Effectiveness of Augmented Reality-Based Learning Media Towards Elementary School Students' Understanding of Concepts in Science: Systematic Literature Review

Irene Milenia Siki[1], Imanuel Herlimus Leba[2]
[1,2]Universitas Negeri Malang, Indonesia

Keyword
Learning Media; Augmented Reality; Concept Understanding; Elementary School

ABSTRACT
This study is to investigate the impact of Augmented Reality (AR)-based learning media on students' understanding of science concepts and to evaluate the effectiveness of this media in the Science learning process. The methodology employed is a Systematic Literature Review (SLR). The data collecting technique refers to the PRISMA method utilizing the databases Google Scholar, Open Knowledge Maps, and Publish or Perish (Scopus). This analysis analyzed publications released throughout 2020 until 2024. There were 20 useful articles out of the 428 total. The analytical method employed is descriptive qualitative. The studied indicators include AR-based learning media, elementary school students' understanding of scientific concepts, and the effectiveness of AR-based learning media in enhancing understanding of these concepts. The study's findings indicate that augmented reality improves student understanding of scientific concepts. AR makes learning more fun and encourages students to think critically and solve problems through visualization of interesting material presentation. As a result, students can understand abstract concepts so as to achieve better learning outcomes. Thus, AR-based media is proven effective in improving students' concept understanding. However, the success of AR implementation is highly dependent on the active role of teachers in guiding students and provide sufficient infrastructural support; hence, teachers must receive training on how to use this technology.

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Corresponding Author
irene.milenia.2321038@students.um.ac.id

INTRODUCTION

Every student has to have an extensive comprehension of the concepts being studied to ensure learning can proceed effortlessly. However, numerous previous research studies have stated that there is a problem in educational institutions, such as the low conceptual understanding of elementary school students regarding the subject matter. For example, the research conducted at a public elementary school in the South Sumedang District, which states that the low conceptual understanding of students is caused by the prevailing usage of instructional techniques in science subjects. Education aims to produce individuals with extensive knowledge. The continual learning process is key for accomplishing the objective. The current learning process emphasizes producing graduates who possess the knowledge

and skills needed in the modern era. Teachers, as learning facilitators, have the responsibility to develop higher-order thinking skills to generate students who are creative, critical thinkers, and collaborative[1] A specific illustration of these abilities is students' capacity to relate and integrate different kinds of information such as text, images, or audio-visual, in order to create a comprehensive understanding of a concept.[2]

Every student has to have an extensive comprehension of the concepts being studied to ensure learning can proceed effortlessly. However, numerous previous research studies have stated that there is a problem in educational institutions, such as the low conceptual understanding of elementary school students regarding the subject matter. For example, the research conducted at a public elementary school in the South Sumedang District, which states that the low conceptual understanding of students is caused by the prevailing usage of instructional techniques in science subjects.[3] An identical issue was found during mathematics lessons for fifth-grade elementary school students, including the implementation of monotonous lecture methods and limiting learning resources beyond textbooks. therefore, student participation in learning activities is less than ideal, causing a lower optimal understanding of the subject study.[4]

Students' understanding of concepts related to the topic of study must be improved in learning through the use of models, methods, approaches, and learning media. Taking advantage of learning media is one of the effective options for teachers. Learning media are tools designed to facilitate interaction between teachers, students, and learning materials, which renders the learning process more effective and efficient.[5] The media applied by teachers to demonstrate concepts can be integrated with new technology, such as AR, which combines theoretical and practical elements, which allows individuals to interact with virtual objects in an actual setting.[6] Further studies state that those are three-dimensional visualizations produced by Augmented Reality technology have proven to be very effective in simplifying complex concepts in science, so those can improve students' understanding.[7] Thus, the usage of this media is expected to improve students' understanding of the teaching material while also encouraging student participation in teaching and learning activities.

