

Development of Augmented Reality Based Smart Cards as A Mathematics Learning Media for Children with Special Needs

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ABSTRACT

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This research aims to design and test the effectiveness of Augmented Reality (Ar based smart card media as a disability-friendly, interactive, and fun mathematics learning tool. This media is expected to be a real contribution in supporting inclusive learning and improving the quality of education for children with special needs in SLB. This research uses the Research and Development (R&D) method. The development model chosen is ADDIE (Analysis, Design, Development, Implementation, Evaluation). The trial subjects were students with special needs and intellectual disabilities at SLB Muhammadiyah Purworejo for the 2025/2026 academic year. The data collection techniques and instruments used in this study are as follows. (1) Questionnaires, given to SLB Muhammadiyah Purworejo teachers, accompanied by a suggestion sheet to obtain input regarding the product being tested. (2) Interviews were conducted with teachers and students (if possible) of SLB Muhammadiyah Purworejo to gather information regarding teacher obstacles in developing and implementing learning, as well as to determine students' difficulties in learning the material. (3) Tests were conducted to obtain student data as research subjects, especially in measuring students' mathematical abilities. The data analysis technique used is product validity data analysis, product practicality and product effectiveness. Smart cards based on augmented reality (AR) as a learning medium for mathematics for children with special needs are suitable for use because they meet the criteria of being valid, practical and effective. It is said to be valid supported by the validity value given by the material validator of 0.98 with very valid criteria and the media validator of 0.96 with a very valid category. Practicality shows a value of 0.97 with very practical criteria. For effectiveness, the pre-test value is 73 while the post-test value is 100, so by using n gain it achieves a high and effective increase.

Keywords: Smart Card, AR (Augmented Reality), Special Needs

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INTRODUCTION

Learning mathematics for children with special needs in Special Needs Schools (SLB) faces various challenges, including conceptual understanding, student engagement, and the limited availability of learning media appropriate to their characteristics. According to Heward in Pristian Hadi Putra, (2021), Children with special needs (ABK) are children with special characteristics that differ from those of children in general, without necessarily showing mental, emotional, or physical disabilities. Children with special needs, such as those with hearing impairments, intellectual disabilities, and autism, often have difficulty understanding abstract material presented verbally or through conventional methods. Therefore, learning media that can present material in a concrete, visual, and interactive manner are needed. The development, obstacles, and learning needs of ABK vary. Learning obstacles experienced by each ABK are generally caused by three things: environmental factors, factors within the child

themselves, and a combination of environmental and internal factors. (Sukadari, 2020)

Visual aids are a medium or learning aid, designed based on the principle that knowledge is perceived or captured through the five senses. Visual aids are one of the learning facilities used by educators for specific materials. Visual aids can be designed based on the needs of students (Arum permatasari, Yuberti, 2019). Visual aids have long been used as an approach to help special needs students understand mathematical concepts more concretely. However, conventional visual aids have limitations in terms of interactivity and flexibility. On the other hand, developments in educational technology have presented Augmented Reality (AR) as an innovative solution capable of simultaneously combining the real and digital worlds. AR allows students to see virtual objects in 3D, hear sounds, and read explanatory text directly through digital devices.

The combination of visual aids and AR technology in the form of AR-based smart cards becomes an interesting and adaptive learning media alternative. These cards not only present images and symbols that are easily recognized by students, but can also be scanned to display interactive content such as animations, sounds, and learning narratives. With this multisensory approach, it is hoped that students can more easily understand mathematical concepts, increase their interest in learning, and strengthen their memory of the material studied. With AR, students can rotate 3D objects so that abstraction is reduced and understanding increases (Cheong, K. H., Chu, C. E., Ng, W. K., & Yeo, 2024).

Through this development research, this researcher aims to design and test the effectiveness of AR-based smart card media as a disability-friendly, interactive, and fun mathematics learning tool. This media is expected to be a real contribution in supporting inclusive learning and improving the quality of education for children with special needs in SLB. Based on the background description above, the question/problem formulation in this study is: Is AR-Based Smart Cards as a Mathematics Learning Media for Children with Special Needs Worth Using?.

