Augmented Reality Technology for Learning Physical Education on Students with Learning Disabilities: A Systematic Literature Review

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HOW TO CITE:
Mokmin, N.A.M. & Rassy, R.P. (2022). Augmented Reality Technology for Learning Physical Education on Students with Learning Disabilities: A Systematic Literature Review. *International Journal of Special Education, 37*(1), 99-111

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DOI:
https://doi.org/10.52291/ijse.2022.37.30

ABSTRACT

Augmented Reality (AR) is one of education's most developed reality technologies in the last few decades. Many subjects have started integrating this technology into their teaching and learning process to create an attractive learning environment and to help the student learning process. As well as for regular students, AR has also been highly tested and developed on students with learning difficulties (SLD) and found positive results. This study focused on students with learning difficulties, which will find out the trends in the development of AR technology in Physical Education (PE). The PE subject is often assessed as one of the subjects which are difficult for children with learning difficulties to follow. By using a systematic review of this topic over the last five years. It is hoped that it will clearly show the development of this technology in physical education, the type of AR technology used, and the types of learning disability groups with which the technology can assist. The results show that the use of AR technology that is integrated into PE learning with SLDs is not found. This is an excellent opportunity for researchers to conduct and develop this research further.

Keywords: systematic review; augmented reality; educational augmented reality; physical education; students with learning disabilities.

INTRODUCTION

As education developed, technology became another important development for this century. Many innovations have been created due to the impact that new technological advancements have had on society (Scherer et al., 2019). In addition to supporting educational approaches, technology has become necessary to support students' learning using various teaching strategies to make education more effective and exciting. On the other hand, if the technology employed does not foster critical thinking, meaning-making, or metacognition, it will result in a passive learning process (Saidin et al., 2015). Over the past decade, the multiple ways in which 'reality' can be experienced are rapidly evolving as a result of the rapid growth of technology (Mann et al., 2018), and augmented reality (AR) is one of the growing technologies in education that has great potential (Cabero-Almenara & Roig-Vila, 2019). It is undeniable that education will continue to develop every year. With this technology, it is hoped that it can be one of the positive changes that provide opportunities and strategies in education to create an innovative and attractive educational environment for students in this era.

AR is defined as a technology that blends digital and physical information (Barroso et al., 2017) that occurs in real-time by using technological devices (Maas & Hughes, 2020). More specifically, AR refers to the loading and merging of virtual objects such as video, sound, photograph, text, 3D models, etc., into real-world views (Tekedere & Göker, 2016). Today, several types of AR have been developed, such as marker-based applications that are based on image recognition, which we frequently see. This technology employs black and white markers to detect the augmented object, while location-based applications operate without the usage of markers. This technique relies on the global positioning system (GPS) or a digital compass to determine the user's location, after which real-world physical things are substituted with, or combined with, augmented objects (Parekh et al., 2020) There's also projection-based augmented reality, often known as Spatial Augmented Reality (SAR) or projection mapping, which operates by projecting virtual data directly into actual space (Ojer et al., 2020).

AR has been widely used to promote various supports in education and more independent life (Akçayır & Akçayır, 2017) learner type (e.g., K-12, higher education, and adult. In this case, AR allows students to learn independently because this technology provides a good learning experience and satisfaction. Apart from education, AR applications have also been developed to make everyday life easier. In its use, AR requires supporting devices in the form of special AR devices, AR glasses, virtual retinal displays (VRD), and what we often find are mobile devices. Mobile devices are often used to support AR technology because, through easily accessible mobile devices, this technology also allows access and dissemination of information about an individual's environment (Gómez-García et al., 2018). On the other hand, integrating technology into the curriculum is becoming an essential part of successful teaching in the educational system.

This makes AR very attractive and valuable in today's learning world, partly because it offers new learning experiences and incorporates the real world with virtual objects that can significantly assist the learning process. Improved academic achievement (Moreno-Guerrero et al., 2020a), increased engagement in training activities (Cheng, 2017), and a pleasant learning environment (Sáez-López et al., 2019) are all outcomes of using AR in teaching and learning. The importance of physical education (PE) in contemporary school education has received international recognition (Yang et al., 2020). In education, PE is one of the subjects that significantly benefits from AR versatility.

However, most PE teachers still use traditional didactic teaching methods in their classrooms, such as giving a reading book that explains a sports activity with several pictures in it; there is also practice time, where the teacher will demonstrate and describe the action. Students tend to follow without thinking, making it difficult to improve the quality of physical education (Zeller, 2017). With AR in the PE teaching and learning process, students can enhance their performance in various ways. Furthermore, recent technological developments have evolved in the increased usage of mobile devices in education, primarily for students with learning disabilities (SLD) or various educational needs.

Augmented Reality in Education

AR is a new set of mobile technologies in which you can view at the same time computer generated media (such as graphics, video, sound, or web-based content) enhance objects or environments in the real world (Garrett et al., 2018). Using smartphones or eye devices, AR uses image recognition technology to identify places, images, markers, or things superimposed on the real world. The difference between AR and virtual reality is that AR does not try to create a fully digital world that users can interact with but instead relies on the integration of the digital

(virtual) domain and the physical (real) environment (Garrett et al., 2018). The three basic concepts that constitute AR are: immersive, interactive, and participatory (Da Silva et al., 2017). Immersion is linked to the feeling of being in the environment. AR's application for multiple domains, especially in education, is on the rise.

For many years, augmented reality (AR) apps have been effectively adopted at various educational levels, subjects of study, and locations, offering students numerous advantages. Garzón (2021) has pointed out that after more than 25 years of AR in education, the technology has evolved rapidly from hardware-based AR in 1995 to Smartglasses Web-based AR. AR positively impacted the education field by increasing the students' motivation and at the same time, proven effective in increasing academic performance (López-Belmonte et al., 2020). In order to get the most out of modern technology to improve education, a few obstacles still need to be resolved. The development of AR applications will follow the development of AR hardware, which will bring new opportunities and difficulties for the field of AR research. The potential for AR technology as a learning tool is considerable, and it has already begun to impact education (Brown et al., 2020). The development of augmented reality technology and pedagogical methods may assist students in absorbing information more quickly (Tan & Tay, 2021).

