Immersive Technologies in Physical Education in Malaysia for Students with Learning Disabilities

Nur Azlina Mohamed Mokmin
Universiti Sains Malaysia, Malaysia

Nurul Nabilah Izzati Binti Ridzuan
Universiti Sains Malaysia, Malaysia

Abstract

Physical education (PE) is a compulsory subject in schools that is vital to ensure students stay healthy and fit. It is widely agreed that everyone should have access to education, regardless of physical limitations. However, there is an ongoing debate on how PE has been taught and used to benefit students with learning disabilities (SLD). SLDs may feel excluded from PE due to lack of support systems, low motivation, and unsuitable learning materials. This paper discusses the development of an app that applies immersive technologies to make PE accessible to SLDs. Virtual reality and augmented reality are immersive technologies in which the user can view virtual media to understand objects in the real world. With these technologies, students can freely control their learning progress and choose the content critical to them based on their circumstances, enabling instruction based on their ability. Optimal Motor Learning Theory and Cognitive Theory of Multimedia Learning (CTML) were used to develop the app. The first phase of this two-stage research process involved creating a VR app and getting feedback from the students who used it. Interviews of students who used the VR trainer and secondary data were used to inform the development of an AR book. The authors found that by combining suitable immersive technologies with motor learning theory and multimedia learning principles, appropriate learning material could be created that facilitates the PE learning process.

Keywords: augmented reality, immersive, physical education, sport, strength exercise, virtual reality

Physical Education (PE) is an elementary and secondary school subject focusing on the human body and psychomotor learning (Andrieux & Proteau, 2016). The course develops skills, knowledge, values, and attitudes required to establish and enjoy an active and healthy lifestyle through extensive learning. Face-to-face learning builds students' confidence and ability to face individual, group, or team challenges (WHO, 2020). In the right PE setting, the lessons can engage students, attract distracted learners' attention, and create an environment that cultivates enthusiasm for physical activities.

The COVID-19 outbreak forced many countries to restrict movement and required education to be home-based and/or online. Schools in 194 countries were closed, and many virtual teaching and learning activities were organized to ensure the learning process continued to achieve the targeted learning outcomes. In European countries and the United States, physical education teaching activities were carried out via live streaming, providing students with recorded videos or links to follow on their own (Filiz & Konukman, 2020). However, physical education is a minor subject in Malaysia that gets little government attention. Resources are allocated to mainstream subjects (Tan, 2021), such as compulsory mathematics and science, and included in national exams.

Many educators found that teaching PE online during the current pandemic was challenging to handle (Varea & González-Calvo, 2020). The teaching process became less physical. This approach also made students less healthy and increased sedentary behavior among otherwise active students (Roe et al., 2021). PE needs observational learning and physical instruction, which adds to teachers' difficulties in ensuring the learning process is maintained or mimics that in a typical classroom before the pandemic. Nevertheless, the students' involvement in physical, sports, recreational, and social activities is a must to produce fit and productive students (Lim et al., 2016). However, there is an ongoing debate on how PE has been taught and used to benefit students with learning disabilities (SLD). Roe et al. (2021) suggest that PE teaching and learning can be carried out successfully at a distance with suitable strategies, including personalization, creativity, and inclusiveness. This paper discusses the development of an app that applies immersive technologies to make PE accessible to SLDs.

Background and Literature Review

According to data from the Department of Special Education, 82 percent of students with disabilities (SWD) in Malaysia in 2020 were classified as having a learning disability (LD). The significant number of SWD with learning disabilities raises issues about the inclusivity of SWD in the Malaysian Education system (Nordin et al., 2019). SWDs that have been assessed as having autism, attention deficit hyperactivity disorder (widely known as ADHD), dyslexia, writing disorders, and dysphagia are classified as students with learning disabilities (SLD) [Radzi et al., 2019]. The Ministry of Education uses the term SLD to characterise pupils who cannot learn in a traditional classroom setting. They have poor reading, writing, and arithmetic skills. Intellectual dysfunction, neurological abnormalities, or neurological processing difficulties may cause their learning disabilities (Nordin et al., 2019).

