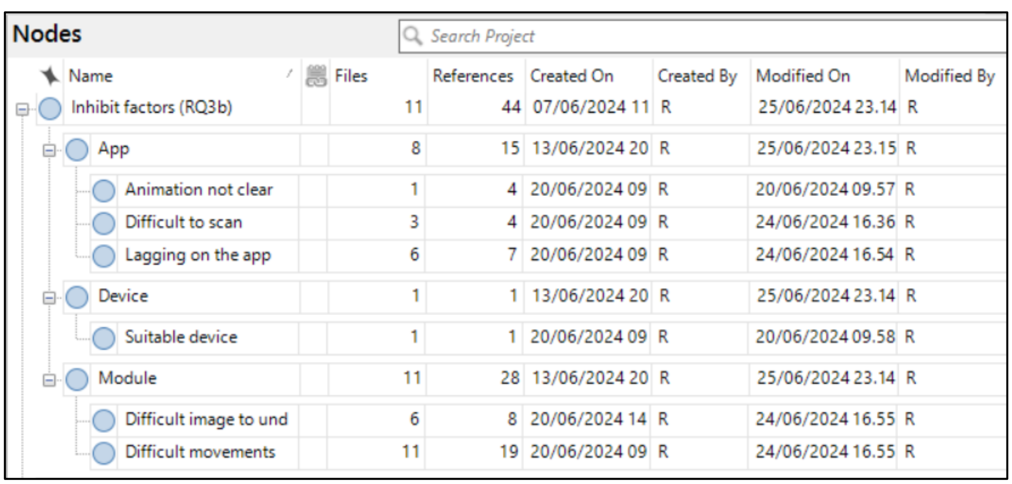
Name	Files	Reference	Created On	Created By	Modified On	Modified By
Inhibit factors (RQ3b)	11	43	07/06/2024 1	R	25/06/2024 23.1	R
Animation not clear	1	4	20/06/2024 0	R	20/06/2024 09.5	R
Difficult image to understand	6	8	20/06/2024 1	R	24/06/2024 16.5	R
Difficult movements	11	19	20/06/2024 0	R	24/06/2024 16.5	R
Difficult to scan	3	4	20/06/2024 0	R	24/06/2024 16.3	R
Lagging on the app	6	7	20/06/2024 0	R	24/06/2024 16.5	R
Suitable device	1	1	20/06/2024 0	R	20/06/2024 09.5	R

Figure 5. 4

Generating Initial Codes on the Application

5.2.3 Phase three: generating themes

In this phase, the codes are reviewed, and patterns identified so that they can form a broader theme or sub-theme by grouping similar codes. Then the researcher created initial candidate themes and subthemes. As can be seen on Figure 5.5, there are three initial candidates' themes for answering research questions 3 part b, which is app, device, and module.



Nodes

Name	Files	References	Created On	Created By	Modified On	Modified By
Inhibit factors (RQ3b)	11	44	07/06/2024 11	R	25/06/2024 23.14	R
App	8	15	13/06/2024 20	R	25/06/2024 23.15	R
Animation not clear	1	4	20/06/2024 09	R	20/06/2024 09.57	R
Difficult to scan	3	4	20/06/2024 09	R	24/06/2024 16.36	R
Lagging on the app	6	7	20/06/2024 09	R	24/06/2024 16.54	R
Device	1	1	13/06/2024 20	R	25/06/2024 23.14	R
Suitable device	1	1	20/06/2024 09	R	20/06/2024 09.58	R
Module	11	28	13/06/2024 20	R	25/06/2024 23.14	R
Difficult image to und	6	8	20/06/2024 14	R	24/06/2024 16.55	R
Difficult movements	11	19	20/06/2024 09	R	24/06/2024 16.55	R

Figure 5. 5

Generating Themes

5.2.4 Phase four: reviewing potential themes

At this stage, existing candidate themes are reviewed and refined. Themes were checked to see if they functioned in relation to the coded data extract and the entire data set.

Interviews analysis

Search Project

Name	Files	Reference	Created On	Created B	Modified On	Modified
Inhibit factors (RQ3b)	11	44	07/06/2024	R	25/06/2024 23.	R
Content Comprehension Challenges	11	28	13/06/2024	R	10/07/2024 14.	R
Complex Visuals	6	8	20/06/2024	R	10/07/2024 14.	R
Conceptual Difficulties	11	19	20/06/2024	R	10/07/2024 14.	R
Device compatibility	1	1	13/06/2024	R	10/07/2024 14.	R
Device suitability	1	1	20/06/2024	R	10/07/2024 14.	R
Technical Issues with the App	8	15	13/06/2024	R	10/07/2024 14.	R
Animation clarity issues	1	4	20/06/2024	R	10/07/2024 14.	R
Lag app performance	6	7	20/06/2024	R	10/07/2024 14.	R
Scanning difficulties	3	4	20/06/2024	R	10/07/2024 14.	R

Figure 5. 6

Reviewing Potential Themes

5.2.5 Phase five: defining and naming theme

At this stage, a detailed analysis of each theme is carried out. The researcher identifies the essence of each theme and determines it, as well as what aspects of the data are captured by each theme. After that, concise and informative names for each theme were developed, so that the names used are more meaningful and in accordance with the existing code (Figure 5.6.).

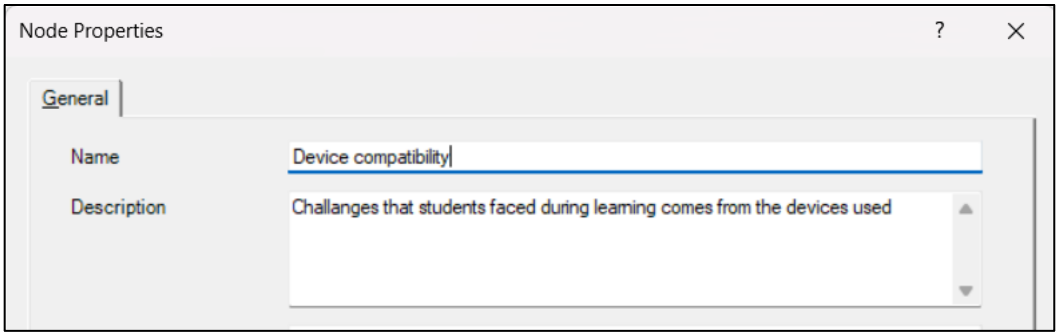


Figure 5. 7

Defined the Themes

Apart from that, at this stage the researcher clearly defined and named each theme (Figure 5.7).

5.2.6 Phase six: producing the report

The final phase in the thematic analysis process is to present the analysis coherently and persuasively. The results of this research were described in detail in the discussion section.

5.2.7 Generating sub-themes

Braun and Clarke's thematic analysis method distinguishes between the different phases involved in identifying themes and sub-themes, although they have similarities. The following are the stages to derive sub-themes in this study:

1. Deeper study Within Themes: After identifying broad themes, additional study within each theme might uncover specific patterns. Sub-themes are identified by examining finer distinctions or specific features of a theme. Researcher examine the data, noting any instances in which participants express issues or frustrations with the AR

software. Codes may include phrases like "technical difficulties," "interface issues," "content clarity," and so on.

2. Identifying certain Aspects or Dimensions: Sub-themes focus on certain components or dimensions within a larger subject. For example, within a topic such as " Technical Issues with the App," sub-themes such as " Animation clarity issues," " Scanning difficulties," and " Lag app performance" may arise, each representing a distinct form of user struggle (Figure 5.8).

Inhibit factors (RQ3b)	11	44	07/06/2024 11	R	25/06/2024 23.14	R
Device compatibility	1	1	13/06/2024 20	R	10/07/2024 14.10	R
Technical Issues with the	8	15	13/06/2024 20	R	10/07/2024 14.12	R
Animation clarity issue	1	4	20/06/2024 09	R	10/07/2024 14.13	R
Scanning difficulties	3	4	20/06/2024 09	R	10/07/2024 14.13	R
Lag app performance	6	7	20/06/2024 09	R	10/07/2024 14.29	R
Content Comprehension	11	28	13/06/2024 20	R	10/07/2024 14.11	R

Figure 5. 8

Identifying potential sub-themes

3. Organizing Data for Nuance: Sub-themes offer a more deep and nuanced interpretation of data. They serve to break down the complexity of a theme and make the study more granular.

4. Screening and Defining Sub-Themes: Sub-themes, like themes, in deriving sub-themes, the process is to undergo screening, refinement, and definition. The researcher verifies that the sub-themes are unique from each other and precisely describes the specific qualities of the theme.

5.3 Results

The results of the data analysis were discussed in this chapter with highlights of the findings based on the four research questions below:

1 How is the Cognitive Load Theory (CLT) and Mayer's Principles of Multimedia Learning applied in the design PE learning and the augmented module for dyslexic students?

2 How are the dyslexic students learning experiences when using augmented module as an assistive learning tool in PE classrooms?

3 a) How does the AR technology and augmented module learning content support the learning process of dyslexic students in PE classrooms?

b) What are the barriers on using AR technology in PE classrooms for dyslexic students?

4 What are the teachers' perspectives on the use of augmented module as an assistive learning tool for dyslexic students in the PE classrooms.

5.3.1 Participants Demographic

This research initially involved two types of participants: the PE teachers and the dyslexic students. Since this research involved two classes (A and B) with a total of 20 students, there were 10 students in each class; this means that there are two PE teachers involved. However, as time went by, two children suffered from eye disease spread in both classes during the third-class meeting, and one student from class B was unable to take part in the research. In other words, only 17 students remained throughout this study. Unfortunately, during the fourth meeting, there were four students from both classes who were infected with the same eye disease, resulting in their withdrawal from this research. Then, on the last day of classes, another student was infected with the same eye disease. Therefore, the total number of participants who took part in the class, starting from the first day to the final sessions, was only 12 students. These 12 students comprised six male and six female students.

Before the intervention, the researcher collected the participants' demography obtained from the students (recording). It was found that as many as 58% of the students were in a range of 17-18 years old (7 students), 25% of them were between 15-16 years old (3 students), and 17% of them were between 19-20 years old (2 students) (Figure 5.8).

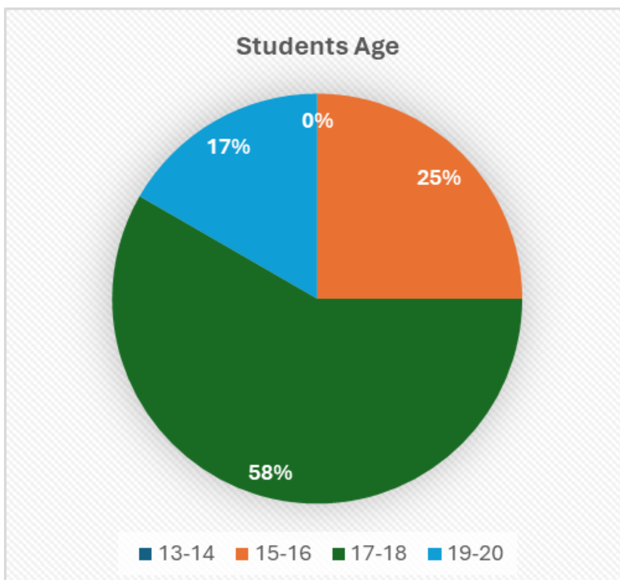


Figure 5. 9

Students Age Range

Furthermore, it was observed that 92% of the students had their own mobile phone (11 students), while 8% did not have a mobile phone (1 student). Figure 5.9 depicts the phone ownership data.

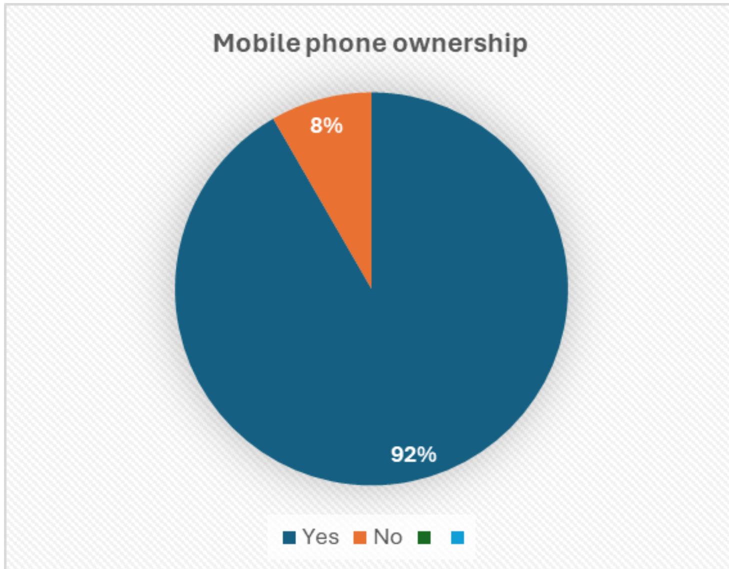


Figure 5. 10

Mobile Phone Ownership

In terms of the frequency of students when using mobile phones, the findings indicated that mostly, they rarely use it (5 students), sometimes use it (5 students), while two of them often use the phone. Mobile phone ownership and frequency of using mobile phone questions were asked to see and ensure that students are used to using mobile phones. The hope is that when the intervention is carried out, they are already familiar with the hardware they use.

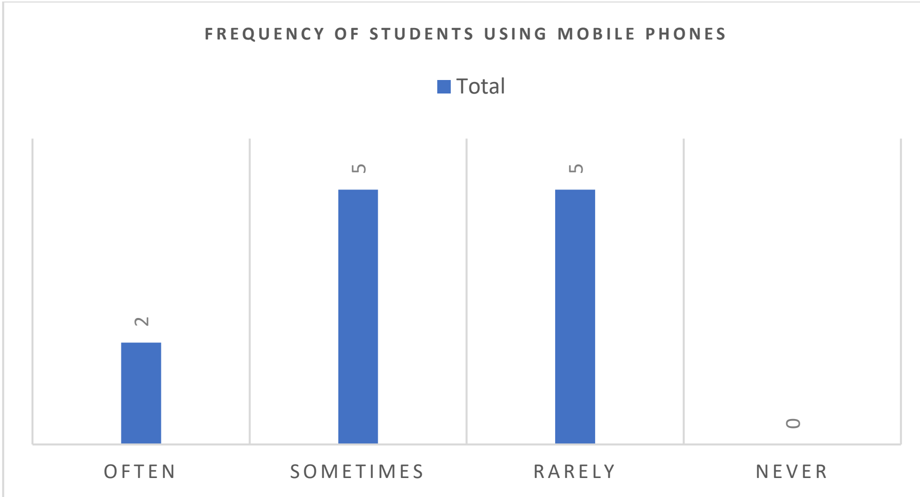


Figure 5. 11

Frequency of Students on Using Mobile Phone

Meanwhile, the students mostly use their mobile phones to access social media, specifically TikTok (7 students) and YouTube (3 students), whereas another two students use their phones to play games and access exercise apps (Figure 5.11). This question was asked to find out how students interact when using mobile phones. It was found that most students use mobile phones to watch TikTok and watch videos on YouTube. As we know that both social media present their content through videos, it can be concluded that students watch and observe more often when using mobile phones (less interaction). The researcher wants to know this so that the interventions given by students are not much different from what they often do, in order to reduce overload when students receive and use new learning aids.

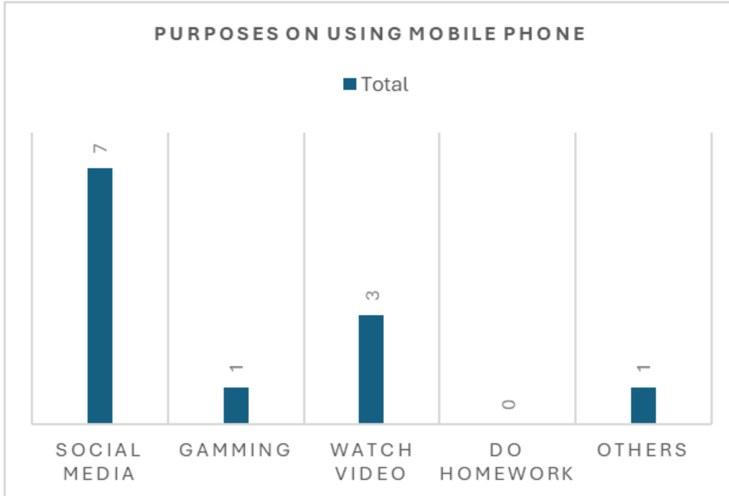


Figure 5. 12

Purposes on Using Mobile Phone

As many as 83% of students stated that they use textbooks when learning in the classroom (10 students), and as many as 17% indicated that they use video on YouTube (2 students) (Figure 5.12).

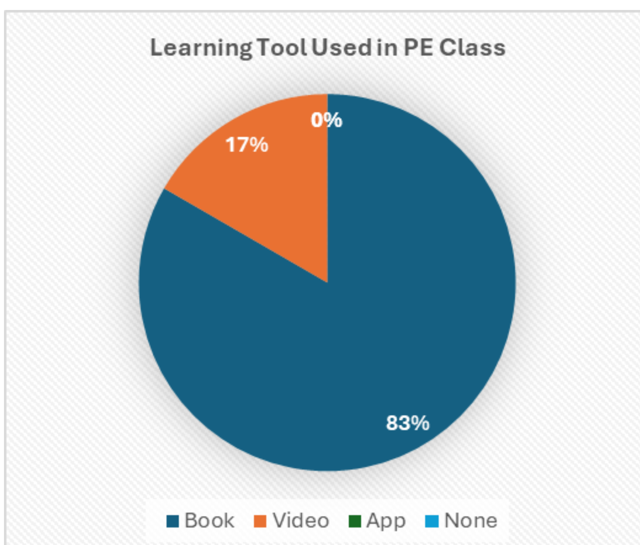


Figure 5. 13

Learning Tools Used in PE Classrooms

Referring to the students, S2, S10, S12, S13, S16, and S19 said that while learning in the classroom, the teacher usually taught using textbooks or monitors in the class to open YouTube to access extra information if it could not be found in the textbook, but teachers mainly referred to the textbook. Meanwhile, there were certain times when the teachers could not attend the class, so they allowed the students to use the school tablet and open YouTube. According to students S3, S12, S16, and S19, they mostly have an extra intervention when learning: accessing YouTube through the tablet by themselves or by the teachers. In conclusion, the learning tools teachers use when teaching in the classroom are textbooks, monitors in the classroom, and school tablets, while monitors and tablets are used to access YouTube.

The results of student demographics show that most of them own and intensively use mobile phones. This means that most of them are familiar with operating it. then most students use mobile phones to play social media (TikTok) which generally contains videos, and the main media used is video (Figure 5.11). In this case, there is a similarity in intervention where the AR application contains 3D animations that are similar to videos whose media is dynamic. The results of this data confirm that teachers and students still use textbooks as the main source for teaching and learning activities in the classroom. This shows that the gap found is getting stronger that dyslexic students still rely on textbooks as the main learning tool in PE classes.

5.3.2 Application of CLT and Mayer's Principles of Multimedia Learning

This study explore the use of Cognitive Load Theory (CLT) and Mayer's Principles of Multimedia Learning in designing augmented modules specifically tailored for dyslexic students. The goal is to understand how these educational theories and principles affect the students. The data used to answer this research question is from interviews, students' reflective journals, researcher observations, and pre and post-tests from the students.