According to physical education teachers, AR is also an excellent instrument for enhancing human motion skills and preserving human health competence (Klochko et al., 2020). Sırakaya & Alsancak Sırakaya (2020) published a study that systematically examined studies in which augmented reality (AR) is implemented to promote science, technology, engineering, and mathematics (STEM) education to see the trends of AR in the education field. There were 42 papers published in journals indexed in the SSCI database investigated. Figure 1. below shows AR result trends in STEM education from their study.

From fig. 1 we can see AR trends in education over the last seven years. The graphic shows that the growth of research in this field is not stable, but in 2016 and 2018 there has been an increase in journal publications, which means that AR has become popular compared to other years. From the research that has been done on AR in the education field, it was found that the use of AR technology improves academic achievement (Moreno-Guerrero et al., 2020a), increasing student contact and interaction with content (Fombona & Vázquez, 2020), as well as student motivation (Bacca et al., 2014).

Trends of Augmented Reality in Physical Education

A number of PE-related apps have also included AR. Chen et al. (2020) have employed augmented reality technology to show older folks Tai-Chi moves. They have created an app that combines specific Tai-Chi movements with augmented reality training that is personalised to the practitioner's skill level. The outcomes demonstrated that the users had successfully picked up the fitness routine and were having success with it. The development

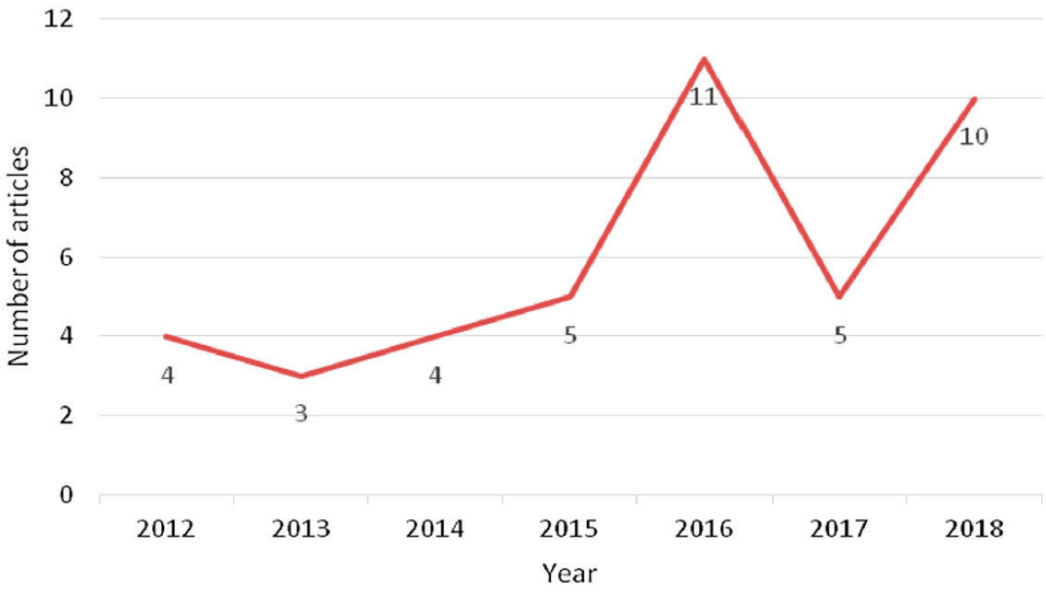

Fig. 1. Trends of AR in STEM (Sırakaya & Alsancak Sırakaya, 2020)

of a second AR fitness app by (Nair et al., 2019) demonstrated that AR may be used for fitness, particularly for Malaysians. At every level of the AR game app, their AR software encourages users to boost their fitness activities. These outcomes demonstrated that the fitness app could benefit from the use of augmented reality technologies.

Research conducted by Saidin et al. (2015) presents an overview of the extant research on the application of AR technology in several fields of study in education. The research shows that only a few areas of study apply AR technology, such as medicine, chemistry, mathematics, physics, biology, astronomy, and history. Some use AR to display 3D objects on the subject for a more natural reality, then for training for medical students and to show augmented video, videoconferencing, and tracked physical props. Sirakaya & Alsancak Sirakaya (2018) conducted research to identify trends of AR on education in 2011-2016, and 105 publications were found in ERIC, EBSCOhost, and ScienceDirect databases.

Figure 2. above shows that AR is mainly used in biology education, engineering education, medical training, and other fields. A recent study conducted by Garzón et al. (2019) conducted a systematic review and meta-analysis of the use of AR technology in education. From the results of his research, it can be seen that the field of education that most implements AR in education is in the natural sciences, mathematics, and statistics totaling 30 studies, which are used when teaching abstract concepts as demonstrated by (Ibáñez et al., 2014), followed by ten studies in the arts and humanities which are included in the field of art, which often implements AR in various museum applications. Furthermore, seven studies on social science, journalism, and information, primarily focusing on psychology. Lastly, there are four studies in engineering, manufacturing, and construction focused on engineering and four in health and welfare. All research conducted by Saidin et al. (2015) and Sirakaya & Alsancak Sirakaya (2018), and Garzón et al. (2019) showed that AR technology is mainly used in science content such as biology, physics, chemistry, math, and medicine. Still, none were conducted in the physical education field.

Augmented Reality with Learning Disability Students

Learning disability is usually caused by a discrepancy in how a person's brain is "wired," to put it simply (Rachamalla & Rafi, 2016). It also has to do with neurological problems that usually cause learning impairment. Children with learning disabilities are just as intelligent as their peers. However, they may struggle with reading, writing, spelling, reasoning, and organizing information if left to their ways or taught in conventional methods (Rachamalla & Rafi, 2016). Individuals with learning difficulties, communication, behavioral, or developmental issues require specialized teaching strategies to enhance learning and skill acquisition (Cifuentes et al., 2016).