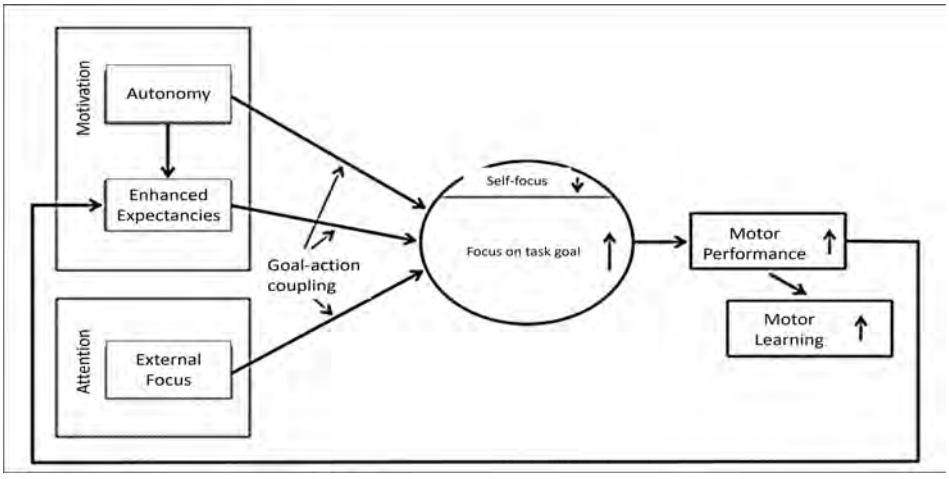
These students also face difficulties during the learning process in PE (Hamizi et al., 2022). According to Di Palma et al. (2018), among the problems are fears of participating, insufficient learning resources, lack of school-based support, and insecurities with others. These difficulties can hinder their true potential in PE and make some learning outcomes impossible to achieve. Therefore, educators should consider the students' unique demands and emphasize improving their concentration and creating a flexible learning environment.

Theories of Motivation and Learning

Wulf and Lewthwaite (2016) introduced the Optimizing Performance Through Intrinsic Motivation and Attention for Learning (OPTIMAL) theory of motor learning, which argued that intrinsic motivation and learning, attention, performance, and knowledge could contribute to motor performance and physical education learning. According to the theory, to increase motivation, it is essential to maintain student autonomy in terms of control over the learning process that can ultimately lead to focusing on the goal. The theory also posited that giving learners control over specific practice areas or using assistive technology can improve motor learning. Combining confidence in their potential to perform effectively with instructions that can raise their external focus can help students achieve successful movement results. These will boost self-efficacy and help solidify the positive impacts of performance, producing a virtuous circle that will have benefits for learning and motivation in the long run.

Learning elements that increase expectations for future completion and support autonomy through perceived control and motivational mediators like self-efficacy, perceived competence, and positive affect accelerate motor learning. Dopamine is released when these motivational variables are met, which aids in brain circuit growth and memory consolidation (Puig et al., 2014). Furthermore, combining OPTIMAL variables increases motor learning by enhancing goal-action coupling efficiency (Wulf & Lewthwaite, 2016). Figure 1 displays the Optimal Theory of Motor Learning. Autonomy and enhanced expectancies are illustrated as motivational, while the external focus is an attention factor that improves learning and performance of motor skills. Autonomy support describes a situation in which a person is given the ability to control or choose certain aspects of practice or performance conditions. Focusing on the movement goal or effect, such as focusing on the dartboard while throwing a dart, is an example of an external focus of attention.

Figure 1
The Optimal Motor Learning Theory (Wulf & Lewthwaite, 2016)



PE has significant effects on the overall growth of SLDs. However, researchers have found several issues the SLDs face in PE (Di Palma et al., 2018; Greguol et al., 2018; Tafuri & Cassese, 2017). According to Kohli et al. (2018), some SLDs have been given inadequate learning materials, are afraid to mingle due to a lack of social skills, are nervous when performing PE, and lack institutional assistance. SLDs' participation in PE classes is also lower than other same-age students in primary and secondary education (Adams, 2016). Thus,

educators must consider the needs of SLDs while providing them with superior PE learning experiences. Educators can work on the necessary modifications to the curriculum and class settings that benefit the students. In a physical education class, better learning guidance makes PE enjoyable and provides positive results. However, there is still a lack of assessment of PE teaching and learning effectiveness in Malaysia and whether the implementation has been catering to the SLD.

Mayer's (2011) Cognitive Theory of Multimedia Learning (CTML) proposes that an elemental overload will occur when cognitive processing exceeds the learner's ability, thereby inhibiting learning. Previous research has shown that when a multimedia course is presented in immersive VR, learners are more likely to experience complete overload than the same course in non-immersive media because the external load increases due to the rise in sensory information (Freeman et al., 2019). This model will be used to distinguish two kinds of cognitive load for the design process of immersive multimedia learning in physical exercise. The first is the inherent cognitive load related to the properties of the learning material, such as its intrinsic difficulties. The other is an unrelated cognitive load associated with the presentation of the material. The CTML is used as a guide alongside the OPTIMAL Motor Learning theory in developing the multimedia design for the app.