As an effort to solve problems in children with special needs, innovative learning media is needed that can facilitate mathematics learning in a concrete, visual, and interactive way. AR-based smart cards are present as an innovative solution. These cards not only present images and symbols that are easily recognized by students, but can also be scanned to display interactive content such as animation, sound, and learning narratives. So it is hoped that it will make it easier for children with special needs to learn mathematics. The state of the art of this research includes: (1) Integration of AR Technology with Visual Cards for Special Needs Schools This research combines conventional visual aids (picture cards) with Augmented Reality (AR) in one learning media. This approach is still rarely used specifically for children with special needs, especially in the context of mathematics learning in Special Needs Schools. (2) Disability-friendly media design, smart cards are designed by considering the characteristics of students with intellectual disabilities, deafness, or autism, such as: Simple and clear visuals Supporting symbols (sign language, icons), multisensory interactions (images, sound, text). This is in accordance with the opinion of Anastasia Roh Ulitona dkk, (2025) that the success of implementing learning media for children with intellectual disabilities is greatly influenced by teacher readiness, limited infrastructure, variations in student characteristics, and the need for individual, interactive learning strategies supported by teacher training and adaptive evaluation. This shows an inclusive and adaptive approach that has not been widely developed in AR-based media. (3) Multisensory Approach in Mathematics Learning. This media allows students to learn through sight, hearing, and movement, which is very important for children with special needs. This is supported by the opinion of [15] which states that the multisensory approach has been identified as an effective strategy to support the learning of young students with special needs. This technology-based multisensory approach is an innovation in mathematics learning methods in SLB. (4) Flexibility of Use in SLB Environments. This media is designed to be used independently by students or accompanied by teachers, without requiring expensive devices or complex internet networks, this is reinforced by the opinion of Jolampong, (2025) who stated that AR media is easier to understand, increases engagement and confidence, and encourages independent learning. "Learners reported that AR flashcards made science terms easier to understand, increased engagement and confidence, and encouraged independent learning" This answers the challenge of limited facilities in many SLB. Simplified Development Model: This study uses a modified development model without

extensive trials, so it is more realistic and applicable to SLB conditions. This provides a methodological contribution for other researchers who want to develop media in limited environments.

METHOD

PeneliThis research uses the Research and Development (R&D) method. According to Sugiyono, (2016) R&D aims to validate and develop products so that they are suitable for effective use. This research develops AR-Based Smart Cards as a Mathematics Learning Media for Children with Special Needs. The development model chosen is ADDIE (Analysis, Design, Development, Implementation, Evaluation), because it has a systematic and flexible flow for designing and developing an effective product (Branch, 2009). Because this research is in a special needs school, the ADDIE steps only reach the implementation and initial evaluation stages, so no extensive trials are carried out. Only initial development. The procedure in this research is in accordance with the ADDIE model which has the following research stages. (1) Analysis Stage, the analysis stage is carried out to identify needs in developing smart cards. Analysis is carried out to examine needs in developing smart cards. This activity includes reviewing the curriculum, learning conditions, student characteristics, and the material to be taught to suit the demands of learning outcomes. In addition, an analysis of media needs is carried out, as well as a review of the school's infrastructure. Data was obtained through observation, interviews with teachers, and literature reviews from related articles and journals. (2) Design Stage, the design aims to produce supporting materials for the implementation of the research. This stage begins with the preparation of material concepts, media, and other components needed in the design process. (3) Development Stage, at this stage, the development of AR-based smart cards as a medium for learning mathematics for children with special needs is carried out and then a validation process is carried out by experts. (4) Implementation Stage, the implementation stage is the application of the design and learning media in real conditions in the classroom through field trials. The trial is carried out after the product is assessed by experts and revised, with the form of implementation being a limited trial. (5) Evaluation Stage, the evaluation stage aims to assess the efficiency and effectiveness of learning as well as assess the feasibility of the product being developed. Product feasibility is reviewed through validity, practicality, and effectiveness tests. Research on AR-Based Smart Cards as a Medium for Learning Mathematics for Children with Special Needs will be carried out at SLB Muhammadiyah Purworejo. The trial subjects are students with special needs and intellectual disabilities at SLB Muhammadiyah Purworejo for the 2025/2026 academic year. The data collection techniques and instruments used in this study are as follows. (1) Questionnaires, given to teachers of Muhammadiyah Purworejo Special School, accompanied by a suggestion sheet to obtain input regarding the product being tested. (2) Interviews were conducted with teachers and students (if possible) of Muhammadiyah Purworejo Special School to gather information regarding teacher obstacles in developing and implementing learning, as well as to find out students' difficulties in learning the material. (3) Tests were conducted to obtain student data as research subjects, especially in measuring students' mathematical abilities.

