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Augmented reality-based training to enhance teachers' knowledge of reproductive health for special needs students

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ABSTRACT

Teachers of special schools face significant challenges in delivering reproductive health education to children with special needs because many teachers do not have adequate knowledge and skills in delivering related topics that require delivery adjustments to the mental, physical, and psychological conditions of students. This study aims to measure the effect of augmented reality-based training on improving special school teachers' understanding of how to deal with puberty problems in children with special needs. Using a quantitative approach with a one-group pretest-posttest experimental design, this study involved 30 special education teachers in Bandung City who were selected by purposive sampling. The training provided focused on sexual and reproductive health education and how to deal with puberty problems using AR tools. The data obtained were analyzed using the Wilcoxon Signed-Rank Test, which showed the effectiveness of AR training, as evidenced by increased subject understanding after attending the training. In addition, the varying improvement in subject scores indicates that individual factors influence learning outcomes. These findings suggest that AR-based training is efficacious in improving teachers' understanding of reproductive health and sexuality education for children with disabilities and indicate the need for a more personalized approach in future training.

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ABSTRAK

Guru Sekolah Luar Biasa (SLB) menghadapi tantangan besar dalam menyampaikan pendidikan kesehatan reproduksi kepada anak berkebutuhan khusus karena banyak guru tidak memiliki pengetahuan dan keterampilan yang memadai dalam menyampaikan topik terkait yang memerlukan penyesuaian penyampaian dengan kondisi mental, fisik, serta psikologis peserta didik. Penelitian ini bertujuan untuk mengukur pengaruh pelatihan berbasis Augmented Reality (AR) terhadap peningkatan pemahaman guru Sekolah Luar Biasa (SLB) dalam menghadapi permasalahan pubertas pada anak berkebutuhan khusus (ABK). Menggunakan pendekatan kuantitatif dengan desain eksperimen one group pretest-posttest, penelitian ini melibatkan 30 guru SLB di Kota Bandung yang dipilih secara purposive sampling. Pelatihan yang diberikan berfokus pada pendidikan kesehatan reproduksi dan seksual serta cara menghadapi permasalahan pubertas dengan menggunakan perangkat AR. Data yang diperoleh dianalisis menggunakan uji Wilcoxon Signed-Rank Test, yang menunjukkan efektivitas pelatihan AR secara signifikan, dibuktikan dengan adanya peningkatan pemahaman subjek setelah mengikuti pelatihan. Selain itu, peningkatan skor subjek yang bervariasi menandakan adanya faktor individu yang memengaruhi hasil belajar. Temuan ini menunjukkan bahwa pelatihan berbasis AR efektif dalam meningkatkan pemahaman guru mengenai pendidikan kesehatan reproduksi dan seksualitas bagi ABK serta mengindikasikan perlunya pendekatan yang lebih personal dalam pelatihan di masa mendatang.

Kata Kunci: *anak berkebutuhan khusus; augmented reality; pelatihan guru; pendidikan kesehatan reproduksi dan seksual*

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INTRODUCTION

Children with special needs or Anak Berkebutuhan Khusus (ABK) often face complex challenges during puberty and in their exploration of sexuality. Physically, ABK may have difficulty understanding the changes occurring in their bodies and often feel awkward due to a lack of understanding and support. In addition, socially, they often face isolation and difficulties building healthy relationships due to limitations in communication and understanding more complex social norms. These challenges can hinder them in physically, emotionally, and socially managing changes during puberty. These obstacles create additional risks for ABK, especially in terms of violence and sexual abuse, as they may be less trained in recognizing and responding to unsafe situations (Nugraheni & Tsaniyah, 2020).

On the other hand, children with special needs often experience limitations in accessing adequate reproductive and sexual health education. Children with special needs differ from average children's mental characteristics, such as sensory, physical, social, emotional, and communication abilities, and therefore require special education services (Meidina et al., 2023). This challenge is further exacerbated by the limited availability of educational materials tailored to the individual needs of children with disabilities, both in written and visual formats. For example, deaf children face significant barriers in the communication process, particularly in terms of limited vocabulary and difficulty in speaking (Zulia et al., 2023). Therefore, appropriate educational methods must be implemented, and the government is expected to pay more attention to reproductive health education for children with disabilities (Bestari et al., 2023).