Immersive Technologies in Learning

Immersive learning uses enhanced simulated or purely artificial environments so that learners can experience scenarios and simulations to produce valuable and engaging knowledge. This technology is becoming popular as it offers learning outcomes by providing authentic experiences. In the field of instructional technology, the terms "virtual reality" and "augmented reality" have been trending for the past five years (Kimmons, 2020). For physical education, the potential usage of VR is limitless. In their study, Jiao and Qian (2020) used VR to teach PE by displaying various videos using the Flipped Learning approach. Their research shows that combining VR and Flipped Learning significantly increased PE students' satisfaction compared to traditional classroom learning. Another study on the application of VR for PE conducted by Brooke et al. (2020) proved that the technology could be used to teach badminton. Their research concluded that VR-based PE training could: (a) improve understanding, (b) teach repeated practice, (c) increase teamwork and mutual support, and (d) promote motivation. In addition, Mokmin (2020) and Mulders et al. (2020) concluded that VR technology could provide additional stimulation to encourage students to engage in PE whenever teacher supervision is unavailable.

Virtual reality often uses a headset to shut out visual stimuli from the outside world. In this immersive alternative, the user can pick up and move objects, turn on and disassemble gadgets, stroll around a room, and interact with virtual characters. Not only can virtual reality technology be utilised to teach knowledge, but it can also be used to teach actions and skills. As long as there is a suitable model library, students can put on virtual reality glasses and watch the steps of action in person. Because this process is computer-controlled, students can watch it repeatedly, slow it down, study it from different angles, or even engage in the action. Students can freely control the pace of instruction and choose the content that is critical to them based on their circumstances and ability (Wu et al., 2021). Virtual reality (VR) allows physically disabled people to try out-of-reach experiences like climbing a mountain, extreme sports, or swimming in the sea for the first time.

Mokmin and Jamiat (2020) discussed the development of a virtual fitness trainer to motivate undergraduate students to engage in physical exercise. Their study showed that most respondents gave positive reviews of the fitness activities with the trainers, and their motor performance increased when learning with the app. However, their design has not been tested for SLDs. Reducing the cognitive load during learning, especially for SLDs, is vital to engage them in learning (Hardiyanti & Azizah, 2019). Therefore, the CTML is used to guide the development process so that the multimedia presented to the students can improve their learning achievement.

People with special needs may benefit from augmented reality (AR), which can help them build everyday life skills. AR allows users to see the real world while overlaying virtual elements on top of it. According to a meta-analysis by Baragash et al. (2020), AR is an appropriate learning medium to enhance the involvement of SWDs in society, teach varied abilities, educate, diversify physical learning, conduct self-care duties, and retain information for an extended period. Because AR has the function of displaying context-sensitive digital information, which can support individual needs at the time and provide timely learning, it is a potent tool for people with disabilities (Walker et al., 2017). The term "augmented reality" refers to virtual reality in which virtual things are placed in real-world settings. The objects can be visualised in front of the users statically or dynamically. This technology allows developers to add labels, videos, or related information to the displayed objects. It is like having a different environment on your mobile device. In addition, AR could lead the blind with guided audio.

These two immersive learning technologies can be used separately or in combination to produce compelling learning experiences. These technologies should be explored as an alternative to typical classroom settings, particularly in the event of a disruption in schooling or immersive learning. The exciting element of immersive learning is that it creates a highly engaged environment for users, both virtually and physically (Kumar, 2020). This allows an instructor to effectively reproduce a variety of actual locations that are not accessible within the confines of a classroom. The virtual content may be so motivating that it has a lasting effect on the learner's mind (Hennick, 2020). The technology typically uses a headset to block external visual stimulation (VR) or overlay visuals over the real world (AR). Because the technology is available on cell phones, it is being more widely used and thus readily available to students (McCarthy & Uppot, 2019).

Our research focused on designing and developing an app that used virtual and augmented reality technology to help physical education students learn more effectively. This study developed five virtual trainers and one augmented trainer using optimal motor learning theory and CTML. The following are the study's primary objectives: (a) to see how effective virtual physical education coaches are at engaging and motivating pupils to participate in fitness activities and (b) to design and develop an AR book and AR app for PE based on the information collected from objective primary and secondary data. The CTML has been used to create the virtual trainer, exercise movements, choose suitable texts, illustrate images, and choose suitable sounds for the app.