The data analysis techniques used are product validity data analysis, product practicality and product effectiveness. (1) Product Validity Analysis. Product validity is analyzed through a questionnaire given to validators, namely media expert lecturers and material expert lecturers. The assessment data are then processed using a Likert scale. According to Wardani, N. & Dani, (2019) the validation score percentage can be calculated using the following formula:

$$P(\%) = \frac{\text{Total score of data collection results}}{\text{skor maksimal}} \times 100\%$$

After the percentage scores from the validation questionnaires of the two experts were calculated, the results obtained in this study were then classified into certain categories using the following scale:

Table 1. Validity Criteria

Criteria	Percentage (%)
Invalid	$0 \leq P \leq 20$
Less Valid	$20 < P \leq 40$

Fairly Valid	$40 < P \leq 60$
Valid	$60 < P \leq 80$
Very Valid	$80 < P \leq 100$

(Sugiyono, 2016)

Based on the table, a product is valid if the results reach 61% or above (2) Analysis of product practicality, analysis of the level of product practicality is carried out through questionnaire response data obtained from teachers. Analysis of product practicality can be calculated using the following formula [9].

$$P(\%) = \frac{\sum_{i=1}^n x_i}{n \times k} \times 100\%$$

P = percentage of response values

$\sum_{i=1}^n x_i$ = total response values

n = number of test subjects

k = highest assessment score

The level of product practicality is determined through the percentage of teacher responses categorized based on the assessment scale (Sofyan & Maesaroh, 2021).

Tabel 2. Skala Persentase Respon Siswa

Interval (%)	Criteria
$80 < P \leq 100$	Very Good
$60 < P \leq 80$	Good
$40 < P \leq 60$	Fair
$20 < P \leq 40$	Poor
$0 \leq P \leq 20$	Poor

(Sulistya, 2018)

Based on Table 2, a product can be considered practical if it meets good criteria, namely with a student response percentage of at least 61%. (3) Product Effectiveness Analysis. The effectiveness test was conducted at the evaluation stage through student pretests and posttests. Data were analyzed using the N-gain score to assess the effectiveness of the developed media. The following is the N-Gain Score formula (Arifin, A. M., Pujiastuti, H., & Sudiana, 2020).

$$N - Gain (g) = \frac{Posttest\ Score - Pretest\ Score}{Maximum\ Score - Pretest\ Score}$$

The N-gain calculation results are then adjusted according to the following criteria.

Table 3. N-Gain Score Categories

N-Gain skor (g)	Improvement Category
$g > 0,7$	Tall
$0,30 < g \leq 0,70$	Currently
$g \leq 1,00$	Low

(Hake, 1999)

After being analyzed with the N-gain score, then by changing it to a percentage to see its effectiveness according to the following table.

Table 4. Interpretation of N-Gain Effectiveness

Percentage (%)	Category
< 40	Ineffective
$40 \leq g \leq 55$	Less Effective
$56 - 75$	Moderately Effective
> 76	Effective

(Ismawati, I., Mutia, N., Fitriani, N., & Masturoh, 2021)

Based on the effectiveness analysis above, learning media is said to be effective if the effectiveness percentage meets the minimum category of being quite effective with a percentage of $> 56\%$.

RESULTS AND DISCUSSION

The findings of the problems in this research were seen when carrying out the needs analysis or in this research at the analysis stage. The findings are as follows: The results of interviews and questionnaires on teacher needs analysis show that for the needs of learning media, teachers say that to support mathematics learning, they really need learning media, but teachers do not have much time to prepare learning media, while the difficulties faced by teachers in teaching mathematics to mentally retarded children are their abilities because for mentally retarded children, their thinking abilities are very far below children their age, so if today they are taught the material tomorrow they have forgotten it, so they have to repeat it many times. For the use of AR, the teacher has never used AR and does not know what AR is like, and he is willing to use AR in mathematics learning, for material that is still very difficult for students is addition and subtraction, for this material students are still trying to understand addition and subtraction under 10, the teacher asks for the media to be made simple considering the abilities of mentally retarded children who are below children their age. And according to the teacher, 3D visual media can help students' understanding of addition and subtraction material but must be used frequently so that they are not easily forgotten. This is supported by studies conducted using appropriate and adapted designs (Meza. S. Dkk, 2025) AR shows great potential as an aid for students with special needs in their learning. According to research (Rakhimzhanova, L., Issabayeva, D., Kultan, J., Baimuldina, N., Issabayeva, Z., & Aituganova, 2025) AR technology has great potential to improve the educational experience of students with special needs. (Denizli-Gulboy, H., Genc-Tosun, D., & Gregori, 2024) and others have shown that AR is a socially acceptable and engaging way for autistic students to learn scientific language. Furthermore, according to a recent study by (Muhaidat, F., Jdaitawi, M., Abu-Joudeh, M., Hussein, E., Rabab'h, B., Kan'an, A., & Talafha, 2022). AR can help people with intellectual disabilities and autism improve their cognitive skills and social interactions, among other talents.