Reproductive health education is crucial for children with disabilities because it can serve as a preventive measure, helping them understand and manage biological changes that occur during puberty and respect the sexual behavior of others. This education is also important to prevent deviant sexual behavior and protect children with disabilities from sexual violence or abuse (Pratiwi & Romadonika, 2020). Several social difficulties faced by children with disabilities, such as "public-private errors" and "stranger-friend errors," often occur during puberty, emphasizing the importance of proper teaching about social boundaries and interaction ethics.

Teachers at Special Education Schools or Sekolah Luar Biasa (SLB) also face significant challenges in delivering reproductive health education to children with special needs. Many teachers lack the knowledge or skills to teach sex education effectively, and limited resources and teaching materials further hinder the delivery of comprehensive sex education (Utama & Hutahaean, 2024). When addressing this topic, it is essential to adapt the delivery method to the mental, physical, and psychological conditions of children with special needs. Teachers hope that reproductive health education is provided to both female and deaf students (Wuryandari et al., 2022).

One solution proposed to overcome these obstacles is using technology, particularly Augmented Reality (AR), which can provide an interactive and visual learning experience. AR technology enables the visualization of difficult-to-understand concepts, such as 3D models of reproductive organs, which can help children with special needs understand complex topics (Meggy & Aprilia, 2024). With its ability to be customized to individual needs, AR can be a highly effective tool in reproductive and sexual education for students with special needs. Educational media, such as animated videos with written explanations, have improved deaf students' understanding of reproductive health (Suntari, 2022).

This study aims to measure the effect of *Augmented Reality* (AR)-based training on improving the understanding of special needs school (SLB) teachers in dealing with puberty issues in children with special needs (ABK). The specially designed *augmented reality* training focuses on reproductive and sexual health education, as well as how to deal with puberty issues in ABK. This training uses AR-based

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devices that allow subjects to access visual and interactive simulations related to physical and psychological changes during puberty. The training combines theory, AR technology demonstrations, and hands-on practice sessions. Therefore, research on the impact of this training on teachers' use of AR media is crucial to improve the quality of education and assist ABK in understanding critical topics such as reproductive and sexual health education. With a flexible and tailored approach, this education can become more effective and inclusive, helping ABK overcome challenges during puberty and protecting them from the risks of harmful sexual behavior.

LITERATURE REVIEW

Children with Special Needs

Children with Special Needs or Anak Berkebutuhan Khusus (ABK) have limitations or abnormalities in various physical, mental, intellectual, social, or emotional aspects, which significantly impact their growth and development processes. Their needs differ from those of their peers, requiring tailored educational approaches and support. ABK requires specialized services or treatment to achieve optimal development caused by the abnormalities or disabilities they experience. Therefore, the design of educational programs, including life skills education, must consider their special needs (Rezieka et al., 2021).

The differences experienced by ABK can include physical, mental, and social behavior aspects (Saputri et al., 2023). This can affect their cognitive development, where children with special needs often experience delays in critical thinking and information processing, which impacts their learning abilities at school. Additionally, they may face challenges in the social-emotional aspect, such as social isolation and difficulty building interpersonal relationships, which can lead to emotional issues like anxiety or depression. Physiologically, the physical limitations experienced by children with special needs can affect their motor skills, impacting their daily and social activities. Education designed for children with special needs must respect equal rights and equal access to education regardless of gender, age, ethnicity, gender, language, or physical condition (Hidayati & Warmansyah, 2021).

Providing appropriate education for children with special needs raises awareness among educators and affirms their right to receive educational services equal to those of other children (Michielsen & Brockschmidt, 2021). Learning for children with special needs requires strategies tailored to the individual needs of students, as each child has unique requirements (Ningrum, 2022). This tailored instruction helps children with special needs reach their full potential and contributes to their cognitive, social-emotional, and physiological development. Specialized and adaptive educational design for children with special needs is essential to enable them to learn optimally according to their unique needs and achieve desired development outcomes.