The Design and Development Process

This study is a multiphase design and development study with a qualitative evaluation component. Interviews were used to understand how immersive physical education trainers can facilitate learning and function as good learning material. The paper aims to answer the following questions: (a) how can a virtual physical education trainer help engage and motivate

students to learn physical exercise and (b) what could be the design of a suitable AR trainer for physical exercise for SLDs? This study was divided into two main phases. Table 1 summarizes the research and design procedure that followed the ADDIE Model.

Table 1
The Design and Development Process

Process	Activities
Analysis	Needs analysis from teacher interviews and secondary resources collection
Design	The design of the five virtual trainer characters and storyboard
Development	The development of the trainers and the app using Unity and Adobe Mixamo
Implementation	The implementation of the app with a head-mounted device and testing in the actual setting
Evaluation	The evaluation of the app using student interviews

Phase 1: The Development of The VR Trainers

A preliminary investigation was done in the school to get an overview and additional information about the teaching and learning process. Unstructured interviews were carried out with five teachers. The questions were: (a) what are the most important things that should be considered in class, (b) will the students understand the 3D object and learn the movements, (c) what is the maximum number of students for each lesson, and (d) what type of learning materials are used in teaching and learning? The teachers listed important things to clarify related to teaching SLD. The students must be in a group of less than 10 per session and the instructions must be done step by step. The students also like a trainer that shows actions that are easy to follow. The needs analysis results were used to select the participants and design the virtual trainers.

Design and Development

In the first phase, five virtual trainers were developed to test how students reacted to the training of physical movements using virtual trainers. Five virtual fitness trainers were created to see how effective virtual physical education coaches engage and motivate pupils to participate in fitness activities. These trainers were developed based on the suggestions from the teachers. The teachers suggested that the trainers show the training steps from the preliminary investigation. The activities must also be fun and attract the students' attention. Thus, the five trainers' movements were unique. They were created based on the optimal motor learning theory, which proposes that students learn motor movements by observing the trainers and the signs of motor actions shown explicitly by the trainers. Different trainer types with animations were used to increase student motivation and interest in physical activity. According to motor learning theory, specific motor techniques can be gained from training the body to perform precise motor movements. The CTML is applied to the design process of the VR trainer. Table 2 gives the usage description of the multimedia principles used for the design.

Table 2
Multimedia Learning Principles, Definition, and the Application

Multimedia Principle	Definition	Usage Description
Coherence	Concise, short, and support the instructional goal	In this design, only the virtual trainers show the movements, accompanied by suitable sound.
Redundancy	Avoid displaying the same content of information using audio and text	The trainers only show the movement with music, and the narration is not applied
Contiguity	The text must be close to the visuals that are the subjects of training	The text was placed near the trainer.
Segmenting	The learning content must be broken down into lessons	The steps were presented in segments and phase by phase to make it easier for the students to follow.
Signaling	Learners must be shown exactly what to see on the screen.	Showing exactly what items they need to pay attention to during the movements

The first trainer was Sharky in Figure 2, where the character displayed funky and enjoyable dance movements. Sharky is dressed as a human with a shark costume to attract the learners' attention. This motion is intended to encourage the learners to warm up before engaging in more vigorous exercise activities. This was from a report by Anderson and Rastegari (2016) that for students with a disability, dance, especially a happy dance, can encourage them to exercise. AJ's second character, displayed in Figure 3, demonstrates more intense activities like running and jumping around. The third trainer is Malcolm in Figure 4, who shows fitness through fighting techniques like punching and kicking. The fourth is Granny's character in Figure 5, which focuses more on dancing and easy movement. Although this character is named Granny, she is a sporty granny with Jazz and Zumba dancing. Figure 6 shows Scarlet's character, which demonstrated vigorous activities in video games like running, zombie fighting, and high kicking. The average duration of activities with each of the characters is approximately five minutes. These characters were developed based on the report by Mokmin and Jamiat, 2020. According to these reports, students with disabilities can learn physical activities from adaptive physical exercise suitable to their learning needs.