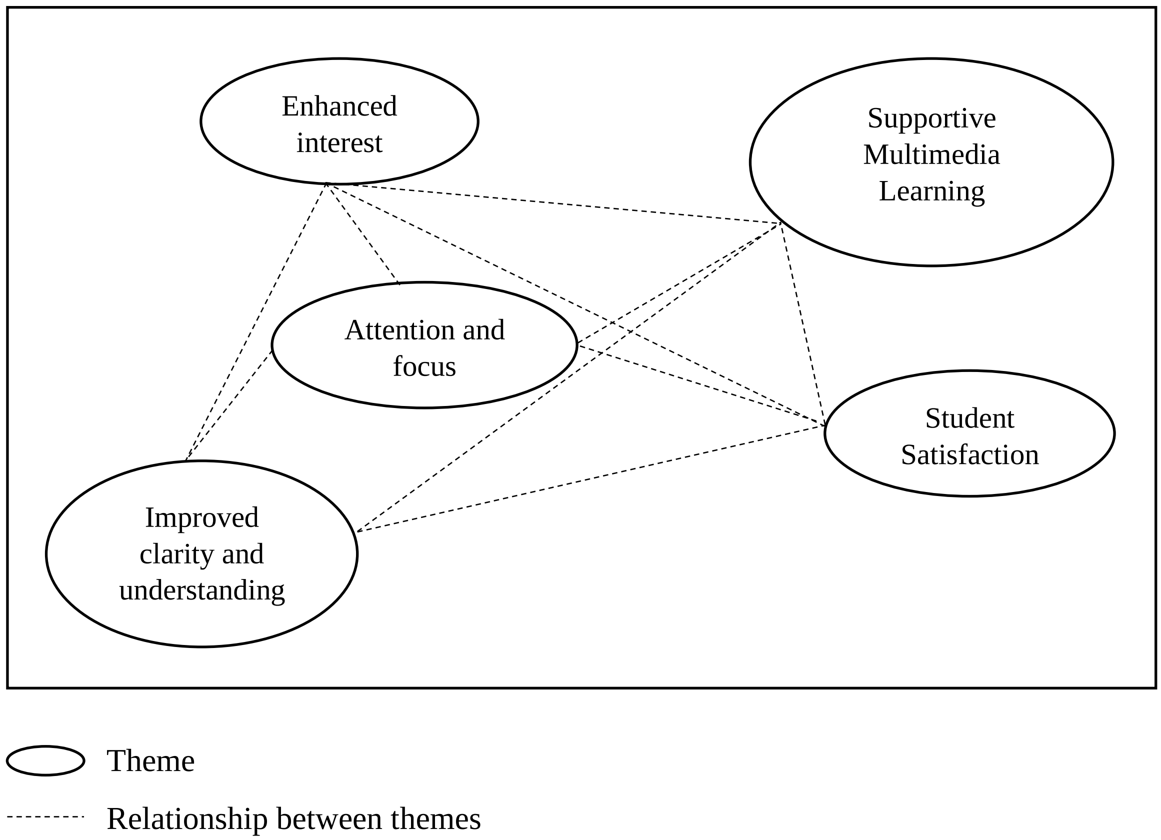


Figure 5. 14

Thematic Map of Theories Applied

The results of the interview analysis to answer the first research question show that there are five related themes. As can be seen in Figure 5.13 shows the thematic map of the related themes.

1. Attention and focus

This theme captures how the use of multimedia learning principles, such as bold text and color contrasts, helps students enhance their focus and attention while reading the module. These design elements guide students to important information and make it easier for them to navigate the content. The following excerpts illustrate this:

- *"Yes, I think it is necessary because bold text draws my attention when I read. When I see it, I can directly focus on the bold text." (S11)*
- *"Yes, it is necessary because when we want to know which activity that we should do, then it is easy to read and directly can see the text." (S16)*
- *"It uses bold text because it has important information, so we can be aware of important information." (S17)*
- *"Yes, it should be bold; if not, I might not understand." (S3)*
- *"Yes, it is necessary because it helps to differentiate." (S4)*
- *"I think it is better to make it bold, so if the teacher asks me to do the activity, it is easy to find." (S5)*

2. Enhanced Interest

This theme reflects how the application of CLT and Mayer's principles increases students' interest in the module. By making the content visually organized and appealing, students find the learning material more engaging and enjoyable. The following excerpts illustrate this:

- *"Yes, it makes it more interesting." (S13)*
- *"Because it looks neater." (S17)*

- *"Yes, it is look different" (S2)*

Apart from that, the results of interviews with teachers also show that the use of AR in PE learning helps increase students' interest, because basically using this learning tool is their first time. The following excerpts illustrate this:

- *"... students are interested in the app because it has movement." (T1)*
- *"It is gaining students interest in learning." (T1)*
- *"... when learning with AR students more interest on it" (T2)*

3. Improved Clarity and Understanding

This theme addresses how the applied theories help students read and understand the text more clearly. Techniques such as using brighter colors, multiple colors for differentiation, and bold text effects enhance readability and comprehension. The following excerpts illustrate this:

- *"Because it is brighter, I can see it clearly." (S10)*
- *"Yes, it is helpful because it makes the text pop up." (S12)*
- *"If using more than one color, I think it is more interesting for me and understandable because we can see the difference." (S11)*
- *"Because I can know which part it is when I read it." (S13)*
- *"The text is clearer to see because it has differences, and the colors contrast with each other." (S16)*
- *"This blue color selection makes the text 'Sessions' clearly visible." (S2)*
- *"It is helping to give the information" (S19)*

4. **Student Satisfaction**

This theme encompasses the overall satisfaction of students with the augmented module. It includes their appreciation for the aesthetic aspects, usability, and the module's effectiveness in aiding their learning process. The following excerpts illustrate this:

- *"The colors are pretty, nice, so it doesn't make people confused." (S2)*
- *"Yes, it is helpful." (S10)*
- *"Yes, it helps me in reading." (S12)*
- *"Yes, it is easy." (S13)*

5. **Supportive Multimedia Learning**

This theme illustrates how the use of multimedia principles, such as combining images and text closed together, supports students' learning. It also highlights the importance of having less text and clear visual aids to facilitate understanding. The following excerpts illustrate this:

- *"It is easy to understand because it has less text." (S5)*
- *"Yes, I can understand because it has images and text, and it is clear enough." (S11)*
- *"Because it has images and text." (S13)*
- *"Because the text is not long." (S17)*

Meanwhile, the results of the researcher observations during the teaching and learning process showed that the use of AR technology in learning made students very interested in the material that would be delivered that day. This happened because they had never found or used similar technology in the classroom before, this was the first time they had used it. The results of the observation also showed that the impact of student interest made them more focused when listening to instructions from the teacher, before using AR itself. When studying with peers, they were seen discussing and exemplifying movements that were understood by each student. During this process, very few students asked the teacher, while two students asked because the images could not be scanned on the module. The rest of the students seemed to enjoy learning with their peers.

The use of the OG approach as a basis for teaching by teachers is also effective, because there are very few students who ask teachers about the movements they should do. The use of multisensory also helps students to connect information so that it is easier for them to understand the information conveyed by the teacher. Students said that they could follow PE classes well (SS10, S11, S12, S13, S16, S17, S18S19). This is also in line with the results of the students' reflective journal which shows that students understand the activities they have to do. S17 said that he understood it. Then, because the AR application focuses on showing 3D animations directly without additional interfaces or other menus, this makes it easier for students to operate the application. S12, S17 and S18 said that they understood the application used.

The use of 3D animation compared to 2D images is considered very effective in providing direct demonstrations to students, S2, S3, S4, S11, S12, S13, S17, and S18 said that they understood the movements shown by the 3D animation displayed by the AR application. On the other hand, the selection of content (Unit 5) which is the basis of knowledge in PE class, and also the selection of exercises that have been adjusted to the students' abilities and safety, students feel that most of them are able to perform the activity (S2, S3, S4, S10, S12, S13, S16, S17, and S18). Meanwhile, the findings from interviews, researcher observations and students' reflective journals are supported by the results of students' pre- and post-tests, which show that there is an increase in students' abilities in performing the exercise movements as shown in Table 5.4.

5.3.3 Students Learning Experiences in Using Augmented Module

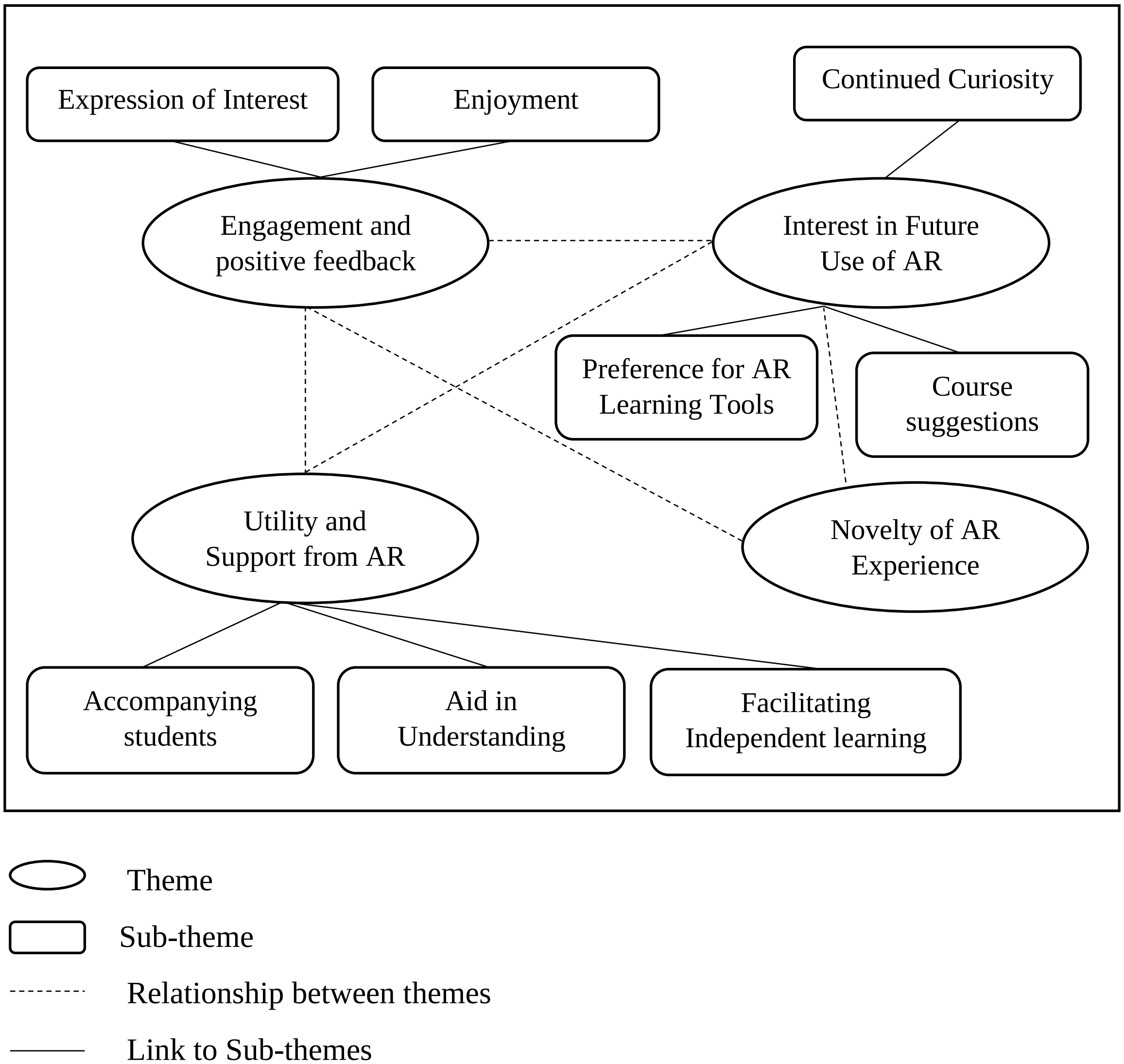


Figure 5. 15

Thematic Map of Students Learning Experiences

This study investigates the learning experiences of dyslexic students using an augmented. This study explore the learning experiences of dyslexic students using an augmented module as an assistive tool in physical education (PE) classrooms. The aim is to understand the impact of augmented module on students in facilitating learning. After participating in PE learning using the augmented module in their classroom, the students were asked about their learning experiences regarding its use. The data used to answer this research question is from interviews, students' reflective journals, and researcher observations. There are four main themes related to this research questions (Figure 5.14).

3. Engagement and Positive Feedback

This theme captures how students interact with and respond to the AR module. It highlights their emotional reactions, such as enjoyment and excitement, and their overall positive feedback about the learning tool.

Sub-themes:

- Enjoyment: Reflects the fun and happiness students feel when using the AR module. The interactive nature of AR makes learning more enjoyable and engaging.

  The following excerpts illustrate this:

  - *“I felt fun because I can use AR” (S11)*
  - *“It is fun" (S12, S13, & S19)*
  - *“I’m happy” (S18)*
  - *“Because it is fun to use” (S2)*

The results of the students’ reflective journals also showed that students enjoyed taking PE classes using the augmented module. S12 said that he enjoyed the class because it is using AR so, it is fun for him. Similar to S12, S17 also stated that learning using AR was fun for him.

- Expression of interest: Indicates the students' interest and excitement about the AR module, showing that they find the tool engaging and captivating.

  The following excerpts illustrate this:

  - *“Yes, it is interesting” (S11)*
  - *“I feel excited because this app is interesting” (S17)*
  - *“I felt it was interesting” (S2 & S19)*
  - *“.... interesting” (S5)*

The results of the students' reflective journals also showed that students were interested in following the class. S11 said that the class using the augmented module was interesting for her because it is different from usual class. S13 also stated that the class was very interesting to her because she did a lot of things. S16 also said the same, she felt that the class was interesting because she learned new things. Meanwhile, S17 said that the class was interesting because there were a lot of interesting things. The rest, S2, S3, S4, S18 and S19 agreed that the class was indeed interesting to them.

4. Interest in Future Use of AR

This theme explores students' enthusiasm for continuing to use AR in their future learning activities. It includes their curiosity about AR, their suggestions for its use in other courses, and their preference for AR over other learning tools.

Sub-themes:

- Continued Curiosity: Students' desire to keep using AR in their studies, indicating sustained interest and curiosity about the technology.

  The following excerpts illustrate this:

  - *"Yes, I want" (S2, S3, S10, S11, S12, S13, S16, S17, and S19)*
  - *"Because if I didn't know, I can use it" (S12)*
  - *"Yes, because it is easy to understand" (S5)*
- Course Suggestions: Students' recommendations for incorporating AR into other subjects, reflecting their belief in its broad applicability.

  The following excerpts illustrate this:

  - *"Maybe arts because it has lots of drawing activity" (S11)*
  - *"Physical education" (S16)*
- Preference for AR Learning Tools: Students' preference for using AR over other learning tools, highlighting the advantages they perceive in AR's interactive and visual nature.

  The following excerpts illustrate this:

  - *"I like the app better because I can learn deeply from it" (S13)*

- *"Using this app, it can show me one by one, but on YouTube, it has lots of movement in a video" (S13)*
- *"I like AR better" (S16)*
- *"I like using a phone because it is more interesting" (S19)*
- *"Because it is more interesting" (S2)*
- *"I prefer to scan using a phone because it is easy to refer to the animation movement" (S5)*
- *"I prefer AR" (S3)*

Just as students that prefer AR as an assistive tool that will be used in the future, teachers also have the same opinion. The following excerpts illustrate this:

- *"AR, because it is new things for them, so they are excited about it and follow instruction on it" (T1)*

  "AR because it is easy to use, and students can directly refer how to do the movement to the animation" (T2)

According to the results of students' reflective journal, S16 and S18 said that they would prefer to use AR in the future because it is easier for them to understand the content.

5. Novelty of AR Experience

This theme describes students' experiences with using AR for the first time. The novelty aspect of AR contributes to their engagement and excitement, making the learning process fresh and interesting.

The following excerpts illustrate this:

- *"... this one is new for me" (S10)*
- *"... this is my first time ..." (S12)*
- *"Yes, first time" (S2,S3,S4,S5,S16,S17,S18,S19)*

The results of the students' reflective journal showed that students never had previous knowledge or experiences on using AR on their learning (S11, S17, and S18). So, the use of AR for this PE class is the first experience for students. This is closely related to the students' great interest in learning to use a new learning tool.

6. Utility and Support from AR

This theme highlights the practical benefits of using AR as a learning tool. It encompasses how AR aids in understanding content, supports students in performing tasks, and facilitates independent learning.

Sub-themes:

- Accompanying Students: AR assists students by providing visual and step-by-step guidance on how to perform movements and tasks.

  The following excerpts illustrate this:
  - *"... it helps me to do the movement" (S11)*
  - *"Because it can show how to do it" (S13)*
  - *"It is easy to use because it just needs to be scanned on the module" (S17)*
  - *"Because I can understand what the app does, and I just follow it. Follow its movement" (S18)*
  - *"It can help me with certain parts that I didn't understand" (S3)*

Apart from the analysis results from students, the results of teacher analysis also show that according to the teacher's point of view, AR is very helpful in assisting students in their learning. The following excerpts illustrate this:

  - *“AR helps students in assisting their learning because it has movements and students will follow it.” (T1)*

- Aid in Understanding: AR helps students better understand movements and concepts by providing clear, visual instructions and examples.

  The following excerpts illustrate this:

  - *"It can help to understand the movement, I can understand more" (S11)*
  - *"... when I see it on the AR, I just realized and understand how to do the exact movement" (S11)*
  - *"Yes, it is helpful" (S3, S12, S11, and S19)*
  - *"If I didn’t understand, it can show me how to do the movement" (S13)*
  - *"Yes, it helps me to understand easier" (S5, S4, S16)*
  - *"It helps me by showing me how to do the movement" (S17)*
  - *"Because I can understand what the app does" (S18)*
  - *"It makes it easier to understand, and I can see it closely" (S4)*

Apart from that, the results of teacher interviews also show that one of the benefits of using AR is that it helps increase students' understanding of movements. The following excerpts illustrate this:

  - *“When seeing the 3D animation, it helps students to see the exact movement. So, the movements students make are more precise” (T1)*

- *"…when we use AR, and scan to the images students can see animation on it, so students can refer the right steps to do the movement on the app" (T2)*
- *"… it is clearly visible for the students of what step or movement the should do." (T2)*

- Facilitating Independent Learning: AR empowers students to learn on their own without constant teacher assistance, promoting autonomy in their learning process. The following excerpts illustrate this:
  - *Yes, I can use it by myself" (S4)*

The results of the students' reflective journals show the role of AR for students. the results show that AR plays a very important role as an assisting tool in the students' learning process. students said that AR is very easy to use by them (S2, S10), because it is easy to use, students just take a phone and scan on the book, it is interesting according to him (S4). S5 also gave the opinion that AR shows the animation that demonstrates the exercises movement. If he saw the exercise image in the textbook, he didn't really understand. In addition, students also feel that the use of augmented modules is very helpful for them in understanding the exercises movement. Students feel that it is easier for them to understand if they see 3D animations in the AR application (S5, S10, S11, S16, S18). Meanwhile, S17 also said that the use of AR helps me to understand quickly.

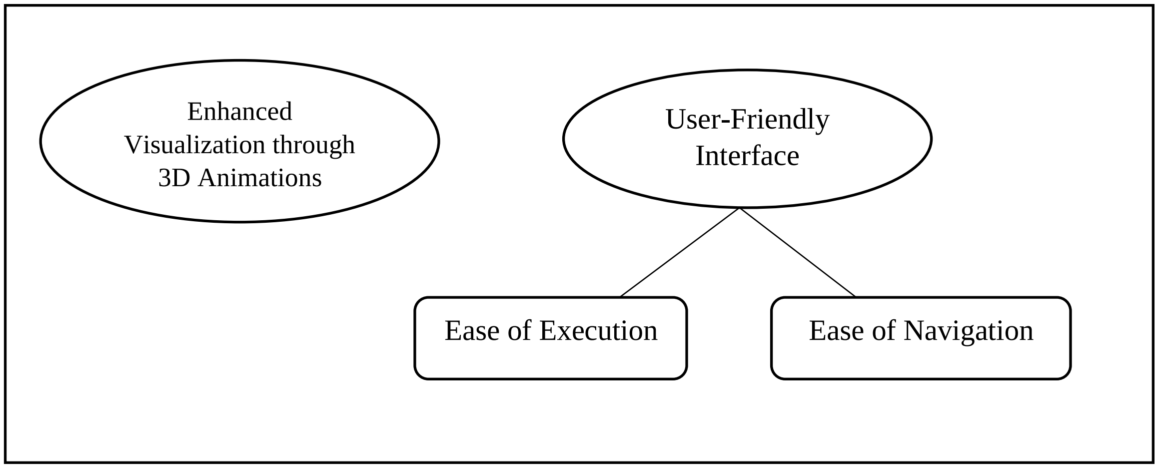
The results of researcher observation show that students are very interested in the learning tools that will be used during the learning process, this can be seen since the end of the second meeting when the teacher began to introduce AR to students. the peak was when students were invited to use the AR application and allowed to learn with peers. they looked very enthusiastic and explored all the movements in the module, even though it had been briefed that the movements learned were 4 movements per meeting. students were also seen exploring the application, in this case they were seen flipping the screen, then moving the tablet closer and further away from the module and also trying to interact with the 3D animation that appeared. as previously explained, the number of students asking questions and depending on the teacher also decreased significantly. students were seen being able to learn and explore content with their peers.