Puberty Issues in Children with Special Needs

Puberty issues among children with special needs (ABK) in Indonesia are complex and require special attention. Puberty, which is marked by physical and emotional changes, poses greater challenges for ABK than for children in general. Children with special needs have limited knowledge about sexual and reproductive health (Sontha et al., 2021). ABK experiences the same physical changes, such as breast development in girls or voice changes in boys. However, these changes are often difficult for them to understand, especially for girls who may not understand menstruation, potentially leading to confusion or even unwanted pregnancies (Meidina et al., 2023). Limitations in verbal and non-verbal communication and difficulties in expressing emotions exacerbate this situation, sometimes leading to frustration and aggressive behavior.

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In addition, hormonal changes during puberty trigger strong emotions, such as anger and fear, which are difficult for children with special needs to manage. They may lack adequate social skills to cope with these emotions, making them vulnerable to behavioral problems (Pratiwi & Romadonika, 2020). Furthermore, children with special needs often face social stigma that exacerbates their isolation during puberty, hindering their social-emotional development and increasing the risk of mental health disorders.

Reproductive and sexual health education is crucial for children with special needs as a preventive measure to help them understand the changes occurring in their bodies and respect others' sexual behavior (Pratiwi & Romadonika, 2020; Wianti & Anggraeni, 2024). This education aims to enable children with special needs to manage biological changes related to puberty, prevent deviant sexual behavior, and protect them from sexual abuse (Nugraheni & Tsaniyah, 2020). Sex education for children with special needs is essentially the same as for typical children. However, it requires more in-depth adjustments based on the child's mental, physical, psychological, and age-related conditions (Meidina et al., 2023). This is also emphasized in research showing that reproductive health education is important for female students and male students with hearing impairments (Wuryandari et al., 2022).

However, in Indonesia, reproductive health education for deaf adolescents still receives little attention from the government. This is indicated by the lack of comprehensive literature discussing reproductive health issues among them, despite their sexual urges and development being the same as those of adolescents in general (Wuryandari et al., 2022). Communication difficulties in deaf children, such as delayed speech and limited vocabulary, make the delivery of sex education challenging for teachers (Zulia et al., 2023). Therefore, the educational methods used in reproductive health education must be tailored to each type of disability. Providing information to children with disabilities requires extra effort and practice to convey the message effectively (Bestari et al., 2023). The government and relevant agencies are encouraged to prioritize reproductive health education for individuals with disabilities, given the importance of flexible approaches tailored to their needs. Reproductive and Sexual Health Education or Pendidikan Kesehatan Reproduksi dan Seksual (PKRS) for individuals with disabilities must be delivered through a flexible approach tailored to individual needs and requires support from all parties, including the government and educators, to ensure that individuals with disabilities can understand and manage their biological and social development effectively.

Reproductive and Sexual Health Education

Sexual and reproductive health education is a learning process that aims to provide a comprehensive understanding of reproductive health, including how to care for reproductive organs, understand physical changes during puberty, and engage in healthy sexual behavior. The main objective of this education is to empower individuals to make responsible decisions about their sexual and reproductive health so that they can live healthy and dignified lives. Sexual and reproductive health is not only related to physical changes or sexual behavior but also includes emotional maturity, social skills, building relationships with others, and developing a positive self-image (Safitri, 2021). However, discussions about reproductive health from the perspective of traditional values, culture, and religion, which mark adolescent reproductive health issues as taboo topics, often attract more attention than recognition of the importance of correct understanding and open discussion of adolescent reproductive health issues (Dungga & Ihsan, 2023).