Figure 2
Sharky with Happy Dance Movements

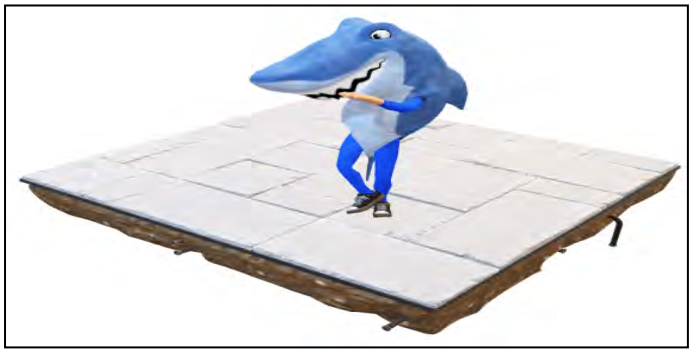


Figure 3
AJ with Exercise Movements

Figure 4
Malcom with Fighting Movements

Figure 5
Granny with Dance Movements

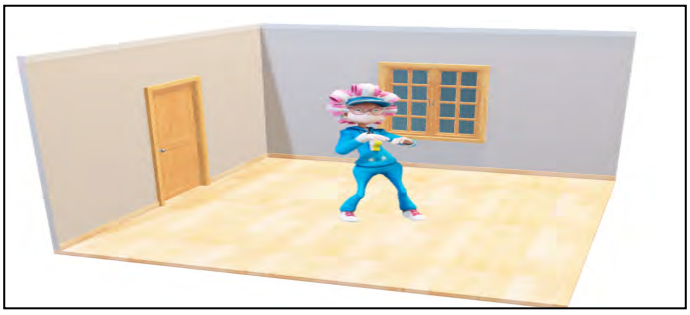


Figure 6
Scarlet with Zombie Fighting

Implementation and Evaluation

The VR Trainers developed were compiled into the app, ready to be used by the students. The developed app was published into a .apk file and linked to a Head Mounted Device (HMD). The facilitators involved in collecting data were trained to use the HMD and run the app. The participants for the evaluation were chosen from a special needs secondary school in Malaysia. The teacher selected the students to join the study who could understand the information and answer all the questions. The ethical committee in the university approved the study. Permission to conduct the sessions was also obtained from the Malaysian Special School Department.

Twelve students were interviewed after they were introduced to the virtual trainers to learn the physical exercise movements. They were aged between 16 to 17 years old and have learning disabilities. Before the exercise started, students' physical fitness was assessed. The students were divided into two groups of six students each. The first group had to follow intense and rigorous exercises with AJ, Malcolm, and Scarlet. The second group required low-intensity movement. Therefore, Granny and Shaky were selected for this group. Both groups were assessed separately inside a gym in one of the educational institutions in Malaysia. They were asked to complete a simple warm-up first and then follow the trainers' movement with a facilitator's help. After the session ended, each participant was interviewed.

Overall, all the participants were able to follow the movements of the trainers. Students who participated in this study also liked the music used in training. They could remember and clearly describe the song used in the activities. However, some students preferred trendier pieces that suited their moods. Some students even expressed enjoyment and excitement in doing a low-intensity salsa and dancing activity. They said the virtual fitness trainers were attractive and willingly followed the movements without coercion. The respondents also suggested adding more trainers to increase their fitness in the long run.

Most said it was 3D and realistically done for all the virtual trainers. A majority said they found Scarlet's movements a bit weird but that it has a value that added to the learning experiences. According to the comments, Scarlet shows specific signs like jumping and running around that provide more student fitness activities. For the combat trainer (Malcolm), students stated that they could learn and hopefully increase their fitness. Most of the students could describe in detail the movements they had learned. They even mentioned "looking around" by one of the trainers to prove that they could remember all the movements. The following are selected quotes from the interviews.

Group 1: Virtual fitness trainers with High-Intensity Movements

Respondent 1:
"The movement is ok. The Scarlet has specific movement and added new fun experience"
"The movement of Malcolm exposed to fitness activities and fitness"
Respondent 2:
"I have done most of the activities previously, but it is ok"
Respondent 3:
"It is too simple for me. The song should be changed to something more trendy"
Respondent 4:
"The movement is not too hard. Easy for me to follow"
Respondent 5:
"The zombie movement is unique. I like it because it is different from the other app I used before because the trainer got movements"
Respondent 6:
"I like it. I sweat a lot"

Group 2: Virtual fitness trainers with Low Intensity Movements

Respondent 1:
"The Sharky training is OK"
Respondent 2:
"Sharky movement is best. It got viral song. But I don't prefer the Salsa movements. It is slower than Sharky"
Respondent 3:
"Should be more movements for Sharky. It is good. "
Respondent 4:
"This make me sweat a lot."
Respondent 5:
"I like the music"
Respondent 6:
"I feel good"

We concluded from the interview that all students prefer Sharky or Scarlet's movements. This is because the actions of the two virtual trainers were easy to understand and follow by the students. The comments and suggestions from the students were used as a guideline to construct the AR book. However, for the first edition of the AR Book, the trainer characters were not included in the AR Book because we had to follow the requirements of the original textbook.