According to Yenioglu et al. (2021), AR can be implemented as a teaching tool for students with special needs to develop their conversational skills, promote learning, increase comfort and confidence, and improve physical, navigation, and social abilities. Integrating AR for children with learning disabilities is one of the learning strategies that can be used as an effort to help children with learning disabilities. AR technology can help disabled kids in a number of ways. According to a meta-analysis

Education Field	f	%
Biology Education	17	19,8
Engineering Education	11	12,8
Medical Training	10	11,6
Other	10	11,6
Physics Education	6	7,0
Informal Education	6	7,0
Language Education	5	5,8
Chemistry Education	5	5,8
Mathematics Education	5	5,8
Special Education	4	4,7
Preschool Education	3	3,5
History Education	2	2,3
Astronomy Education	2	2,3

Fig. 2. The use of AR in the Educational Field (Sirakaya & Alsancak Sirakaya, 2018)

study by (Baragash et al., 2020), AR is an effective learning tool for promoting students with disability (SWD) involvement in society, teaching a variety of abilities, teaching different physical learning, performing self-care chores, and long-term memory retention. AR is a powerful tool for persons with disabilities because it has the capability of showing context-sensitive digital information, which can meet individual requirements at the time and give timely learning (Walker et al., 2017).

It is crucial for those of us who create learning materials for special education to comprehend the cutting-edge tools at our disposal and use them to cater to the individual needs of our students. Teachers may use text tags that AR software can read to mark real-world objects with context-relevant terms. When using multi-step activities, augmented reality (AR) apps can read difficult terminology aloud, display additional information about academic subjects, provide video lessons, provide thorough information about future programmes, or give people advice to enhance independent living. If we take into account the practical use of AR in education and a more user-friendly entertainment value design, AR can offer a variety of alternatives.

Physical activity is necessary for children with disabilities to develop properly; yet, choosing an appropriate physical activity for children with impairments can be difficult. Even more challenging is integrating them in a regular physical education lesson (Clemente, 2017). The students with disabilities are less active than their able-bodied counterparts, which could be due to a variety of barriers to physical activities that these persons confront at all levels of society (Úbeda-Colomer et al., 2019). Using AR technology in students' physical activities becomes a new strategy that can be investigated to re-encourage the spirit of children with disabilities to carry out physical activities and sports in the same way as their peers.

METHODOLOGY

In order to achieve the study's objectives, the process of a systematic review was conducted using the suggested reporting items for systematic reviews and meta-analysis (PRISMA) review protocol, which includes a search strategy, the selection criteria, and data extraction and analysis procedures (Liberati et al., 2009). The research questions (RQs) on this research are:

(1) What was the trend of AR application in physical education during the 2015-2021 period?

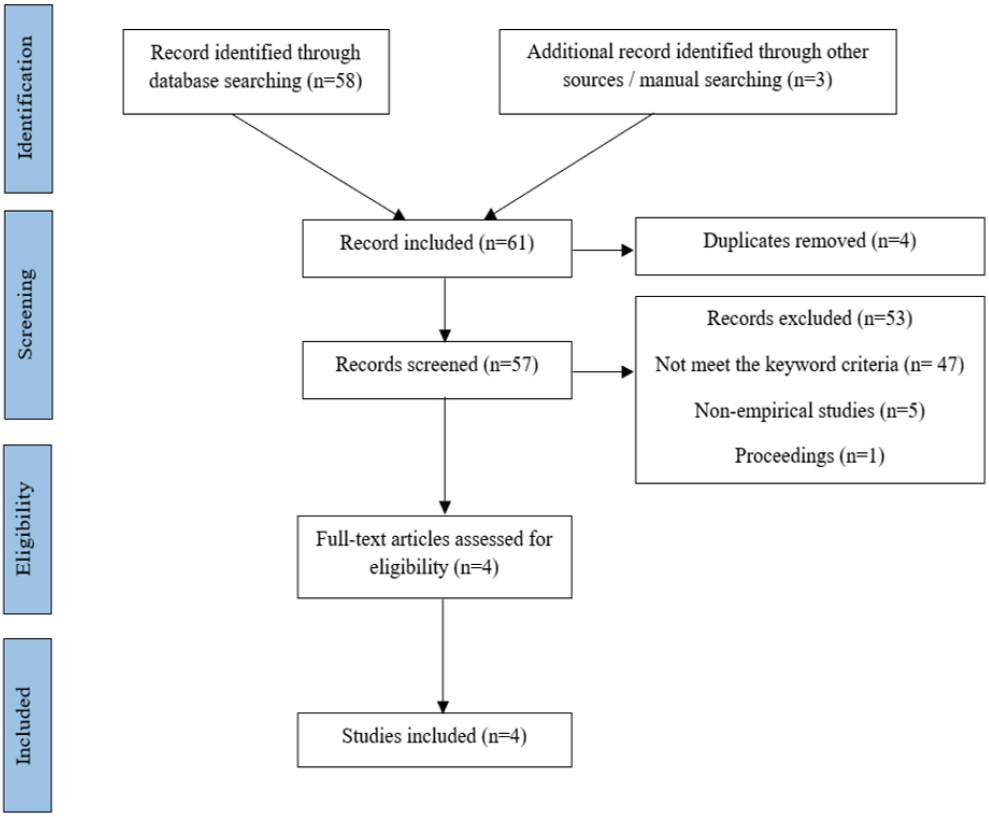

Fig. 3. Flow chart of the PRISMA-based selection process

(2) What is the development of research on using AR technology in the physical education field by involving students with learning disabilities (SLD) as participants?
(3) What variables are used in the research of AR in the PE field with SLD?
(4) What kind of AR types are used in the PE field with SLD?
(5) What types of learning disabilities groups has the AR application been studied in the PE field of study?

A systematic search was done to identify the empirical studies on augmented reality in physical education with learning disabled students as a research sample. The studies selected were published between 2015 and 2021, which was identified by using a combination of databases, such as ERIC, PubMed, ScienceDirect, PsychINFO, Google Scholar, Elsevier, EBSCOhost, Routledge (Taylor & Francis), SAGE, IEEExplore, and Springer.

