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The implementation of augmented reality to develop early childhood students' gross motoric skill: a systematic review

La aplicación de la realidad aumentada para desarrollar la motricidad gruesa de los alumnos de educación infantil: Una revisión sistemática

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Abstract. The development of technology has revolutionized the world of education. Augmented Reality (AR) is one of the media that is starting to be developed for the learning process. AR has become a potential tool to improve the learning process among children. This study aims to systematically review previous research related to the application of AR to develop students' gross motor skills in early childhood education. The data collection process was carried out using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method which was adapted in this study. Identification results from five databases (SCOPUS, Pubmed, OpenAlex, Google Scholar, and Crossref) obtained 2807 publication documents. Bibliometric analysis was conducted on 1938 eligible articles, and 10 articles were selected as a literature review. The results of the bibliometric analysis showed less significant results on AR research in developing early childhood motor skills. However, overall AR research in early childhood education has experienced significant development. More attention and focus is needed regarding the development of early childhood motor skills research through the integration of AR technology. Thus, AR research in early childhood education is not limited to cognitive, but also focuses on motor skills as well.
Keywords: digitalization, learning media, preschool, children development.

Resumen. El desarrollo de la tecnología ha revolucionado el mundo de la educación. La Realidad Aumentada (RA) es uno de los medios que está empezando a desarrollarse para el proceso de aprendizaje. La RA se ha convertido en una herramienta potencial para mejorar el proceso de aprendizaje de los niños. Este estudio pretende revisar sistemáticamente las investigaciones previas relacionadas con la aplicación de la RA para desarrollar las habilidades motoras gruesas de los alumnos de educación infantil. El proceso de recopilación de datos se llevó a cabo utilizando el método de los Elementos de Información Preferidos para Revisiones Sistemáticas y Metaanálisis (PRISMA), que fue adaptado en este estudio. Los resultados de la identificación de cinco bases de datos (SCOPUS, Pubmed, OpenAlex, Google Scholar y Crossref) obtuvieron 2807 documentos de publicaciones. Se realizó un análisis bibliométrico de 1938 artículos elegibles y se seleccionaron 10 artículos como revisión bibliográfica. Los resultados del análisis bibliométrico mostraron resultados menos significativos sobre la investigación de RA en el desarrollo de habilidades motoras en la primera infancia. Sin embargo, en general, la investigación sobre RA en la educación infantil ha experimentado un desarrollo significativo. Es necesario prestar más atención y centrarse más en el desarrollo de la investigación de las habilidades motoras de la primera infancia mediante la integración de la tecnología RA. Por lo tanto, la investigación sobre RA en educación infantil no se limita a lo cognitivo, sino que también se centra en las habilidades motoras.
Palabras clave: digitalización, medios de aprendizaje, preescolar, desarrollo infantil.

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Introduction

Technology always changes dynamically and gradually (Li & Huang, 2020). The Industrial Revolution 4.0 has brought major changes to technological development in the 21st century (Park et al., 2020). The revolution in electronic devices has brought changes in social activities in society (Truchly & Petrík, 2015). A significant influence is shown by the development of mobile phones, which are currently switching functions and are referred to as smartphones (Wahyuningtyas et al., 2021).

In the 2000s, mobile phones only functioned as a tool to transfer textually and audio information. After that, technology fluctuated and influenced mobile phones so that they could be used to capture static or dynamic objects (Wang, 2015). The development continued until a software system called android was created (Alkindi et al., 2021). The android system combined with a phone, created a new device called a smartphone. Smartphones have a significant impact marked by more modern community activities (Choi et al., 2014). Modernization that occurs in the community has an impact on the educational environment (Thoms et al., 2023). The impact that occurs is that the educational process is digitized. Digital-based learning provides a new learning experience for students, and the learning process becomes more attractive than conventional learning (Camacho-Sánchez et al., 2022).

Conventional learning is considered less interesting because of the monotonous learning process using paper-based (Purba et al., 2021). The role of digital devices in providing learning improvisation is effective in increasing students' interest in learning (Brata et al., 2022). However, behind the success of digitizing learning, there is a small obstacle related to the existence of students who are still experiencing technological backwardness (Pruet et al., 2016). This happens because the family environment is less able to provide education about digitalization (Yu et al., 2021). The educational environment provides a solution by providing technology-based learning to early childhood (Liu & Hwang, 2023). The availability of a digital-based learning

process, especially since they were young is expected to overcome the problem of technological backwardness.

Research related to technology-based learning applied to early childhood at the pre-school level has been intense. The development of technology in the world of learning has progressed with the creation of Augmented Reality (AR) technology for learning (Reilly & Dede, 2019). AR is a technology that combines the real world with digital systems in real time (Gecu-Parmaksiz & Delialioglu, 2019). Thus, creating visual animations that appear real when viewed with the naked eye through smartphones or other digital devices (Hou et al., 2017).