Previous research regarding the thorough integration of AR has proven limited, and existing studies often do not delve to how AR can help students understand abstract concepts. Additionally, contextual factors that influence the effectiveness of AR, such as the learning environment and teacher support, have not yet been explored in extensively. The perceptions and experiences of students when utilizing AR media are frequently disregarded

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[1] Anti Muthmainnah, Amalia Dwi Pertiwi, and Tin Rustini, "Peran Guru Dalam Mengembangkan Keterampilan Abad 21 Siswa Sekolah Dasar," *Jurnal Ilmiah Wahana Pendidikan* 9, no. 4 (2023): 41–48, https://doi.org/10.5281/zenodo.7677116.

[2] Dea Fajar Meilawati, "Analisis Pemahaman Konsep Matematis Siswa Kelas 4 Sekolah Dasar" (Majalengka, August 2020).

[3] Tresna Nurdiani Agustin, Ani Nur Aeni, and Atep Sujana, "Pengaruh Media Pembelajaran Berbasis Augmented Reality Terhadap Pemahaman Konsep Pada Materi Sistem Peredaran Darah Kelas V SD," *INNOVATIVE: Journal Of Social Science Research* 4, no. 4 (2024): 5810–19, https://j-innovative.org/index.php/Innovative.

[4] Jumaena, Salmilah, and Nilam Permatasari Munir, "Efektivitas Media Pembelajaran Augmented Reality (AR) Pemodelan Bangun Ruang Terhadap Pemahaman Konsep Geometri Siswa Kelaas V Sekolah Dasar," *REFLEKSI : Jurnal Pendidikan* 12, no. 3 (2024): 149–60, https://p3i.my.id/index.php/refleksi.

[5] Muhammad Hasan dkk., *Media Pembelajaran* (Klaten: Tahta Media Group, 2021).

[6] Pradita, Aeni, and Sujana, "Pengaruh Media Augmented Reality Untuk Meningkatkan Pemahaman Konsep Siswa Kelas IV SDN Tegalkalong Pada Materi Fotosintesis."

[7] Winda Anggriyani Uno, "Pengembangan Media Pembelajaran Interaktif Berbasis Augmented Reality Untuk Meningkatkan Pemahaman Konsep IPA," *JPDP : Jurnal Pendidikan Dan Pembelajaran* 4, no. 1 (2024): 28–33.

so, it important to understand how student's feel about learning via AR. Additionally, the methodologies used in previous research less mentions and the impacts are unclear, this is indicating the need for more standardized analysis. The lack of literature reviews on previous studies using various research methods provides researchers the opportunity to examine various literature related to the implementation of augmented reality in learning. Therefore, the current research examines an expanded variety of articles published in Sinta and Scopus accredited journals. The purpose of the review of the literature is to understand the utilization of the media that can improve the students' understanding of the learning material and hope that media can stimulate the student participation during the teaching and learning activities. The results of this study will probably use as a guideline for teachers, schools, and policymakers regarding how to utilize AR, as an instructional tool, as well as to improve and enhance the quality of the AR media created; and as a reference for future researchers to develop and implement AR, especially in elementary schools.

RESEARCH METHOD

The research method used is a systematic literature review. A literature review is a research technique aimed at collecting and verifying various theories or topics related to the research issue from reliable sources such as articles, books, and recognized websites. The search strategy used refers to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) method. The databases used are Google Scholar, Open Knowledge Maps, and Publish or Perish (Scopus). This research uses a descriptive method to analyze qualitative data.

There are six steps used in the research, including (1) organizing and preparing the data that will be analyzed, as a result of search findings of articles from various reliable databases relevant to the research topic; (2) reading and reviewing all the data to determine the significant data for the research; (3) coding every piece of information by sorting similar data to identify themes that will be highlighted in the research; (4) applying labels as the basis for generating descriptions, through constructing descriptions from the themes that have been previously identified; (5) establishing connections among themes, by combining current themes to produce a theoretical framework; and (6) providing the meaning and interpretation about the topic as the final result of the research.[8]

The final data obtained by the researchers and directed by the PRISMA diagram were subsequently analyzed to identify several indicators being investigated, such as (1) AR learning media. (2) Understanding of Natural Science (IPA) concepts among elementary school students. (3) The effectiveness of AR media on concept understanding.