The following keyword search terms were used during the electronic scanning phase: ('Augmented Reality' OR 'Augmented Reality Technology' OR 'Augmented Reality system') in ('Physical Education' OR 'Sports' OR 'Sports Education') with ('Disabilities' OR 'Disability' OR 'Disabled' OR 'Disorder' OR 'Special needs') students. The selected study will also be reviewed based on the title, abstract, method, and results to ensure its relevance to other studies. The literature review flow diagram is shown in fig. 3 which demonstrates the process from identification, screening, eligibility, and the included articles.

Search results through online databases using the keywords mentioned above resulted in 61 articles. The three articles identified come from additional records identified through other sources or manual searching.

Eligibility Criteria

To obtain relevant papers to this research, exclusion, and inclusion criteria are applied and used for reporting systematic reviews and meta-analyses according to the population, intervention, comparison, outcomes, and study (PICOS) design principles (Methley et al., 2014) entitled SPIDER, was recently developed for more effective searching of qualitative research, but remained untested beyond its development team. Methods: In this article we tested the 'SPIDER' search tool in a systematic narrative review of qualitative literature investigating the health care experiences of people with Multiple Sclerosis. Identical search terms were combined into the PICO or SPIDER search tool and compared across Ovid MEDLINE, Ovid EMBASE and EBSCO CINAHL Plus databases. In addition, we added to this method by comparing initial SPIDER and PICO tools to a modified version of PICO with added qualitative search terms (PICOS. Meanwhile, this study's exclusion and inclusion criteria are described in table 1.

After the screening process following the predetermined criterion, four articles met the requirements, 47 articles did not meet the keyword criteria, five articles were non-empirical studies, and one was proceedings. Four articles that met the criteria, they used AR with disability children for sports activities instead of learning PE at school. The details of articles shown on table 2:

In order to improve the physical strength of children with disabilities, the first article by (Lin & Chang, 2015) in the table above creates an AR application in the form of an interactive gesture game that was created in Scratch 2.0. With Scratch 2.0, real-world and virtual reality views may be created simultaneously using an augmented reality feature that uses the programming environment to detect body motion. This study is based on a case study

Table 1. **Exclusion and Inclusion Criteria**

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

Table 2. **List of Research Included**

Number	Author (year of publication)	Purpose
1	(Lin & Chang, 2015)	Enhancing the body strength of children with disabilities using a body motion interactive game.
2	(Graf et al., 2019)	Identify the potential of iGYM to accommodate a variety of abilities and mobility aids in exergames.
3	(Lu et al., 2020)	Evaluate different tracking algorithms and compare their performance to finalize the player detection and filtering method for iGYM.
4	(Nebytova et al., 2021)	Prove the effectiveness of augmented reality technology to enhance learning in the educational and training process on track and field athletics.

that used the ABAB structure and had a 2-month baseline and intervention trial period. Three participants in this study, each with a different developmental disability, were involved. The first individual had from developmental disabilities, the second from cerebral palsy, and the last from moderate multiple disabilities. The purpose of this application was to increase the motivation of these disabled children to move their bodies. According to the research findings, three children with developmental difficulties saw a considerable improvement in their scores during the intervention.

In order to enable co-located physical play experiences for people with mobility limitations and their non-disabled peers, projected augmented reality (AR) in the form of an interactive floor system was used in study conducted by (Graf et al., 2019), because people with disabilities frequently lack opportunities to play physically with their peers without mobility aids, and the reverse is also true. The foundation of iGYM is the idea of peripersonal circle interaction and movable game mechanics that allow for customized game calibration and wheelchair-accessible manipulation of virtual targets on the floor. 8 people with mobility disabilities were included in the study's sample, 5 of whom utilized power wheelchairs and 3 manual wheelchairs. The other 4 participants took part without using any mobility assistance because they did not have any mobility issues.Higher adaption levels were not necessarily desirable, according to the results. The tastes of the players varied and were also influenced by their desire for challenge. Whether or not athletes were in wheelchairs, perceptions of fairness were frequently developed.

Using the same application, Lu et al. (2020) evaluated different tracking algorithms and compared their performance to finalize the player detection and filtering method for iGYM to measure the effectiveness of each tracking approach for players, by comparing two adaptive filtering-based tracking techniques: the particle filter and the Kalman filter. The findings indicate that iGYM's real-time player tracking system built on a Kalman filter has been effectively demonstrated to the public for inclusive play amongst kids and parents with and without disabilities.

Lastly, research conducted by (Nebytova et al., 2021) proved AR technology's effectiveness in enhancing learning in the educational and training process on track and field athletics. The aim of this study was to demonstrate how effectively augmented reality technology can improve learning during the instructional and training phases of track and field athletics for young deaf children, and quantitative approaches generated from mathematical-statistical methods are used (elementary level group, ages 7 - 10 years). The 20-meter run at the beginning of the flight, the 100-meter race, the standing long jump, and the time trial jump rope are the primary tests to evaluate the effectiveness of training with AR technology. All of the testing criteria used in this study have demonstrated positive dynamics regarding the effectiveness of the application of AR technology. The technique is very easy to apply and operate. The findings of this study can be applicable to several other children with special needs who participate in sports, in addition to the deaf athletes mentioned above.

RESULTS

The outcomes of the five research questions will be presented in this section. First and foremost, the focus will be on the most recent developments in AR technology in physical education to determine current trends. The second research question determines the most recent outcome in AR technology in PE areas with disabled students. The third is to decide which variables are commonly employed in AR studies in physical education, followed by what types of AR are used in this field of research, and the last is to determine which disability groups are being examined.