5.3.4 Factors that Support and Inhibit the Use of AR Technology and Augmented Module

The research questions were divided into two, and each research question was discussed separately: a) How does the AR app and module learning content support the learning process of dyslexic students in PE classrooms? and b) What are the barriers to using AR technology in PE classrooms for dyslexic students?. Meanwhile, the data used to answer this research question is from interviews, students' reflective journals, and researcher observations.

a) Factors from AR Technology and Augmented Module That Support the Learning Process of Dyslexic Students

This study explores the support provided by an augmented reality (AR) app and module in enhancing the learning process of dyslexic students in physical education (PE) classrooms. The goal is to understand how AR technology aids these students during their learning.



Theme

Sub-theme

Link to Sub-themes

Figure 5. 16

Thematic Analysis of Students' Supporting Factors When Learning Using AR

A summary of factors supporting students during their learning using the augmented module as their assistive technology can be seen in Figure 5.15. There are two main themes related to answering this question.

1. Enhanced Visualization through 3D Animations

This theme encapsulates how 3D animations in the AR module improve students' comprehension of movements and activities. The dynamic and visual aspects of these animations offer clearer and more effective learning aids than static images or text. The following excerpts illustrate this:

- *"I can understand it because it has movement on it" (S10)*

- *"When I see it on paper and see it on the AR, I just realized how the real movement should I do. So, the movements are different from the paper." (S11)*
- *"If I didn't understand, it can show me how to do the movement" (S13)*
- *"Because it shows the movement, it is easy to follow" (S16)*
- *"... it shows the right movement" (S17)*
- *"Because I can see the animation movement" (S19)*
- *"When we use it, we can see it and refer to the animation movement" (S2)*
- *"Because it can translate to us (translate from image to animation video)" (S3)*
- *"Because it has animation movements so I can understand" (S4 & S5)*

2. User-Friendly Interface

This theme describes the ease with which students can interact with the AR app and module. It highlights the app's intuitive design, which makes it accessible and helpful for dyslexic students.

Sub-themes:

- Ease of executions: This sub-theme describes how simple it is for students to perform tasks and activities using the AR module. The straightforward design helps reduce cognitive load, making it easier for students to follow along and engage with the content.

  The following excerpts illustrate this:
  - *"... Yes, because it is easy to do" (S5 & S18)*
- Ease of navigations: This sub-theme addresses the simplicity of navigating through the AR app. A user-friendly interface ensures that students can quickly

learn to use the app without additional frustration, allowing them to concentrate on the learning material.

The following excerpts illustrate this:

- *it is easy to use" (S2, S5, S11, S12, S13, S16, S17, S18, S19)*
- *"... it is easy to learn and to see" (S3)*

The results of the students' reflective journals show that several things that are supporting factors for students are the use of easy-to-use AR applications and also the selection of easy-to-do exercise movements. S2, S3, S4, S5, S11, S13, and S17 said that the exercises are easy to do all of them said they can do it referring to the 3D animation. In addition, students also said that the AR application was easy for them to use (S2, S3, S4, S5, S11, S12, S13, S17, and S18). S16 also added that the application was easy to understand because it has demonstration movement on it. The results of the researcher's observations also show that 3D animation plays a very important role in helping students understand the material they must understand. On the other hand, AR applications that are easy to operate and have minimal menus and user interfaces also help students to stay focused on the 3D animation displayed.

b) Barriers in Using AR Technology and Augmented Module in PE Classrooms

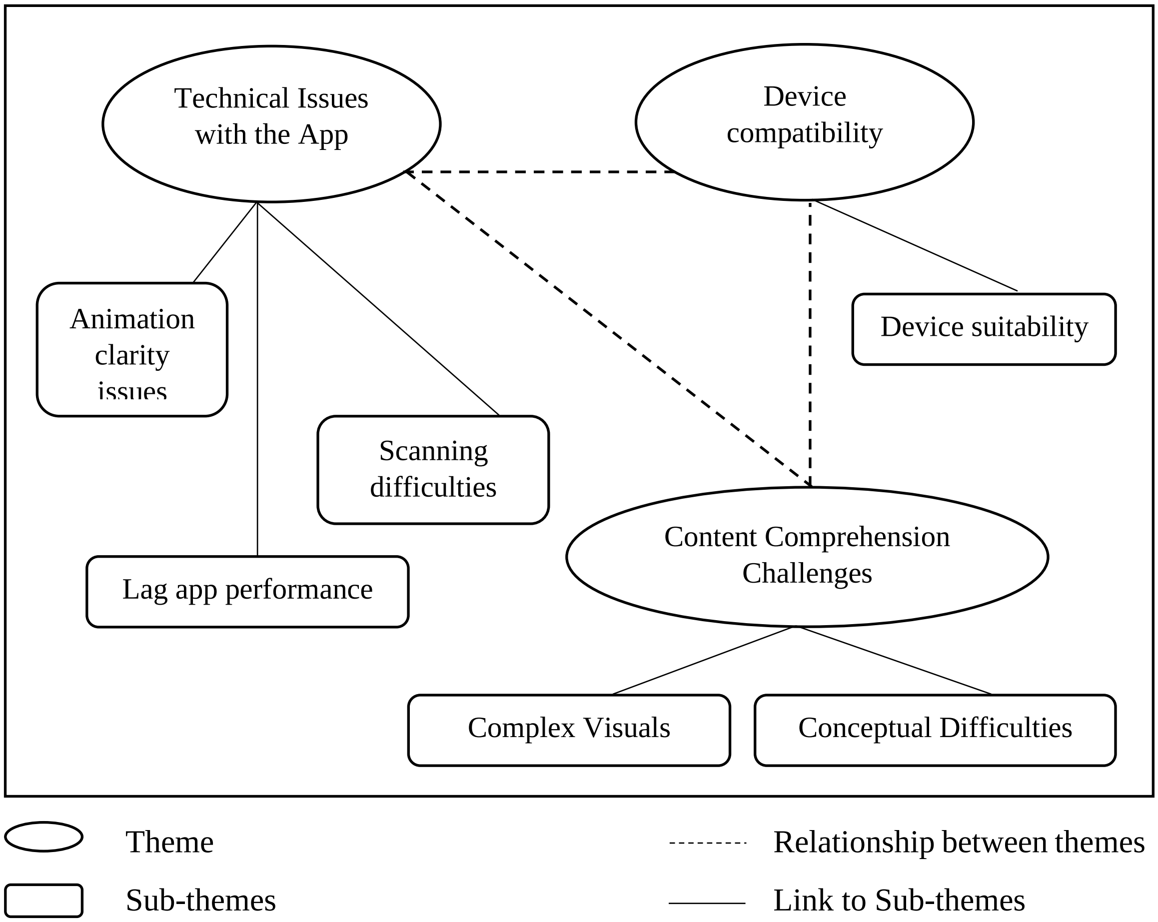


Figure 5. 17

Thematic map of students' barrier on using augmented module in learning

This study explore the barriers dyslexic students face when using augmented reality (AR) technology in physical education (PE) classrooms. Understanding these barriers is crucial for improving AR tools to better support dyslexic students' learning experiences. There are three main themes related to answering this research question.

1. Content Comprehension Challenges

This theme encompasses the difficulties that students face in understanding and interpreting the content presented through the AR module. These challenges are primarily due to the complexity of the visuals and the inherent difficulty of certain concepts.

Sub-themes:

- Complex Visuals: This sub-theme captures the students' struggles with understanding movements or body positions depicted in AR animations and images. The visuals can sometimes be too complicated or unclear, making it hard for students to comprehend the intended actions.

  The following excerpts illustrate this:

  - *"I didn't understand, like how to move the body" (S18)*
  - *"... sometimes I don't know how to do the movement" (S3)*
  - *"... when I see the images, I don't really understand it is difficult" (S4)*
  - *"From the images I don't know how to do the movement" (S5)*

The summary of complex visuals can be seen in Table 5.1.

Table 5. 1

Complex Visuals

Total movement	Activity 1	n	Activity 2	n	Activity 3	n
Session 1	Shoulder rotation		Bending		Push up	
Session 2	Side curl	1	Scissor jump	2	Sit up	

Session 3	Body stretching	Star jump	Up and down the bench	
Session 4	Twist the body forward	Superman plank	Squat jump	2

- Conceptual Difficulties: This sub-theme highlights the specific exercises and movements that are conceptually challenging for students to grasp, despite the assistance provided by the AR module. These difficulties arise from the inherent complexity of the movements.

  The following excerpts illustrate this:

  - *"Squat jump and scissors squat" (S4, S5, and S10)*
  - *"Scissors jump, because when I see the images, the hand when we are jumping seems like straight forward, but when I see on the app, it is to the left and right" (S11)*
  - *"The one involved jumping movement" (S12, and S17)*
  - *"Squat jump is difficult" (S13)*
  - *"Flashback to the front and side curls, when I'm trying to do it I didn't understand how to do the movement" (S18)*
  - *"Scissors jump is difficult" (S3, and S19)*
  - *"Bending, and going up and down the bench" (S2)*

Table 5.2 depicts the summary of difficult movements to perform as claimed by the students.

Table 5. 2

Difficult Movements to Perform

Total movement	Activity 1	n	Activity 2	n	Activity 3	n
Session 1	Shoulder rotation		Bending	1	Push up	
Session 2	Side curl		Scissor jump	7	Sit up	
Session 3	Body stretching		Star jump	1	Up and down the bench	1
Session 4	Twist the body forward		Superman plank		Squat jump	6

The results of the students' reflective journal show that there are several movements that students find difficult to carry out. S10 says that the bending movement is difficult a bit. S12 said that scissors jump is difficult to do due to the unclear animation on the app. S16 also says that squat jumps are a bit difficult. Meanwhile S17 said that all the movements are good but she can't do the jumping movements because she feels that her body is heavy to do it. S18 said that she understood the demonstration shown by the animation but she could not do the movements (bending, scissors jump and squat jump). S2 said that he had difficulties doing Up and down the bench and plank superman, finally S4 and S5 said that they had difficulties on doing scissors jump and plank superman.

2. Device Compatibility

This theme addresses issues related to the suitability and performance of devices used to run the AR app. Variations in device performance can affect the usability and effectiveness of the AR module.

Sub-theme:

- Device Suitability: This sub-theme captures the differences in clarity and performance across various devices, such as phones and tablets. These differences can impact the students' experience with the AR module, particularly when the performance is not optimal.

  The following excerpts illustrate this:

  - *"... And then if I open the app using my phone it is clear enough, but then open it through tablet it is lagging" (S10)*

3. Technical Issues with the App

This theme highlights the technical problems that students encounter when using the AR app. These issues can disrupt the learning process and diminish the overall effectiveness of the AR module.

Sub-themes:

- Animation Clarity Issues: This sub-theme focuses on the clarity of the animations within the AR app. Some animations, particularly those involving specific movements, are not clear enough for students to understand.

  The following excerpts illustrate this:

  - *"Scissors jump is not clear" (S10)*
  - *"Maybe on foot, the animation isn't clear. Usually, the jumping activity is not really clear on the foot" (S10)*

The summary of animation clarity issues can be seen in Table 5.1. The results of the students' reflective journal also showed that there were unclear animations which hampered the students' learning process (S16). S10 said that "Because the animation “jump scissors” looks weird, so I didn't really understand", S13 said that "... but I should see it many times on Up and down the bench and squat jump part", S18 ""But there is one activity that I didn't understand which is the squat jump, and I cannot do it because I didn't understand".

Table 5. 3

Animation Clarity Issues

Total movement	**Activity 1**	**n**	**Activity 2**	**n**	**Activity 3**	**n**
Session 1	Shoulder rotation		Bending		Push up	
Session 2	Side curl	1	Scissor jump	2	Sit up	
Session 3	Body stretching		Star jump		Up and down the bench	
Session 4	Twist the body forward	1	Superman plank		Squat jump	

- Lag App Performance: This sub-theme addresses the lagging performance of the AR app, which interrupts the learning flow and frustrates students.

  The following excerpts illustrate this:

  - *"... and then there are some laggings ..." (S10)*
  - *"The app is lagging" (S5, and S12)*
  - *"There are lagging when I’m using the app, but overall, it is okay, I can use it" (S13)*

- *"But the movement of the 3D character sometimes is not the same" (S2)*

The results of the students' reflective journal also showed that students did not understand the animation because the animation was lagging and inside the font the animation was shaking (S12).

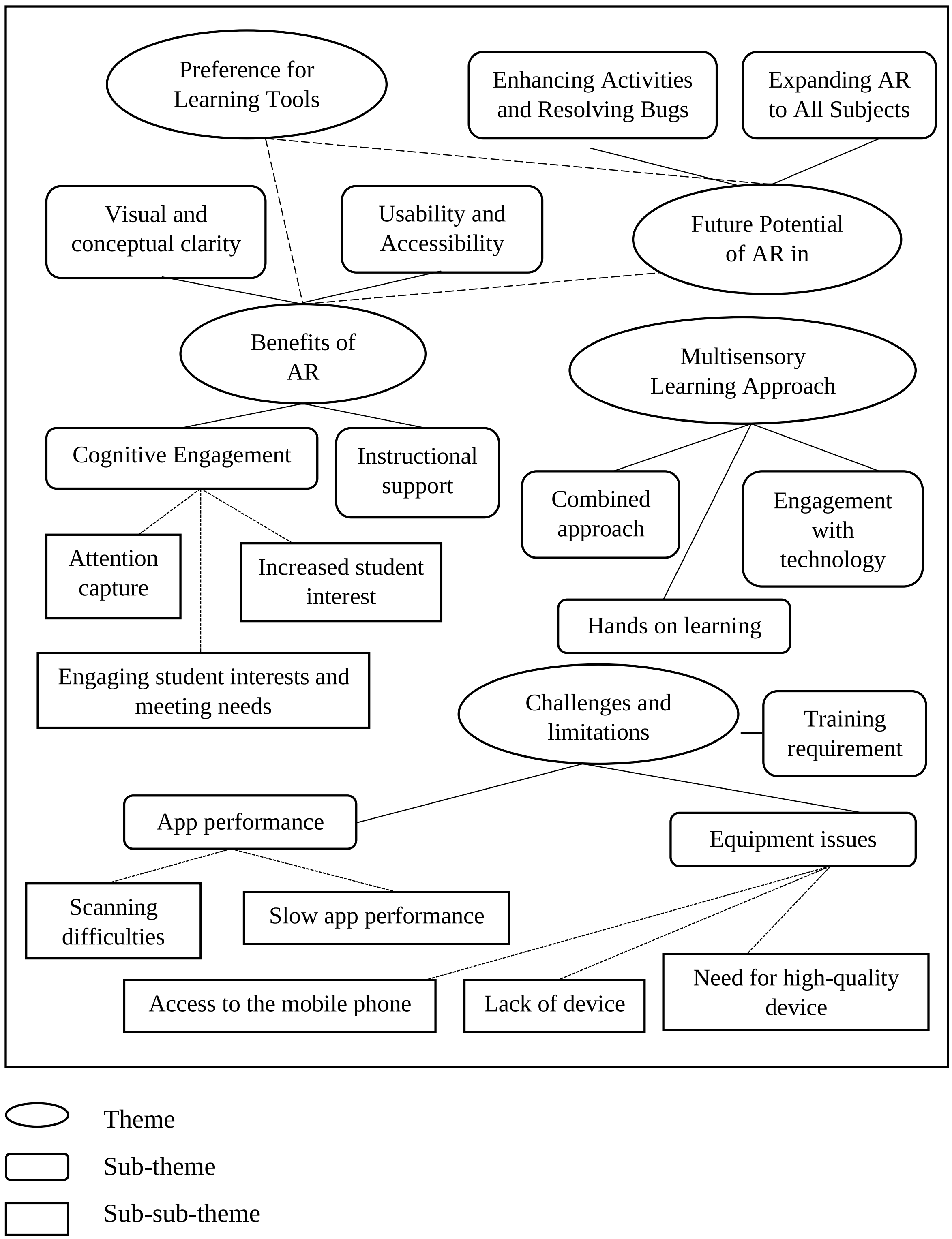
- Scanning Difficulties: This sub-theme highlights the problems students face when trying to scan images to access the 3D animations. Difficulties in scanning prevent students from engaging with the intended content. The following excerpts illustrate this:
  - *"... there are some images that are difficult to scan such as scissors jump it is a bit difficult to scan" (S10)*
  - *"It is difficult when scan into the images" (S19)*

    "Yes, when the images cannot be scanned" (S13)

The results of the students' reflective journal also showed that there was a lag on the tablets used in class. "Difficult a bit because the tab is lagging" (S10 and S16). Similar things were also found when the observation took place. Some tabs are lagged so that the image is very slow to appear and sometimes the image cannot be scanned. This happens because the android version of the tab is quite old, so it does not support the AR application used. This is the factor that most disrupts the student learning process.

5.3.5 Teachers' Perspectives on the Use of Augmented Module

To address this research question, five main themes emerged from the data: Benefits of AR, Challenges and Limitations, Future Potential of AR in Education, Preference for Learning Tools, and Multisensory Learning Approach. Each theme includes various sub-themes and insights from teachers' perspectives.



-------- Relationship between themes

——— Link to Sub-themes

.... Link to Sub-sub-themes

Figure 5. 18

Thematic map of teacher's perspectives of AR in the classrooms

1. **Benefits of AR**

This theme encompasses the various advantages that augmented reality (AR) brings to the educational experience of dyslexic students in PE classrooms.

Sub-themes:

- Cognitive Engagement: AR captures students' attention and stimulates their interest through dynamic and interactive elements, making learning more engaging and effective.

  Sub-sub-themes:

  - Attention Capture: The ability of AR animations to draw and hold students' attention, making the learning process more effective. The following excerpts illustrate this:

    "The animation itself is concise and attracts students' attention because the animation pops up." (T1)

    "AR attracts students' attention to learn" (T2)

  - Engaging Student Interests and Meeting Needs: The interactive and technological elements of AR that increase student interest and cater to their learning preferences. The following excerpts illustrate this:

“Something that moves, that has a lot of colors, students will be more interested in that.” (T1)

“I see that students have great interest and are more interested in things that use technology.” (T2)

- Increased Student Interest: The use of technology in AR that appeals to students' interests and enhances their learning experience. The following excerpts illustrate this:

  “I see that students have great interest and are more interested in things that use technology because it has movement.” (T1)

  “... when learning with AR students will interest on it.” (T2)

- Instructional Support: AR aids in the instructional process by providing clear, visual guides that help students understand and perform physical movements correctly. The following excerpts illustrate this:
  - *"AR helps students in assisting their learning because it has movements and students will follow it." (T1)*
- Usability and Accessibility: AR technology is user-friendly and accessible, allowing students to navigate and utilize it independently due to their familiarity with technology. The following excerpts illustrate this:
  - *"The rest of the students can do it themselves, because now students are more advanced in technology." (T2)*
  - *“... its ease of us ... “ (T2)*

- Visual and Conceptual Clarity: AR enhances the clarity of instructions and concepts by offering direct visualization and detailed animations, helping students comprehend and execute movements accurately.

  Sub-sub-themes:

  - Direct visualization: The capability of AR to show movements directly when images are scanned, aiding in understanding.

    The following excerpts illustrate this:

    "When we scan the images, it will directly show the movement of the images." (T2)

    "… when we use AR and scan it on the images, students can directly refer and follow the animation" (T1)

  - Enhanced Clarity and Understanding: The ability of AR to provide clear and precise visual instructions, helping students perform movements accurately.

    The following excerpts illustrate this:

    "When seeing the movement, it helps students to see the exact movement. So, the movements students make are more precise." (T1)

    "… but when we use AR, and scan to the images students can see animation on it, so students can refer the right steps to do the movement on the app" (T4)

    "…it is clearly visible for the students of what step or movement the should do." (T4)

The results of interviews and reflective journals of students also showed that AR made them interested during PE class. The results of observations also showed similar results. Students also paid more attention and focused when receiving instructions from the teacher. In addition, the use of AR as an assisting tool was found to be very targeted because AR plays a very important role in the student learning process so that it helps them understand the exercise movements being studied. The easy use of the application and the minimal menus and user interfaces in the application also help students to focus more on 3D animations only, so as not to break students' focus. And most importantly, with 3D animation, this plays a very important role in accompanying students to learn as a tool that helps students see demonstrations of the movements they are studying. The pre- and post-test results also showed an increase in students' ability to perform the exercise movements in the module.

2. Challenges and Limitations

This theme addresses the obstacles and constraints associated with implementing AR in PE classrooms for dyslexic students.

