# Perception of school community towards the use of Augmented Reality digital media on students' critical thinking in Elementary School

**Saki, Budi Usodo, Eka Budhi Santosa**

Universitas Sebelas Maret
saki.vet@gmail.com

**Abstract**
Technological advancements present Augmented Reality (AR) based learning media that can provide interactive learning experiences to help students understand difficult concepts and improve critical thinking skills. This study aims to identify students' critical thinking skills, explore how teachers develop these skills, and determine perceptions of the use of AR. A qualitative approach was used with data collection through questionnaires distributed to students and teachers in several elementary schools. Students showed varied critical thinking skills with generally good potential. Most respondents had a positive perception of AR as a learning tool that increases motivation and engagement. Integration of AR technology into the curriculum is recommended to maximize students' learning experience.
**Keywords:** Perception of School Citizens, Use of AR Digital Media, Critical Thinking.

**Abstrak**
Kemajuan teknologi menghadirkan media pembelajaran berbasis Augmented Reality (AR) yang mampu memberikan pengalaman belajar interaktif untuk membantu siswa memahami konsep sulit dan meningkatkan kemampuan berpikir kritis. Penelitian ini bertujuan mengidentifikasi kemampuan berpikir kritis siswa, mengeksplorasi cara guru mengembangkan kemampuan tersebut, serta mengetahui persepsi terhadap penggunaan AR. Pendekatan kualitatif digunakan dengan pengumpulan data melalui angket yang disebarkan kepada siswa dan guru di beberapa sekolah dasar. Siswa menunjukkan kemampuan berpikir kritis yang bervariasi dengan potensi yang umumnya baik. Sebagian besar responden memiliki persepsi positif terhadap AR sebagai alat pembelajaran yang meningkatkan motivasi dan keterlibatan.Integrasi teknologi AR ke dalam kurikulum disarankan untuk memaksimalkan pengalaman belajar siswa.
**Kata kunci:** Persepsi Warga Sekolah, Penggunaan Media Digital AR, Berpikir kritis.

## INTRODUCTION

The development of digital technology has created various innovations that change many aspects of life, including in education. One innovation that is now receiving attention in basic education is Augmented Reality (AR). AR allows the integration of digital objects in a real environment, making the learning experience more interactive and interesting. In the context of primary education, the application of AR is able to overcome the increasingly complex learning challenges in this digital era (Akçayır & Akçayır, 2017).

The application of AR in education has been shown to have a significant impact on student engagement and motivation to learn, as well as helping to understand difficult concepts. A study from Bacca et al. (2019) states that AR-based learning makes it easier for students to visualize abstract and complex concepts, which is often a big challenge in conventional learning methods. In Indonesia, attention to improving the quality of basic education is increasing along with the need to equip the younger generation with critical and analytical thinking skills (Yuniarti, 2020). The increasing interest in the application of AR in education suggests that AR has great potential to be integrated in the primary school curriculum to improve students' critical thinking skills and interest in learning.

The phenomenon observed in this study is the low critical thinking skills of students in elementary schools. According to Widiastuti (2019), traditional learning methods such as lectures and memorization are losing their effectiveness, especially for students who are accustomed to digital technology in their daily lives. This condition is exacerbated by students' low interest in learning, especially in subjects that require understanding abstract and difficult concepts. On the other hand, students show increased motivation and interest when technologies such as AR are introduced in learning activities, as reported by Garzón and Acevedo (2020). Therefore, this study focused on the use of AR as a learning medium to develop students' critical thinking skills.

The importance of critical thinking skills in basic education cannot be ignored. Critical thinking allows students to analyze information, make conclusions, as well as solve problems independently (Paul & Elder, 2014). AR is considered to be helpful in developing these skills because direct interaction with learning content offered by AR technology can stimulate students to think analytically and critically. However, although there is evidence showing the benefits of using AR in learning, the perceptions of teachers, students, and parents towards the effectiveness of AR are still diverse and have not been widely explored in depth, especially in Indonesia (Azuma, 1997).