Reproductive health education has specific objectives, including increasing adolescents' knowledge about their bodies and reproductive processes and reducing the risk of unwanted pregnancies, sexually transmitted infections (STIs), and sexual violence. Health education on reproductive health is essential to prevent the emergence of various reproductive health problems (Nurchandra et al., 2020). This

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education also provides the knowledge and skills to encourage adolescents to adopt positive and responsible attitudes toward their reproductive health. The WHO highlights several challenges in adolescent reproductive health, such as the perception of menstruation as a taboo topic, high rates of sexually transmitted infections, and violence in intimate relationships (Baroroh, 2021). This indicates that good reproductive health education in formal settings is crucial to addressing these challenges.

Reproductive health education in formal institutions can shape a good, structured, and sustainable understanding among adolescent students (Baroroh, 2021). Health education effectively improves adolescents' knowledge about reproductive health and sexually transmitted diseases (Sulastri & Astuti, 2020). Therefore, comprehensive and human rights-based reproductive health education must be pursued to ensure access to appropriate information and services for every individual.

Reproductive and sexual health education for children with special needs (ABK) is an important aspect that needs to be considered in their education process. ABK has unique needs and challenges related to understanding sexuality, so an appropriate educational approach is essential. Like other children, ABK experiences hormonal development and sexual desire. However, they often do not receive adequate information about social boundaries, consent, and appropriate sexual behavior. In Indonesia, sexual education for ABK is still minimal and often not integrated into the formal curriculum. This makes them vulnerable to sexual violence and manipulation by others (Pratiwi & Romadonika, 2020). Additionally, the lack of information regarding reproductive health education and menstruation for children with special needs will affect menstrual hygiene, personal health patterns, and behavior (Demang & Dewi, 2020).

Augmented Reality Media (AR)

Augmented Reality (AR) is a technology that enables the integration of digital elements into the real environment interactively. This technology provides a visual experience that combines virtual objects, such as images, videos, or 3D models, with the real world through various devices such as smartphones, tablets, or special headsets (Cahyaningsih, 2020). Using camera sensors and object recognition, AR detects the user's environment and inserts relevant digital elements in real time, significantly enriching the user's learning experience. Augmented Reality media in education aims to improve students' understanding of abstract and complex concepts while increasing engagement and motivation in the learning process (Nistrina, 2021).

In an educational context, AR offers numerous benefits, particularly in helping students understand difficult material that is challenging to grasp through conventional methods. Hence, AR is also referred to as an educational medium. An educational medium can convey messages from teachers to students in a way that is easier to understand, thereby achieving learning objectives (Maghfiroh & Bahrodin, 2022). With 3D visualization and animation, AR offers a more interactive and engaging way for students to understand complex concepts. The application of AR in learning can significantly enhance students' understanding and engagement. This finding highlights the importance of AR as an effective learning tool, particularly in improving the quality of education in school settings, including for students with special needs (Meggy & Aprilia, 2024).

Additionally, AR provides a more immersive and realistic learning experience, where students can interact directly with virtual objects as if they were in the real world (Indahsari & Sumirat, 2023). This technology helps students visualize two- or three-dimensional objects in a real-world environment, facilitating a deeper and more tangible understanding of the concepts being taught (Sari et al., 2023). AR helps in understanding and increases learning motivation because this technology provides an interesting and comprehensive learning experience (Cuhanazriansyah, 2023).

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AR in interactive learning emphasizes the same basic principles as Virtual Reality (VR), namely, interactive, real-time, comprehensive, and involving three-dimensional objects. This will increase students' interest in learning, as the use of technology in education, especially in the teaching and learning process, has been proven to increase students' interest in learning because it provides new and engaging learning experiences so that students will not feel bored during the learning process (Putra & Salsabila, 2021). AR enables students to combine the real and virtual worlds visually, creating a richer and more immersive learning environment (Cuhanazriansyah, 2023).

Implementing this technology, especially in schools serving children with special needs, holds great potential in supporting more inclusive and adaptive learning tailored to the unique needs of these students. AR media offers an innovative approach to education for children with special needs. With its ability to increase interest in learning, facilitate concept understanding, and support soft skills development, AR is a valuable tool for creating inclusive and effective learning experiences for children with special needs. Thus, AR is an exciting technology and offers an effective learning solution to improve students' understanding, engagement, and motivation in the learning process.