FINDINGS AND DISCUSSION

This research used six stages of literature review such: The first step is to organize and prepare the data for analysis. Data were obtained from databases such as Publish or Perish, Open Knowledge Maps, and Google Scholar, using keywords by the following keywords: Augmented Reality (AR) media in elementary schools and elementary school students' understanding of science concepts, resulting in 428 articles. The second step is all articles were read and reviewed totally 428 articles, 300 were irrelevant, leftover 128 articles. From 128 articles, 56 articles were not relevant, relevant, so 72 articles; 42 were selected and 30 were not selected for certain reasons, so there are only 42 articles that are suitable for the research. The third step, the researcher sorted the 42 similar articles to align to the research topic. After reading and analyzing, 22 articles were found to be irrelevant for details, 8 articles contained theories that were not suitable, 4 articles had insufficient results, and 10 articles

[8] Sugiyono, *Metode Penelitian Kuantitatif Kualitatif Dan R&D*, 2018.

contained irrelevant data. Therefore, 20 articles are eligible to be considered for this research. The following is a diagram of the data search results using the PRISMA diagram based on the previous explanation.

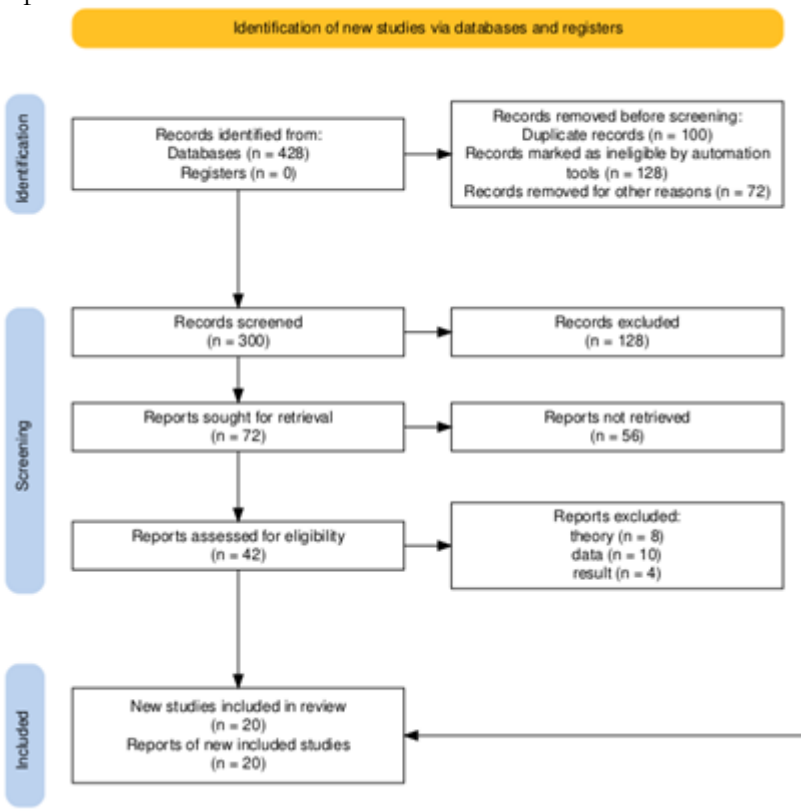

Figure 1. PRISMA Diagram

Steps four to six of this research include the researcher constructing a thematic description of Augmented Reality-based learning media and the understanding of Natural Science (IPA) concepts among elementary school students. The fifth step is connecting the concepts, such as the effectiveness of AR media in optimizing concept understanding, as well as the factors that influence AR effectiveness. The sixth stage is to draw conclusions and interpretations about the themes explained in the section of discussion. The following is a diagram related to the publication year and the type of research used by articles relevant to this study.