Several previous studies support the effectiveness of AR in education. For example, a study conducted by Billinghurst and Duenser (2012) showed that AR helps students to better understand lessons in an interactive way. This is also supported by another study which states that the visualization provided by AR improves students' memory and deepens the understanding of the concepts taught (Kaufmann & Schmalstieg, 2003). In elementary schools, the use of AR technology is proven to increase learning motivation by more than 50%, as well

as encourage student engagement in group discussions and collaboration (Radu, 2014).

In Indonesia, early studies showed that elementary school students exposed to AR media in learning showed higher interest and improved understanding of the material taught. However, challenges in AR implementation also arise, such as the availability of devices, training for teachers, and limited school infrastructure (Harjanto, 2022).

Based on observations in the field, most primary schools in Indonesia do not have adequate access to AR technology, and there are still few teachers who are trained in utilizing this technology. This condition creates obstacles in optimizing AR for learning, although its benefits have been recognized by several parties. These obstacles indicate the need to further examine how the perceptions and readiness of school community in implementing AR, as well as how AR can be implemented effectively to improve students' critical thinking skills.

In this study, the problem to be solved is related to the use of Augmented Reality (AR) based learning media in elementary schools. First, how are students' critical thinking skills affected by the use of AR in the learning process? Second, what are the methods applied by teachers to develop students' critical thinking skills through AR technology? Third, how do teachers and students perceive the use of AR and its impact on improving critical thinking skills?

By answering these questions, this study aims to identify and analyze students' critical thinking skills gained from AR-based learning media, explore the development strategies used by teachers, and understand the perceptions of both parties regarding the effectiveness of AR in increasing learning motivation and engagement. Through a qualitative approach and data collection from questionnaires distributed to students and teachers in several elementary schools, this research is expected to provide in-depth insights into the potential use of AR in education and recommendations for the integration of this technology into the curriculum.

This research is supported by various literatures that show the benefits of AR in education. Akçayır and Akçayır (2017) revealed that AR technology not only attracts students' attention, but also facilitates the understanding of abstract concepts by making them more concrete and easy to understand. Another study by Bacca et al. (2019) showed that AR helps improve critical thinking skills and spatial visualization, especially in subjects that require visualization, such as science and mathematics. In the context of learning in elementary schools, AR integration also shows benefits in increasing student participation, especially when faced with complex content that requires in-depth analysis (Garzón & Acevedo, 2020).

However, it should be noted that the literature also points to challenges in the use of AR, especially regarding accessibility and educator readiness. Wu et al. (2013) noted that the main barriers to AR implementation in schools are the availability of devices and adequate training for teachers. This research is expected to contribute to a deeper understanding of the perceptions of

Indonesian school community towards the use of AR, as well as how this technology can be effectively applied to improve critical thinking skills in elementary school students.

With the rapid advancement of technology, AR is an innovation that has the potential to change the learning paradigm in elementary schools. This research is expected to provide a more comprehensive understanding of how AR can be accepted and implemented in learning to improve students' critical thinking skills. In addition, this research also aims to identify the barriers and challenges faced in the implementation of AR, so that it can be a reference for policy makers and schools in integrating this technology in the basic education curriculum.

## METHOD

This research uses a qualitative method. According to Sugiyono (2015), qualitative data is data in the form of words, schemes, and images. Qualitative research is a type of research with an emphasis on process and meaning that is not tested or measured as precisely as possible with descriptive data. Thus, qualitative descriptive research is used in this study to analyze the perceptions of school residents on the use of Augmenty Reality digital media on students' critical thinking at Bayan State Elementary School, Surakarta City, 2024. Variables measured in the form of student perceptions of the use of Augmenty Reality digital media on critical thinking which includes: namely understanding of concepts, ability to analyze, ability to evaluate, and creativity of students in solving problems related to building block spaces and questionnaires to measure student perceptions of Augmenty Reality digital media on critical thinking include aspects: the attitude of students, the learning process of Mathematics, and supporting infrastructure. The learning material measured is the material of the beam space.