METHODS

The approach used in this study was quantitative with an experimental method, using a one-group pretest-posttest design. This design allowed researchers to observe changes in teachers' understanding before and after training so that the effectiveness of AR training could be measured directly. The research subjects were 30 special needs teachers in Bandung who were selected using purposive sampling based on specific criteria, such as teaching experience in special needs schools and involvement in teaching children going through puberty. This study focused on the effect of specially designed augmented reality training on reproductive and sexual health education and how to deal with puberty issues in children with special needs. The training conducted in this study uses AR-based devices that allow subjects to access visual and interactive simulations related to physical and psychological changes during puberty. Thus, the training studied combines theory, AR technology demonstrations, and hands-on practice sessions. The main instrument in this study is a test consisting of a pretest and a posttest. The test includes multiple-choice questions designed to measure teachers' understanding of the material taught. The pretest was conducted before the training began, while the posttest was administered after completion. The data obtained from the pretest and posttest were analyzed using a non-parametric statistical test, namely the Wilcoxon Signed-Rank Test. This test was chosen because the research design did not involve a control group and only measured changes in one group (SLB teachers). This test was used to determine whether there was a significant difference between the pretest and posttest results, reflecting an increase in teachers' understanding after participating in AR training.

RESULTS AND DISCUSSION

Research Results

Based on the results of data analysis, training using Augmented Reality (AR) showed significant effectiveness in improving the understanding of special needs school (SLB) teachers regarding reproductive health and sexuality education for children with special needs (ABK).

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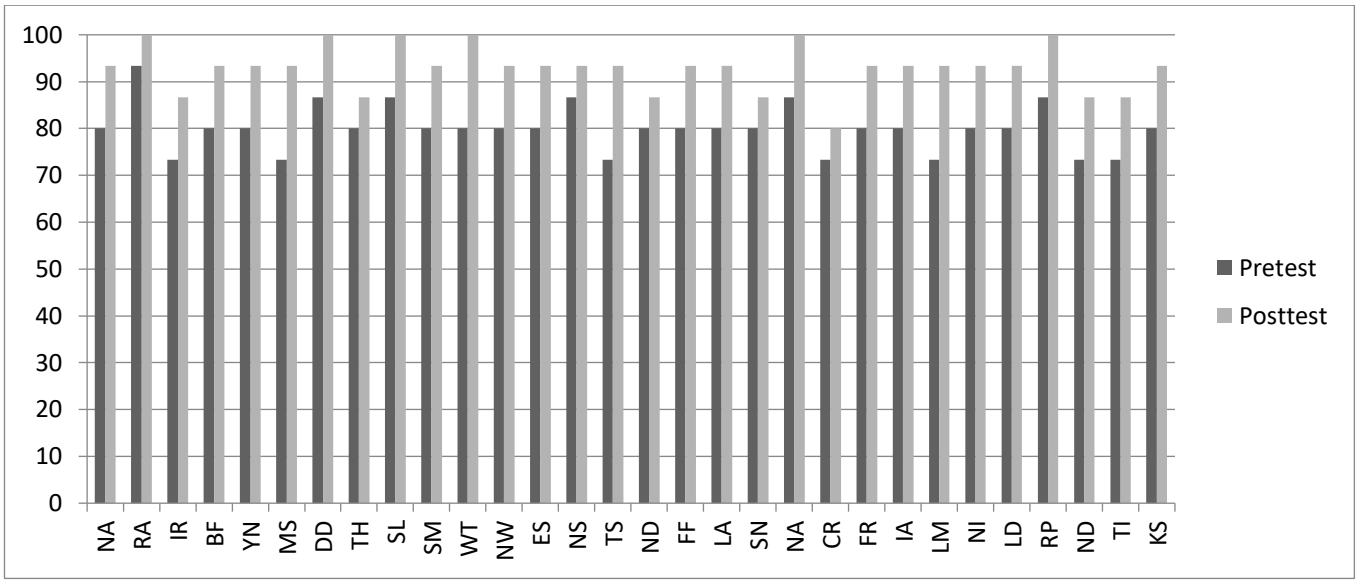