For an interview with one of the mentally retarded students, we asked for help from the class teacher because the child was not yet familiar with our team. To maintain the child's psychology, we asked the teacher to help conduct the interview and fill out the questionnaire. The results of the interview and questionnaire of the mentally retarded child are as follows: the child likes math lessons, the child likes pictures especially 3D gambits, and they feel it is easier to learn using pictures than numbers, they really like 3D pictures that can move and they really want to try cards that can turn into 3D pictures. So based on the results of the interview and questionnaire by the teacher and the mentally retarded student, they need interesting media so that math lessons are more interesting and easy to understand, especially for mentally retarded children. This is reinforced by Research conducted by (Patiño, D. H. C., Muñoz, L., Villarreal, V., Pardo, C., Núñez, I., Navarro, N., Fernández-Arroyo, L. V., Dobrescu, C. C., & Rodríguez, 2024) found that the use of AR picture books that provide immediate feedback to students with autism spectrum disorder (ASD) on their progress, while receiving high marks in terms of innovation and usability, increases student motivation.

Next, the design stage. At this stage, researchers created AR learning media designs for children with special needs. The initial design results for AR-based smart cards as a mathematics learning medium for children with special needs are as follows.



Figure 2. Initial design of the Smart card

The next stage is Development, which includes expert validation. Several validators are involved in this stage, including material validation, media validation, and validation from psychology experts. Here are some inputs from several validators. Material experts provided several suggestions regarding mathematics learning materials, including simplifying the material and adapting it to students with special needs. The following is input from one of the material experts.:

No	Keterangan	Aman digunakan
D. Saran Validator	Soal dibuat lebih mudah lagi	
E. Kesimpulan	☐ Layak ☒ Layak dengan revisi ☐ Tidak layak	
F. Tanda Tangan Validator	Nama Validator: Addiel Niengsarie Srientamie	
	Tanda Tangan:	
	Tanggal: 26 Januari 2026	

Figure 3. Material validation

So, based on the feedback, we revised the subtraction material under 20 to addition material under 10, and removed the levels we originally had. Here are the revised smart card materials:

Figure 3. Material Display



Based on input from two subject matter experts to adapt the material to children with special needs, we revised the material. It now includes additions under 10. We used two validators for the media expert. The media expert assessed the suitability of the learning media for children with special needs. There were no revisions for the learning media. Next, we used a psychology expert; the validator for the psychology expert was a psychology lecturer at Muhammadiyah University of Purworejo. One of the suggestions given was that the material be adapted to the abilities of children with special needs. Therefore, the psychology expert made the same revisions as the subject matter expert.

The next stage is the Implementation stage, which is the implementation stage. The implementation took place on Thursday, February 12, 2026, at Muhammadiyah Purworejo Special Needs School with one research subject. We conducted the research in the library because the classroom was used for learning. At the beginning of the research, we introduced the research subjects to make them feel comfortable with us. We started with light stories to break the ice because the subjects seemed afraid. After the subjects felt relaxed, we began the research. We conducted the research using cellphones by scanning the barcode on a smart card. At the beginning of the lesson, we introduced the learning features available on the smart card. Students were very interested in the 3D images that could move. Then, we began asking the subjects to learn to use the smart card. At first, the students were still hesitant to press the smart card, but after some time, we gradually asked them to try playing it themselves. And the students were happy and said that calculating using the smart card was easier. This is reinforced by (Loriebel Orbeta Paquidongan, MAED-Math, Angelito D. Gardose, 2025) who agree that media greatly increases student engagement, which is a key mediator between student motivation in learning and their actual engagement in the learning process, stating that media can significantly increase student engagement. This is also conveyed by (Geedallah, 2025) who emphasized that every subject requires learning media to develop students' reading, critical thinking, and creativity skills.