The data collection technique in this study used a questionnaire with a Likert scale.  As for data analysis, we analyzed using interactive analysis according to Miles and Huberman which consists of four components of the analysis process, namely, data collection, data reduction, data presentation, and data withdrawal.
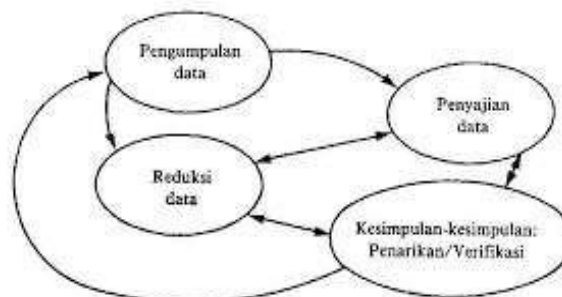


Figure 1: Miles and Huberman Interactive Analysis Chart

Data collection was conducted on September 28, 2024 at SDN Bayan Kota Surakarta. T here are 50 students in class V of SDN Bayan Kota Surakarta consisting of 26 girls and 24 boys. Four Likert scale categories were used to analyze the data in this study: Strongly Agree (SS), Agree (S), Disagree (TS), and Strongly Disagree (STS). The researcher created twenty questions for the sample or respondents using the above four categories to answer. Each sample

answer has a qualitative description. From the previous four categories, two responses were negative: one positive and one negative. To calculate the average, the percentage of responses was divided by the number of questions in the questionnaire.

## RESULTS AND DISCUSSION

The use of Augmented Reality (AR) in learning has shown a positive impact on students' concept understanding, although there are still technical challenges that need to be overcome. The following analysis outlines the results of surveys and interviews with teachers regarding the effectiveness, technical support, infrastructure readiness, and challenges in implementing AR in the classroom.

Table 1. Percentage and Category of Questionnaire Response

| Aspects | SS | S | N | TS | TSS |
|---|---|---|---|---|---|
| Do you find AR easy to use in learning? | 33,3 | 51,3 | 15,4 | 0 | 0 |
| Do you feel comfortable when using AR in learning? | 41 | 33,3 | 23,1 | 0 | 0 |
| Are the instructions for using AR clear and easy to understand? | 30,8 | 51,3 | 15,4 | 0 | 0 |
| Does AR help you understand the material better? | 35,9 | 43,6 | 17,9 | 0 | 0 |
| Does AR make it easier for you to complete learning tasks? | 35,9 | 46,2 | 17,9 | 0 | 0 |
| Does using AR make difficult concepts easier to understand? | 30,8 | 48,7 | 17,9 | 0 | 0 |
| Does AR make it easier for you to remember the material you have learned? | 30,8 | 48,7 | 17,9 | 0 | 0 |
| Does AR make it easier for you to remember the material you have learned? | 28,2 | 56,4 | 12,8 | 0 | 0 |
| Does AR make you more motivated to learn? | 30,8 | 46,2 | 23,1 | 0 | 0 |
| Are you more excited to learn when using AR? | 43,6 | 38,5 | 15,4 | 0 | 0 |
| Does the use of AR increase your interest in the material being taught? | 33,3 | 43,6 | 20,5 | 0 | 0 |
| Does AR make the learning process more fun for you? | 41 | 35,9 | 20,5 | 0 | 0 |
| Does the visual display of AR capture your attention during learning? | 35,9 | 43,6 | 17,9 | 0 | 0 |
| Do AR's interactive features help you engage more actively in learning? | 23,1 | 56,4 | 17,9 | 0 | 0 |
| Do you focus more on learning when using AR compared to other methods? | 23,1 | 51,3 | 20,5 | 0 | 0 |
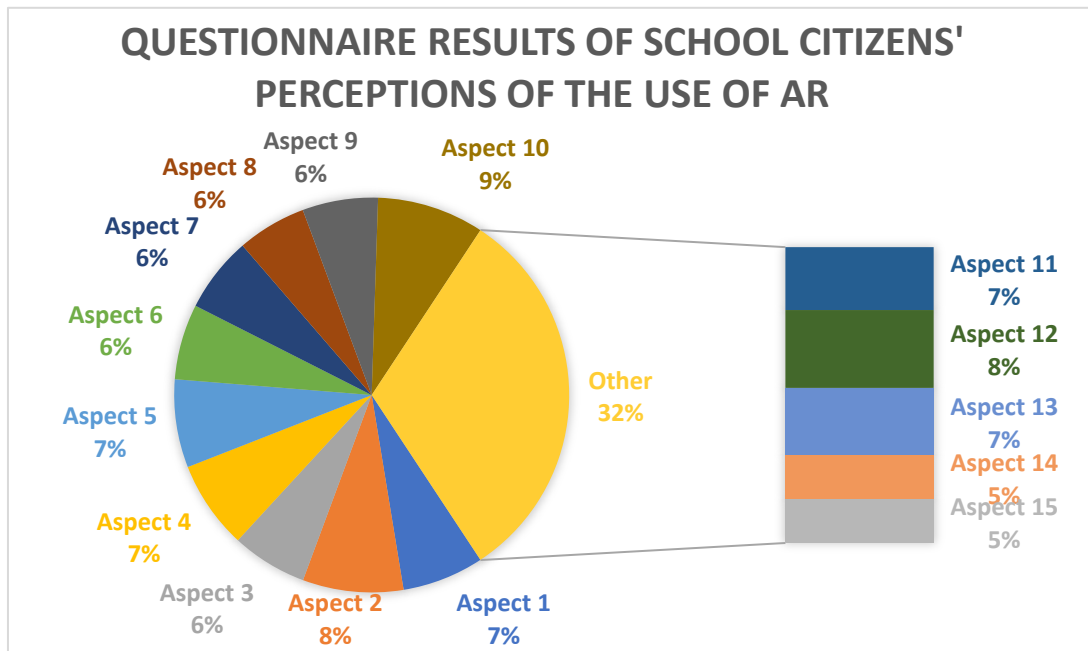
Figure 1. Percentage Distribution of Perceived Use of AR