The application of AR technology in video games provides a high attraction to its users, especially in early childhood (Ongoro et al., 2024). Graphic displays that spoil the eyes, provide an experience that feels real to its users (Aydoğdu, 2022). Based on this, the educational environment tries to make adjustments by applying AR to the learning process. The application aimed at early childhood is expected to have an impact on reducing the technological limitations experienced by a child in the future (Su et al., 2018). In addition, AR increases the learning interaction of early childhood, so that they do not easily experience boredom and are interested in learning (Huang et al., 2016).

On the other hand, AR technology in the Physical Education (PE) for early childhood has begun to develop (Ramli et al., 2023; Masmuzidin & Aziz, 2018). Similar to developments in general education, the implementation of this technology into PE provides a more varied and modern movement learning experience. A student or child will understand more about the movements learned through a visualization. This is also because in early childhood, children's ability to read or understand a command through sound is very limited. Thus, the development of research such as AR technology in PE in early childhood, provides a significant role when learning is carried out.

This research systematically reviews previous studies to find out the implementation of augmented reality to develop early childhood students' gross motoric skill. Early childhood education, especially in PE that is progressing will have an impact on primary, secondary and further education. Learning movement that has been given from an early age, will be a foundation for a child in learning basic movements or advanced movements at the next level of education. The role of PE learners who are more literate in technology and understand digitalization, improves the quality of movements learning that is not monotonous. The improved quality of movement learning has an impact on the quality of PE, and will produce quality human resources for the future.

Methods

Study Design

A qualitative approach was used in this study using a systematic review design. The data collection process uses the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method. The data retrieved was sourced from SCOPUS, Pubmed, OpenAlex, Google Scholar, and Crossref database (Table 1).

Table 1.
Research Databases

Source	Paper	Cites	Cites/Year	H-Index
SCOPUS	2	56	4.67	2
Pubmed	1	0	0	0
OpenAlex	454	13566	178.50	54
Google Scholar	891	52270	1072.46	88
Crossref	590	7107	75.61	41
Total	1938	72999	1331.24	-

Procedure

The data collection process of previous research documents using the keywords "augmented reality" AND "motor skill" AND "children" AND "preschool", which was carried out on September 3, 2024. The inclusion criteria in this study were documents written in the form of articles and in English. The use of English is necessary to avoid misperceptions during the review process. Exclusion criteria in this study are documents that are not written in the form of articles and are not in English.

The selection of articles used for literature review is based on articles with the most citations. The most citations reflect the quality of an article, which means that the article is often a reference for other researchers to develop new research. Selection of relevant articles with keywords is also necessary to ensure the results of the literature review are in line with the research objectives. We used the annotation method to annotate articles that were relevant to this research. Although the basis of the selection of articles for literature review is the most citations, it does not rule out the possibility of articles with a small number of citations due to the process of relevance to the keywords and objectives of this study.

Result

The result of PRISMA screening process

The screening process carried out using the PRISMA flowchart, obtained 2807 documents identified on the databases based on the keywords used (Figure 1). The results were screened again to sort out documents in the form of articles and were not published in English. Eligibility process was carried out to screening the articles that used for bibliometric analysis and literature review. The final result was obtained 1938 articles for bibliometric analysis with 10 articles most cited and relevant.

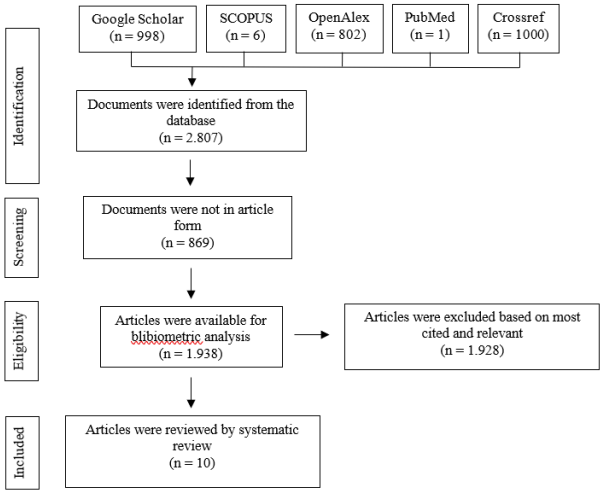

Figure 1. PRISMA flowchart of the article selection process

Research Publication of Augmented Reality in Early Childhood Education

In 1931-2000, research in the field of AR technology in PE for early childhood began, but did not progress (Table 2 and Figure 2). In those years there was no possibility of AR technology being applied to the educational process. AR technology was only discovered and developed in the 1965s, and at the beginning of its development it will certainly experience trial and error. Entering 2001-2015, there began a significant increase in publications. Publications in the form of scientific articles, books, or other scientific works. This increase shows the urgency of researchers in this field to develop and refine AR technology. This allows the integration of AR technology with various fields. The focus of research is not only about technology, but it has begun to make the technology more useful for all people in various fields. The five years after that, namely in 2016-2020, experienced a sharp increase. The number of publications increased by almost 500 publications in just 5 years. The intensity of publications that occurs is proof that research in previous years has a significant impact in the future. In 2021 until now, publications are still being carried out and have increased quite significantly. As many as 1105 publications have been published at the end of this year. This number will continue to grow, considering that this year is still running and research is still being carried out.