The next stage is the evaluation stage, where the media's validity, practicality, and effectiveness are assessed. Validity is assessed through validation of the material, media, and psychology experts. Based on the validation sheet, the assessment data is then processed using a Likert scale. According to (Wardani, N. & Dani, 2019) the validation score percentage can be calculated using the following formula:

$$P(\%) = \frac{\text{Total score from data collection}}{\text{maximum score}} \times 100\%$$

Table 1. Material Validation Results

No	Validator	Value
1.	Validator 1	0,96
2.	Validator 2	1,00
Average		0,98

From the table above, the material validation is considered very valid, with a score of 0.98.

Table 2. Media Validation Results

No	Validator	Value
1.	Validator 1	0,92
2.	Validator 2	1,00
Average		0,96

From the table above, the material validation is considered very valid with a score of 0.96.

This is because it meets the validity criteria. Next is practicality. Practicality can be seen from the results of the teacher and student practicality questionnaire. The results of the teacher and student practicality questionnaire are as follows:

Table 3. Results of Student and Teacher Response Questionnaire

No	Responding	Value
1.	Teachers	1,00
2.	Students	0,94
Average		0,97

The table above shows a score of 0.97, categorized as very practical. Therefore, AR-based smart cards for children with special needs are considered practical. To assess the effectiveness of using the pre-test and post-test scores for students with special needs, we used n-gain. The pre-test score was 73, while the post-test score was 100. Therefore, using n-gain achieved significant improvement and was effective. Therefore, based on the validity, practicality, and effectiveness of AR-based smart cards as a learning tool for children with special needs, it is suitable for use.

DISCUSSION

The novel aspects of this study include: (1) The integration of AR technology with visual cards for special needs schools (SLB); this research combines conventional visual aids (picture cards) with Augmented Reality (AR) into a single learning medium. This approach is rarely used specifically for children with special needs, particularly in the context of mathematics instruction in special needs schools. This is supported by Ahmad, A., & Junaini, (2020), who state that AR provides a new experience for learners by enabling them to "see" the existing environment overlaid by digital learning content. (2) Disability-friendly media design; the smart cards were designed with the characteristics of students with intellectual disabilities in mind, featuring simple and clear visuals, supporting symbols (sign language, icons), and multisensory interaction (images, sound, text). This is reinforced by the view of Cabero-Almenara, J., Guillén-Gámez, F. D., Ruiz-Palmero, J., & Palacios-Rodríguez, (2022) that the design of disability-friendly media is essential to guarantee equity in learning opportunities, allowing for multisensory interaction through images, sounds, and text.

The primary finding of this study is the challenge of creating learning media for students with intellectual disabilities, given their diverse abilities and difficulty visualizing abstract concepts. This is supported by research Patel, D. R., Cabral, M. D., Ho, A., & Merrick, (2020) stating that educational interventions should focus on concrete experiences and multisensory approaches to facilitate learning. Interviews with teachers revealed that the media typically used was insufficient for helping students with intellectual disabilities grasp basic mathematical concepts, leading to boredom during lessons. This aligns with the view Springer, (2020) that little is known about the mathematical development of students with intellectual disabilities, and traditional instructional methods often fail to sustain their engagement. The

AR-based smart cards display digital objects (such as numbers, shapes, and arithmetic operations) over physical cards in real-time, allowing students to hear, see, and explore information simultaneously. The interactive nature of the cards boosts student interest, and their portability enables independent study at home. Preliminary testing showed improved arithmetic skills; competency tests administered after using the AR-assisted smart cards revealed a rise from a pre-test score of 73 to a post-test score of 100, indicating a high and effective N-gain improvement. Student and teacher responses were overwhelmingly positive (97%), and validity assessments confirmed the cards were suitable for use, achieving a validity score of 96%. Consequently, the AR-assisted smart cards are deemed appropriate for students with intellectual disabilities. This was evident in the students' enthusiastic attitude during the study; the moving objects displayed by the cards captured their interest and facilitated a better understanding of the material. These findings are supported by research Pamolarco, (2022), which concluded that the use of digital flashcards in teaching mathematics improves vocabulary acquisition in children with disabilities and is therefore recommended.