Based on the data presented, we can discuss students' critical thinking skills, how teachers develop these skills, as well as teachers' and students' perceptions of the use of Augmented Reality (AR) and its impact on critical thinking.

### 1. Identification of Students' Critical Thinking Skills

The data showed that the majority of students found AR easy to use in learning (84.6% found it sufficient and very sufficient). However, there were still 15.4% who found it difficult. This shows that students generally have good critical thinking skills in using AR technology, although there are some who still need more help.

Students also felt that AR helped them understand the material better (79.5% stated moderately and very moderately). This indicates that AR can encourage students to analyze and synthesize information, one of the aspects of critical thinking. However, there were 17.9% who felt doubtful, so there is still room for improvement.

### 2. An Exploration of Teachers' Ways of Developing Critical Thinking Skills

Teachers have an important role in developing students' critical thinking skills. Some ways that can be done include:
a. Integrating AR in the Curriculum: Using AR consistently in various subjects to help students link theory with practice. Planned use of AR can facilitate more interactive learning.
b. Provide Clear Instructions: Based on the data, 30.8% of students felt that the instructions for using AR were not clear. Teachers need to ensure that the instructions for using AR are clearly delivered and easy to understand so that students can use this technology effectively.

c. Encourage Discussion and Collaboration: Using interactive features in AR to encourage students to discuss and work together in completing tasks. This can increase engagement and develop their critical thinking skills through different perspectives.
d. Provide Constructive Feedback: Clear and constructive feedback can help students understand their mistakes and encourage them to think more deeply about the material learned.

## 3. Teachers' and Students' Perceptions of the Use of AR

a. Dari hasil survei, siswa secara umum merasa AR membuat pembelajaran lebih menyenangkan (76,9% menyatakan cukup dan sangat cukup), yang berkontribusi pada motivasi mereka untuk belajar (77% merasakan motivasi meningkat). Hal ini menunjukkan bahwa AR dapat meningkatkan ketertarikan dan motivasi siswa, sehingga mereka lebih aktif dalam belajar.
b. Namun, ada beberapa indikator yang menunjukkan bahwa masih ada siswa yang merasa kurang terlibat, seperti 23,1% siswa yang tidak merasa lebih fokus saat menggunakan AR dibandingkan metode lain. Ini menandakan bahwa meskipun AR memiliki potensi besar, implementasi yang kurang optimal dapat menghambat efek positifnya.