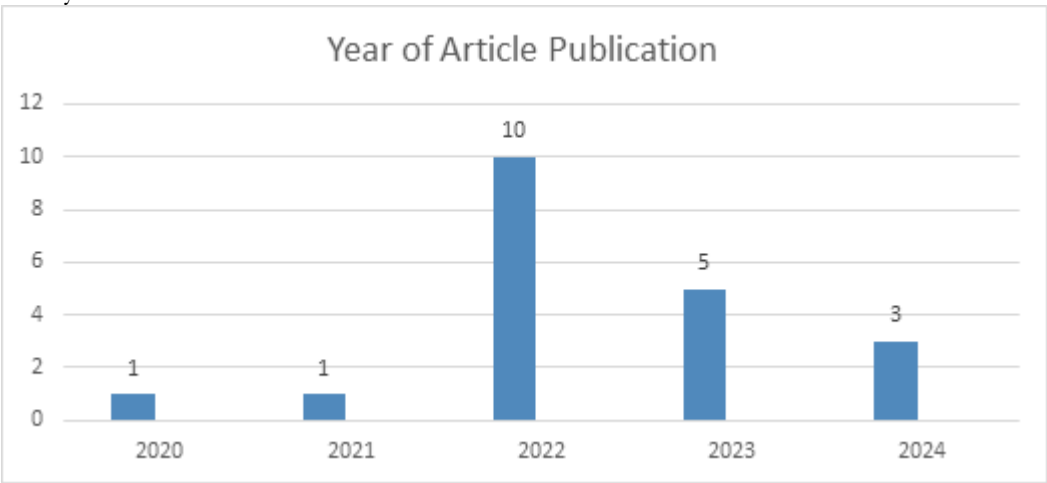

Figure 2. Article Publication Year Diagram

Based on Figure 2. The diagram of the publication years of articles relevant to indicates that there are there are 10 articles from 2022, 5 articles from 2023, 3 articles from 2024, and 1 article each from 2020 and 2021. Regarding the type of research used can be seen in the following diagram.

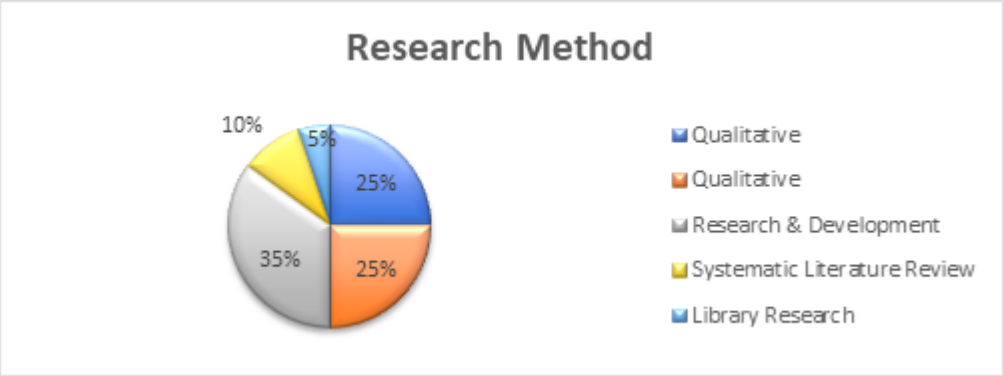

Figure 3. Research Method

Based on Figure 3. the method of research applied in those articles are as follows: 7 articles or percentage of 35% use the Research & Development method, 5 articles or percentage of 25% use the quantitative and qualitative research method, 2 or percentage of 10% use the systematic literature review method and 1 article or percentage of %, uses the library study method.