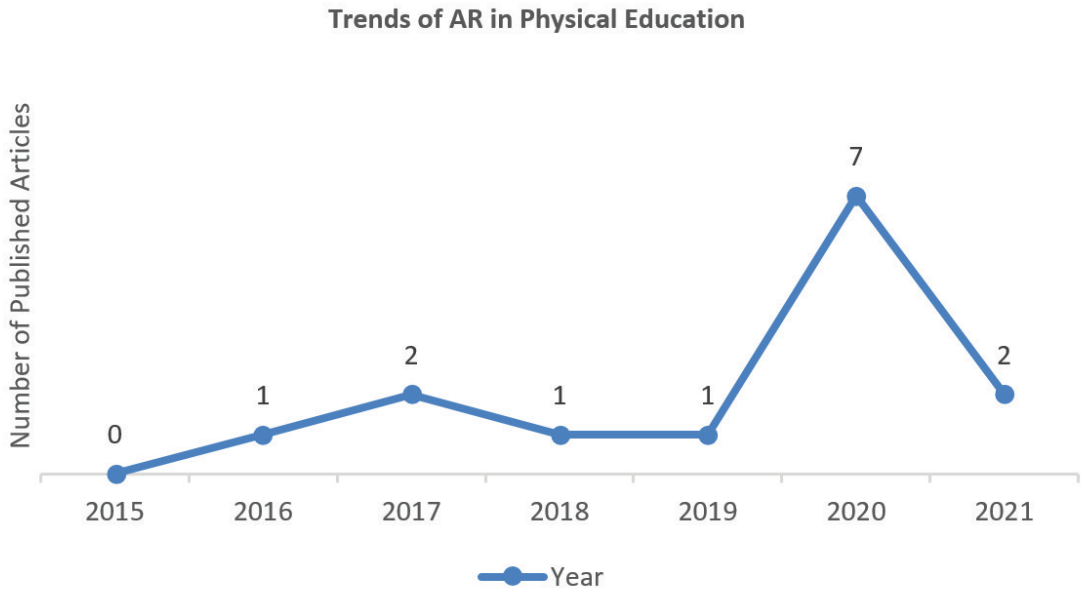

Fig. 4. Recent Trends of AR in Physical Education

Trends of AR Technology in Physical Education from 2015-2021

From 61 articles collected from 2015-2021, there are 14 articles related to the application of AR in the PE field.

Figure 4 above shows that there were no papers published in 2015. Every year from 2016 to 2017, the number of published articles increased, but in 2018 and 2019, the number of published articles decreased compared to the previous year. Lastly, in 2020, there was a rapid spike of seven published articles, followed by a reduction in 2021. We may deduce from the graph that while researchers' interest in this topic is still low, research in this field began to gain traction in 2020, as indicated by the significant number of papers published in that year compared to the average number of published articles in prior years. The trend answers the first research question, showing that few researchers are aware of the many positive impacts resulting from the integration of this technology, as demonstrated by the graph from the last five years of research in education.

The development of research on the use of AR technology in the PE field with SLDs as participants

From fig. 3, 61 articles have been successfully collected according to the specified keywords. After the analysis process, none of the articles that conducted a study on the use of AR in PE with SLDs during 2015-2021. Then there are four articles found that was almost similar with the main topic which the use of AR in learning sports with disability children. Still, the articles found were more comprehensive in scope and more inclined to physical activities, including sports activities and training for paralyzed athletes, not specifically in the physical education field. Even though many advantages are resulting from the use of AR in the PE field that several researchers have carried out. However, there are four studies in physical activity, three of which help children with disabilities in sports and other basic physical activities.

List of Variables Used in The Research of AR in the PE Study

Research question number three aims to determine what variables are used in research on the implementation of AR technology in the PE field by focusing on students with learning disabilities as participants.

As shown in table 3, one study employs physical play experiences of the participants as the dependent variable, one article uses health improvement of participants, and two articles use body movement. Two articles use inclusive AR floor projection as an independent variable. One article uses AR-based interactive games, and the last article uses AR sports and game training. From some of the studies above, it can be seen that most of the research conducted in the sports field for SLDs tries to examine the effects resulting from the use of AR on SLDs' body movements and health improvement.

Types of AR Technology Used in the PE Field with SLD

The three articles that are shown in table 3 applied projection-based AR that works by projecting artificial light onto an actual surface. In some cases, it allows the user to

Table 3. **List of Variables used in Research of AR in PE studies**

Author	Dependent Variable	Independent Variable
(Lin & Chang, 2015)	Body movement	AR-based interactive game
(Graf et al., 2019)	Physical play experiences	Inclusive AR floor projection system
(Lu et al., 2020)	Body movement	Inclusive AR floor projection system
(Nebytova et al., 2021.)	Health improvement	AR sports and game training method

interact with it, and the other used markerless AR type, which does not require a marker to display particular 3D objects. One of the articles uses AR interactive games. It aims to increase the motivation of children with developmental impairments to participate in physical activities by integrating a web camera that tracks movement and allows participants to interact with the project physically. The two articles use floor projected AR in exergames to help students with disability movement to get experience playing a hockey game like their peers, and the last article which used markerless AR uses AR interactive sports games to evaluate the training effect in the educational and training process on track and field athletics.

We can conclude that all articles were developed in the field of physical activity, which aims to help SLDs; more specifically, three of the articles researched the field of sports, and one of them in the area of simple physical activity. The results shown above answer research question number 4, whereby the whole article shows that the most used types of AR are projection based that allow detection of the interaction between the user and the projection through its changes, and markerless types, where the AR application overlays 3D material into a scene and holds it to a fixed point in space without requiring prior knowledge of the user's environment. This is in accordance with the target sample they tested, namely students with learning disabilities who then focused on seeing their body movements when using the application. This will greatly facilitate researchers and participants by using the projection-based AR and markerless AR type.

List of Disability Groups that Participate in the Research of AR Technology in the PE Field.

The four articles show that three types of disabilities are included in the research. One article included SLD with developmental disabilities as participants consisting of three students, each of whom has different skills: developmental disabilities, cerebral palsy, and moderate multiple disabilities. Then the following article included SLD with hearing disorders in their research. About two articles tested on SLD with mobility disabilities that have been assisted with mobility aids. We can conclude that research on AR used in physical activities with SLD from the four studies found that research on mobility disabilities dominates, followed by developmental disabilities that also affect their bodies' movement. The reviews are essential to know the type of AR and variables used in the study. Most of the articles try to see what effect this technology has on children with disabilities that interfere with their mobility.