Sub-themes:

- App Performance Problems: Issues related to the speed, responsiveness, and overall performance of the AR app that can negatively impact the learning experience. The following excerpts illustrate this: *"... it is a little slow." (T1)*

  Sub-sub-themes:

  - Scanning Difficulties: Challenges encountered while scanning images to activate AR features, which can disrupt the learning process. The following excerpts illustrate this: *"There are difficulties in scanning the images on the module ..." (T1)*

- Slow app performance: This sub-sub theme pertains to the technical issues encountered by teachers and students while using the augmented reality (AR) app. It focuses on how the lagging or slow responsiveness of the app affects the learning process. The following excerpts illustrate this: *"it is a little slow" (T1)*

- Equipment issues: This sub-theme focuses on the various problems related to the availability and quality of devices required to use the augmented reality (AR) app effectively in the classroom.

  Sub-sub-themes:

  - Access to the Mobile Phone: This sub-sub theme addresses the challenges related to students' and teachers' access to mobile phones necessary for using the AR app. The following excerpts illustrate this: *"…access to the phone, because in the school students are not allowed to bring their phone" (T4)*
  - Lack of Device: This sub-sub theme highlights the problem of insufficient devices available for use in the classroom. The following excerpts illustrate this: *"I think the challenges are, I have to provide a large number of cell phones for each person. if we have these facilities, it is very easy to teach." (T4)*
  - Need for High-Quality Device: This sub-sub theme discusses the requirement for high-quality devices that can run the AR app smoothly

without technical issues. The following excerpts illustrate this: *"... I think it requires better quality phone, such as big Ram, etc…" (T1)*

- Training Requirements: The necessity for teachers to provide training to students on how to effectively use the AR app due to a lack of prior exposure to such technology.

  The following excerpts illustrate this:

  - *"Students didn't know how to do it, because we are lack of learning materials like that, then as a teacher I should train them to use it..." (T2)*

Similar to the results of teacher interviews, the results of student interviews, and student reflective journals show that application performance such as slow applications and difficulty in detecting images are the main problems faced by students. Then the problem in the future that is likely to be faced is the unavailability of devices to run the AR application itself. This will be faced by most schools that do not have facilities such as tabs or mobile phones that can be used by students in class. The results of the researcher's observations also saw that the main problem faced by students was when using the application, but it was less responsive when they tried to scan images on the module. Several times this made them frustrated and skipped to the next exercise movement.

3. Future Potential of AR in Education

This theme explores the potential future applications and improvements of AR technology in educational settings from teacher's perspectives.

- Enhancing Activities and Resolving Bugs: Suggestions for adding more activities to the AR app and fixing existing technical issues to improve the overall learning experience. The following excerpts illustrate this:
  - *"I suggest adding more activities, exercises, and fixing the lagging problem." (T1)*
- Expanding AR to All Subjects: The potential to implement AR technology across various subjects beyond PE, thus broadening its application and benefits in education. The following excerpts illustrate this:
  - *"I suggest continuing to develop this research because it is interesting to use and can be implemented in every subject." (T4)*

From the results of student interviews, many of them said that they hope to continue using AR technology in the future and can use it in subjects other than PE. because they have felt the benefits and ease of learning with the help of this technology. This is in line with what was conveyed by the teacher. From the results of the researcher's observations, it was also seen that the existence of this technology as an assistive tool greatly helps both students and teachers to carry out their respective roles. Teachers are helped to demonstrate exercise movements to students while students feel they can more intensely see and repeat the demonstrations they have learned.

4. Preference for Learning Tools

This theme reflects teachers' preferences for AR over traditional learning tools due to its interactive nature and the immediate visual feedback it provides.

The following excerpts illustrate this:

- *"I choose AR rather than video because when we use AR, the animation can directly pop up when the image is scanned." (T1)*
- *"AR because compared to the videos, students can only see it, and students are used to using it. AR is new to them, so they are more interested and like to use it." (T4)*
- *"We cannot be separated from the learning material in the textbook. When using AR, students can read and see the movement at the same time, so it helps assist and improve student understanding." (T4)*
- *"It is easy to use, and students can directly refer how to do the movement to the animation." (T1)*

From the results of interviews and reflective journals of students, most of them prefer augmented modules as the main learning tools compared to textbooks or videos. The reason they do not choose textbooks is because it is difficult to interpret 2D images in textbooks into sports movements or exercises. Then the reason they do not choose videos is because they are less interactive and there are no specific videos that show demonstrations of the movements they need. For example, they want to find a video tutorial for the star jump movement, most video tutorials are long and there are also several movements in one video. This makes it difficult for students to adjust the duration of the video and find the movements they want to know. Compared to AR which is more interactive and shows demonstration movements one by one based on the images that students scan. This is considered more helpful for them when learning.

5. Multisensory Learning Approach

This theme highlights the importance of using a multisensory approach in teaching to enhance students' learning experiences.

- Combined Approach: Integrating detailed teaching, images, and demonstrations to create a comprehensive and engaging learning experience.

  The following excerpts illustrate this:

  - *"The teacher should teach in detail, show the images, then demonstrate it to the students and lastly ask them to do it themselves. So, if the teacher combines these two conditions, students will find it more fun and interesting." (T4)*

- Engagement with Technology: Combining traditional teaching methods with technology to engage students, especially those with disabilities, and to keep pace with modern educational trends.

  The following excerpts illustrate this:

  - *"I think it is necessary because we should combine the learning method because we are going to the 4.0 era. So, technology is necessary in learning, despite that disabled students are usually more interested if the teacher uses technology " (T4)*

- Hands-on Learning: Emphasizing practical, active learning to keep students engaged and interested, moving beyond passive learning methods to more interactive and dynamic approaches.

  The following excerpts illustrate this:

- *"More hands-on activities, moving when learning, make students more engaged and interested rather than just sitting still they will get bored quickly." (T4)*

Based on the observation results, the application of the multisensory approach is very helpful for students in connecting the information obtained during learning into one unit. such as when students get the first information from the teacher's explanation, then from the module, to learning with peers using AR technology. all information obtained from various sensors supports and is related to each other. this helps students to understand the material taught at the meeting.

5.3.6 Movement Ability Results

In addition to the interviews, observation and reflection, the students were also required to sit for the pre and post-tests regarding their movement abilities. The findings of these pretests and posttest on movement abilities are shown in Table 5.4. It can be seen that the student's movement ability has improved from the pretest to the posttest. Although the increased level among some of the students was not significant, the findings indicated that all of them scored higher in their posttest compared to their pretest. The results of students' movement ability support the findings in several research questions (RQ 1, and 4), where they felt that the augmented module had assisted their learning. Table 5.5 shows the average score of each session or movement in each activity

Table 5. 4

Summary of Students Movement Ability Results

Num	Students Code	Class	Activity 1 Flexibility				Activity 2 Muscle Strength				Activity 3 muscle endurance			
			Pre-Test		Post Test		Pre-Test		Post Test		Pre-Test		Post-Test	
			Score	Grade	Score	Grade	Score	Grade	Score	Grade	Score	Grade	Score	Grade
1	S2	A	9	D	18	A	9	D	17	B	10	D	15	B
2	S3	A	9	D	18	A	11	D	17	B	10	D	15	B
3	S4	A	9	D	20	A	10	D	17	B	10	D	16	B
4	S5	A	8	D	20	A	9	D	16	B	9	D	17	B
5	S10	A	7	E	16	B	7	E	14	C	11	D	14	C
6	S11	B	8	D	19	A	7	E	15	B	7	E	17	B
7	S12	B	7	E	20	A	8	D	18	A	8	D	10	D
8	S13	B	8	D	19	A	7	E	16	B	8	D	15	B
9	S16	B	9	D	19	A	10	D	19	A	11	D	17	B
10	S17	B	9	D	20	A	10	D	15	B	11	D	15	B
11	S18	B	9	D	16	B	8	D	15	B	10	D	14	C
12	S19	B	8	D	17	B	7	E	16	B	9	D	12	C

Table 5. 5

Assessment information

Score	Description
1	Very different movements
2	Different movements
3	Neutral
4	Similar movement
5	Precise movement

Table 5. 6

Average Score of Each Session

Average Score of Each Session

Flexibility					Muscle Strength					Muscle Endurance				
Session 1	Session 2	Session 3	Session 4	Score (Avg)	Session 1	Session 2	Session 3	Session 4	Score (Avg)	Session 1	Session 2	Session 3	Session 4	Score (Avg)
4.62	4.46	4.54	4.46	4.52	4.46	2.85	4.77	4.08	4.04	4.00	4.08	3.77	2.85	3.67

The student movement ability results in Table 5.4 are summary scores from each student's pre- and post-test. The assessment guide is found in Table 5.5 following the assessment from the textbook. The minimum score is 1 if the movement demonstrated is very different from the actual movements, while the maximum score is 5 for each movement if the student demonstrates precise movements. So, if a student gets the maximum score in each activity (four movements/sessions) they get a maximum score of 20. Meanwhile, table 5.6 is the result of the average score of each session on each activity which has a maximum score of 5. Below is a summary of the scores and problems faced by students in each exercise activity.

Flexibility (Activity 1)

In activity 1, flexibility has the highest total score (4.52) which shows that in this activity there are movements that are quite easy for students to do. Compared to other activities. Based on Table 5.6, Session 2 and Session 4 have the same average but were lower than the other sessions in this activity. Referring to Table 5.3, a total of two student said that the animations in session 2 (side curl) and session 4 (twist the body forward) were not that clear. Also, in Table 5.1 regarding difficult images to understand, one students stated that session 2 (side curl) had images that were difficult to understand.

Muscle Strength (Activity 2)

In the second activity, which is muscle strength, the lowest average value in this activity was in Session 2, which was 2.85. Based on Table 5.3, two students claimed that Session 2 (scissor jump) has unclear animation. Moreover, in Table 5.2 regarding difficult movements to perform, 9 students said that this session had movements that were difficult to perform, most of them said scissor jump (7), bending (1) and star jump (1) is difficult to perform. In addition, in Table 5.1 regarding difficult images to understand, two students stated that the images on the module used in Session 2 were difficult to understand.

Muscle Endurance (Activity 3)

For the last activity, which involves muscle endurance, the last session had the lowest average of 2,85 based on Table 5.2 concerning difficult movements. As many as six students mentioned that the movement in Session 4 (squat jump) and one (up and down bench) was difficult to perform. In addition, based on Table 5.1, two students said that the images session 4 (squat jump) were difficult to understand.

5.4 Summary

This chapter has explained all findings obtained from data collection and analysis. The writing of the results follows each research question. Overall, before the intervention, or in a traditional class, students said that there are two types of environments for them to learn PE: the first is learning the activities theoretically in the classroom, then the next is practicing it outside the classroom or outdoors. When learning in the classroom, they usually use textbooks and some use tablets, to access YouTube and the videos are also shown several times by the teacher using the projector or TV screen in the classroom. When learning PE in class, some students feel bored and sleepy due to the use of textbooks. In addition, most students have problems understanding the pictures in the textbook as they do not know how to make movements by only referring to the pictures. Often, they depend on the teachers to demonstrate the movements in the textbook. From the teacher's side, they also explained some difficulties in teaching PE in the classroom, namely students who do not understand the pictures, have difficulty catching and understanding the instructions and also fewer students to perform the movement or activity. The use of technology and tools in the classroom is also limited because the use of YouTube videos requires Internet access, and not all classes have adequate Internet connections.

However, the study's findings highlight the significant benefits and challenges of using AR technology in PE classrooms for dyslexic students. Cognitive Load Theory (CLT) and Mayer’s Principles of Multimedia Learning effectively enhance students' focus, engagement, and understanding of content, making the learning process more interesting and satisfying. Dyslexic students reported positive experiences with AR, finding it fun, engaging, and supportive in aiding comprehension and independent learning. The 3D animations and user-friendly interface of the AR module further facilitated understanding and ease of use. However, barriers such as complex visuals, conceptual difficulties, device compatibility issues, and technical problems with the app were identified. Teachers recognized the benefits of AR in capturing attention, supporting instruction, and providing visual clarity but also pointed out the need for improved app performance and additional training. Despite these challenges, teachers saw potential in expanding AR's application across subjects and integrating it into a multisensory learning approach to enhance student engagement and hands-on learning experiences.

CHAPTER 6

DISCUSSION

6.1 Introduction

This research was conducted to explore the use of augmented modules as an assisting tool in PE classrooms for dyslexic students. The augmented module is a PE module integrated with AR technology. This module contains exercise activities adapted from a PE textbook for special education. AR technology appeared when the students opened the camera in the AR application on the Android device and pointed it at the image in the module. In general PE textbooks, there were many images containing demonstration movements. After being directed at the image, a 3D animation appeared that demonstrated the relevant movement. The previous chapter discussed the results of data analysis. In contrast, this chapter explains more about the findings of the analysis, the research contribution and implication, recommendations for further research, and provides its conclusion.

6.2 Discussion of the findings

This chapter discusses the results obtained from data analysis based on each research question. Each finding is complemented by a discussion of previous research and related theories.

6.2.1 Research Question 1

This first section aims to answer the first research question: "How are the Cognitive Load Theory (CLT) and Mayer's Principles of Multimedia Learning applied in the design of PE learning and the augmented module for dyslexic students?" According to Sweller et al. (1998), the CLT theory assumes an effectively limitless long-term memory that stores schemas with varying degrees of automation, as well as a limited capacity working memory with partially autonomous subcomponents to deal with auditory/verbal material and visual/2- or 3-dimensional information. The goal of CLT was to offer recommendations for how information should be presented so that the learners could engage in activities that would help them maximize their intellectual capacity. On the other hand, it is known that dyslexic students have major problems in reading, such as remembering words, skipping words while reading, difficulty in writing, detecting letters b and d, p and q, numbers 6 and 9 in reverse, as well as the mixed perception of letters and numbers in words (Tırıl & Okumuş, 2022).

Meanwhile, according to Fletcher and Tobias (2005), multimedia principles state that people learn more effectively when exposed to words and images. It means that people learn best when presented with a combination of visuals and words instead of focusing on a single medium, instructional designers should combine words (text or narration) with visuals (pictures, animations, or videos). Information presented in a variety of formats will help learners in better information processing and integration (Mayer, 2014a). The goals of this theory are to better understand how individuals learn from words and visuals, as well as to develop multimedia instruction that enhances learning (Mayer, 2014a).

However, when learning at school, the students were still required to use textbooks as the main learning tool and read the book to understand the movements in the pictures that they would later try to perform as a physical activity. Meanwhile, cognitive overload occurs when a learner is overwhelmed by a combination of intrinsic, external, and germane loads (Debue & van de Leemput, 2014). From the data obtained, all students and teachers said they still use textbooks in learning PE in the classroom to refer to the topics. This is a gap found in the way of learning in PE classes.

The application of Cognitive Load Theory (CLT) and Mayer's Principles of Multimedia Learning in the augmented module for dyslexic students in PE classrooms was strategically utilized to optimize germane load, manage intrinsic load, and reduce extrinsic load. These principles were essential in enhancing students' learning experiences and overcoming the unique challenges faced by dyslexic learners.

Optimization of Germane Load

To optimize germane load, the researcher employed multimedia principles that include presenting information through both words and pictures. This is grounded in Mayer's Multimedia Principle, which suggests that people learn better from a combination of words and pictures than from words alone (Mayer, 2009). The augmented module incorporated animations alongside text, allowing students to better visualize and understand physical movements. For instance, S10 reported, *"I can understand it because it has movement on it"* and S11 also reported *"When I see it on paper and see it on the AR, I just realized how the real movement should I do. So, the movements are different from the paper."* These responses indicate that the multimedia elements helped deepen students' cognitive processing and enhanced their comprehension of complex physical activities. Recent research supports the efficacy of multimedia learning, showing that the integration of visuals and text can significantly improve comprehension and retention (Plass et al., 2020; Fiorella & Mayer, 2018).

Management of Intrinsic Load

Intrinsic load basically concentrates on the material's inherent complexity, regardless of how it is taught or acquired (Mehrotra & Gunalakshmi, 2020). To manage intrinsic load, the researcher implemented the Pre-training Principle, which involves providing students with preliminary information to help them understand the core material more effectively. This was crucial in preparing students to handle the inherent complexity of the PE content. By familiarizing students with key concepts and movements beforehand, the module reduced the initial cognitive burden, allowing students to focus more on the learning tasks.

For example, S11 expressed that signaling principles, such as the use of bold text to highlight important information, were beneficial: *"Yes, I think it is necessary because bold text draws my attention when I read. When I see then I can directly focus on the bold text."* The effectiveness of pre-training in reducing cognitive load and improving learning outcomes has been demonstrated in several recent studies (Lee & Mayer, 2018; Scheiter et al., 2020). These findings are also supported by Mayer (2014b), who stated that pre-training supports students to focus on the causal connections in the multimedia explanation since they already know the names and characteristics of the key segments.

Reduction of Extrinsic Load

Extrinsic load refers to how information is delivered and how simple or difficult it is for a certain learner to process it (Mehrotra & Gunalakshmi, 2020). This, unlike the intrinsic load, is controllable. Extraneous cognitive load is an unnecessary cognitive load that can be altered by educational interventions (Orru & Longo, 2019). The reduction of extrinsic load was addressed through several principles: coherence, signaling, redundancy, and spatial contiguity.

a. Coherence Principle: According to Mayer (2014a) coherence principle is that people learn better when unnecessary material is eliminated rather than included. This principle advises against including extraneous material that does not support learning (Mayer, 2009). The augmented module was designed to present information succinctly and clearly, avoiding unnecessary details that could distract students. Students noted that the module was more engaging and easier to follow, with feedback like S13 reported *"Yes, it is more interesting"* and S17 *"Because it looks neater."*. Research by Chandler and Sweller (2020) supports the importance of minimizing extraneous information to avoid overloading students' cognitive capacity.

   This is in line with Mayer's (2009) coherence principle, which has three complementary forms: (1) learning is enhanced when interesting but irrelevant pictures and words are removed from a multimedia presentation; (2) learning is improved when music and sounds that are interesting but irrelevant are removed from a multimedia presentation; and (3) learning is enhanced when unnecessary words and symbols are removed from a multimedia presentation. When all of the complementary forms were applied, the extraneous load was reduced, thus creating effective learning.

b. Signaling Principle: According to Mayer (2014a), the signaling principle is applied when cues are included to emphasize how the key information is arranged. This principle involves highlighting essential information to guide learners' attention. Cerveny and LaCotti (2003) define highlighting as a teaching approach that involves emphasizing the main concepts and illustrative details to assist students in improving the structure of their reading. The use of bold text and clear markers in the module helped students identify key points quickly, as noted by S17: *"It uses bold text because it has important information so we can be aware of important information"* and S4 *"Yes, it is necessary because it helps to differentiate."*

    This results in line with Macaya and Perea, (2014) research findings, it was demonstrated that people respond quicker to bold texts than to plain words. Evidence from a study by de Koning et al. (2020) indicates that signaling can effectively direct attention and improve learning outcomes. This is also supported by Tante and Sass's (2023) research used a highlighting strategy for reading comprehension instruction, which was proven to positively affect students' development of reading comprehension skimming subskills. The results also showed that using highlighting techniques to teach reading helps students become proficient in scanning subskills, which enhances their reading ability.

c. Redundancy Principle: According to Sweller et al. (1998), numerous sources of information are self-contained and can be used independently of one another, resulting in the redundancy effect. Repetitive on-screen text in multimedia presentations has the potential to overload the visual channel (Clark and Mayer, 2008) due to the fact that the image enters the pupil's visual perception channel through the eyes and is processed there. According to this principle, redundant information should be avoided as it can overwhelm learners (Mayer, 2009). The module effectively balanced text and visuals, ensuring that both were necessary and supportive of each other. S5 appreciated the concise presentation, saying, *"It is easy to understand because it has less text"* and S13 *"Because it has images and text."* A study by Zander et al. (2019) highlights the detrimental effects of redundant information on cognitive load and learning efficiency.

These findings are in line with Young et al. (2015) research who found that, compared to students who did not receive redundant instructional design, those who received redundant material required a longer reaction time. This is a very visible effect when doing the observations. When the students opened the module and started looking at the first image on that day's topic, they seemed confused about what kind of movement they should do to make it look like the one in the image. However, when they started using AR by pointing the camera at the application and then 3D animation appeared, they looked amazed and immediately understood the movements that they previously felt confused about.

d. Spatial Contiguity Principle: This principle emphasizes presenting corresponding words and pictures close together (Mayer, 2009; Mayer, 2014a). The augmented module adhered to this principle by integrating text and animations in a cohesive manner, making it easier for students to correlate the two and understand the material. Feedback from S16 such as *“The text is clearer to see because it has differences, and the colors are contrasting to each other”* highlights the effectiveness of this approach. Thus, the implementation of this principle was proven to help students read and integrate information in the form of images and text. Research by Zhu et al. (2018) shows that spatial contiguity can significantly enhance learning by reducing the cognitive effort required to integrate information from separate sources.