## 4. Impact of AR on Critical Thinking

Overall, the use of AR in learning shows a positive impact on students' critical thinking skills. With AR, students can explore difficult concepts that become easier to understand, improving comprehension and retention of the material. However, challenges remain in ensuring all students have an equitable and enjoyable learning experience.

To support further development of students' critical thinking, teachers need to periodically evaluate teaching methods and student engagement. Through the right approach, AR can be an effective tool to develop the critical thinking skills that students need in an ever-changing world.

| Name | Class | How do you assess the impact of using AR on students' concept understanding in learning? | Is there a significant difference in student understanding before and after the use of AR in your classroom? | Do you think the school has provided enough technical support to ensure the use of AR runs smoothly? | How is the readiness of technology infrastructure in your school to support the use of AR in the learning process? | What are some of the technical challenges you or your students face when using AR, and how does the school handle these challenges? |
|---|---|---|---|---|---|---|
| Nunuk Nurcahyani A | 3A/B | positive impact on students in the use of technology | there is an improvement in the quality of the learning process | exists with chromebooks | quite supportive | if lower grade students need supervision |
| Sulistiyatmoko | 6/C | Makes it easier for students to understand geometry concepts | Previously, students only imagined and did not understand the concept. after using AR, children are more enthusiastic and their understanding has increased. | already, providing supporting facilities and infrastructure | is ready with the presence of LCD and adequate internet network | not yet accustomed to using this AR, conducting IHT and Kombel to improve the ability of teachers to use AR. |
| Inoe Saputro, S.Pd. | IV/B | very impactful because it can attract children's attention because it includes new things that children want to know. | Previously students still had difficulty imagining the material but after the use of AR they understood better. materi | already, technical support in the form of lcd projectors to explain to students and adequate internet wifi signals | The school infrastructure is very well prepared both in terms of buildings and also all the infrastructure facilities such as lcd projectors, wifi, chromebooks, etc. | by teaching students to better understand the material or things that are still difficult for them. |
| Bambang Sukiyatmojo | Pjok | Very influential | Of course there are | Already there needs improvement | In the usa improvement | Students still have no special guidance |
| Habibi, S.Pd | VI/C | The use of Augmented Reality (AR) applications in mathematics learning has a | There is, because with the use of AR, students will be more interested in learning so that | Still in planning and preparation | For school infrastructure readiness in using AR applications, it is very supportive. This is indicated | There needs to be training / workshops for educators in the use of Augmented |

| | | | | | |
|---|---|---|---|---|---|
| | | positive impact and good benefits for students, especially in understanding geometry / flat building material. | later it can spark the enthusiasm and understanding of children in mathematics material. | | by the availability of supporting facilities such as: adequate internet network, 1 teacher 1 laptop, the existence of a computer laboratory, LCD projector, and laptop home book for students. | Reality (AR) applications. |
| Trisni Sri Emawati | 3/C | The use of Augmented Reality (AR) in learning flat shapes has enormous potential to improve students' concept understanding. However, careful planning and implementation are needed so that the use of AR can provide optimal results. | Before AR: Students often have difficulty visualizing abstract geometry concepts, especially in 3D. And often feel bored because they only memorize formulas without understanding them. After AR: With AR, students can directly see geometry shapes in an interactive 3D form. This helps them build a stronger mental model and understand the relationship between shapes better. And increase students' enthusiasm for learning. | I think the school where I teach has provided enough technical support to ensure the use of AR runs smoothly. | I think the School infrastructure is ready enough to support the use of AR in the learning process. | Not all students have devices (smartphones, tablets, or AR glasses) that are compatible with AR apps. Connection may be poor at any time. |
| Listina Nuris Syamsiyah,S. Pd | IV/ B | The impact of using AR in learning has a positive impact on students' understanding of concepts, in teaching and learning activities that require more innovation and interaction. | There is a significant difference from before the use of AR and after the use of AR. Students in the class became more active and enthusiastic about learning. Their understanding also began to | The school has prepared technical support to ensure teachers use IT media such as AR to make learning more fun and can be followed well by students. | The school infrastructure is sufficient to support the use of AR in the learning process, for example, each teacher has received a laptop inventory and each class can be accessed by the WIFI network, | The challenges faced are the readiness of teachers in planning which requires sufficient time, as well as the WIFI network that must be smooth when teachers apply |