Phase 2: The Development of an AR Book

Needs Analysis

The design at this stage was based on semi-structured interviews done to know how students responded to the lessons with virtual trainers and secondary data concerning the appropriate design of physical exercise movements collected from the textbooks and teaching materials from the Department of Special Education, Malaysia. Additional information was also

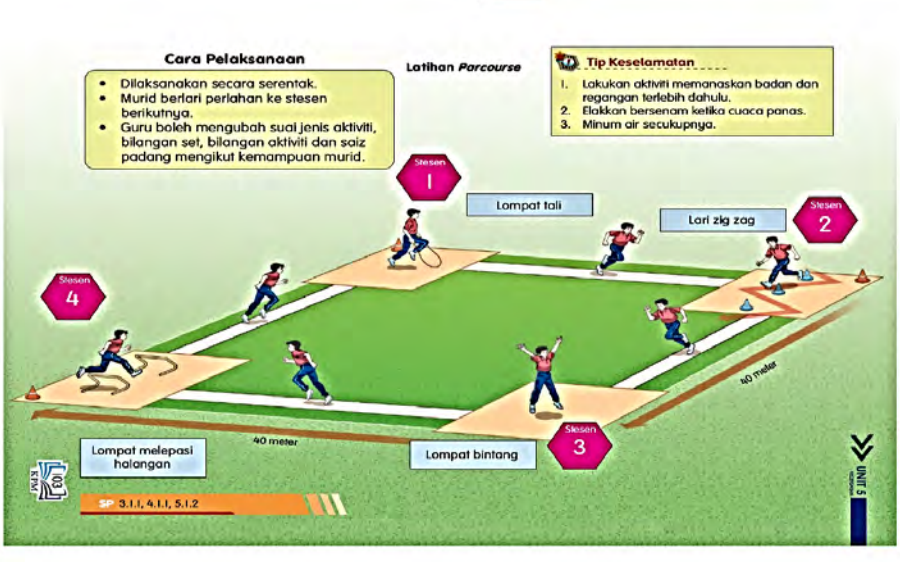
collected from reports and research papers for the second phase. Based on the feedback from Phase 1 and the information collected in Phase 2, AR books and an AR app were developed to facilitate physical education for students with disabilities.

Design and Development

Selecting the best design for an AR trainer suitable for physical exercise involved analyzing the information from official sources such as textbooks as well as using the CTML principles. The content covered was as follows: (a) Stretching, (b) Muscle Strength, (c) Parcourse Training, and (d) Fitness Test. All movements were designed based on the guidelines from the official textbook the Ministry of Education provided.

The parcourse activity was specially designed for students with a learning disability. Parcourse is a set of training that often gives a well-rounded workout based on health-related fitness concepts (MacDonald et al., 2017). This is a fitness activity with checkpoints designed to increase the students' fitness level and be suitable for special needs students (Mustaffa et al., 2019). Thus, the activity was chosen to be included in this study. The training was done by referring to the Physical Education textbook published by the Department of Special education with the title, "Pendidikan Jasmani dan Pendidikan Kesihatan Pendidikan Khas Tingkatan 4," translated as "Health and Physical Education for Form Four Special Needs Students." Figure 7 displays the screenshot of the parcourse training. The textbook covers one year of the syllabus for the secondary form four students in the Malaysian Special Education school system. In the textbook, students are provided instructions on fitness activities to do in class for PE.

Figure 7
The Parcourse Training in Special Education PE textbook (Mustaffa et al., 2019)



Based on the interview data, the authors concluded that the activities must be increased and follow a particular order. According to the students, good fitness trainers must have a specific training routine to engage users and improve fitness. For a virtual trainer to gain the users' attention, it must be designed in 3D and provide a good animation design. They like vigorous activities and a human-like trainer. Therefore, for the AR book design, the training started with stretches, followed by particular fitness activities that target muscle areas. The students also

stated that they could understand and follow the routine with repetitive movements. These items were added to the design for the AR book.