Seraji et al. (2020) research findings showed that the mean achievement scores increased considerably when multimedia content was presented with text in image adjacency. It happened because, during learning, spatial continuity facilitates the successful integration of words and pictures and stimulates more attempts to do so, which can lead to significant learning results (Johnson & Mayer, 2012). As demonstrated by Mayer and Moreno (2002) and consistent with the findings of this study, people learn more thoroughly and efficiently when text is positioned on a screen in close proximity to the corresponding image, both in terms of location and physical position.

The combined application of these principles resulted in high levels of student satisfaction and improved learning outcomes. Students reported that the module was visually appealing and easy to use, which facilitated better engagement and understanding. Comments like *"The colors are pretty, nice, so it doesn't make people confused" (S2)* and *"Yes, it is easy" (S13)* indicate that the design effectively met their needs and preferences. This aligns with findings from a study by Roscoe et al. (2020), which demonstrated that well-designed multimedia educational tools can enhance student engagement and learning effectiveness. In conclusion, the strategic application of Mayer's Principles of Multimedia Learning and CLT in the augmented module significantly supported dyslexic students in PE classrooms. By optimizing germane load, managing intrinsic load, and reducing extrinsic load, the module enhanced focus, interest, clarity, and overall learning satisfaction, demonstrating the importance of well-designed multimedia learning tools for dyslexic students.

6.2.2 Research Question 2

The findings for RQ 2, which explore dyslexic students' learning experiences when using an augmented module as an assistive learning tool in PE classrooms, demonstrate several key benefits and areas of impact. The themes identified include engagement and positive feedback, interest in the future use of AR, novelty of the AR experience, and the utility and support provided by AR.

Firstly, the use of AR significantly enhances student engagement and elicits positive feedback. Students reported enjoying the use of AR and finding it fun and interesting. In line with these findings, Kim and Yoon (2021) stated that physical tools like media and learning applications are made with the intention of facilitating and enhancing learning. By given its ability to increase their interest in learning, particularly in the classroom, this media and technology application has a significant impact on instructors and students (Puhka et al., 2023). According to Kim et al. (2018) and Savela et al. (2020), technology has the power to change monotonous and uninteresting learning instructions into an exciting and engaging environment, which eventually improves student performance (Akçayır & Akçayır, 2017; Squires, 2017). On the other hand, Di Serio, Ibáñez, and Kloos (2018), research found that AR could enhance student motivation and engagement by making learning more interactive and enjoyable. The dynamic and interactive elements of AR captured students' attention and sustained their interest, supporting the idea that engaging multimedia elements can foster a deeper connection with the learning material (Radu, 2018).

Secondly, the study reveals a sustained interest in the future use of AR, with students expressing curiosity and enthusiasm about continuing to use AR for learning. This is consistent with the work of Garzón, Pavón, and Baldiris (2019), who found that AR could stimulate ongoing interest and curiosity in learners by providing novel and immersive learning experiences. Students suggested using AR for other subjects and appreciated its ease of use and ability to present information clearly and effectively. The novelty of the AR experience also played a significant role in students' positive reception. Many students had not previously used AR in their learning, which made the experience unique and intriguing. This novelty factor is crucial in educational settings, as it can break the monotony of traditional learning methods and introduce new ways of interaction and engagement (Cheng & Tsai, 2020).

Lastly, the utility and support provided by AR were evident in how students perceived its role in aiding their understanding and facilitating independent learning. AR's ability to provide clear, visual representations of movements and concepts was particularly beneficial for dyslexic students, who often struggle with traditional text-based instructions. This feature has also assisted students in learning complicated aspects of the subjects covered (Milgram, 2012). A previous study by Gnidovec et al. (2020) on AR-based instructional materials also proved that they assisted students in understanding the complexities of the human circulatory system. During their learning, students enjoyed the class and said that they were excited. In addition, they absorbed the information well from both sources. This was confirmed by the results of the students' movement abilities in Table 5.11, which shows the test results before and after the intervention

This finding also aligns with Mayer's principles of multimedia learning, which emphasize the importance of using multiple representations to enhance understanding (Mayer, 2020). Meanwhile according to Chandler and Sweller (1991), in understanding the learning topic, students may be required to analyze multiple sources of information at the same time, which will usually result in inefficient information acquisition. Additionally, AR's support for independent learning empowers students to learn at their own pace and revisit concepts as needed, aligning with the findings of Ibáñez and Delgado-Kloos (2018) regarding the benefits of AR in promoting self-directed learning.

In the context of exploring students' learning experiences after physical education learning in class using AR applications, the findings show that AR technology has a positive impact on students' engagement, motivation, and understanding of physical activity. In this respect, these findings support and differ from Rogers' (2010) statement that SpLD have deficits in motor or perceptual skills, thereby affecting their performance in various domains (visual, auditory, kinesthetic, tactile). Talking about motor and perceptual skills improvement, findings from this research show that the AR app's 3D animations helped students understand movements better than pictures in textbooks, improving their kinesthetic and visual skills. This aligns with the idea that SpLD students have deficiencies in these areas and benefit from enhanced visual and kinesthetic aids. Research by Smith and Harvey (2018) indicates that using multimedia tools in PE can significantly enhance motor skills in SpLD students by providing clear visual and kinesthetic cues, supporting Rogers' assertion that these students require additional support in these domains.

Then regarding increased engagement and interest, findings from this research showed that the use of AR technology increased students' engagement and interest in learning activities, which can be attributed to the multisensory approach addressing their perceptual deficiencies. According to a study by Johnson et al. (2021), AR and VR technologies can significantly improve engagement and motivation among SpLD students by providing interactive and immersive learning experiences that cater to their unique needs, thereby supporting Rogers' (2010) statement.

Meanwhile, there are several different results from Roger's (2010) research. First is regarding minimal auditory enhancement. Findings from this study indicate that AR apps primarily focus on visual and kinesthetic enhancement, with little emphasis on auditory support. This suggests that although the technology effectively addresses visual and kinesthetic deficits, it may not fully support the development of auditory skills as outlined by Rogers (2010). Research by Patel and Singh (2019) highlights the need for auditory elements in educational tools for SpLD, suggesting that AR technology must incorporate more auditory features to comprehensively support all perceptual domains.

Second is about individual variability. Some students showed more significant improvement than others, indicating variability in how SpLDs responded to AR technology. This suggests that although AR can be beneficial, it may not be able to address motor and perception impairments uniformly as suggested by Rogers (2010). A study by Lin and Chen (2020) emphasized that SpLDs demonstrate diverse student needs and responses to educational interventions, thus highlighting the need for personalized approaches. This suggests that although AR technology supports Rogers' general statements, the variability in student responses suggests that a more nuanced understanding is needed.

In conclusion, the use of AR in PE classrooms for dyslexic students significantly enhances engagement, sustains interest, introduces novel learning experiences, and provides substantial utility and support. These findings underscore the potential of AR to transform educational practices by making learning more interactive, engaging, and effective for diverse learners.

6.2.3 Research Question 3

a) Factors that support the learning process of dyslexic students

The findings for RQ 3(a), which explore how the AR app and module learning content support the learning process of dyslexic students in PE classrooms, highlight the significant role of enhanced visualization through 3D animations and the user-friendly interface of the AR app. These aspects contribute to an improved understanding of movements and concepts, making learning more accessible and effective for dyslexic students. This is in line with the study by Anggara et al. (2021), who found that using technology in the classroom, such as AR technology, has improved students' understanding and learning. This is also supported by the finding of Yangin (2023), which also showed that AR has increased student motivation and understanding. In addition to supporting learning, understanding and retention, AR has also motivated the learners (Cipresso et al., 2018).

Enhanced visualization through 3D animations emerged as a critical factor in supporting dyslexic students' learning. Students reported that the movement-based visualizations provided by AR helped them to understand how to perform physical exercises more accurately than static images in textbooks. According to Islim & Cagiltay (2014), when it comes to VR and AR tools, 3D animation can be used as a dynamic way of creating visual material. Studies by Garzón, Pavón, and Baldiris (2019) and Bacca et al. (2018) support these findings, demonstrating that AR’s dynamic and interactive nature significantly improves comprehension and retention of complex information by providing clear and immediate visual feedback.

According to Liarokapis and Anderson (2016), overall, due to the realistic 3D models on the AR app, the visualization experience was highly beneficial and can be rated as excellent. Instructional materials with animated-based practical examples created with AR technology enhanced students' interest and motivation in the subject, and their application in classes that include teaching problem-solving abilities can be utilized in future studies (Cevahir et al., 2022).

The user-friendly interface of the AR app also played a crucial role in facilitating the learning process. Students found the AR app easy to navigate and use, which reduced cognitive load and allowed them to focus on the learning content rather than the tool itself. This ease of use is crucial for dyslexic students, who may struggle with more complex interfaces (Chen et al., 2020). The design of the AR app aligns with the pre-training principle of cognitive load theory, which emphasizes the importance of familiarizing learners with the interface and basic concepts before introducing complex tasks (Sweller, Ayres, & Kalyuga, 2019).

Furthermore, the findings indicate that AR technology's ability to provide direct visualization and enhanced clarity significantly aids dyslexic students in understanding and performing movements. This aligns with Mayer's (2020) principles of multimedia learning, specifically the modality and multimedia principles, which suggest that presenting information through multiple modalities (visual and auditory) can enhance learning. The spatial contiguity and signaling principles of multimedia learning, which suggest that information should be presented close together in time and space, are evident in how the AR app integrates text and animations seamlessly (Mayer, 2020). This integration helps students see the immediate application of instructions, thereby reducing the extraneous cognitive load associated with trying to mentally connect separate pieces of information (Wang et al., 2021). This is in line with Hughes et al. (2019) research stating that this is not the only technique to teach, but is the most successful method for teaching skills to children that require more help and direction, clarity, feedback, and practice.

In a broader context, these findings are supported by recent research highlighting the effectiveness of AR in educational settings. For instance, Cheng and Tsai (2020) found that AR applications significantly improve learning outcomes by providing immersive and interactive learning experiences that cater to diverse learning needs. Similarly, Ibáñez and Delgado-Kloos (2018) emphasize that AR can transform traditional educational practices by making learning more engaging and accessible, particularly for students with learning disabilities. On the other hand, from the interviews and observations, it was also seen that the use of AR in PE learning has facilitated and enabled students to learn independently. These findings have also supported that of Valladares Ríos et al. (2023) research, stating that adding immersive technology such as virtual and AR technology improves self-learning by encouraging active student engagement and meaningful learning experiences.

In conclusion, the use of AR in PE classrooms provides substantial support for dyslexic students by offering enhanced visualization through 3D animations and a user-friendly interface. These features align with key principles of multimedia learning and cognitive load theory, ensuring that learning is both effective and accessible. The positive impact of AR on dyslexic students' learning experiences underscores its potential as a valuable tool in inclusive education, capable of meeting the diverse needs of all learners.

b) Barriers to using AR technology in PE classrooms for dyslexic students

The findings of RQ 3(b), which explore the barriers to using AR technology in PE classrooms for dyslexic students, reveal significant challenges related to content comprehension, device compatibility, and technical issues with the AR app. These barriers highlight the complexities involved in integrating AR technology effectively into educational settings, particularly for students with specific learning needs.

Content comprehension challenges were a major barrier identified by dyslexic students. They reported difficulties in understanding complex visuals and executing certain movements, such as the squat jump and scissors jump. These challenges can be linked to the intrinsic cognitive load associated with processing and understanding complex information (Sweller, Ayres, & Kalyuga, 2019). The cognitive load theory suggests that when learners encounter complex or unfamiliar tasks, their cognitive resources are heavily taxed, leading to difficulties in comprehension (Chen & Huang, 2020). Studies by Chen, Wang, and Yu (2020) and Lin et al. (2018) have similarly found that AR's effectiveness can be hindered by the complexity of visual content, which may overwhelm students, especially those with learning disabilities.

On the other hand, this also happens because students' perspectives when viewing 3D animation are different, because users can see the animation 350 degrees depending on the angle, they see it from.

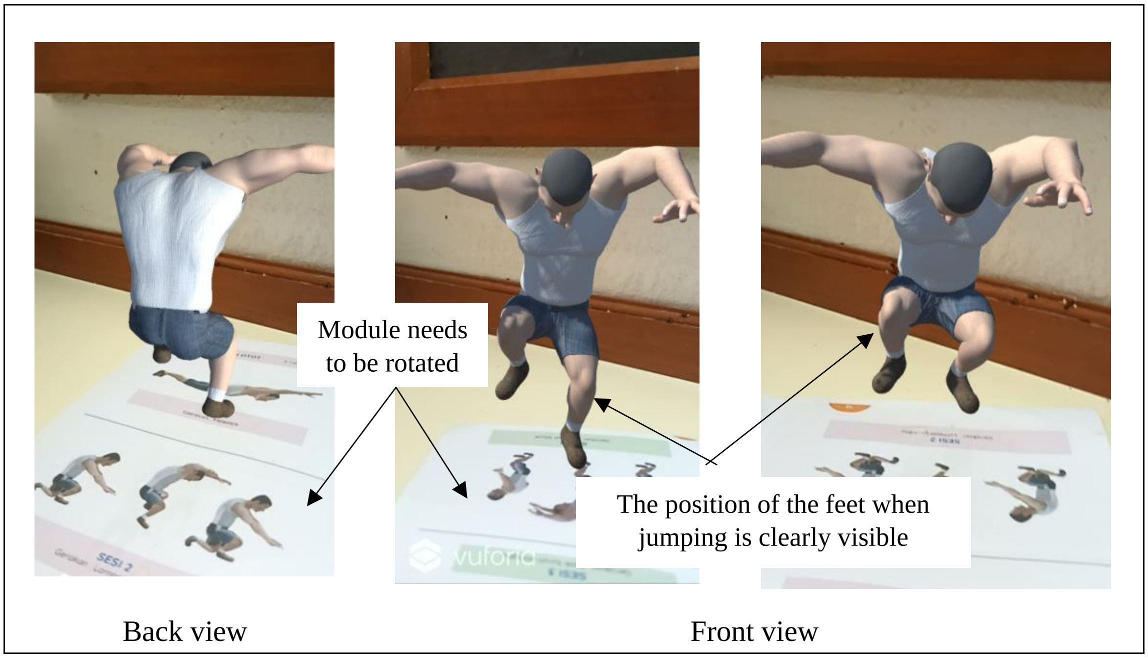


Figure 6. 1 3D animation perspectives

During the movement ability test, it was also observed that the students were confused about several jumping movements when performing them. When the teachers asked why they got confused when doing the exercise, they responded that the animation depicted an indistinct area of the leg, which they found ambiguous. In contrast, looking back over the application, the 3D animation provided a reasonably clear demonstration. This can be seen in Figure 6.1, where the position of the feet when jumping was clearly visible. However, students have to rotate the book so they can see the 3D animation from the front perspective. If they do not rotate it, the animation will automatically appear and be visible from the avatar's back perspective, which makes it unclear.

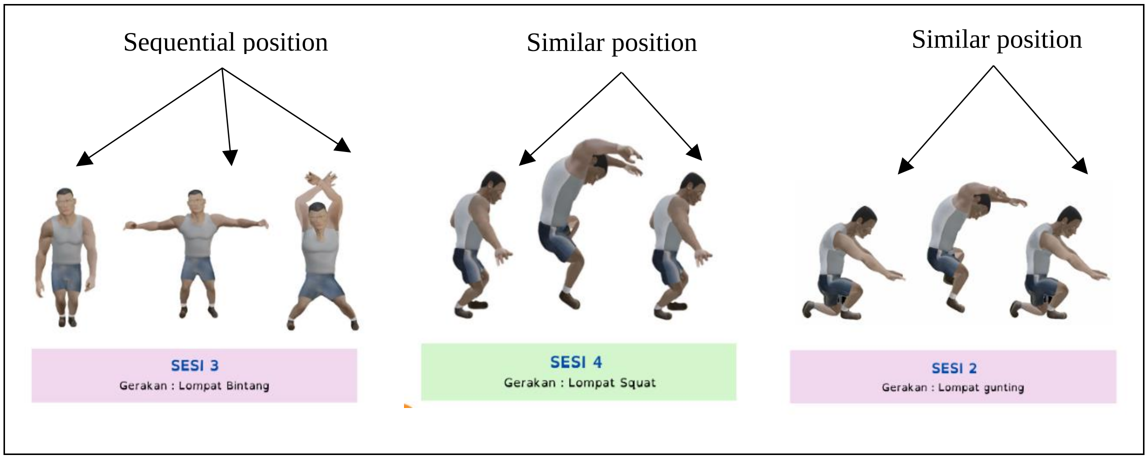


Figure 6. 2 Jumping movements

On the other hand, students said that movements such as squat jump and scissor jump had confusing images because, according to them, they were not the same as those in the animation. However, based on the observations, this might make students confused because among the other pictures, these two pictures have three repetitions of the avatars. There was one more picture, the star jump, which had three repetitions of the avatars, but students did not have a problem with it. This is because they are familiar with this movement, and between one avatar and another, it has a continuous sequence of movements. As shown in Figure 6.2, different from the star jump, the scissor jump and squat jump have the same avatar position between the first and the last. This confused the students because when three avatars were combined in one frame, they did not form a continuous sequence of movements.

Meanwhile, device compatibility issues also posted significant barriers, as students reported that the AR app performed differently across various devices. For instance, the app was clear on phones but lagged on tablets. This inconsistency can disrupt the learning process, causing frustration and disengagement among students. The effectiveness of AR is heavily dependent on the hardware it runs on, and device compatibility is a known issue in AR applications (Garzón, Pavón, & Baldiris, 2019). This barrier highlights the need for standardized technological infrastructure in schools to ensure equitable access to AR tools (Ibáñez & Delgado-Kloos, 2018). Technical issues with the AR app, such as animation clarity problems, lagging performance, and difficulties with image scanning, were also significant barriers. These technical problems can increase the extraneous cognitive load, which distracts students from the learning task and reduces the overall efficacy of the AR tool (Mayer, 2020). The signaling principle of multimedia learning suggests that clear and precise visual cues are essential for effective learning (Wang et al., 2021). When these cues are unclear or the app lags, students may struggle to follow along, reducing the educational benefits of AR. Research by Cheng and Tsai (2020) supports these findings, indicating that technical reliability is crucial for the successful implementation of AR in educational contexts.

In conclusion, while AR technology holds significant promises for enhancing learning for dyslexic students, several barriers must be addressed to realize its full potential. Content comprehension challenges, device compatibility issues, and technical problems with the AR app can hinder its effectiveness. Addressing these barriers requires a comprehensive approach, including simplifying visual content, ensuring device compatibility, and improving the technical reliability of AR applications. These steps are essential to leverage AR's benefits and provide an inclusive and effective learning environment for all students.

6.2.4 Research Question 4

The findings of RQ 4, which explores teachers' perspectives on the use of augmented modules as assistive learning tools for dyslexic students in PE classrooms, reveal both significant benefits and notable challenges. Teachers identified several advantages of AR, including cognitive engagement, instructional support, usability and accessibility, and visual and conceptual clarity. However, they also highlighted challenges such as app performance problems, scanning difficulties, and the need for additional training. Furthermore, teachers expressed optimism about the future potential of AR in education and showed a preference for AR learning tools over traditional methods.

Teachers noted that AR significantly enhances cognitive engagement by capturing students' attention and increasing their interest in learning activities. The dynamic and interactive elements of AR, along with its integration of technology, were particularly effective in meeting students' needs and sustaining their interest. This finding aligns with previous research, which indicates that AR can effectively capture attention and increase motivation among students (Ibáñez & Delgado-Kloos, 2018; Cheng & Tsai, 2020). Additionally, the ability of AR to provide direct visualization and enhanced clarity helps dyslexic students understand complex movements better, thereby improving their overall learning outcomes. Teachers reported that students could follow the precise movements depicted in AR animations, which aligns with Mayer's multimedia learning principles that emphasize the importance of clear visual representations in reducing cognitive load and facilitating learning (Mayer, 2020).

However, the implementation of AR also faces significant barriers. Teachers pointed out issues with app performance, including lagging and difficulties in scanning images, which can hinder the learning process. These technical challenges are consistent with findings from other studies that highlight the need for reliable and user-friendly AR applications to ensure effective learning experiences (Garzón et al., 2019; Chen & Huang, 2020). Moreover, teachers emphasized the necessity of training for both students and educators to use AR effectively. This need for training underscores the importance of providing adequate support and resources to ensure successful integration of AR in educational settings (Ibáñez & Delgado-Kloos, 2018).