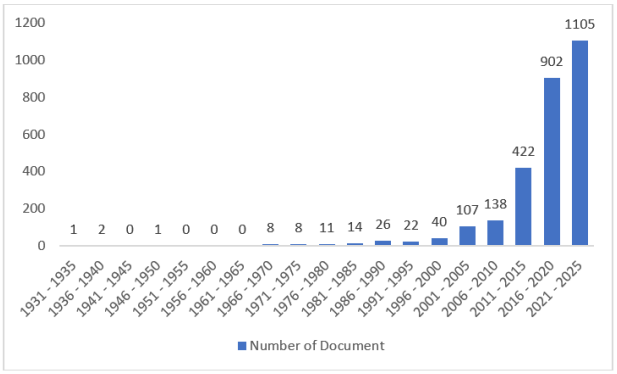

Figure 2. Diagram of Research Publication

Table 2.
Research publication of AR in PE for Early Childhood Education

Year of Publication	Number of Document	Cited	Percentage of Publication (%)
1931 - 1935	1	0	0.04
1936 - 1940	2	28	0.07
1941 - 1945	0	0	0.00
1946 - 1950	1	0	0.04
1951 - 1955	0	0	0.00
1956 - 1960	0	0	0.00
1961 - 1965	0	0	0.00
1966 - 1970	8	24	0.29
1971 - 1975	8	27	0.29
1976 - 1980	11	4851	0.39
1981 - 1985	14	1867	0.50
1986 - 1990	26	584	0.93
1991 - 1995	22	1086	0.78
1996 - 2000	40	1865	1.43
2001 - 2005	107	9324	3.81
2006 - 2010	138	9577	4.92
2011 - 2015	422	17076	15.03
2016 - 2020	902	29462	32.13
2021 - 2025	1105	10773	39.37
Total	2807	86544	100.00

Keyword Trend and Density of AR in PE for Early Childhood Education

The bibliometric analysis results presented the variation of correlation between keywords from the screening results of the PRISMA method (Figure 3). The keyword "augmented reality" shows a wide correlation with various other keywords. This supports the explanation in the previous sub-section, which states that AR research is starting to develop and expand in various fields. The correlation with "preschool" and "children", proves the implementation of AR for the development of a child. The intended implementation is through education and non-education.

The keyword "virtual reality", shows the relationship between AR technology and Virtual Reality (VR). These two technologies are technologies that are developed rapidly in this era of digitalization. Aspects or fields that can be said to be advanced and modern, are those that successfully develop technology. The world of education will be considered modern and up-to-date, when it is able to implement this technology in the learning process at various levels. Keywords such as "motor skills", "motor skills", and "basic movement skills" show a less strong correlation with AR technology. However, there is still a strong correlation with "preschool". This is an indication that more in-depth research needs to be done in the development of motor skills, especially in early childhood. The use of AR technology in early childhood will be appropriate in supporting them to learn motion effectively and efficiently.

When viewed in the density visualization (Figure 4), the strongest areas are "augmented reality", "preschool children", "augmented reality application", and "human". While "motor skills", "motor skills", "learning disability", "basic movement skills" and "adaptive behavior", are some of the weak areas or can indicate the need for research related to these topics or keywords. Through the strengthening of these areas, AR research can be further expanded, especially in early childhood motor development.