| | | | increase and focus when learning the material through the use of AR. AR | | making it easier to apply AR in the classroom. | the use of AR. |
|---|---|---|---|---|---|---|
| Anton Taufiq | Agama | Good | Available | Sufficient | Ready | Briefing |

From the results of interviews conducted with several teachers regarding the impact of using Augmented Reality (AR) in learning, several important themes can be identified relating to students' concept understanding, technical support, infrastructure readiness, and challenges faced. The following is an analysis based on the answers given:

1. Impact of AR Use on Students' Concept Understanding
   most teachers reported that the use of AR has a significant positive impact on students' concept understanding. Some teachers, such as Inoe Saputro and Habibi, mentioned that AR helps students in understanding difficult material, especially in geometry and flat building concepts. The use of AR allows students to see interactive 3D shapes, which were previously difficult to imagine. This shows that AR not only improves understanding but also changes the way students learn from simply memorizing formulas to a deeper understanding.
2. Differences in Understanding Before and After the Use of AR
   Almost all respondents agreed that there was a significant difference in students' understanding before and after the use of AR. This is reflected in the increased enthusiasm and engagement of students during the learning process. Students become more active, able to build stronger mental models, and have a higher learning spirit after being exposed to AR technology. These changes indicate that AR has the potential to improve learning effectiveness.
3. Technical Support from the School
   The majority of teachers feel that the school has provided sufficient technical support to facilitate the use of AR. Facilities such as LCD projectors, adequate internet networks, and other technological devices are already available. However, some teachers, such as Bambang Sukiyatmojo, mentioned that there is still a need for further improvement, especially in terms of special guidance for students in using AR. This indicates that although technical support is available, improvement in the aspects of training and guidance for students is highly needed.
4. Readiness of Technology Infrastructure
   The school's infrastructure is generally considered sufficiently ready to support the use of AR. Most teachers reported that facilities such as wifi, laptops, and other supporting devices are adequate. However, some challenges still exist, such as the unequal access to devices among students. Trisni Sri Emawati highlighted that not all students have devices compatible with AR applications, which can be an obstacle in the implementation of learning.
5. Challenges Faced
6. The technical challenges faced in the use of AR vary. Some teachers mentioned that the lack of habit in using AR among students could be an obstacle. Teachers also noted that additional training for teachers is still needed

to ensure that they can use AR effectively in learning. The issue of unstable internet connectivity is also mentioned as a challenge that can affect the smooth use of AR.

The use of Augmented Reality (AR) in learning shows results that are in line with constructivism theory, where effective learning involves students' active involvement in building understanding through interactive experiences. Based on the results of the study, the majority of students felt that AR helped them understand difficult concepts, especially in geometry and flat shapes. This is consistent with the results of previous research which states that AR can improve students' understanding of abstract concepts through interactive 3D visualization (Bacca et al., 2014). Thus, AR not only facilitates understanding of the material, but also supports students in building stronger mental models.

In addition, AR is also proven to increase students' learning motivation, as indicated by survey data showing that 76.9% of students find learning more enjoyable. This is in line with research from Wu et al. (2013), who stated that AR technology can create a more interesting and fun learning environment. This motivation plays an important role in increasing students' active participation, which in turn supports the development of critical thinking skills. However, challenges such as uneven access to devices and unstable internet connections need to be overcome so that the positive impact of AR can be felt equally.