Despite these challenges, teachers were optimistic about the future potential of AR in education. They suggested enhancing AR activities, resolving technical bugs, and expanding AR to all subjects, reflecting a broader vision for AR's role in education. This forward-looking perspective aligns with recent literature that advocates for the continued development and integration of AR technologies to enhance educational outcomes across various disciplines (Garzón et al., 2019; Lin et al., 2018).

In summary, while teachers recognize the substantial benefits of using AR modules as assistive learning tools for dyslexic students in PE classrooms, they also acknowledge the challenges that need to be addressed. Technical issues, training requirements, and device compatibility are critical areas that need improvement to maximize the effectiveness of AR in education. The positive perspectives on the future potential of AR and the preference for AR learning tools indicate a promising direction for the future integration of AR in education. Teachers' positive perspectives on AR's potential to enhance learning experiences and improve student engagement underscore its value as a transformative educational tool. By leveraging AR's ability to enhance cognitive engagement through attention capture and interactive elements, educators can cater to diverse learning needs and preferences, particularly benefiting dyslexic students in PE classrooms.

Moreover, the emphasis on AR's role in providing direct visualization and clarity aligns with Mayer's principles of multimedia learning, which emphasize the importance of clear, concise visual presentations to support learning (Mayer, 2020). This alignment suggests that AR not only captures attention but also aids in reducing cognitive load by presenting information in ways that are easier for students to understand and retain. However, addressing the identified challenges is crucial for realizing AR's full potential in education. Issues such as app performance problems and scanning difficulties highlight the need for ongoing technological advancements and improvements in AR applications (Garzón et al., 2019; Chen & Huang, 2020). Additionally, the necessity of training for both students and teachers underscores the importance of professional development to effectively integrate AR into curriculum and instructional practices (Ibáñez & Delgado-Kloos, 2018).

Looking forward, the recommendations to enhance AR activities, resolve technical bugs, and expand AR across all subjects reflect a proactive approach towards leveraging technology for educational advancement (Lin et al., 2018). This forward-thinking perspective not only supports the integration of innovative learning tools but also encourages continuous improvement and adaptation to meet evolving educational needs. In conclusion, while challenges exist, the findings underscore the promising role of AR in enhancing educational experiences for dyslexic students in PE classrooms. By addressing technical issues, providing adequate training, and exploring broader applications, educators can harness AR's potential to foster engaging, effective, and inclusive learning environments.

Overall, the results of this study are consistent with earlier research on the effectiveness of augmented reality (AR) for dyslexic students. Recent research has demonstrated that AR can considerably improve the learning experience of dyslexic children by offering interactive and visually appealing content, hence overcoming the challenges associated with traditional text-based techniques. For example, applications like the ARLexic game have been created to help dyslexic youngsters improve their reading and writing skills by providing an immersive and supportive learning environment that promotes engagement and learning results (Garzón et al., 2019; Gupta et al., 2021).

From the perspective of dyslexic students, these augmented reality technology not only make learning easier, but also more enjoyable. According to the study's findings, the ability to visualize complex concepts in 3D improves students' comprehension of abstract or difficult-to-understand issues. This is especially significant in areas such as physical education, where understanding movements and spatial concepts are essential. AR reduces cognitive load and makes learning more intuitive by delivering a holistic learning experience, corroborating the good effects found in earlier studies (Guillen-Sanz et al., 2022; Köse and Güner-Yildiz, 2021). These findings highlight AR's potential as a revolutionary tool in special education, particularly for dyslexic students, by providing personalized support that targets their specific learning requirements and obstacles.

6.3 Summary

This chapter contains a discussion of the findings obtained in this research and their relationship to previous research. The discussion is divided and discussed following the order of the research questions. This research addressed the gap in learning methodologies for dyslexic students in PE classes, focusing on the use of augmented reality (AR) technology as an assistive tool. By employing AR to visualize textbook images, the study aimed to explore the use of this new assistive tool among dyslexic students. The findings revealed that AR technology significantly improved students' learning experiences, motivation, and movement abilities. Teachers also found AR to be a valuable addition to traditional teaching tools, making lessons more interactive and easier to comprehend.

CHAPTER 7

CONCLUSION

7.1 Overview of Findings

In response to the research questions, the following key findings are presented from the study on augmented reality (AR) as an assistive learning tool for dyslexic students in physical education (PE) classrooms:

1. The use of Theoretical Frameworks: The integration of Mayer's Multimedia Learning Principles and Cognitive Load Theory (CLT) have been successfully included into the AR module. This module reduces cognitive overload and enhances comprehension through the use of clear 3D animations and well-structured text. These concepts promote better focus and retention, making learning more accessible to dyslexic students.
2. Student Learning Experiences: Dyslexic students report that the AR module helped them learn effectively. The dynamic and engaging quality of the AR information allows for better comprehension and performance of physical activities. The module reduces frustration while increasing enjoyment, resulting in greater engagement and satisfaction.
3. Learning Process Support: The AR app and module learning material considerably enhance the learning process by delivering dynamic visualizations and interactive components that are tailored to the needs of students. The design aids in

simplifying complicated topics, providing personalized learning opportunities, and enhancing overall comprehension and application of PE content.

4. Implementation Barriers: While the results of this study suggest that AR technology has many benefits, it does face significant challenges. Key barriers include equipment limitations, technology issues, and the requirement for training prior to use. Furthermore, ensuring that AR content is fully available to all students is critical to more effective future adoption of the technology.
5. Teacher Perspectives: AR modules were generally viewed positively by teachers, who saw the potential to increase engagement and understanding in PE classes for dyslexic students. However, they highlighted issues such as the importance of training, device availability, and accessible content design. Addressing these challenges is critical to making the most of AR technology.

In conclusion, this study demonstrates that augmented reality technology is very promising as an assistive tool for dyslexic children in PE lessons. Although AR modules provide numerous advantages in terms of improving the learning experience and aiding the educational process, overcoming constraints relating to technology, training, and accessibility is crucial to successful deployment and eventual widespread acceptance.

7.2 Implications of This Study

This research aims to explore the use of augmented modules in PE classes, as assisting tools for dyslexic students. There are two implications of this study which:

a) Theoretical Implications

This study provides significant theoretical contributions to the fields of educational technology and special education, particularly through the lens of Cognitive Load Theory (CLT) and Mayer's principles of multimedia learning.

I. Validation of Cognitive Load Theory (CLT):

The findings affirm that optimizing germane load through multimedia principles can enhance the learning experiences of dyslexic students. By integrating 3D animations, the study reduced the intrinsic cognitive load, making it easier for students to understand and perform physical education activities.

The study supports the pre-training principle by showing that providing students with prior knowledge through interactive AR can manage intrinsic cognitive load effectively. This approach ensures that students are better prepared to engage with the learning material.

The coherence, signaling, redundancy, and spatial contiguity principles were instrumental in reducing extraneous cognitive load. The augmented modules presented information in a clear, concise, and logically structured manner, which minimized distractions and focused students' attention on essential content.

II. Support for Mayer’s Principles of Multimedia Learning:

The use of AR technology aligns with Mayer's principles, particularly the principles of multimedia, modality, and personalization. These principles helped create an engaging learning environment that catered to the unique needs of dyslexic students, enhancing their comprehension and retention of information.

The study demonstrates that multimedia learning principles can be effectively applied to special education, providing a framework for developing instructional materials that accommodate diverse learning abilities.

b) Practical Implications

The practical implications of this study are relevant for educators, policymakers, and technology developers aiming to improve educational outcomes for students with dyslexia through the use of AR technology.

I. Enhanced Educational Practices:

The integration of AR in PE classes provided an innovative approach to teaching, making lessons more interactive and engaging. Teachers reported that AR helped them demonstrate physical movements more effectively, which improved students' understanding and performance.

The positive student feedback highlights the potential of AR to transform traditional learning environments, suggesting that schools should adopt similar technologies to support students with learning disabilities. This approach can be extended to other subjects, providing a comprehensive solution for inclusive education.

II. Policy and Infrastructure Development

The study underscores the need for educational institutions to invest in AR technology and related training for teachers. Ensuring that educators are proficient in using AR tools will maximize the technology's benefits and enhance its integration into the curriculum.

Policymakers should consider developing standardized AR applications that are compatible with various devices, ensuring broader accessibility. Collaboration with technology developers to create user-friendly and reliable AR applications can address the technical challenges identified in the study.

The government and educational bodies should explore the possibility of integrating AR technology into national textbooks. This would provide a consistent and effective tool for students across different regions, ensuring equal access to innovative learning resources.

In conclusion, the study's implications highlight the importance of leveraging theoretical frameworks like CLT and multimedia learning principles to develop effective educational tools. Practically, the successful implementation of AR technology in PE classes for dyslexic students sets a precedent for its broader application, advocating for investment in technology and training to enhance inclusive education.

7.3 Recommendation Future Research

In light of the findings from this study on the efficacy of augmented reality (AR) as an assistive tool for dyslexic students in physical education classes, several critical recommendations for future research emerge. These recommendations aim to further enhance the integration and effectiveness of AR technology in educational settings, particularly for students with learning disabilities. By addressing issues of long-term impact, technological compatibility, curriculum integration, instructional design principles, inclusive practices, ethical considerations, and teacher training, future research can significantly contribute to optimizing AR's potential as a transformative educational tool.

I. Longitudinal Studies and Extended Interventions

Conduct longitudinal studies to assess the long-term impact of augmented reality (AR) interventions on dyslexic students' learning outcomes and motivation over an extended period. This would help understand whether the initial positive effects observed in short-term interventions persist or change over time. Investigating factors that may influence sustained interest and engagement, such as novelty effects or adaptation to technology, could provide valuable insights for educators and researchers.

II. Customized AR Application Development

Future research should focus on developing AR applications that are compatible with various operating systems and devices commonly used in educational settings. This includes ensuring compatibility with school policies on device usage and exploring options for home-based learning where students can utilize AR tools independently. Collaboration with technology developers and educational institutions can facilitate the creation of user-friendly AR applications tailored to the specific needs of dyslexic students.

III. Integration of AR in Educational Curriculum

Advocate for the integration of AR-enhanced textbooks and learning materials into educational curricula, potentially through partnerships with government bodies and educational publishers. By embedding AR technology directly into educational resources, students can access interactive content that enhances comprehension and engagement beyond traditional methods. This initiative can also promote digital literacy and innovation in education.

IV. Application of Cognitive Load Theory and Multimedia Learning Principles

Further explore the application of Cognitive Load Theory (CLT) and principles of multimedia learning in designing educational content for dyslexic students. Future research can refine instructional strategies based on these theories to optimize learning experiences, reduce cognitive load, and improve information retention. Tailoring AR content to align with CLT guidelines ensures that educational materials are accessible and effective for diverse learning needs.

V. Inclusive Educational Practices

Promote inclusive educational practices by continuing to develop AR applications that cater to diverse learning styles and abilities. Research should emphasize accessibility features, such as audio descriptions, text-to-speech capabilities, and customizable interfaces, to accommodate students with varying levels of dyslexia and other learning disabilities. Collaborations with special education professionals and stakeholders can provide valuable insights into best practices for inclusive AR implementation.

VI. Ethical Considerations and Data Privacy

Address ethical considerations surrounding the use of AR in educational settings, including data privacy, security protocols, and equitable access to technology. Future research should prioritize safeguarding student privacy while leveraging AR technologies to enhance learning experiences. Engaging stakeholders in discussions about responsible technology use can inform policies and practices that protect students and promote ethical educational innovation.

VII. Teacher Training and Professional Development

Invest in teacher training programs that prepare educators to effectively integrate AR technologies into their teaching practices. Providing professional development opportunities on AR applications, pedagogical strategies, and classroom management techniques can empower teachers to harness the full potential of AR for enhancing educational outcomes. Collaborative efforts between educational institutions, technology providers, and professional organizations can support ongoing teacher development in digital learning environments.

By pursuing these avenues for future research, educators, researchers, and policymakers can advance the implementation of AR technologies as valuable tools for supporting dyslexic students in physical education and beyond, fostering inclusive and engaging learning environments.

7.4 Conclusions

This research addresses a significant gap in the educational approach for dyslexic students within physical education (PE) classes, where traditional learning tools such as textbooks pose challenges due to difficulties in reading and interpreting textual information. Dyslexic students often struggle with understanding and visualizing movement instructions from static images in textbooks. Recognizing this issue, the study explores the integration of augmented reality (AR) technology as an assistive tool to enhance learning experiences in PE. By using marker-based AR, students can scan images in their textbooks and view 3D animations of movements like push-ups, facilitating easier comprehension and engagement.

The findings demonstrate that AR modules not only provided a novel and engaging learning experience for dyslexic students but also sparked their curiosity and motivation to explore this new technology. Students reported increased interest in learning PE concepts and improved focus on problem-solving tasks. From the perspective of teachers, integrating AR modules offered a more interactive and effective instructional method compared to traditional tools like textbooks and YouTube videos. Teachers highlighted AR's ability to simplify demonstrations, provide clear visual aids, and maintain the integrity of textbook content, thereby enhancing teaching effectiveness without relying solely on internet-dependent resources.

Furthermore, this research applied cognitive load theory (CLT) and Mayer's multimedia learning principles to design AR modules tailored to dyslexic students' needs. By minimizing cognitive load through clear visual representations and integrating multiple modalities, AR modules effectively supported students' understanding and retention of PE concepts. Teachers noted positive outcomes, with students demonstrating comprehension of instructions and expressing enthusiasm during the learning process. The feedback from students underscored their satisfaction with AR-based learning, highlighting its effectiveness in overcoming learning barriers associated with dyslexia.

Looking ahead, future research should focus on addressing technical challenges and optimizing AR applications to ensure seamless integration into educational settings. Continued development and refinement of AR technologies, coupled with ongoing teacher training, are essential to maximize its potential as an inclusive educational tool.

Ultimately, the study contributes to advancing inclusive education practices by leveraging technology to enhance learning experiences and support diverse learning needs in PE classrooms. .

7.5 Summary

This chapter provides an overview of the findings of this study, implications, recommendations for future research as well as conclusions for this research. It is hoped that this chapter can help the reader to reach the conclusion of this research as a whole clearly and obtain insight into future research.

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APPENDICES

APPENDIX A: STUDENT'S DEMOGRAPHIC FORM

Personal Information	
Name:	Class:

Please circle the most appropriate answer(s) to the following questions

1. Which age range do you belong to?
   a) 13-14 b) 15-16 c)17-18 d) 19-20
2. Do you have your own mobile phone?
   a) Yes b) No
3. How often do you use your mobile phone to study?
   a) Often b) Sometimes c) Rarely d) Never
4. What do you usually use your mobile phone for?
   a) Social media b) Gamming c) Watching on YouTube
   d) Do homework e) other ____________
5. How often do you learn physical education in a week?
   a) 1 time a week b) 2 times a week c) 3 times a week 4) 4 times a week
6. What tools do you usually learn physical education with?
   a) Book b) Video c) Mobile Phone App d) None
7. Are you interested in learning physical education with a mobile phone?
   a) Yes b) No

APPENDIX B: PRE-INTERVIEW GUIDELINE FOR STUDENTS

I am Regania Pasca Rassy, a Ph.D student from the Center for Instructional Technology and Multimedia at the Universiti Sains Malaysia. This interview aims to explore your experience in physical education class dan your learning process when doing physical movements. This interview is going to be audio recorded. All the information and audio recordings will be kept confidential and will be used for academic purposes only. This interview will take approximately 5-10 minutes.

Introduction

Can you briefly introduce yourself?

Questions

1. How does your teacher usually teach PE in class?
2. How do you feel when learning PE in class? Why?
3. Is there anything you don't like about PE? Why?
4. Do you find it easy or hard to understand the textbook in PE class?
5. What do you like about using textbooks in PE class?
6. What do you not like about using textbooks in PE class?
7. Are the pictures in the book clear or confusing? Why?
8. Is it easy or hard to do the sports movements shown in the book? Why?

APPENDIX C: IN DEPTH INTERVIEW GUIDELINE FOR STUDENTS

I am Regania Pasca Rassy, a Ph.D student from the Center for Instructional Technology and Multimedia at the Universiti Sains Malaysia. This interview aims to explore your experience in physical education class dan your learning process when doing physical movements. This interview is going to be audio recorded. All the information and audio recordings will be kept confidential and will be used for academic purposes only. This interview will take approximately 15-20 minutes.

Questions

Students learning experiences.

1. Have you used an app to learn PE before?
2. How do you feel when learning physical education using an AR application?
3. In what ways did the AR app help you with PE?
4. Would you want to use the app again for learning PE? Why or why not?
5. Would you like to use the app for PE again? Why?

Application usage.

6. Was the AR app easy or hard to use? Can you explain why?
7. What problems did you have while using the AR app for PE? Please tell me about it.

Learning content.

8. Are the instructions on the module easy or difficult to understand? Why?

9. Are the physical movements in the module easy or difficult to do? Why?

Visual perception.

10. Are the images in the module clear or confusing? Why?

11. Are the 3D objects in the AR app clear or confusing? Why?

APPENDIX D: PRE-INTERVIEW GUIDELINE FOR TEACHER

I am Regania Pasca Rassy, a Ph.D student from the Center for Instructional Technology and Multimedia at the Universiti Sains Malaysia. This interview aims to explore your experience in physical education class dan your learning process when doing physical movements. This interview is going to be audio recorded. All the information and audio recordings will be kept confidential and will be used for academic purposes only. This interview will take approximately 10-20 minutes.

Introduction

Can you briefly introduce yourself?

Questions

Classroom experiences.

1. How do you usually teach physical education in your classroom?
2. How long have you been teaching physical education for disability students?
3. What difficulties do you often experience when teaching physical education with SLDs in class?

Teaching with media.

4. Have you used any learning media related to technology to facilitate your physical education classroom? If yes, please explain.
5. For what purposes do you usually use learning media in your class? Please give some examples.

6. What tools or resources do you think would help teachers in teaching physical education?
7. What do you think problems related to learning media or technology are often encountered when teaching physical education with learning disabilities?
8. Based on your experience, what are the main benefits for the students when learning with new learning media?

Teacher perspectives.

9. In your opinion, do you think new learning media or technology is important for teaching physical education to students with learning disabilities? Why or why not?

APPENDIX E: IN DEPTH-INTERVIEW GUIDELINE FOR TEACHER

I am Regania Pasca Rassy, a Ph.D student from the Center for Instructional Technology and Multimedia at the Universiti Sains Malaysia. This interview aims to explore your experience in physical education class dan your learning process when doing physical movements. This interview is going to be audio recorded. All the information and audio recordings will be kept confidential and will be used for academic purposes only. This interview will take approximately 15-20 minutes.

Questions

Teacher's experiences on using AR app.

1. What difficulties/problem do you experience when teaching using AR app?
2. How do you think AR apps can help you teach in class? explain the condition (example: as a tool to help student visualize the senaman movement).

AR on learning disability student.

3. Based on your experiences, how is the the AR app helping students in learning PE?
4. What do you think are the benefits of AR apps on learning disability student?
5. What do you think are the obstacles students experience when using AR apps?

Using AR in teaching PE.

6. What do you think are the advantages of using the AR app in the PE classroom?
7. What do you think is the weakness from using AR apps in the PE classroom?

8. In your opinion, in the future is it necessary to use technology to facilitate physical education in the classroom? Why?

AR vs Video.

9. In your opinion, which technology is more helpful for you to teach PE in classroom, is it video or AR applications?
10. In your opinion, which technology is more effective in assisting students when learning PE in class, is it video or AR applications?
11. If you can choose, which technology would you use to help you teach PE in class, video or AR app? Explain why.
12. Do you have any comments and suggestions?