Overall, this study found that the trend of using AR in PE subjects in the last five years did not experience a significant increase; from fig. 4, it can be seen that there was even a decrease and increase every year, which showed unstable growth. The use of AR technology in PE subjects involving SLDs has not been found. So far, the scope of research that has been carried out has only been on the use of AR in PE classes or the use of AR in children with disabilities in the context of physical activity and sports, which are dominated by developmental disabilities who have physical growth disabilities. In fact, if AR is used in sports classes, it can be beneficial in learning. This shows that not many researchers are aware of the scope of this promising research.

DISCUSSION

A systematic review is a methodology of critically evaluating, summarizing, and seeking to reconcile evidence (Petticrew & Roberts, 2006). It includes a thorough search for all relevant published and unpublished work on a subject (Siddaway et al., 2019). Prior studies on systematic review and meta-analysis of augmented reality in educational settings by Garzón et al. (2019) try to employ quantitative data analysis to understand the specific needs of particular users or the effect of AR on education. Involves 61 studies that were published in scientific journals and conference proceedings between 2012 and 2018. These findings suggest that AR has a moderate impact on learning effectiveness.

Yu et al. (2022) conducted A thorough search of the ScienceDirect database turned up 19 publications related to the systematic review of the literature on the advantages and difficulties associated with using augmented reality (AR) in STEM education. Further investigation of these articles resulted in four themes of AR advantages: its contribution to learners, the learning outcomes, the interaction of AR, and other benefits. These four themes further produced a total of 16 sub-themes, while the challenges aspect of AR resulted in 5 sub-themes. The most reported benefit of AR is that it stimulates learning achievement. Some observed that the challenges imposed by AR are concerned with marker detection and usability. Four topics of AR advantages resulted from further research into these articles: its usefulness to learners, the learning results, the interaction of AR, and other benefits. The difficulties component of AR generated five sub-themes, whereas the other four themes generated 16 sub-themes. The most frequently mentioned advantage of AR is that it stimulates learning achievement, and some people have noted that the difficulties presented by AR are related to marker detection and usability.

Lastly, is research on Augmented Reality in Educational Inclusion. A Systematic Review on the Last Decade by Quintero et al. (2019) states that using Augmented Reality (AR) to achieve educational inclusion has not been deeply explored. This systematic review describes the state of employing augmented reality as an educational technology that considers all students' requirements, including those with a disability. Scopus, Web of Science, and Springer Link searches were conducted on 50 studies published between 2008 and 2018. The findings indicate that more research has been done on using augmented reality (AR) for inclusive education in the sciences. The drive, interaction, interest-creating abilities of the student, and the improvement of communication skills in students with disabilities, particularly those with hearing issues, all factors that support inclusive education, were among the most representative benefits recorded for the population with impairments.

In this study, a systematic review was used to see trends in the use of AR in PE in the last six years. Then proceed to a more specific analysis of articles that include SLD as research participants. In the early stages, 61 articles were found from the online database search results, which were then analyzed. Only 14 articles were found that discussed the application of AR technology in PE, and the increase is uncertain every year from 2015 - 2021, but there is a significant increase in 2020. The trends obtained from the analysis show that many researchers have not overlooked the use of AR technology in the PE field. This finding is in line with Moreno et al. (2020), Sirkaya & Alsancak Sirkaya (2018), Mast et al. (2017), state that the most popular applications of augmented reality technology in education are in the fields of biology, engineering, and medical training, and contrast, physical education is still not widely used. This topic can be a research opportunity for researchers, given the many benefits students and teachers can feel during the learning and teaching process.

The answer to the second research question indicates that there are no studies on the use of augmented reality (AR) technology in PE classes, specifically including students with learning difficulties. Even though this technology is beneficial and can be one of the learning strategies that can be applied, research shows that in adaptive PE classes in Indonesia, lack of learning materials (55.56%%) is a factor that significantly affects the inhibition of the learning process (Purnama, 2020). On the other hand, integrating AR technology into inclusive physical education or physical education for disabled students is very helpful for students and teachers in learning and teaching. In line with research by Yenioglu et al. (2021) states that AR can be implemented as a teaching tool for students with special needs to develop their conversational skills, promote learning, increase comfort and confidence, and improve physical, navigation, and social abilities. Other than that, the use of this technology in learning PE has several benefits, such as interface interaction (Lin & Chang, 2015), providing physical play experiences for children with movement disabilities (Graf et al., 2019), the ease of a system that can provide the real-time feedback to various kinds of disabilities (Lu et al., 2020), and has also effectively helped deaf children in practicing track and field athletics (Nebytova et al., 2021).

However, from the 14 articles, four articles were found that work on the physical activity environment and involved SLD. Most of the four articles in this study use markerless AR to detect body movement as the dependent variable and Inclusive AR floor projection as the independent variable. This study was mostly done with SLD with mobility disabilities, followed by developmental disabilities and hearing disorders. We can conclude that most of the research carried out in this area is still focused on students with mobility limitations and aims to help them interestingly train their movements to attract their attention so that these children are motivated to carry out the physical activities that are required for their health and enabling children with disabilities to ex-

perience playing sports that is difficult for them to play, unlike their peers. As for the weakness in this study, the main topic to be studied was not found, which article that studied on the use of AR technology in PE subjects involving SLDs, so from the results of the article selection process using Prisma, the research continued to examine the use of AR with children with disabilities in the scope of sports and physical activity.

Overall, the effectiveness of using AR technology has shown positive dynamics. This technology is quite simple in its application and use (Nebytova et al., 2021). It allows participants to physically connect with the project to increase the motivation of children with developmental difficulties to engage in physical activity (Lin & Chang, 2015). From previous research that has been done regarding systematic reviews on AR in educational settings and inclusive education, we can see that using this method, will be very helpful in summarizing and concluding all relevant articles in order to see the core problems, trends, and others who want to study as a whole. The first and third studies explain that AR is widely used in the field of science in formal and inclusive education, where these results are still very general. The same is the case in the second study, which focuses on STEM education. In contrast, this study focuses on examining one subject, PE, and involving children with disabilities as a new area of research that is more in-depth and detailed.