Research relevant to the current study includes: Singh, S., & Zeeshan, (2025), titled *The Impact of Augmented Reality (AR) and Virtual Reality (VR) in Special Education Math Instruction: A Systematic Review*, which demonstrates that AR/VR enhances engagement and the understanding of abstract concepts among children with special needs. Bulut, M., & Ferri, (2023), in *A Systematic Literature Review on Augmented Reality in Mathematics Education*, concluded that AR is effective in increasing interactivity and the understanding of mathematical concepts, though research specifically targeting children with special needs remains limited. Ahmad, A., & Junaini, (2020), in *Augmented Reality for Learning Mathematics: A Systematic Literature Review*, emphasized AR's potential to visualize abstract concepts and boost motivation, noting that its implementation in special education schools remains rare. Aldalalah, Aldalalah, O., Ababneh, Z., & Bawaneh, (2019), in *Effect of Augmented Reality and Simulation on the Achievement of Mathematics and Visual Thinking among Students*, found that AR improves mathematics achievement and visual thinking skills. Alqarni, A., & Alzahrani, (2021), in *Augmented Reality Applications in Teaching Mathematics for Students with Learning Disabilities*, focused on children with learning disabilities; results showed that AR aids in understanding basic concepts and increases motivation. Arsyad, M., Rahman, A., & Sari, (2022), in *Integrating Augmented Reality in Mathematics Learning for Students with Special Needs*, demonstrated that AR is adaptable for children with special needs, assisting in the visualization of simple arithmetic operations. Commonalities between these studies and the current research include: a focus on AR as a medium for mathematics instruction; the enhancement of student motivation and engagement; the visualization of abstract concepts into concrete forms; the provision of multisensory experiences (visual, audio, interactive); and relevance to children with learning disabilities or special needs. Based on these commonalities, AR media can enhance understanding among students with special needs. Differences between previous studies and the current research lie in the methodology: some utilized a systematic review approach (Singh & Zeeshan; Bulut & Ferri; Ahmad & Junaini). Some studies involve direct classroom experiments (Aldalalah; Alqarni & Alzahrani; Arsyad), whereas the present study employs research and development methodology. A key factor distinguishing this study is the scarcity of mathematics learning media for students with intellectual disabilities; consequently, the research focuses on developing learning media specifically for this group. There is also a difference regarding the target population: while some studies focus on general education students (Bulut & Ferri; Ahmad & Junaini), this study focuses on children with special needs – specifically those with intellectual disabilities – at SLB Muhammadiyah Purworejo.

This research goes beyond merely using AR as a visual medium; it integrates the technology with smart cards – tools that are simple and familiar to children with special needs, particularly those with intellectual disabilities. The study introduces an innovative approach by combining traditional media (cards) with modern technology, making the tools more adaptable for this demographic. While many international studies have explored AR in mathematics education, few specifically target children with special needs. This research addresses that gap by focusing on accessibility, inclusivity, and the adaptation of mathematical content for students with special needs. It offers a disability-friendly learning media model suitable for use by teachers in both special education schools and inclusive mainstream schools. In doing so, the study advances understanding of how technology can foster equity in education.

AR-based smart cards serve not only as assistive tools but also as a pedagogical strategy that emphasizes active student engagement, charting a new course for the development of practical, cost-effective, and easily implementable technology-based learning media.

CONCLUSION

Smart cards based on augmented reality (AR) as a learning medium for mathematics for children with special needs are suitable for use because they meet the criteria of validity, practicality, and effectiveness. Validity is supported by the validity value given by the material validator of 0.98 with the criteria of very valid and the media validator of 0.96 with the category of very valid. Practicality shows a value of 0.97 with the criteria of very practical. For effectiveness, the pre-test value is 73 while the post-test value is 100, so by using n gain achieves high and effective improvements.