From a teacher's perspective, the results show that the use of AR helps students move from simply memorizing formulas to a deeper understanding. This is in line with the principle of Problem-Based Learning, where students are encouraged to solve real problems with the help of technology. Teachers also highlighted the need for additional training and guidance to maximize the use of AR. This supports the findings from previous studies which state that technical and pedagogical readiness are key factors for successful integration of technology in education (Azuma et al., 2011).

Overall, the results of this study reinforce the idea that AR has great potential in supporting interactive learning and the development of 21st century skills, such as critical thinking and collaboration. However, to optimize its benefits, it requires adequate technical support, continuous training for teachers, as well as inclusive infrastructure development so that all students can experience the benefits of this technology.

## CONCLUSION

Based on data analysis and interviews with teachers regarding the impact of Augmented Reality (AR) in learning, the following conclusions can be drawn: The use of AR has proven to have a significant positive impact on students' conceptual understanding. Most teachers reported that AR helps students understand difficult material, especially in geometry and flat shapes concepts, by providing an interactive and engaging learning experience. The use of this technology not only enhances understanding but also encourages students to shift from rote memorization methods to deeper comprehension.

Most respondents indicated a significant difference in student understanding before and after the use of AR, with students showing increased enthusiasm, engagement, and a higher learning spirit. Technical support from the school, such as adequate facilities and ready technology infrastructure, contributes to the effectiveness of AR usage. However, several challenges still need to be addressed, including the need for additional training for teachers and uneven access to AR devices among students. The readiness of the school's technology infrastructure is

considered quite good, but there are still shortcomings in terms of AR device accessibility for all students. Another challenge faced includes unstable internet connectivity and the need for special guidance in the use of AR. Therefore, careful planning and the development of teachers' skills through continuous training are very important to optimize the use of AR in learning.

Overall, AR has great potential to enhance learning effectiveness if these challenges can be overcome. With the right support and initiatives, AR can become an effective tool for enhancing students' critical thinking skills and conceptual understanding in education.

## REFERENCES

Akçayır, M., & Akçayır, G. (2017). Advantages and challenges associated with augmented reality for education: A systematic review of the literature. *Educational Research Review, 20*, 1-11.

Bacca, J., Baldiris, S., Fabregat, R., Graf, S., & Kinshuk. (2019). Augmented reality trends in education: A systematic review of research and applications. *Educational Technology & Society, 17*(4), 133-149.

Garzón, J., & Acevedo, J. (2020). Meta-analysis of the impact of augmented reality on students' learning gains. *Educational Research Review, 31*, 100-110.

Johnson, B., & Christensen, L. (2012). *Educational research: Quantitative, qualitative, and mixed approaches* (4th ed.). London: SAGE Publications Ltd.

Kim, C., Mirusmonov, M., & Lee, I. (2010). An empirical examination of factors influencing the intention to use mobile payment. *Computers in Human Behavior, 26*(1), 310-322.

Kementrian Pendidikan dan Kebudayaan RI. (2011). *Peraturan Mendiknas tentang Satuan Pengawasan Internal (Permendiknas Nomor 47 tahun 2011)*. Jakarta: Penulis.

Paul, R., & Elder, L. (2014). *Critical thinking: Tools for taking charge of your professional and personal life*. Pearson Education.

Kamaruddin, M. A., & Zainuddin, N. (2020). The Effect of Augmented Reality on Students' Critical Thinking Skills in Science Education. *International Journal of Instruction*, 13(2), 145-162.

Bacca, J., Baldiris, S., & Fabregat, R. (2014). Augmented Reality Trends in Education: A Systematic Review of Research and Applications. *Educational Technology & Society*, 17(4), 133-149.

Dunleavy, M., & Dede, C. (2014). Augmented Reality Teaching and Learning in Higher Education: A Review of the Literature. *Educational Technology Research and Development*, 62(4), 573-590.

Zhang, Y., & Zheng, Y. (2016). The Impact of Augmented Reality on Learning Outcomes in Educational Settings: A Meta-Analysis. *Computers & Education*, 106, 1-10.