Figure 1. Comparison of Pretest-Posttest Results
Source: Author's Research 2024

The graph in **Figure 1** above compares several subjects' pretest and posttest scores. The Y axis represents the scores, while the X axis represents the subjects' initials. Each subject has two bars, one for the pretest score and one for the posttest score. From the graph, it can be seen that there is an increase in scores from the pretest to the posttest for most subjects. This indicates that the AR training intervention effectively improves participants' understanding. Although there is an overall increase, the graph shows that the level of improvement varies among subjects.

Table 1. Data Analysis Results with Wilcoxon Signed Rank Test

		N	Mean Rank	Sum of Ranks
Pretest - Posttest	Negative Ranks	0[a]	.00	.00
	Positive Ranks	30[b]	15.50	465.00
	Ties	0[c]		
	Total	**30**		

Sumber: Author's Research 2024

Table 2. Test Statistics

	Posttest - Pretest
Z	-4.7821[b]
Asymp. Sig. (2-tailed)	.00001

Sumber: Author's Research 2024

The analysis shown in **Tables 1** and **2**, conducted using the Wilcoxon Signed-Rank Test, produced a Z value of -4.7821, with a very low significance level (p-value) of less than 0.0001. A negative Z value and low significance indicate a statistically significant difference between the pretest and posttest results. This shows that AR training was successful in improving the participants' overall understanding.

Table 3. Statistical Values of Pretest-Posttest Results

No.	Statistics	Statistical Values	
		Pretest	Posttest
1.	Sample Size	30	30

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2.	Ideal Score	100	100
3.	Lowest value (minimum)	73,3	86,7
4.	Highest value (maximum)	93,3	100
5.	Value Range (*Range*)	20	13,3
6.	Average Value (*Mean*)	80	93,1

Sumber: Author's Research 2024

Table 3 shows that the range of pretest scores was greater than that of posttest scores (pretest range 20, posttest range 13.3), indicating that participants' knowledge varied greatly before the training. This may have been due to participants' differences in educational backgrounds, teaching experience, and technology proficiency. After the training, the range of scores became smaller, indicating that participants' knowledge after the training became more uniform and homogeneous. The AR training appears to have been successful in standardizing teachers' understanding, although there were still differences in the level of improvement.

The distribution of score improvements also shows interesting variations. Four out of 30 participants experienced an improvement of 20 points, indicating that they made optimal use of the AR training. Conversely, 6 participants only experienced an increase of 6.6 points, while the majority (20 participants) experienced an increase of 13.3 points. This variation indicates that several factors may influence individual learning outcomes, including learning motivation, interest in technology, prior experience with the material, and the level of adaptation to the AR technology used in the training.

Discussion

The results of this study indicate that AR-based training is significantly effective in improving teachers' understanding of reproductive and sexual health education materials for children with special needs. However, differences in score improvements indicate that AR training needs to be complemented with a more individualized approach to consider the subjects' background and readiness to use technology. For participants whose scores did not increase significantly, further evaluation is needed to identify the obstacles they faced, such as limitations in technology mastery or a lack of motivation. This study also revealed important implications for developing training programs for special needs teachers. The training curriculum for special needs teachers must be supplemented with material that prepares teachers to use AR in learning. This is because teachers often need additional guidance to develop their technological skills.

Training plays an important role in improving teachers' ability to operate the latest technology applications so that they are better prepared to utilize various digital tools in the learning process. With proper training, teachers understand how the applications work and can integrate them effectively into classroom teaching, ultimately improving student interaction and engagement. The use of AR technology in training can be an effective alternative to improve the quality of learning. However, further research is needed to identify factors that can maximize the effectiveness of AR training. In addition, it is also important to conduct long-term evaluations to measure the sustainability of the training's impact on teachers' classroom practices.