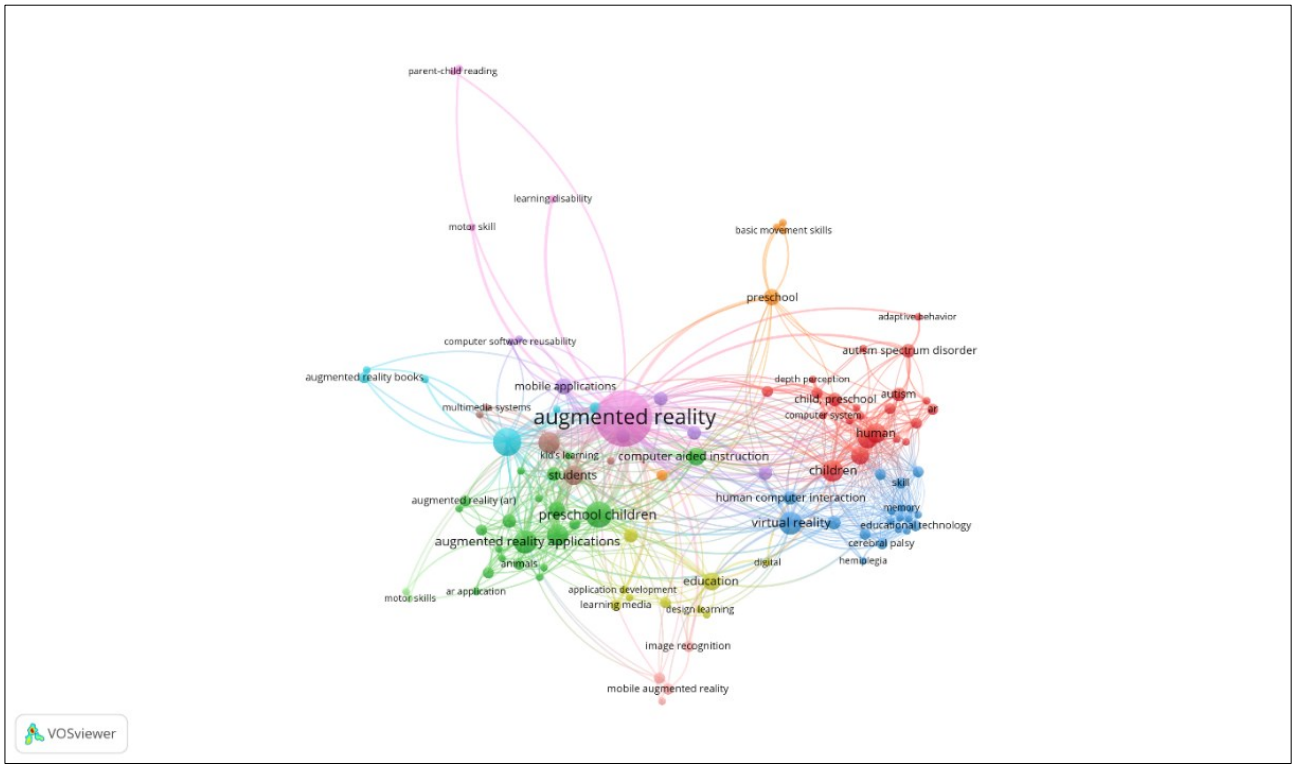

Figure 3. Keyword trend

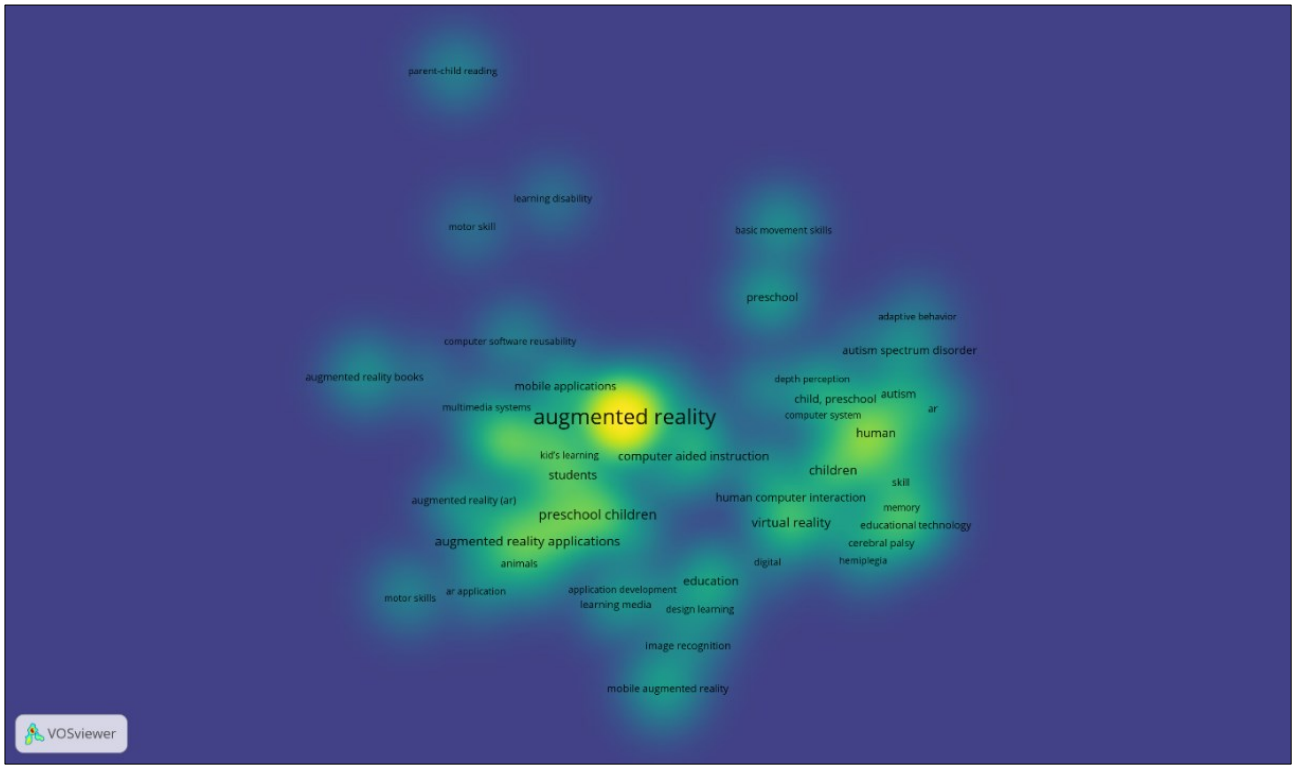

Figure 4. Keyword density

Research Trend of AR in PE for Early Childhood Education

Based on the results of bibliometric analysis of AR research development in PE in early childhood, it shows a significant development in 2018 - now (Figure 5). In line with the previous discussion (Table 2 and Figure 2) about "Research Publications", research experienced a significant increase in the range of 2016-2020 and 2021-present. Judging from Figure 5, in 2018 - 2019 research focused on the development of AR technology to be more comprehensive

with the integration of VR technology as well. Then entering 2020-2022, research began to enter the realm of early childhood education. In addition, research aimed at knowing the development of a child also began to be carried out. The development of movement skills using AR technology also began to be researched, but not too significantly. In 2023 until now, research began to lead to