REFERENCES

- Ahmad, A., & Junaini, S. N. (2020). Augmented reality for learning mathematics: A systematic literature review. *International Journal of Emerging Technologies in Learning (IJET)*, 15(6), 106–121. <https://doi.org/https://doi.org/10.3991/ijet.v15i16.14961>
- Aldalalah, O., Ababneh, Z., & Bawaneh, S. (2019). Effect of augmented reality and simulation on the achievement of mathematics and visual thinking among student. *International Journal of Emerging Technologies in Learning (IJET)*, 14(3), 164–185.
- Alqarni, A., & Alzahrani, M. (2021). Augmented reality applications in teaching mathematics for students with learning disabilities. *Journal of Education and Learning*, 10(4), 12–25.
- Anastasia Roh Ulitona dkk. (2025). Medan Terjal Inklusi: Problematika Guru Dalam Merancang Media Pembelajaran Yang Efektif Bagi Anak Tunagrahita. *Indo-MathEdu Intellectuals Journal*, 6(3), 4515–4526. <https://doi.org/https://doi.org/10.54373/imeij.v6i3.3164>
- Arifin, A. M., Pujiastuti, H., & Sudiana, R. (2020). Pengembangan media pembelajaran STEM dengan augmented reality untuk meningkatkan kemampuan spasial matematis siswa. *Jurnal Riset Pendidikan Matematika*, 7(1), 59–73. <https://doi.org/https://doi.org/10.21831/jrpm.v7i1.32135>
- Arsyad, M., Rahman, A., & Sari, D. (2022). Integrating augmented reality in mathematics learning for students with special needs. *International Journal of Educational Insights and Innovations*, 3(2), 45–58.
- Arum permatasari, Yuberti, dan W. A. (2019). Pengembangan Lampu Sensor Berbasis arduino Uno Sebagai Alat Peraga Fisika. *Indonesian Journal Of Science And Mathematics Education*, (3), 380–387.
- Branch, R. M. (2009). Instructional Design: The ADDIE. In Department of Educational Psychology and Instructional Technology University of Georgia e, 53(9).
- Bulut, M., & Ferri, R. B. (2023). A systematic literature review on augmented reality in mathematics education. *European Journal of Science and Mathematics Education*, 11(3), 345–360.
- Cabero-Almenara, J., Guillén-Gámez, F. D., Ruiz-Palmero, J., & Palacios-Rodríguez, A. (2022). Teachers' digital competence to assist students with functional diversity. *British Journal of Educational Technology*, 53(1), 65–84. <https://doi.org/https://doi.org/10.1111/bjet.13167>
- Cheong, K. H., Chu, C. E., Ng, W. K., & Yeo, D. J. (2024). Implementing GeoGebra 3D Calculator With Augmented Reality in Multivariable Calculus Education. *IEEE Access*, 85455–85464. <https://doi.org/https://doi.org/10.1109/ACCESS.2024.3394531>
- Denizli-Gulboy, H., Genc-Tosun, D., & Gregori, E. (2024). Teaching students with autism spectrum disorder how to use an augmented reality application and the vocabulary of the natural sciences. *International Journal of Developmental Disabilities*, 1–17. <https://doi.org/https://doi.org/10.1080/20473869.2024.2424606>.
- Dkk, M. S. (2025). Efektivitas Penggunaan Teknologi Augmented Reality (Ar) Dalam Pembelajaran Siswa Berkebutuhan Khusus: A SYSTEMATIC LITERATURE REVIEW. *Jutech*, 6(2), 539–554. <https://doi.org/https://doi.org/10.31932/jutech.v6i2.6000>
- Geedallah, N. M. A. A. and A. E. M. (2025). The Effectiveness of Using Some Instructional Materials in Teaching Writing Skills. *International Journal of E*, 13(1), 84–91. <https://doi.org/https://doi.org/10.37745/ijellr.13/vol13n1>
- Hake, R. R. (1999). Analyzing change/gain scores. AREA-D American education research association's