CONCLUSION

The findings of this study indicate that the trend of using AR technology on PE subjects in the last five years is very low. It is proven that every year there is only an increase in one article and a decrease in one article, which shows unstable growth. However, in 2020 there will be a significant increase. This indicates that researchers have begun to see the potential for research in this area. As previously explained, AR has many benefits in education, especially PE. With the technology offered, AR can help teachers as teaching material assistance when teaching PE in class. This can also help students learn the sports movements in the book because of student interaction with applications and direct visual assistance, which students can see on their smartphones. This can help increase their interest and motivation to learn.

Furthermore, no similar research has been found so far regarding the implementation of AR on PE subjects involving learning disability students as participants. This result shows that researchers have not paid attention to this research topic, even though this technology is beneficial and helps children with learning disabilities to learn. The personal assistance offered in this technology can directly help students with disabilities understand the sports movements exemplified in the book. It is the same with other students, by using AR technology in the learning process can also increase the learning interest of students with disabilities. This field has great potential to be researched, considering that few researchers focus on this topic, and few AR applications support it. This can be a suggestion and further research for researchers and developers to be able to jointly integrate this AR technology into adaptive and inclusive PE in schools.

ACKNOWLEDGEMENT

None.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

FUNDING

This work was supported by the Universiti Sains Malaysia (Short Term Grant) [304.PMEDIA.6315301].

REFERENCES

Akçayır, M., & Akçayır, G. (2017). Advantages and challenges associated with augmented reality for education: A systematic review of the literature. *Educational Research Review*. https://doi.org/10.1016/j.edurev.2016.11.002

Cabero-Almenara, J., & Roig-Vila, R. (2019). The motivation of technological scenarios in Augmented Reality (AR): Results of different experiments. *Applied Sciences (Switzerland)*, *9*(14). https://doi.org/10.3390/app9142907

Cheng, K. H. (2017). Reading an augmented reality book: An exploration of learners' cognitive load, motivation, and attitudes. *Australasian Journal of Educational Technology*, *33*(4), 53–69. https://doi.org/10.14742/ajet.2820

Cifuentes, S. C., García, S. G., Andrés-Sebastiá, M. P., Camba, J. D., & Contero, M. (2016). Augmented Reality experiences in therapeutic pedagogy: A study with special needs students. *Proceedings - IEEE 16th International Conference on Advanced Learning Technologies, ICALT 2016*. https://doi.org/10.1109/ICALT.2016.23

Clemente, I. (2017). Barriers and facilitators to participation in physical activity for children with disability. *Physiotherapy (United Kingdom)*, *97*, eS1131. http://0-ovidsp.ovid.com.wam.city.ac.uk/ovidweb.cgi?T=JS&PAGE=reference&D=emed13&NEWS=N&AN=71883717

Da Silva, I. C. S., Klein, G., & Brandão, D. M. (2017). Segmented and detaile visualization of anatomical structures based on augmented reality for health education and knowledge discovery. Advances in Science, Technology and Engineering Systems, 2(3), 469–478. https://doi.org/10.25046/aj020360

Garrett, B. M., Anthony, J., & Jackson, C. (2018). Using Mobile Augmented Reality to

Enhance Health Professional Practice Education. Current Issues in Emerging ELearning, 4(1), 10. https://scholarworks.umb.edu/cieeAvailableat:https://scholarworks.umb.edu/ciee/vol4/iss1/10

Garzón, J. (2021). An overview of twenty-five years of augmented reality in education. Multimodal Technologies and Interaction, 5(7). https://doi.org/10.3390/mti5070037

Garzón, J., Pavón, J., & Baldiris, S. (2019). Systematic review and meta-analysis of augmented reality in educational settings. *Virtual Reality*, *23*(4), 447–459. https://doi.org/10.1007/s10055-019-00379-9

Gómez-García, M., Trujillo-Torres, J. M., Aznar-Díaz, I., & Cáceres-Reche, M. P. (2018). *Augment reality and virtual reality for the improvement of spatial competences in Physical Education*. https://doi.org/10.14198/jhse.2018.13.proc2.03

Graf, R., Benawri, P., Whitesall, A. E., Carichner, D., Li, Z., Nebeling, M., & Kim, H. S. (2019). Igym: An interactive floor projection system for inclusive exergame environments. *CHI PLAY 2019 - Proceedings of the Annual Symposium on Computer-Human Interaction in Play*, 31–43. https://doi.org/10.1145/3311350.3347161

Guerrero, A. J., García, S. A., Parejo, M. R. N., Soto, M. N. C., & García, G. G. (2020). *Augmented Reality as a Resource for ImprovingLearning in the Physical Education Classroom.pdf*.

Ibáñez, M. B., Di Serio, Á., Villarán, D., & Delgado Kloos, C. (2014). Experimenting with electromagnetism using augmented reality: Impact on flow student experience and educational effectiveness. *Computers and Education*, *71*, 1–13. https://doi.org/10.1016/j.compedu.2013.09.004

Klochko, O. V., Fedorets, V. M., Uchitel, A. D., & Hnatyuk, V. V. (2020). Methodological aspects of using augmented reality for improvement of the health preserving competence of a Physical Education teacher. *CEUR Workshop Proceedings*, *2731*, 108–128.

Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C., Gøtzsche, P. C., Ioannidis, J. P. A., Clarke, M., Devereaux, P. J., Kleijnen, J., & Moher, D. (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health-care interventions: explanation and elaboration. *BMJ (Clinical Research Ed.)*. https://doi.org/10.1136/bmj.b2700

Lin, C. Y., & Chang, Y. M. (2015). Interactive augmented reality using Scratch 2.0 to improve physical activities for children with developmental disabilities. *Research in Developmental Disabilities*, *37*, 1–8. https://doi.org/10.1016/j.ridd.2014.10.016

López-Belmonte, J., Moreno-Guerrero, A. J., López-Núñez, J. A., & Hinojo-Lucena, F. J. (2020). Augmented reality in education. A scientific mapping in Web of Science. Interactive Learning Environments, 0(0), 1–15. https://doi.org/10.1080/10494820.2020.1859546