disability groups, both in terms of attitudes and other physical disorders. Research on early childhood development is also still shown through the keyword "basic movement skills". This is evidence of the attention of researchers in evaluating and developing AR research in PE for early childhood.

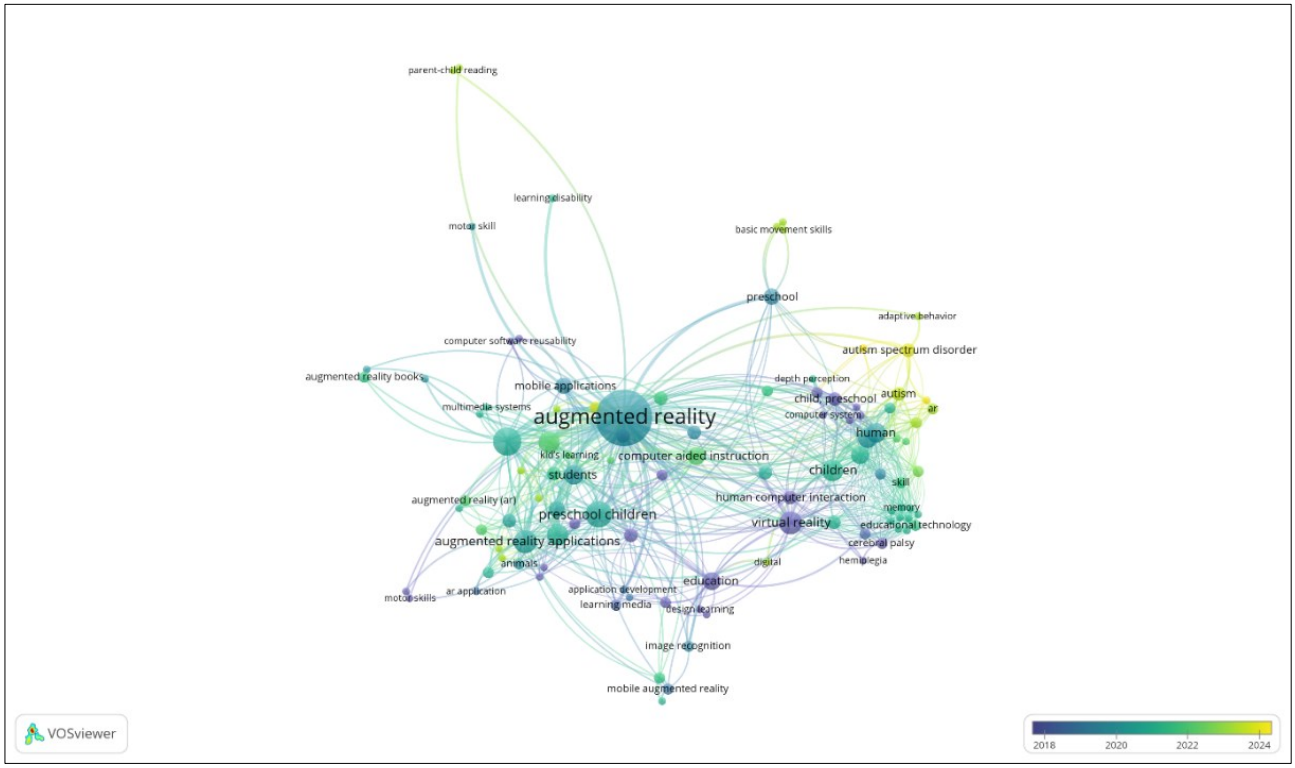

Figure 5. Research Trend

Literature Review on AR Implementation to Develop Early Childhood Students' Gross Motoric Skill

The literature review was conducted with the aim of understanding the research focus in the development and implementation of AR for early childhood motor skills (Table 3). The articles selected are those with the most citations and discuss the implementation of AR in early childhood motor skills. Through this literature review, it will provide an overview or visualization related to the focus of previous research. Thus, it can be used as an evaluation by other researchers for the latest research and develop AR research in early childhood education to improve motor skills.