The analysis of secondary data such as reference books and formal guidelines from the Ministry of Education was the basis for creating the AR book and the AR trainer. AR is relayed to the students using AR-printed books and apps downloaded from the app store. The book has eight pages, excluding the cover and end page. There are two methods of learning with this book. The student can just read and follow the steps illustrated or use the AR app to view the animated version of the activities. Table 3 describes the sources and how they were applied in the design of the AR book.

Table 3
The Resources for the Design of the AR Book

Item	Source	The resources applied in the design
Special Need School Textbook	Health and Physical Education for Form Four Special Needs Students (Mustaffa et al., 2019)	The design of the parcourse training in the book was used as a guide for the fitness course training in the AR book
Immersive Multimedia Design Principles	Immersion Principle in Multimedia Learning (Makransky & Mayer, 2022)	The application of CTML for immersive learning
Suggestions from Reports on Physical Exercises for SLD	Activities suitable to engage SLD in PE (McMahon et al., 2020) How SLD learn (Hardiyanti & Azizah, 2019)	At-home activities for SLD

With the AR book, the students will have to learn the physical exercises, starting with stretching. The first activity stretches the Stemocleidomstoid, Pectoralis Major, Deltoid, External Oblique, and Latissimus Dorsi muscles. The students have to perform neck, shoulder side, and hamstring stretching. The next part is focused specifically on muscle endurance with more intense activities. The students must perform push-ups, sit-ups, bench-ups and down, squat, and jump. The targeted muscles are Pectoralis Major, Biceps, Triceps, Abdominal Muscle, Quadriceps, Hamstring, Gluteus Maximus, and Gastrocnemius. The last activity is the fitness test compulsory for most sports activities. In this test, the students will have to do shoulder rotation, body curling, side bend, giant steps, and back legs stretching. Table 4 describes the students' activities and the target output. The book used the Malay language as it is the native language of the students and the original textbook also used Malay. Figure 8 displays a page from the book that functions as a marker where the students can use their smartphones to view the AR overlay of activities. Figure 9 shows the animation overlay when the camera from the student's smartphone hits the marker.

Figure 8
The Page from the AR Book

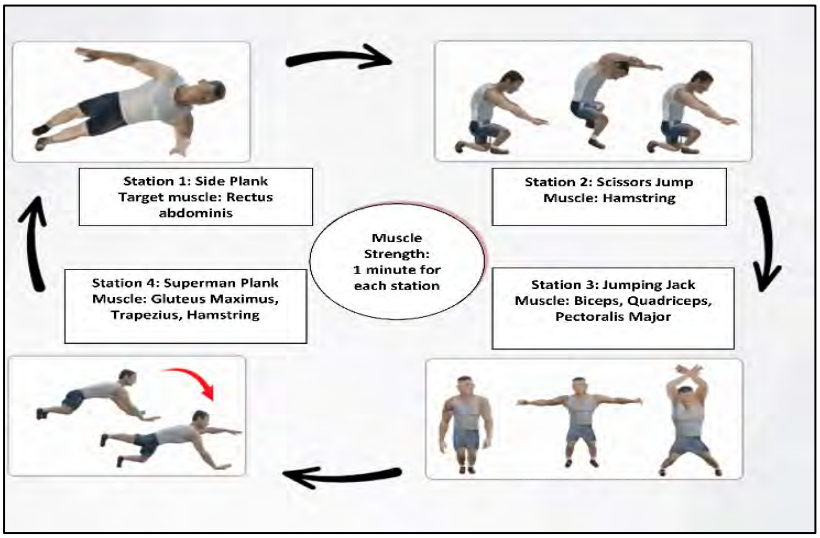


Figure 9
The AR Overlay

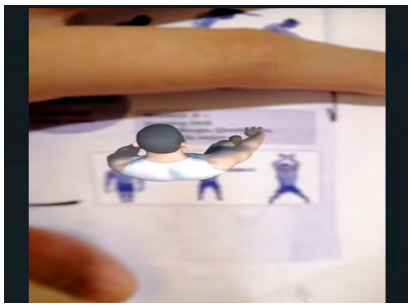


Table 4
The Activities, Motions Illustrated, and Target Outcome

Activities	Motions Illustrated	Target outcome
Stretching	Neck Stretching	Stemocleidomstoid
	Shoulder	Pectoralis Major, Deltoid
	Side Stretching	External Oblique, Latissimus Dorsi
	Hamstring	Hamstring, Gluteus maximus
Muscle Endurance	Non-stop Push up,	Pectoralis Major, Biceps, Triceps
	Sit-up	Abdominal Muscle
	Bench up and Down	Quadriceps, Hamstring
	Squat and Jump	Gluteus Maximus, Gastrocnemius
Fitness Test	Shoulder Rotation, Body Curling, Side Bend, Big Steps, Back Legs Stretching	To measure fitness by measuring the frequency, intensity, and time for each activity