Klein, J., & Rojas, M. (2017). Exploring the Impact of Augmented Reality on Learning Outcomes in Primary Education: A Case Study. *Journal of Educational Technology Systems*, 45(3), 358-376.

Böckers, K., et al. (2018). The Impact of Augmented Reality on Critical Thinking Skills: A Study in Higher Education. *Journal of Computer Assisted Learning*, 34(2), 169-181.

Hwang, G.-J., & Chen, C.-H. (2017). Augmented Reality in Education: A Review of Recent Research and Future Directions. *Educational Technology & Society*, 20(3), 1-14.

Liu, T.-C., et al. (2019). The Effectiveness of Augmented Reality on Learning Outcomes: A Meta-Analysis and Systematic Review. *Educational Psychology Review*, 31(1), 1-24.

Radu, I. (2014). Augmented Reality in Education: A New Approach to Enhance Learning Experiences. *International Journal of Interactive Mobile Technologies*, 8(2), 42-47.

Billinghurst, M., & Duenser, A. (2012). Augmented Reality in the Classroom. *Computer Graphics and Applications*, IEEE, 32(2), 12-15.

Sari, D., & Rahmawati, F. (2020). Pengaruh Media Pembelajaran Augmented Reality Terhadap Hasil Belajar Siswa SD pada Materi IPA. *Jurnal Pendidikan dan Pembelajaran Dasar*, 3(1), 45-54.

Hidayati, N., & Putri, R. (2021). Persepsi Siswa Terhadap Penggunaan Media Digital dalam Pembelajaran Matematika di Sekolah Dasar. *Jurnal Pendidikan Matematika Indonesia*, 6(2), 101-110.

Widiastuti, E., & Supriyadi, S. (2020). Pengaruh Penggunaan Aplikasi Augmented Reality terhadap Minat Belajar Siswa SD pada Materi Bangun Ruang. *Jurnal Ilmiah Pendidikan Dasar*, 5(1), 15-25.

Fitria, D., et al. (2021). Implementasi Media Augmented Reality untuk Meningkatkan Keterampilan Berpikir Kritis Siswa SD pada Pelajaran IPA. *Jurnal Inovasi Pendidikan Dasar*, 6(2), 89-97.

Sukmawati, L., & Iskandar, I. (2020). Pengaruh Media Pembelajaran Berbasis Augmented Reality terhadap Hasil Belajar dan Minat Siswa di Sekolah Dasar. *Jurnal Teknologi Pendidikan*, 22(3), 238-246.

Pratiwi, N., & Setiawan, B. (2021). Analisis Persepsi Siswa terhadap Media Pembelajaran Digital dalam Meningkatkan Berpikir Kritis di SDN X Surabaya. *Jurnal Penelitian Pendidikan*, 18(1), 67-75.

Kusumaningtyas, D., & Santoso, H.B.(2020). Efektivitas Penggunaan Media Digital dalam Pembelajaran Matematika di Sekolah Dasar untuk Meningkatkan Kemampuan Berpikir Kritis Siswa.*Jurnal Penelitian dan Evaluasi Pendidikan*, 24(2), 123-132.

Arifin, Z., & Wibowo, A.(2020). Penggunaan Augmented Reality dalam Pembelajaran IPA untuk Meningkatkan Minat dan Hasil Belajar Siswa Sekolah Dasar.*Jurnal Ilmiah Pendidikan dan Pembelajaran*, 9(3), 99-108.

Yulianti, R., et al.(2022). Dampak Penggunaan Media Pembelajaran Augmented Reality terhadap Minat Belajar dan Kemampuan Berpikir Kritis Siswa.*Jurnal Pendidikan Dasar Nusantara*, 7(1), 55-64.

Suhardi, R., & Anwar, M.(2021). Persepsi Guru dan Siswa terhadap Implementasi Media Augmented Reality dalam Proses Pembelajaran di Sekolah Dasar.*Jurnal Teknologi dan Pendidikan Indonesia*, 10(2), 112-120.