Constructivist learning theory states that direct experience and interaction with material can improve understanding. AR provides an interactive learning environment, allowing teachers to see and interact with content directly, aligning with active learning principles (Arisanti et al., 2024). This is consistent with other research findings that one of the biggest challenges for teachers in teaching is visualizing abstract concepts, such as those in science education (Hafis et al., 2024). With the positive impact of AR training, it is known that AR can be used to create personalized learning plans for students with special needs. AR technology enables the visualization of difficult-to-understand concepts, such as 3D models of

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reproductive organs, making it easier for students with special needs to understand complex topics (Hafis et al., 2024). With the positive impact of AR training, it is known that AR can be used to create personalized learning plans for students with special needs. AR technology enables the visualization of difficult-to-understand concepts, such as 3D models of reproductive organs, making it easier for students with special needs to understand complex topics (Meggy & Aprilia, 2024). Similarly, improvements in teachers' skills and understanding of integrating AR technology have brought significant changes in English teaching methods (Umisara et al., 2024).

In the learning process, it is crucial to gain hands-on experience. AR provides simulations allowing users to learn through real-life experiences, not just text or static images. This helps users remember information better because they are actively engaged in learning. The results of this study also indicate the benefits of AR on teachers' knowledge and skills. This is supported by other statements that training activities can increase teachers' knowledge and improve their skills in using an application (Ningsih, 2021; Nurcahyo et al., 2022).

This study has proven the effectiveness of AR technology in improving the quality of learning for children with special needs. Several strategic steps need to be taken to maximize the potential of AR in inclusive education. Further analysis shows that most participants experienced increased scores after the training. Some participants even achieved maximum scores on the post-test. This indicates that the AR-based learning method can attract the interest and attention of teachers so that the material presented can be more easily understood and remembered. Although there were differences in learning outcomes, this needs to be identified further. This includes a more in-depth analysis of teachers' mastery of technology, motivation, and readiness to use AR.

Comprehensive reproductive health education is crucial, providing a strong foundation for in-depth understanding among teachers and students. AR technology can be integrated into a more holistic strategy to enrich their knowledge and awareness of reproductive health interactively and effectively. Additionally, attention should be given to the availability of supporting resources, such as software and learning content that is more specific and tailored to the needs of training participants. Collaboration between academics, practitioners, and technology developers is needed to create more innovative and relevant AR solutions in inclusive education, particularly reproductive and sexual health education. AR training not only offers solutions to improve teachers' understanding of reproductive and sexual health materials but also opens opportunities for further research into integrating interactive technology into formal education, especially in special education.

CONCLUSION

Based on the results of this study, it can be concluded that Augmented Reality (AR) training effectively improves special needs teachers' understanding of reproductive health and sexuality education materials. Furthermore, although this short-term training showed positive results, further research is needed to evaluate the long-term impact of this training on teachers' classroom practices. It is essential to monitor how teachers apply their understanding in the classroom to assess whether this training results in sustainable changes in teaching methods and students' understanding. This will also help identify whether AR technology is truly effective in improving teaching skills in the long term. The training can improve teachers' knowledge of interactive learning media, but further steps are needed to ensure that the skills acquired are applied in classroom teaching practices. Overall, it can be concluded that this training is efficacious in improving teachers' understanding of reproductive health and sexuality education for children with special needs. This can be seen from the increase in the average subject scores on the post-test compared to the pre-test.

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However, there were still some participants whose scores did not change significantly. This needs further attention to identify the factors that influence the differences in learning outcomes among participants. In addition, further research is needed to measure the long-term impact of this training on teachers' classroom teaching practices. Recommendations for further research include conducting studies with larger sample size and involving various types of schools, analyzing factors that influence differences in participants' learning outcomes in greater depth, developing AR training modules that are more specific and tailored to the needs of each participant, and conducting long-term evaluations to measure the sustainability of AR training's impact on teachers' classroom practices.

AUTHOR'S NOTE

The author declares that there are no conflicts of interest related to the publication of this article and confirms that the data and content of the article are free from plagiarism.

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