Table 3.
Literature review on AR in PE for Early Childhood Education

Author	Cited	Method	Finding
(Chang et al., 2020)	97	Experimental Study	The findings indicate that AR-assisted instruction is more effective than video-assisted instruction, and the effects are better for more difficult motor skills learning.
(Mast et al., 2017)	15	Research and Development	The current prototypes give us the opportunity to test if Spatial Augmented Reality is a useful addition to PE.
(Putri et al., 2021)	2	Research and Development	The researcher found that the interactive augmented reality storybook about self-cleaning with mare had three eligibility criteria, namely being effective, efficient and attractive to stimulate motor development about personal hygiene in children aged 4-5 years.
(Wang et al., 2024)	1	Survey Study	Augmented Reality Integrated STEM Preschooler (ARISP) module significantly increases children's engagement and motivation in learning activities.
(Guinet et al., 2021)	20	Research and Development	The study validates the accuracy of the HoloStep algorithm, integrated with a Hololens augmented reality headset, in measuring gait parameters for both healthy individuals and children with cerebral palsy, showing high precision and potential for future gait rehabilitation interventions using augmented reality games.
(Lin & Chang, 2015)	105	Research and Development	The study found that using an interactive augmented reality game developed in Scratch 2.0 significantly improved physical activity performance in children with developmental disabilities during the intervention period.
(Spinosa et al., 2020)	10	Comparative Study	The study found no significant differences in children's motor skill performance between digital augmented reality and live demonstrations, suggesting that AR technology can be a viable tool for teaching motor skills.
(Welsby et al., 2024)	1	Research and development	The study found that a co-design process successfully engaged end-users, including clinicians, children with developmental coordination disorder, and caregivers, to create an augmented

			reality intervention prototype for improving motor skills, ensuring the intervention met their needs and experiences.
(Yoo et al., 2017)	57	Comparative Study	The study found that EMG biofeedback augmented with virtual reality significantly improved neuromuscular control, elbow extension, and biceps strength in children with spastic cerebral palsy, demonstrating superior benefits compared to EMG biofeedback alone.
(Bai et al., 2015)	179	Research and Development	Study involving children with ASC aged 4 to 7 demonstrated a significant improvement of pretend play in terms of frequency, duration and relevance using the AR system in comparison to a non computer-assisted situation.

Using AR to Learn Motor Skills

Learning the movement or motoric of an early childhood, requires media that is interesting and easily understood by a child. The use of AR in motor learning, provides an effective stimulus to a child. Visualization displayed through AR technology, makes it easier for children to understand the movements learned. Research by Chang et al., (2020), explains that the use of AR is very suitable in learning difficult movement skills. Supporting this, research by Putri et al., (2021) explained that AR is able to provide a good stimulus to a child in learning motor skills. In addition, the use of AR can also fulfill the needs of movement and provide new learning experiences for children with disabilities (Welsby et al., 2024). The use of AR-based Hololens technology has also proven effective in measuring the gait of normal and disabled people (Guinet et al., 2021). These things are proof that by utilizing AR, motor learning in early childhood can be developed.

AR Improve Physical Activity in Disabilities

Physical activity is necessary for a person to maintain their health and fitness. A child's good physical activity will prevent them from health problems when they are teenagers or adults. In children with disabilities, the intensity of their movement may be lower, due to physical developmental disorders. Research conducted by Lin & Chang, (2015), explained that games developed using AR can increase physical activity in children with disabilities. Motivation in activities in children with disabilities can also be increased through the development of the Augmented Reality Integrated STEM Preschooler (ARISP) module (Wang et al., 2024). Through the use of AR technology, children with disabilities can be helped to be more motivated to move without feeling limited. They will be able to do activities like humans in general.

AR Enhance Frecuency of Play in Children

The use of AR technology can provide a more modern play experience to a child. The development of interactive and innovative content provides motivation for a child to continue playing. Educational elements also need to be considered in developing games for early childhood. In children with Autism Spectrum Condition (ASC) disorders, the use of AR is considered appropriate to increase the frequency of playing children with ASC (Bai et al., 2015). This explanation is in line with the explanation in the previous subsection, that through AR a child will be more motivated to move. This phenomenon will have an impact on the duration or intensity of a child in playing as well.