Discussion

Optimal Motor Learning Theory states that motivation and attention are essential to improve motor performance and achieve targeted motor learning. When educators and learning material

developers consider an appropriate design for physical exercise education, the student's motivation is essential. Motivation is the contributing factor that makes the students keep doing the exercise until specific targets are achieved. The students will be engaged and active in physical activities when the learning materials can motivate them to do the activities (Mokmin & Jamiat, 2021). According to this theory, for motivation, students must be given autonomy in learning control, and eventually they can focus on their goals. We found that motor learning can be enhanced by allowing learners to control specific aspects of exercises or assistive devices. During the movement restriction times, such as the pandemic, when the students must stay mostly at home, they must be motivated to follow through with the training to maintain a certain level of activity and physical fitness.

This study demonstrated how observational learning, even in a virtual context, is beneficial for physical education. One of the most prevalent instructional approaches for motor learning acquisition is demonstration or observation (D'Innocenzo et al., 2016). Thus, in the first phase of this study, five types of virtual trainers were introduced to allow the students choice of the trainer(s) they wanted to learn the exercise from and facilitate their learning. They could also freely rewind and pause whenever needed throughout the lessons. Through the interviews, students indicated they were satisfied with the activities they had completed and could easily navigate among the trainers and explore which activities they wanted to do. The trainers' catchy sounds and different appearances also motivated and attracted the learners to move along. In this study, the virtual trainers were set in various settings with different levels of exercise to keep the students engaged and motivated when doing the movements. According to Andrieux and Proteau (2016), when several skill levels are imposed, the students' learning through observation also improves. Here, technology helped the trainer to teach remotely with a virtual trainer. Although an in-person trainer may be the best choice, these virtual trainers are practical when remote learning with technology is needed. Nevertheless, for an efficient PE app, more activities should be added in the future.

AR is the next emerging technology after VR for instructional content designers due to its effectiveness in providing immersive learning (Ariffin et al., 2022) and ease of access. In the era of disrupted education, where face-to-face learning in classroom settings is sometimes impossible to implement, some schools have to opt for immersive technologies. Various studies have shown that learning becomes more exciting by implementing AR technology for physical education, leading to more positive learning outcomes. Chen et al. (2020) have used AR technology to demonstrate Tai-Chi movements to older adults. They have developed an app that applied augmented reality-assisted training with selected Tai-Chi movements tailored to the practitioner's ability. The results showed that the users successfully learned the fitness exercise and got positive outcomes in their activities.

In this study, the AR has been designed according to the specific guidelines from the physical education textbook. The activities started with stretching that targeted specific muscle points, which the AR technology illustrated immersively. The other activities in the book are muscle strength and fitness training, which are also immersively taught to the students. For students with disabilities, AR is an excellent potential tool, as suggested by learning material developers as it can facilitate the unique needs of special needs students.

The best strategy for PE in current distance home learning is to supplement the traditional teaching with creatively designed and personalized resources based on the students' needs (Roe et al., 2021). Both VR and AR technologies used in this study can help developers and educators facilitate the teaching and learning process of PE.

Conclusion

This study examined how students can learn physical education via virtual trainers and the most effective design of a virtual trainer from the students' perspective. However, the virtual trainer and the AR book have not been tested for different types of disabilities, and more virtual trainers should be added to improve the app. The results, alongside secondary data information, were used to design and develop an AR book with an AR app as a learning material for students with learning disabilities. Since the book is developed for the usage of the students with special needs, the five virtual trainers are not included in the book's first publication. It is possible to be included for the subsequent publication of the book for public use. The results show that immersive technology designed using the Optimal Motor Learning Theory and carefully implementing the Cognitive Theory of Multimedia Learning can be a suitable learning material for PE and should be considered for inclusion in the learning material design for students with disabilities. For future study, we suggest the book and the trainer be tested with different groups of disabilities and more movements added for the virtual trainers.

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Corresponding author: Nur Azlina Mohamed Mokmin
Email: nurazlina@usm.my