APPENDIX F: MOVEMENT ABILITY ASSESEMENT RUBRIC

BORANG UJI STANDARD KECERGASAN FIZIKAL KEBANGSAAN (SEGAK)

SEKOLAH MENENGAH

Kelas : Pendidikan Khas: SpLD Dyslexia

Nama :

Jantina :

Umur :

Bil	**Jenis Ujian**	**Skor**	**Note**
	Kelenturan		
1.	Putaran bahu		
2.	Ringkuk Sisi		
3.	Regangan Badan		
4.	Kilas Balik ke Hadapan		
Indeks Jisim Badan			
Jumlah Skor / Gred			

Bil	**Jenis Ujian**	**Skor**	**Note**
	Kekuatan Otot		
1.	Melentik		
2.	Lompat Gunting		
3.	Lompat Bintang		
4.	Plank Superman		
Indeks Jisim Badan			
Jumlah Skor / Gred			

Bil	Jenis Ujian	Skor	Note
	Daya Tahan Otot		
1.	Tekan Tubi		
2.	Bangkit Tubi		
3.	Naik Turun Bangku		
4.	Lompat Squat		
Indeks Jisim Badan			
Jumlah Skor / Gred			

Note:

Skor 1 = Pergerakan sangat berbeza

Skor 2 = Pergerakan berbeza

Skor 3 = Neutral

Skor 4 = Pergerakan serupa

Skor 5 = Pergerakan tepat

Skor Markah Keseluruhan

Jumlah Skor Kesluruhan	Gred	Pernyataan
18-20 markah	A	5 Bintang
15-17 markah	B	4 Bintang
12-14 markah	C	3 Bintang
8-11 markah	D	2 Bintang
4-7 markah	E	1 Bintang

Sumber: Panduan Standard Kecergasan Fizikal Kebangsaan untuk Murid Sekolah Malaysia (SEGAK). (2016). Kementerian Pendidikan Malaysia

APPENDIX G: STUDENTS REFLECTIVE JOURNAL

Students Reflectives Journal

Please reflects your today’s learning by answering this questions.

1. How did using the AR app help you learn in today's class?
2. What specific challenges did you encounter while using the AR application today?
3. Did the 3D animations help you understand how to do the exercises?
4. Did you find the instructions and movements in the module clear and easy to follow?
5. Were the physical movements demonstrated in the AR application easy to perform? If not, please explain what made them challenging.

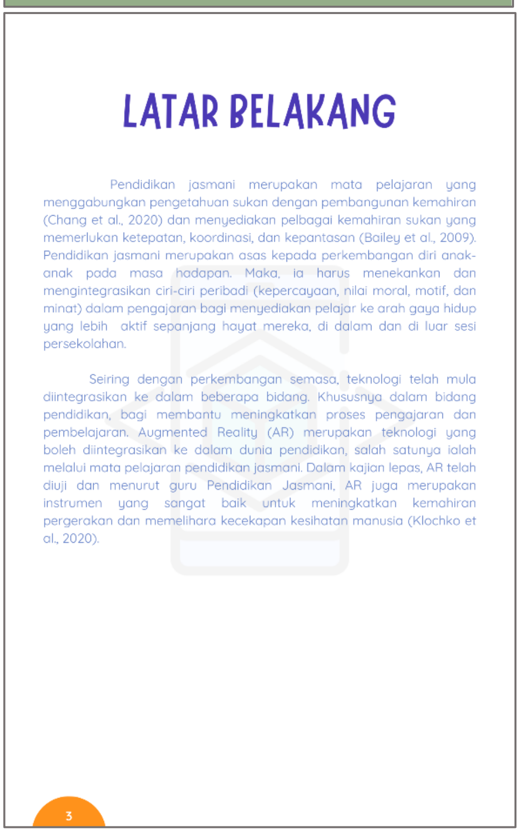
APPENDIX H: AUGMENTED MODULE

PENDIDIKAN JASMANI DAN KESIHATAN

MODUL APLIKASI SENAMAN AR

ISI KANDUNGAN

2



LATAR BELAKANG

Pendidikan jasmani merupakan mata pelajaran yang menggabungkan pengetahuan sukan dengan pembangunan kemahiran (Chang et al., 2020) dan menyediakan pelbagai kemahiran sukan yang memerlukan ketepatan, koordinasi, dan kepantasan (Bailey et al., 2009). Pendidikan jasmani merupakan asas kepada perkembangan diri anak-anak pada masa hadapan. Maka, ia harus menekankan dan mengintegrasikan ciri-ciri peribadi (kepercayaan, nilai moral, motif, dan minat) dalam pengajaran bagi menyediakan pelajar ke arah gaya hidup yang lebih aktif sepanjang hayat mereka, di dalam dan di luar sesi persekolahan.

Seiring dengan perkembangan semasa, teknologi telah mula diintegrasikan ke dalam beberapa bidang. Khususnya dalam bidang pendidikan, bagi membantu meningkatkan proses pengajaran dan pembelajaran. Augmented Reality (AR) merupakan teknologi yang boleh diintegrasikan ke dalam dunia pendidikan, salah satunya ialah melalui mata pelajaran pendidikan jasmani. Dalam kajian lepas, AR telah diuji dan menurut guru Pendidikan Jasmani, AR juga merupakan instrumen yang sangat baik untuk meningkatkan kemahiran pergerakan dan memelihara kecekapan kesihatan manusia (Klochko et al., 2020).

3

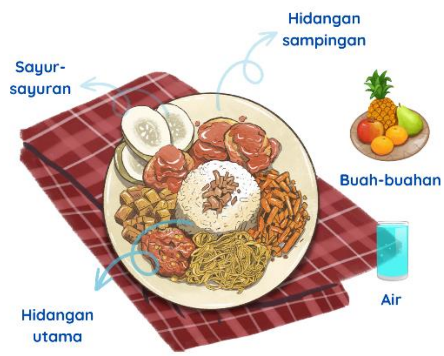
BAB I

PEMAKANAN SEIMBANG

UNTUK REMAJA

4

PEMAKANAN SEIMBANG



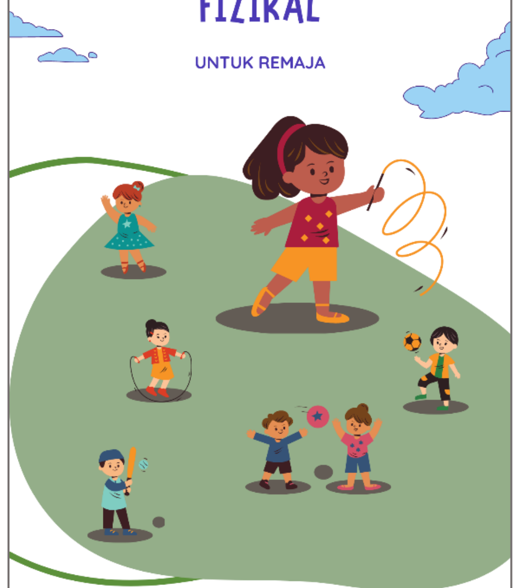
Pinggan Makan Saya : Satu Hidangan

Pemakanan seimbang merupakan tabiat memilih makanan yang hendak dimakan bagi tujuan memperbaiki atau mengekalkan kesihatan. Makanan yang seimbang perlu mengandungi komposisi nutrien seperti karbohidrat, protein, lemak, vitamin dan garam galian pada kadar yang betul. Kekurangan nutrien boleh menyebabkan berlakunya malnutrisi.

BAB II

CADANGAN AKTIVITI FIZIKAL

UNTUK REMAJA



CADANGAN AKTIVITI FIZIKAL

UNTUK REMAJA DI SEKOLAH

Tahukah Anda?

Gaya hidup yang positif, seperti melibatkan diri dalam aktiviti fizikal harian adalah bermanfaat untuk remaja yang mengalami masalah pembelajaran. Dalam jangka masa panjang, permainan luar, aktiviti kecergasan, dan sukan rekreasi dapat membantu meningkatkan kesihatan dan kesejahteraan bagi semua golongan remaja termasuk kumpulan istimewa (kurang upaya).

Jenis aktiviti fizikal

Aktiviti fizikal ialah sebarang aktiviti yang melibatkan pergerakan badan anda. Ia termasuk aktiviti harian serta sukan dan senaman yang teratur.

Aktiviti fizikal ringan tidak ketara mengubah pernafasan atau degupan jantung anak anda. Ini termasuk aktiviti seperti berdiri, berjalan santai, mengayuh kerusi roda dengan santai atau bermain alat muzik.

Aktiviti fizikal sederhana membuatkan anak anda bernafas laju. Ini boleh termasuk berjalan cepat, mengayuh kerusi roda secara pantas, menari, latihan bebanan dan berenang.

Aktiviti berat meningkatkan degupan jantung anak anda dan membuat mereka bernafas lebih laju. Aktiviti berat boleh berlaku dalam permainan atau aktiviti seperti berbasikal (termasuk berbasikal tangan), bola sepak, sukan berkerusi roda dan beberapa bentuk tarian.

Contoh Aktiviti Fizikal Ringan

Contoh Aktiviti Fizikal Sederhana

Contoh Aktiviti Fizikal Berat

BAB III

AKTIVITI SENAMAN

MENGGUNAKAN SENAMAN AR APP

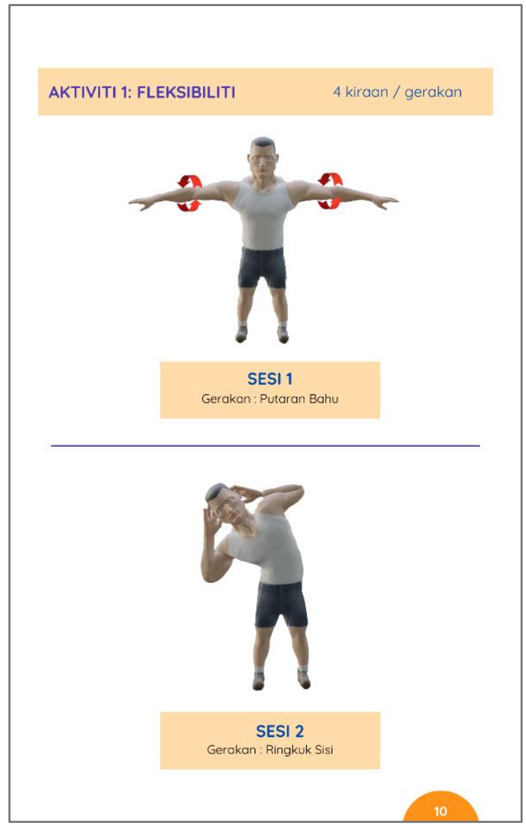
vuforia

Cara Menggunakan Aplikasi

Dalam bab ini, pelajar boleh melihat animasi objek 3D seperti gambar di atas dengan cara berikut:

- Buka aplikasi SENAMAN AR.
- Kemudian halakan kamera pada imej dalam modul.
- Objek 3D akan muncul untuk menunjukkan pergerakan animasi.

9

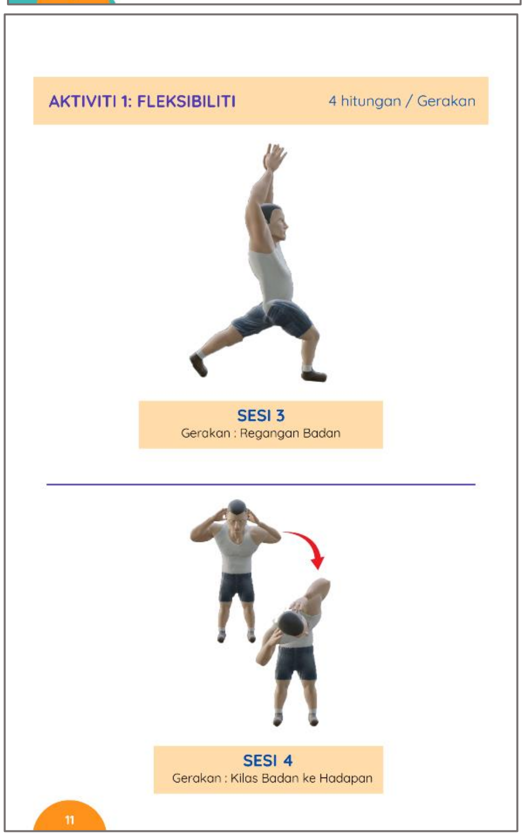


AKTIVITI 1: FLEKSIBILITI 4 kiraan / gerakan

SESI 1
Gerakan : Putaran Bahu

SESI 2
Gerakan : Ringkuk Sisi

10

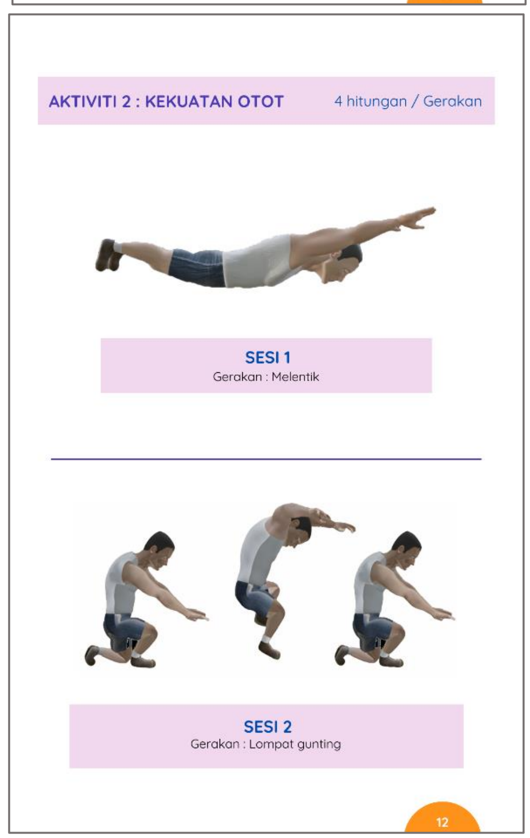


AKTIVITI 1: FLEKSIBILITI 4 hitungan / Gerakan

SESI 3
Gerakan : Regangan Badan

SESI 4
Gerakan : Kilas Badan ke Hadapan

11



AKTIVITI 2 : KEKUATAN OTOT 4 hitungan / Gerakan

SESI 1
Gerakan : Melentik

SESI 2
Gerakan : Lompat gunting

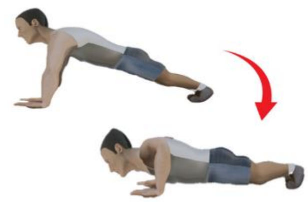
12

AKTIVITI 2 : KEKUATAN OTOT 4 hitungan / Gerakan

SESI 3
Gerakan : Lompat Bintang

SESI 4
Gerakan : Plank *Superman*

AKTIVITI 3: DAYA TAHAN OTOT 4 hitungan / Gerakan



SESI 1
Gerakan : Tekan Tubi

SESI 2
Gerakan : Bangkit Tubi

AKTIVITI 3: DAYA TAHAN OTOT 4 hitungan / Gerakan

SESI 3
Gerakan : Naik turun bangku

SESI 4
Gerakan : Lompat Squat

PENUTUP

Modul ini diwujudkan sebagai alat bantuan untuk pelajar mempelajari beberapa gerakan senaman atau gimnastik menggunakan teknologi *Augmented Reality* dalam bentuk aplikasi mudah alih. Ini bertujuan untuk memberi gambaran keseluruhan pergerakan sukan atau gimnastik kepada pelajar, melalui demonstrasi animasi objek 3D.

Pada masa hadapan, aplikasi ini diharap berguna sebagai medium sokongan pembelajaran bagi mata pelajaran pendidikan jasmani di dalam bilik darjah, memberi inspirasi dan idea kepada penyelidik dan pembangun.

APLIKASI SENAMAN AR DIBUAT OLEH : KU MUHAMMAD ZAFRI
MODUL SENAMAN AR DIKEMBANGKAN OLEH : REGANIA PASCA RASSY

APPENDIX I: QUALITATIVE EXPERT VALIDATION

RESEARCH INSTRUMENTS VALIDATION FORM BY EXPERT

Title of the Study	: Exploring the Use of Augmented Reality Technology in Physical Education Learning App on Students with Learning Disabilities.
Researcher Name	: Regania Pasca Rassy
Programme	: Doctor of Philosophy (Ph.D.)
Field of Research	: Performance Technology / Augmented Reality (AR)
School/Center	: Center for Instructional Technology and Multimedia
Matric No	: P-QD0024/21(R)

I have read and reviewed the attached instruments. I hereby certify that the instruments are valid for obtaining data that is needed to complete this study by taking into consideration the view and suggestions below:

1. As written in the feedback
   ……………………………………………………………………………………………
2. ……………………………………………………………………………………………
   ……………………………………………………………………………………………
3. ……………………………………………………………………………………………
   ……………………………………………………………………………………………

Verified by:

DR. ROHAYA ABDULLAH
Senior Lecturer
School of Educational Studies
Universiti Sains Malaysia
Penang.

Signature and Official Stamp

Name	: DR. ROHAYA ABDULLAH
Position	: PENSYARAH UNIVERSITI
Faculty/Department	: PUSAT PENGAJIAN ILMU PENDIDIKAN

SAMPLES OF EXPERTS FEEDBACK

Research Title: Exploring the Use of Augmented Reality Technology in Physical Education Learning Apps on Students with Learning Disabilities

Research Questions and data sources:

Research Question	Data Sources
RQ1: How is What are the learning experiences of the students with learning disability in learning physical education using AR technology? RQ2: How are the AR learning content characteristics that support thelearning disability students learning process and barriers to using AR technology for physical education? How do the AR learning content characteristics support the learning process for learners with disabilities? What are the barriers in using AR technology in physical education for learners with disabilities?	• Interview • Direct observation (teacher report) What do you mean by direct observation? Normally, in qualitative research, data from the teacher would be from interviews not observation. You can just say students' SCORE/PERFORMANCE as you are using a rubric • Participant Observation (researcher report) you can say checklist
RQ3: How is the teachers' perspective on the use of Augmented reality technology in Physical Education classrooms with learning disability students? What are the teachers' perspectives on the use of AR technology in Physical Education with learners with disabilities?	• Interview with teacher • Direct observation (teacher report) • Participant Observation (researcher report)
RQ4: How does AR affect learning disability students' visual perception? Why do you want to look at visual perception? Or do you want to see this: How does AR affect learners with disabilities' visions (or eye coordination?)	• Movements Skills rubric • Direct observation (teacher report) • Participant Observation (researcher report)

SAMPLES OF EXPERTS FEEDBACK

Appendix B: Pre-Interview Guide for Students

I am Regania Pasca Rassy, a Ph.D student from the Center for Instructional Technology and Multimedia at the Universiti Sains Malaysia. This interview aims to explore your experience in physical education class dan your learning process when doing physical movements. This interview is going to be audio recorded. All the information and audio recordings will be kept confidential and will be used for academic purposes only. This interview will take approximately 15-20 minutes.

Introduction

Can you briefly introduce yourself?

Questions

1. Do you enjoy learning physical education? Why?
2. Is there anything you don't like about physical education? Why?
3. Is it difficult to do sports or gymnastic movements in physical education? Please explain.
4. How does your teacher teach physical education at school? Pease describes
5. Have you felt bored when learning physical education in class? Why?
6. Do you usually use books or other media when studying physical education in class?
7. Have you ever taught learnt physical education using an application on your phone?
8. Are you interested ~~if you want~~ to learn physical education using an application on your phone?

I am not sure about the use of these interview questions as you already have the information in the demographic data. If these questions do not serve any purpose like preliminary study or to answer any RQ, then you can just omit this part. If they are meant to establish a rapport with the students, you can just ask one or two questions, just to set the atmosphere.

Appendix C: In depth-Interview Guide for Students

I am Regania Pasca Rassy, a Ph.D student from the Center for Instructional Technology and Multimedia at the Universiti Sains Malaysia. This interview aims to explore your experience in physical education class dan your learning process when doing physical movements. This interview is going to be audio recorded. All the information and audio recordings will be kept confidential and will be used for academic purposes only. This interview will take approximately 15-20 minutes.

Introduction

Can you briefly introduce yourself?

Questions

1. Is this your first time learning physical education using an application?
2. How does it feel when learning physical education using an AR application?
3. Is the AR application difficult to use or easy? why?
4. What difficulties did you encounter when learning Physical education using AR applications? Please describe
5. Are the instructions on the module easy or difficult to understand? Why?
6. Are the images shown in the module easy or difficult to understand? Why?
7. Are the 3D objects in the AR application easy or difficult to understand? Why?
8. Are the physical movements in the module easy or difficult to do? Why?
9. Do you prefer to learn physical education using an application or not? Why?
10. Do you think this application helps you during learning? how?
11. After this, do you want to learn to use the application again? Why?

These questions are well constructed but I would suggest that you be more specific according to the RQ. For examples RQ2 needs to investigate on the learning content characteristics . I do not really see these elements in your interview. My suggestion would be, for you to divide your interview questions based on your RQs so that you would get a comprehensive data.

SAMPLES OF EXPERTS FEEDBACK

Appendix F: Interview Guide for Teacher

I am Regania Pasca Rassy, a Ph.D student from the Center for Instructional Technology and Multimedia at the Universiti Sains Malaysia. This interview aims to explore your experience in physical education class dan your learning process when doing physical movements. This interview is going to be audio recorded. All the information and audio recordings will be kept confidential and will be used for academic purposes only. This interview will take approximately 15-20 minutes.