Spatial AR for Physical Education

Spatial ability is the ability to understand the relationship of objects in a room. The integration of Spatial AR (SAR) technology in physical education provides a more innovative and attractive learning model. Customizable and dynamic virtual running tracks, targets that can change places, as well as virtual obstacles or obstacles, are some examples of SAR technology. Research by Mast et al., (2017), developed SAR technology for balance skills in physical education learning. Mast et al. (2017) stated that SAR technology could be a useful option for physical education. Digitalization in physical education will provide more interest in learning to a child in the present.

Physical Enhancement through AR Technology

Early childhood physical development does need to be a concern for parents and teachers. Physical development in children with disabilities does not necessarily go as well as other normal children. Special attention and methods are needed in monitoring their physical development. The integration of technology in the development process of a child with a disability is one of the appropriate choices. Modern and sophisticated technology makes it possible to provide what is needed by a child with a disability. Through research Yoo et al., (2017), EMG Biofeedback technology has an influence on the physical development of children with disabilities, especially those with cerebral palsy. This tool was developed using AR technology integrated with VR technology. This makes it possible to measure the strength and range of motion of the arm. The results of the measurements taken can be used as an evaluation in observing the development of a child, especially with disabilities.

Discussion

The development of Augmented Reality (AR) technology in the world of education has experienced significant development from year to year (Ramli et al., 2023). AR plays a role in digitizing the learning process in schools. In PE for early childhood, the application of AR is able to provide a more comprehensive understanding to students. The visualization provided provides a stimulus that is more easily understood by early childhood. This is in accordance with the limitations of early childhood in understanding and digesting verbal and audio information. This systematic review research aims to analyze research in applying AR technology to develop motor skills in early childhood education.

The results of the systematic review presented research trends that developed significantly. Data presentation displayed through diagrams, shows a significant and sharp in-

crease since 2011. The increase in publications on this research continues to fluctuate until now. Systematic review research by (Masmuzidin & Aziz, 2018), explained that the trend of AR research in early childhood education has increased significantly in recent years. Bibliometric analysis conducted in this study shows that the development of AR in early childhood education has expanded in recent years. The emergence of intercorrelations on research topics such as inclusive education, Virtual Reality (VR), motor learning, proves that previous studies have begun to pay attention to the motor development of an early childhood.

On the other hand, research related to learning or motor development in early childhood is still not very significant. The results of the blibiometry analysis, showed a lack of significant correlation and low density displayed. The results of the literature review also show that research on early childhood motor development has not really focused on early childhood in general. The results point more in the direction of research on motor development in young children with disabilities. Therefore, the findings from this study need to be a concern for future research in developing research related to motor development in early childhood. The intended development is to provide a more comprehensive explanation and fill the gaps in previous research. So as to be able to provide a broader understanding to readers or other researchers in developing motor skills in early childhood.

AR is rapidly gaining traction in early childhood education as a dynamic and engaging tool for improving the learning experience of young children. AR integrates digital content with the real world, allowing children to interact with and manipulate virtual objects while staying grounded in a physical learning environment. The application of AR in early childhood education is increasingly being researched, and its benefits for enhancing cognitive, motor, and social skills in children are becoming evident. According to (Kayaduman & Sağlam, 2024), AR applications are particularly effective in preschool education, offering an immersive, interactive learning experience that significantly increases children's engagement and motivation.

Moreover, AR-based learning media have shown great potential in improving psychomotor development in young learners. The use of AR-based Android applications, for instance, enables children to engage in more complex and varied learning experiences, as highlighted by (Yusof et al., 2022). These applications allow children to interact with educational content through gestures and body movements, thereby enhancing their motor skills while simultaneously developing their cognitive abilities. The research by (Spinosa et al., 2020) similarly points out that AR technology is an effective tool for demonstrating human movement, making it an ideal medium for teaching motor skills to young children. Furthermore, AR has been found to be an especially useful tool for children with developmental coordination disorders (DCD), as it can be tailored to the specific needs of the learners, providing the feedback and repetition necessary for skill development (Lino et al., 2021).

Despite the evident benefits of AR in early childhood education, there are concerns related to the health implications of prolonged use of AR technology. Yavtushenko et al., (2023) showed a highlighted the potential negative effects of AR on children's health, particularly on eye health and physical fitness. The immersive nature of AR can cause eye strain and fatigue, especially when children are exposed to screens for extended periods. Additionally, the increasing use of digital devices in educational settings has raised concerns about the sedentary nature of such activities, which can contribute to obesity and other health problems in children. As noted by (Kaur, 2023), there is a growing need for parents and educators to supervise children's use of AR technology and ensure that it is used in moderation. Measures such as incorporating physical activities within AR applications or alternating screen time with more physically active tasks can mitigate these risks.