- devisi. *D. Measurement and Research Methodology*, 1(4), 48–56.
- Ismawati, I., Mutia, N., Fitriani, N., & Masturoh, S. (2021). Pengembangan Media Pembelajaran Fisika Berbasis Web Menggunakan Google Sites Pada Materi Gelombang Bunyi. *Schrodinger Jurnal Ilmiah Mahasiswa Pendidikan Fisika*, 2(2). <https://doi.org/https://doi.org/10.30998/sch.v2i2.4348>
- Jolampong, C. T. (2025). Enhancing Science Vocabulary Acquisition Through Augmented Reality (Ar) Flashcards Among Grade 3 Learners. *EPRA International Journal of Multidisciplinary Research (IJMR)*, 11(6), 893–903. <https://doi.org/https://doi.org/10.36713/epra22506>
- Loriebel Orbeta Paquidongan, MAED-Math, Angelito D. Gardose, P. (2025). The Mediating Role of the Use of Instructional Media Utilization on the Relationship between the Study Interest and Engagement of Students in Learning Mathematics. *International Journal of Humanities Social Sciences and Education (IJHSSE)*, 12(8), 51–70. <https://doi.org/https://doi.org/10.20431/2349-0381.1208006>
- Muhaidat, F., Jdaitawi, M., Abu-Joudeh, M., Hussein, E., Rabab'h, B., Kan'an, A., & Talafha, F. (2022). A Meta Analysis on Augmented Reality Application for Individuals with Intellectual Disability. *International Journal of Information and Education Technology*, 12(9), 970–976. <https://doi.org/https://doi.org/10.18178/ijiet.2022.12.9.1708>
- Pamolarco, A. F. (2022). Effectiveness of Digital Flashcards in Enhancing Engagement and Vocabulary Acquisition in Mathematics: The Case of Students with Learning Disabilities. *AIDE Interdisciplinary Research Journal*, 2(1), 45–56.
- Patel, D. R., Cabral, M. D., Ho, A., & Merrick, J. (2020). A clinical primer on intellectual disability. *Translational Pediatrics*, 9(1), s23–s25. <https://doi.org/https://doi.org/10.21037/tp.2019.09.09>
- Patiño, D. H. C., Muñoz, L., Villarreal, V., Pardo, C., Núñez, I., Navarro, N., Fernández-Arroyo, L. V., Dobrescu, C. C., & Rodríguez, M. (2024). AutismAR Discovery: Evaluation of an Augmented Reality Application to Support the Learning of Children With Autism Spectrum Disorder in Panama. *IEEE Revista Iberoamericana de Tecnologías Del Aprendizaje*, 19, 296–305. <https://doi.org/https://doi.org/10.1109/RITA.2024.3466171>
- Pristian Hadi Putra, D. (2021). Pendidikan Islam untuk Anak Berkebutuhan Khusus (Kajiantentang Konsep, Tanggung Jawab dan Strategi Implementasinya). *Fitrah: Journal of Islamic Education*, 2(1), 80–95.
- Rakhimzhanova, L., Issabayeva, D., Kultan, J., Baimuldina, N., Issabayeva, Z., & Aituganova, Z. (2025). Using Augmented Reality to Teach Digital Literacy Course to Primary School Children with Special Educational Needs. *European Journal of Educational Research*, 14(1), 55–71. <https://doi.org/https://doi.org/10.12973/eu-jer.14.1.55>
- Singh, S., & Zeeshan, I. (2025). The impact of augmented reality (AR) and virtual reality (VR) in special education math instruction: A systematic review. *Journal of Special Education Technology*.
- Sofyan, D., & Maesaroh, S. (2021). Pengembangan Perangkat Pembelajaran Menggunakan Deduktif Induktif Berbantuan Geogebra Dalam Meningkatkan Kemampuan Berpikir Kreatif Siswa Pada Masa Pandemi. *JPMI: Jurnal Pembelajaran Matematika Inovatif*, 4(1), 149. <https://doi.org/10.22460/jpmi.v4i1.149-160>
- Springer, P. (2020). The mathematical progress of students with an intellectual disability in inclusive classrooms. *Springer Education Review*, 12(4), 215–230.
- Sugiyono. (2016). *Metodologi Penelitian Kualitatif, Kuantitatif, dan R&D*. Jakarta: Alfabeta.
- Sukadari. (2020). Pelayanan Anak Berkebutuhan Khusus (ABK) Melalui Pendidikan Inklusi. *Jurnal Pendidikan Dan Pembelajaran Ke-SD-An*, 7(2), 336 – 346.
- Sulistya, D. A. (1AD). Pengembangan Quantum Teaching Berbasis Video Pembelajaran Camtasia Pada Materi Permukaan Bumi Dan Cuaca. *Profesi Pendidikan Dasar*, 2, 169. <https://doi.org/https://doi.org/10.23917/ppd.v1i2.5067>
- Wardani, N. & Dani, F. (2019). Kesalahan Siswa dalam Menyelesaikan Soal Cerita Dengan Menggunakan Kriteria Watson. *Jurnal Sesiomandika*, 2(1a), 15.