Introduction

Can you briefly introduce yourself?

Question

1. What deficiencies do physical education teachers often face in special schools when teaching?
2. What learning tools or media (book, video, app) do you often use in teaching physical education in classrooms?
3. Have you used any learning media related to technology to facilitate your physical education classroom?
4. For what purposes do you usually use learning media in your class? Please give some examples.
5. In your opinion, is it necessary to use new learning media or technology to teach physical education with learning disability students?
6. What problems related to learning media or technology are often encountered when teaching physical education with learning disabilities?
7. Based on your experience, what are the main benefits for the students when learning with new learning media?
8. Are there any problems encountered when teaching using technology?
9. Based on your observation, how is the experience that students receive when learning using the AR app?
10. What do you think are the benefits that students receive from using AR apps?
11. What do you think are the obstacles students experience when using AR apps?
12. How do you think AR apps can help you teach in class? explain the condition
13. In your opinion, in the future is it necessary to use technology to facilitate physical education classes? Why?
14. Do you have any comments and suggestions?

The questions are well constructed; however I feel that q1-q4 will not help you answer your RQ.

I am not sure what your mother tongue is and your purpose for conducting your interview and observation in English language. The principle of qualitative study is to get a rich data, hence it's best to conduct the interview in your mother tongue/ first language. That is something for you to think about.

APPENDIX J: QUANTITATIVE EXPERT VALIDATION (RUBRIC)

RESEARCH INSTRUMENTS VALIDATION FORM BY EXPERT

Title of the Study	: Exploring the Use of Augmented Reality Technology in Physical Education Learning App on Students with Learning Disabilities.
Researcher Name	: Regania Pasca Rassy
Programme	: Doctor of Philosophy (Ph.D.)
Field of Research	: Performance Technology / Augmented Reality (AR)
School/Center	: Centre for Instructional Technology and Multimedia
Matric No	: P-QD0024/21(R)

I have read and reviewed the attached instruments. I hereby certify that the instruments can be used in this study since the instrument was adapted from reliable source.

Verified by:

Dr. Nurullizam Jamiat
Pensyarah
Pusat Teknologi Pengajaran dan Multimedia
Universiti Sains Malaysia
11800 USM PULAU PINANG

Signature and Official Stamp

Name : Nurullizam Jamiat

Position : University Lecturer

Faculty/Department : Centre for Instructional Technology & Multimedia, Universiti Sains Malaysia

APPENDIX *K*: INSTRUCTIONAL DESIGN EXPERT VALIDATION

Lampiran A(i)

UNIVERSITI SAINS MALAYSIA

RESEARCH INSTRUMENTS VALIDATION FORM BY EXPERT

Title of the Study	: Exploring the Use of Augmented Reality Technology in Physical Education Learning App on Students with Learning Disabilities.
Researcher Name	: Regania Pasca Rassy
Programme	: Doctor of Philosophy (Ph.D.)
Field of Research	: Performance Technology / Augmented Reality (AR)
School/Center	: Center for Instructional Technology and Multimedia
Matric No	: P-QD0024/21(R)

I have read and reviewed the attached instruments. I hereby certify that the instruments are valid for obtaining data that is needed to complete this study by taking into consideration the view and suggestions below:

1. On activity 1 : fleksibiliti, need to add animation on two sessions
2. (sesi 1 & 2), and activity 2 : kekuatan otot, add animation on sesi 1.
3. ....

Verified by:

Signature and Official Stamp

Name :
Position :
Faculty/Department :

TS. DR. MAGESWARAN A/L SANMUGAM
Senior Lecturer
Centre for Instructional Technology and Multimedia
Universiti Sains Malaysia

RESEARCH INSTRUMENTS VALIDATION FORM BY EXPERT

Title of the Study	: Exploring the Use of Augmented Reality Technology in Physical Education Learning App on Students with Learning Disabilities.
Researcher Name	: Regania Pasca Rassy
Programme	: Doctor of Philosophy (Ph.D.)
Field of Research	: Performance Technology / Augmented Reality (AR)
School/Center	: Center for Instructional Technology and Multimedia
Matric No	: P-QD0024/21(R)

I have read and reviewed the attached instruments. I hereby certify that the instruments are valid for obtaining data that is needed to complete this study by taking into consideration the view and suggestions below:

1. All suggestions has be fulfilled. Good.
2. ....
3. ....

Verified by:

Signature and Official Stamp

Name : TS. DR. MAGESWARAN A/L SANMUGAM
Position : Senior Lecturer
Faculty/Department : Centre for Instructional Technology and Multimedia, Universiti Sains Malaysia

APPENDIX L: CONTENT EXPERT VALIDATION

RESEARCH INSTRUMENTS VALIDATION FORM BY EXPERT

Title of the Study	: Exploring the Use of Augmented Reality Technology in Physical Education Learning App on Students with Learning Disabilities.
Researcher Name	: Regania Pasca Rassy
Programme	: Doctor of Philosophy (Ph.D.)
Field of Research	: Performance Technology / Augmented Reality (AR)
School/Center	: Center for Instructional Technology and Multimedia
Matric No	: P-QD0024/21(R)

I have read and reviewed the attached instruments. I hereby certify that the instruments are valid for obtaining data that is needed to complete this study by taking into consideration the view and suggestions below:

1. ………………………………………………………………………………………………
………………………………………………………………………………………………
2. ………………………………………………………………………………………………
………………………………………………………………………………………………
3. ………………………………………………………………………………………………
………………………………………………………………………………………………

Verified by:

____

Signature and Official Stamp

Name	: MOHAMAD AMIN BIN IBRAHIM
Position	: TEACHER
Faculty/Department	: SM PENDIDIKAN KHAS VOKASIONAL MERBOK

APPENDIX M: APPROVAL LETTER TO CONDUCT A RESEARCH FROM MINISTRY OF EDUCATION MALAYSIA

KEMENTERIAN PENDIDIKAN MALAYSIA
BAHAGIAN PERANCANGAN DAN PENYELIDIKAN DASAR PENDIDIKAN
ARAS 1-4, BLOK E8
KOMPLEKS KERAJAAN PARCEL E
PUSAT PENTADBIRAN KERAJAAN PERSEKUTUAN
62604 PUTRAJAYA

TEL : 0388846591
FAKS : 0388846579

Ruj. Kami : KPM.600-3/2/3-eras(17127)
Tarikh : 10 Ogos 2023

REGANIA PASCA RASSY
NO. KP : C4251323

DESASISWA BAKTI PERMAI, USM
11800 GELUGOR
PULAU PINANG

Tuan,

KELULUSAN BERSYARAT UNTUK MENJALANKAN KAJIAN :
EXPLORING THE USE OF AUGMENTED MODULE AS ASSISTIVE LEARNING TOOLS FOR DYSLEXIC STUDENTS IN PHYSICAL EDUCATION SUBJECT

Perkara di atas adalah dirujuk.

2. Sukacita dimaklumkan bahawa permohonan tuan untuk menjalankan kajian seperti di bawah telah diluluskan dengan syarat :

" KELULUSAN INI BERGANTUNG KEPADA KEBENARAN PENGARAH BAHAGIAN PENDIDIKAN KHAS DAN PERTIMBANGAN PENTADBIR SEKOLAH. PIHAK PENTADBIR SEKOLAH PERLU MENELITI KESESUAIAN MODUL YANG DIBANGUNKAN SEBELUM DIGUNAKAN OLEH MURID. PENGUTIPAN DATA MELIBATKAN MURID HENDAKLAH DILAKSANAKAN OLEH DENGAN BANTUAN GURU SEKOLAH BERKENAAN. PENGLIBATAN, PEMERHATIAN SERTA RAKAMAN VIDEO TERHADAP AKTIVITI PENGAJARAN DAN PEMBELAJARAN MURID DI DALAM BILIK DARJAH TIDAK DIBENARKAN. "

3. Kelulusan adalah berdasarkan kepada kertas cadangan penyelidikan dan instrumen kajian yang dikemukakan oleh tuan kepada bahagian ini. Walau bagaimanapun kelulusan ini bergantung kepada kebenaran Jabatan Pendidikan Negeri dan Pengetua / Guru Besar yang berkenaan.

4. Surat kelulusan ini sah digunakan bermula dari **14 Ogos 2023** hingga **30 November 2023**

5. Tuan dikehendaki menyerahkan senaskhah laporan akhir kajian dalam bentuk *hardcopy* bersama salinan *softcopy* berformat pdf dalam CD kepada Bahagian ini.Tuan juga diingatkan supaya mendapat kebenaran terlebih dahulu daripada Bahagian ini sekiranya sebahagian atau sepenuhnya dapatan kajian tersebut hendak diterbitkan di mana-mana forum, seminar atau diumumkan kepada media massa.

Sekian untuk makluman dan tindakan tuan selanjutnya. Terima kasih.

"BERKHIDMAT UNTUK NEGARA"

Saya yang menjalankan amanah,

Ketua Penolong Pengarah Kanan
Sektor Penyelidikan dan Penilaian Dasar
b.p. Pengarah
Bahagian Perancangan dan Penyelidikan Dasar Pendidikan
Kementerian Pendidikan Malaysia

salinan kepada:-

BAHAGIAN PENDIDIKAN KHAS
JABATAN PENDIDIKAN KEDAH

* SURAT INI DIJANA OLEH KOMPUTER DAN TIADA TANDATANGAN DIPERLUKAN *

APPENDIX N: APPROVAL LETTER TO USE LEARNING MATERIALS IN PHYSICAL EDUCATION TEXTBOOK FROM MINISTRY OF EDUCATION MALAYSIA

KEMENTERIAN PENDIDIKAN MALAYSIA
MINISTRY OF EDUCATION MALAYSIA
Bahagian Sumber dan Teknologi Pendidikan
Educational Resources and Technology Division
Persiaran Bukit Kiara
50604 KUALA LUMPUR
MALAYSIA

Tel : 603-2081 7777
Fax: 603-2081 7788

Ruj. Kami: KPM.600-6/2/1 Jld.3 (50)
Tarikh: 31 Mac 2023

Regania Pasca Rassy
Wakil Pelajar
Pusat Teknologi Pengajaran dan Multimedia (PTPM)
Universiti Sains Malaysia
11800 USM
Pulau Pinang

Puan,

PERMOHONAN UNTUK MENGGUNAKAN BAHAN DALAM BUKU TEKS UNTUK AKTIVITI KAJIAN

Dengan segala hormatnya perkara di atas dirujuk dan surat puan bertarikh 27 Mac 2023 kepada Bahagian Sumber dan Teknologi Pendidikan (BSTP) Kementerian Pendidikan Malaysia (KPM) adalah berkaitan.

2. KPM sangat menghargai usaha pelajar Pusat Teknologi Pengajaran dan Multimedia (PTPM) Universiti Sains Malaysia (USM) dalam menjalankan kajian bagi membangunkan media pembelajaran baharu untuk kanak-kanak bermasalah pembelajaran dalam kelas pendidikan jasmani melalui pembinaan aplikasi *Augmented Reality* (AR) serta berhasrat untuk menggunakan bahan ajar (gambar dan aktiviti) dalam buku teks Pendidikan Jasmani dan Pendidikan Kesihatan (Pendidikan Khas) Tingkatan 4 milik KPM.

3. Inisiatif ini dilihat amat sesuai dalam era pembelajaran digital selaras dengan perkembangan teknologi dan persekitaran pembelajaran murid agar seiring dengan peredaran zaman.

4. Sehubungan dengan itu, berkenaan dengan permohonan puan:

i) KPM **tiada halangan** dalam penggunaan bahan ajar dari buku teks milik KPM tersebut selaras dengan Seksyen 13 (Akta 332) Akta Hak Cipta 1987 yang menyatakan bahawa:

"...secara urusan wajar termasuk bagi maksud **penyelidikan**, pengajian persendirian, kritikan, ulasan atau pelaporan berita atau peristiwa semasa;

Dengan syarat bahawa ia disertai dengan perakuan tajuk karya itu dan penciptaannya..."

...2/-

ii) Kebenaran ini adalah **tertakluk kepada kelulusan** permohonan yang dimohon oleh pelajar PTPM USM ke Bahagian Perancangan dan Penyelidikan Dasar Pendidikan KPM melalui https://eras.moe.gov.my/

5. Semoga inisiatif yang dilakukan ini dapat memperkukuhkan lagi penyampaian kandungan pembelajaran dan seterusnya meningkatkan kefahaman murid. Sekiranya puan ingin mendapatkan maklumat lanjut berkaitan perkara ini bolehlah berhubung dengan Puan Rasinah binti Zakaria di talian 03-88844373 / e-mel (rasinah.zakaria@moe.gov.my).

Sekian, terima kasih.

"MALAYSIA MADANI"

"BERKHIDMAT UNTUK NEGARA"

Saya yang menjalankan amanah,

(ZAINAL BIN ABAS)
Pengarah
Bahagian Sumber dan Teknologi Pendidikan
Kementerian Pendidikan Malaysia

s.k.:

i) Fail Timbul

RAS/SSPK_hakcipta

APPENDIX O: APPROVAL LETTER TO CONDUCT A RESEARCH FROM MINISTRY OF EDUCATION MALAYSIA, FROM SPECIAL EDUCATION DEPARTMENT

KEMENTERIAN PENDIDIKAN MALAYSIA
BAHAGIAN PENDIDIKAN KHAS
ARAS 2, BLOK E2,
KOMPLEKS KERAJAAN PARCEL E
PUSAT PENTADBIRAN KERAJAAN PERSEKUTUAN
62604 PUTRAJAYA

Tel.: 03-8884 9190
Faks: 03-8888 6670
Laman Web://www.moe.gov.my

Ruj. Kami : KPM.600-2/1/4 Jld. 9 (88)
Tarikh : 21 Ogos 2023

Regania Pasca Rassy
Desasiwa Bakti Permai
Universiti Sains Malaysia
11800 Gelugor
PULAU PINANG

Puan,

PERMOHONAN KEBENARAN MENJALANKAN AKTIVITI KAJIAN: *EXPLORING THE USE OF AUGMENTED MODULE AS ASSISTIVE LEARNING TOOLS FOR DYSLEXIC STUDENTS IN PHYSICAL EDUCATION SUBJECT*

Dengan hormatnya saya merujuk perkara di atas dan surat daripada Bahagian Perancangan dan Penyelidikan Dasar Pendidikan [Rujukan: KPM.600-3/2/3-eras(17127)] bertarikh 10 Ogos 2023 adalah berkaitan.

2. Sukacita dimaklumkan bahawa Bahagian Pendidikan Khas (BPKhas), Kementerian Pendidikan Malaysia (KPM) tiada halangan untuk membenarkan puan menjalankan kajian bertajuk ***Exploring The Use of Augmented Module as Assistive Learning Tools for Dyslexic Students in Physical Education Subject***. BPKhas mengambil maklum bahawa kajian ini akan dilaksanakan ke atas murid disleksia di Sekolah Menengah Pendidikan Khas Vokasional (SMPKV Merbok).

3. Walau bagaimanapun, BPKhas, KPM ingin mengingatkan puan bahawa:

3.1 penyertaan guru dan murid dalam kajian adalah secara sukarela;

3.2 pengutipan data melibatkan murid hendaklah dilaksanakan dengan bantuan guru sekolah berkenaan;

...2/-

"KECEMERLANGAN INSAN ISTIMEWA, KEGEMILANGAN BERSAMA"

3.3 mendapatkan kebenaran bertulis daripada ibu bapa/penjaga;

3.4 menjalankan aktiviti kajian tanpa mengganggu waktu pengajaran dan pembelajaran (PdP); dan

3.5 penglibatan, pemerhatian serta rakaman video terhadap aktiviti PdP murid di dalam bilik darjah tidak dibenarkan;

3.6 memastikan modul yang dibangunkan bersesuaian dengan murid dan diteliti oleh pentadbir sekolah sebelum digunakan oleh murid; dan

3.7 tidak menyentuh perkara yang bertentangan dengan Dasar Pendidikan Negara serta isu-isu sensitif peribadi murid berkeperluan pendidikan khas dan keluarga mereka.

4. Surat kelulusan ini sah digunakan bermula dari **tarikh surat ini dikeluarkan hingga 30 November 2023**. Walau bagaimanapun, kelulusan ini turut bergantung kepada pengetua sekolah yang berkenaan.

5. BPKhas juga berharap agar puan dapat mengemukakan senaskah laporan akhir kajian berkenaan setelah kajian tersebut disiapkan untuk rujukan dan simpanan Bahagian ini.

Sekian, terima kasih.

"MALAYSIA MADANI"

"BERKHIDMAT UNTUK NEGARA"

Saya yang menjalankan amanah,

(HAJAH SALMAH BINTI JOPRI)
Pengarah
Bahagian Pendidikan Khas
b.p. Ketua Setiausaha
Kementerian Pendidikan Malaysia

s.k.: Pengetua
Sekolah Menengah Pendidikan Khas Vokasional Merbok

APPENDIX P: SAMPLE OF TEACHER OBSERVATION REPORT

Teacher's observations

Group 1

Activity 1			
S3		S5	
1	The right hand is not straight	1	The movement is correct
2	The movement is correct	2	The movement is correct
3	The body is to forward	3	The movement is less stable when landing
4	The movement is correct	4	The body is moving when doing the movement
Activity 2			
1	The movement is correct	1	The movement is correct
2	Leg movements are not straight when jumping	2	Leg movements are not straight when jumping
3	The movement is correct	3	The movement is correct, but the hand is not straight
4	The movement is correct	4	Leg movements are not straight when jumping
Activity 3			
1	The movement is correct	1	The movement is correct
2	The hand position is not raised	2	The hand position is not raised
3	The movement is correct	3	The movement is correct
4	The movement is correct	4	The movement is correct

Group 2

Activity 1			
S2		S4	
1	The hand position does not rotate 360 degrees	1	The hand position does not rotate 360 degrees
2	Bodies move together	2	The body is not low enough
3	Stepping feet are too small (not wide enough)	3	Stepping feet are too small (not wide enough)
4	The movement is correct	4	Bodies move together
Activity 2			
1	The position of the legs is not straight and not lifted completely	1	The position of the legs is not straight and not lifted completely
2	the position of the legs is not straight and not crossed	2	the position of the legs is not straight and not crossed
3	The movement is correct	3	The movement is correct
4	The knee position is less stable	4	The movement is correct, but the legs is not straight
Activity 3			
1	The movement is correct	1	The movement is correct
2	Hands are not raised	2	The movement is correct
3	The movement is correct	3	The movement is correct
4	Hands are not raised	4	Hands are not raised

APPENDIX Q: SAMPLE OF RESEARCHER FIELD NOTES REPORT

07/09/2023
Class 5A

Field Notes

Descriptive Notes	Reflective Notes
10.30 The teacher opened the class, briefing the students and started with stretching activity. A total of 10 students participated	Teacher starts the class by doing stretching first for all students
10.43 Start teaching movement 1 Students do movements from their respective places. The environment is safe for them to do movements. Tables and chairs have been conditioned.	The teacher explained to the students and showed them the exercises movements on the module. Then the teacher demonstrates the correct movement on the module and explained to the students function of the movement for their body
10.45 Start teaching movement 2 Students do movements from their respective places. The environment is safe for them to do movements. Tables and chairs have been conditioned.	The teacher explained to the students and showed them the exercises movements on the module. Then the teacher demonstrates the correct movement on the module and explained to the students function of the movement for their body
10. 47 Start teaching movement 3 Students do movements from their respective places. The environment is safe for them to do movements. Tables and chairs have been conditioned.	The teacher explained to the students and showed them the exercises movements on the module. Then the teacher demonstrates the correct movement on the module and explained to the students function of the movement for their body
10.50 Start teaching movement 4 Students do movements from their respective places. The environment is safe for them to do movements. Tables and chairs have been conditioned.	The teacher explained to the students and showed them the exercises movements on the module. Then the teacher demonstrates the correct movement on the module and explained to the students function of the movement for their body
10.55 Student and teacher doit all movements together	Teacher and students do the exercises movements together
11.00 Students divided and explored in a group	Students started learning in peers. Students are given two modules and one tablet.

LIST OF PUBLICATIONS

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Rassy, R. P. & Mokmin, N. A. M. (2023). Exploring Learning Disability Students Experiences in Using AR Technology in Physical Education. In M. Koc, O. T. Ozturk & M. L. Ciddi (Eds.), *Proceedings of ICRES 2023-- International Conference on Research in Education and Science* (pp. 56-69), Cappadocia, Turkiye. ISTES Organization.

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