In addition to health concerns, the implementation of AR in early childhood education also presents challenges related to digital literacy. While AR is a powerful tool for engaging children in the learning process, it also requires educators to be proficient in using the technology (Liu et al., 2023). The effective use of AR in the classroom depends on teachers' ability to integrate AR content into the curriculum and to manage technical issues that may arise during its use. According to (Fitria, 2023), AR technology should be accompanied by teacher training programs that ensure educators have the necessary skills to facilitate AR-based learning. Furthermore, equity is another challenge that must be addressed, as not all schools have access to the necessary technological infrastructure to implement AR effectively (Martin et al., 2018).

From a developmental perspective, AR has shown promising results in improving early childhood motor skills, particularly for children with special needs. Bai et al. (2015) demonstrated that children with Autism Spectrum Conditions (ASC) showed a significant improvement in pretend play frequency and relevance when using AR systems compared to traditional play methods. AR provides a unique environment where children with developmental disabilities can practice skills in a controlled, supportive space while receiving real-time feedback, which has been shown to enhance their learning outcomes (Lin & Chang, 2015). Additionally, validated the accuracy of an AR system in measuring gait parameters in children with cerebral palsy, showing high potential for future rehabilitation interventions using AR games (Guinet et al., 2021). These findings suggest that AR technology can be an invaluable tool for special education, providing tailored interventions that meet the unique needs of each child. Moreover, AR's ability to provide real-time feedback is essential for young children who often need immediate reinforcement to learn new skills. This feature makes AR an ideal medium for teaching motor skills and physical activities, as children can see the results of their actions and make adjustments accordingly (Chang et al., 2020).

While the benefits of AR are clear, it is important to

continue refining its application in early childhood education. Co-designing AR interventions with input from end users children, parents, and educators ensures that AR tools are not only effective but also user friendly and aligned with the needs of young learners. The study by (Welsby et al., 2024) demonstrates the value of co-design in developing an AR intervention for children with developmental coordination disorders (DCD), ensuring that the final product was relevant, engaging, and easy to use. Co-designing AR tools with input from diverse stakeholders can also help address concerns related to accessibility and equity, ensuring that AR-based learning tools are available to all children, regardless of their socio-economic background.

However, this research is the limited scope of studies focused on the application of augmented reality (AR) in early childhood motor skills development. While AR has been widely explored for cognitive and learning outcomes, its application in motor skill development remains underresearched, particularly in preschool education. The systematic review revealed a lack of robust data on how AR can be effectively integrated into physical education, leaving gaps in understanding its full potential for enhancing gross motor skills. Furthermore, most reviewed studies focus on special needs populations, which may not be fully generalizable to the broader early childhood population.In conclusion, the integration of AR into early childhood education offers numerous benefits for enhancing motor development and increasing engagement and motivation in young learners. Studies consistently show that AR can be a powerful tool for teaching motor skills, particularly in special education settings where children require tailored, interactive learning experiences. However, the implementation of AR in early childhood education must be approached with caution, ensuring that children's health is prioritized and that educators are equipped with the necessary skills to facilitate AR-based learning. With the right balance of technology and pedagogy, AR has the potential to revolutionize early childhood education, providing children with immersive, engaging, and effective learning motor experiences.

Conclusion

Research related to AR in early childhood education, especially in developing motor skills, has developed not too significantly. This is evidenced by the lack of a strong relationship between motor skill keywords and AR. If analyzed in general about the application of this technology in early childhood education, research has been going quite well and has developed significantly. AR technology has had a significant impact on early childhood education. Despite the high impact, there has been no equalization or expansion to other aspects of education. As explained earlier, AR research on early childhood motor skill development is still very minimal. As for research on the development of motor movements, it is more directed at children with special needs.

Based on the results and findings of this systematic review, it is necessary to expand AR research on aspects of early childhood motor skill development. Research on the development of early childhood movement skills that is more comprehensive, will provide visualization to educators and parents. The research will provide education regarding the importance of motor development to be considered and evaluated from an early age. The integration of technology such as AR in these developments is expected to provide an easier picture and understanding for a child. Facilities that are attractive and spoil the eyes of a child, will make him more motivated in learning motor skills. However, it is necessary to pay attention to utilizing this technology for the early childhood learning process. The role of educators and parents is needed to limit excessive interaction with AR technology. Physical health will be affected if less attention and supervision is given, especially on the health of a child's eyes.

This systematic review research succeeded in obtaining a finding, namely the importance of conducting more comprehensive research related to the development of early childhood motor skills. Research related to this has indeed been done, but it has not been able to provide a comprehensive understanding. Through more significant developments, it will also have a positive impact on early childhood education. Innovations provided through research will provide new experiences in learning motor skills for a child. Thus, the quality of education can be improved through innovation in early childhood education.

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