Lu, P., Lim, J., Graf, R., & Kim, H. S. (2020). IGYM: An Inclusive Augmented Reality Exergame for People of All Abilities. *IEEE Workshop on Signal Processing Systems, SiPS: Design and Implementation*, *2020-Octob*, 1–6. https://doi.org/10.1109/SiPS50750.2020.9195226

Maas, M. J., & Hughes, J. M. (2020). Virtual, augmented and mixed reality in K–12 education: a review of the literature. *Technology, Pedagogy and Education*, *29*(2), 231–249. https://doi.org/10.1080/1475939X.2020.1737210

Mann, S., Furness, T., Yuan, Y., Iorio, J., & Wang, Z. (2018). *All Reality: Virtual, Augmented, Mixed (X), Mediated (X,Y), and Multimediated Reality*. *X*. http://arxiv.org/abs/1804.08386

Mast, D., Bosman, M., Schipper, S., & de Vries, S. (2017). *BalanSAR*. 625–631. https://doi.org/10.1145/3024969.3025085

Methley, A. M., Campbell, S., Chew-Graham, C., McNally, R., & Cheraghi-Sohi, S. (2014). PICO, PICOS and SPIDER: A comparison study of specificity and sensitivity in three search tools for qualitative systematic reviews. In *BMC Health Services Research*. https://doi.org/10.1186/s12913-014-0579-0

Moreno, F. C., Serrano, M. H. G., Fombana, J., & Tascon, M. G. (2020). *The Emergence of Technology in Physical Education:A General Bibliometric Analysis with a Focus onVirtual and Augmented Reality* (p. 24).

Nebytova, L. A., Katrenko, M. V, Savin, D. I., & Zhuravleva, Y. I. (2021). *Augmented Reality in the Training Process of Children with Hearing Disorders*. 330–339.

Ojer, M., Alvarez, H., Serrano, I., Saiz, F. A., Barandiaran, I., Aguinaga, D., Querejeta, L., & Alejandro, D. (2020). Projection-based augmented reality assistance for manual electronic component assembly processes. *Applied Sciences (Switzerland)*, *10*(3). https://doi.org/10.3390/app10030796

Parekh, P., Patel, S., Patel, N., & Shah, M. (2020). Systematic review and meta-analysis of augmented reality in medicine, retail, and games. *Visual Computing for Industry, Biomedicine, and Art*, *3*(1). https://doi.org/10.1186/s42492-020-00057-7

Purnama, H. N. (2020). *Faktor Penghambat Guru Pendidikan Jasmani*.

Quintero, J., Baldiris, S., Rubira, R., Cerón, J., & Velez, G. (2019). Augmented reality in educational inclusion. A systematic review on the last decade. *Frontiers in Psychology*, *10*(AUG), 1–14. https://doi.org/10.3389/fpsyg.2019.01835

Rachamalla, S. ., & Rafi, D. M. (2016). Learning Disabilities: Characteristics and Instructional Approaches. *International Journal of Humanities, Social Sciences and Education*, *3*(4). https://doi.org/10.20431/2349-0381.0304013

Saidin, N. F., Halim, N. D. A., & Yahaya, N. (2015). A review of research on augmented reality in education: Advantages and applications. *International Education Studies*, *8*(13), 1–8. https://doi.org/10.5539/ies.v8n13p1

Scherer, R., Siddiq, F., & Tondeur, J. (2019). The technology acceptance model (TAM): A meta-analytic structural equation modeling approach to explaining teachers' adoption of digital technology in education. *Computers and Education*, *128*(September), 13–35. https://doi.org/10.1016/j.compedu.2018.09.009

Siddaway, A. P., Wood, A. M., & Hedges, L. V. (2019). How to Do a Systematic Review: A Best Practice Guide for Conducting and Reporting Narrative Reviews, Meta-Analyses, and Meta-Syntheses. In *Annual Review of Psychology* (Vol. 70, Issue January). https://doi.org/10.1146/annurev-psych-010418-102803

Sirkaya, M., & Alsancak Sirkaya, D. (2018). Trends in Educational Augmented Reality Studies: A Systematic Review. *Malaysian Online Journal of Educational Technology*, *6*(2), 60–74. https://doi.org/10.17220/mojet.2018.02.005

Sırakaya, M., & Alsancak Sırakaya, D. (2020). Augmented reality in STEM education: a systematic review. *Interactive Learning Environments*, *0*(0), 1–14. https://doi.org/10.1080/10494820.2020.1722713

Tan, S. Y., & Tay, N. N. W. (2021). Integrating augmented reality technology in education: vector personal computer augmented reality. *F1000Research*, *10*, 987. https://doi.org/10.12688/f1000research.72948.1

Tekedere, H., & Göker, H. (2016). Examining the effectiveness of augmented reality applications in education: A meta-analysis. *International Journal of Environmental and Science Education*.

Úbeda-Colomer, J., Devís-Devís, J., & Sit, C. H. P. (2019). Barriers to physical activity in university students with disabilities: Differences by sociodemographic variables. *Disability and Health Journal*, *12*(2), 278–286. https://doi.org/10.1016/j.dhjo.2018.11.005

Yang, Q. F., Hwang, G. J., & Sung, H. Y. (2020). Trends and research issues of mobile learning studies in physical education: a review of academic journal publications. *Interactive Learning Environments*, *28*(4), 419–437. https://doi.org/10.1080/10494820.2018.1533478

Yenioglu, B. Y., Ergulec, F., & Yenioglu, S. (2021). Augmented reality for learning in special education: a systematic literature review. *Interactive Learning Environments*, *0*(0), 1–17. https://doi.org/10.1080/10494820.2021.1976802

Yu, J., Denham, A. R., & Searight, E. (2022). A systematic review of augmented reality game-based Learning in STEM education. *Educational Technology Research and Development*, *20*(January). https://doi.org/10.1007/s11423-022-10122-y

Zeller, J. (2017). Reflective Practice in the Ballet Class: Bringing Progressive Pedagogy to the Classical Tradition. In *Journal of Dance Education* (Vol. 17, Issue 3, pp. 99–105). https://doi.org/10.1080/15290824.2017.1326052