Articles relevant to this research are further divided into three topics such as AR-based media, understanding of science concepts, and the use of AR-based media on students' understanding of science concepts as presented in the following table:

Table 1. Current Research

Topic	Research	Result of the Research
AR-based learning media	Farid, 2023; Santi, Nuriman, and Mahmudi, 2022; Indriani et al., 2023; Wibowo, Putri, and Mukmin, 2022; Rusli et al., 2023; Marini et al., 2022; Zuniari et al, 2022; Umamah et al., 2020.	Augmented Reality (AR) has revolutionized the way people learn. By combining the real and digital worlds, AR provides a more interactive and enjoyable learning experience. Research states that AR can optimize students' conceptual understanding, learning enthusiasm, and general learning outcomes. AR additionally enables students to explore complex topics through a more comprehensive and interesting style. However, the implementation of AR nevertheless confronts a few obstacles such as the lack of devices and infrastructure. To fully realize the potential of AR in learning, assistance by multiple stakeholders is required so that this technology can be accessible to all students.
Student concept understanding	Rahmat et al., 2024; Azizah, Zmaroni, and Ginanjar, 2022; Lestari, Rini, and Gumilar, 2024; Barkah, Rini, and Amaliyah, 2022;	Conceptual understanding is a complex cognitive ability. Research indicates that students' conceptual understanding is not only influenced by their cognitive abilities but also caused by variables such as motivation, interest, and the learning environment. The use of varied teaching methods and engaging learning media can help

	Gumilar, 2023; Susanti, Asrin, and Khair, 2021.	students build greater comprehension of concepts. However, low student interest and the lack of sufficient instructional materials frequently become challenges to accomplishing learning objectives.
The effectiveness of AR toward students' conceptual understanding	Safira, Rahim, and Palangi, 2022; Vari, 2022; Riyanti, Farudin, and Wijayanti, 2024; Kurniawan and Julianto, 2022; Zuleni and Marfilinda, 2022; Setiawan dkk, 2023.	Augmented Reality (AR) is a highly effective tool to improve students' understanding of science concepts. By visualizing abstract concepts, AR renders learning more interesting and interactive. Research shows that the use of AR may significantly enhance student learning outcomes. However, the success of using AR is dependent on the teacher's part in instructing the learners.

Source: Researcher's analyzed, 2024

Table 1 displays that there are eight studies focusing on AR-based learning media, six studies exploring students' conceptual understanding, and six additional studies examining the effectiveness of AR on students' understanding of science concepts. The following is an extended discussion of the research findings:

Augmented Reality-based learning media

Augmented Reality-based learning media provides an incredible chance to transform educational activities. AR provides a more dynamic, engaging, and effective learning experience by integrating the real world and the digital world. AR is capable of providing deep and memorable learning experiences for students. The advantage of media particularly AR involves the capability to provide students full control of the speed and structure of their educational experiences. This is similar to other research that states which significant improvements in learning outcomes are possible when lessons are customized according to the needs of the students.[9]

One of the of the popular AR applications is the metaverse. The advantages of the metaverse in education are increased learning motivation, opportunities to ask questions, problem-solving skills, and collaboration among students. Additionally, the metaverse can also help students understand complex ideas through practical instruction methods. For teachers, these benefits are contributing to the development of students' creativity, ensuring effective student participation in subjects, and allowing students to progress through subjects at their own level.[10]

AR applications can be implemented to teach complex science subjects, such as the solar system, through a captivating way that is simpler to understand. Students can virtually tour the solar system, observe planets from various angles, and also simulate astronomical events through AR. In addition, other researchers further emphasize the potential of AR in science education. The combination of textbooks and AR can enhance students' interest and enthusiasm in learning. Topics such as the water cycle, animal classification, and the human

[9] Valentina Rossi Wibowo, Kharisma Eka Putri, and Bagus Amirul Mukmin, "Pengembangan Media Pembelajaran Berbasis Augmented Reality Pada Materi Penggolongan Hewan Kelas V Sekolah Dasar," *PTK: Jurnal Tindakan Kelas* 3, no. 1 (November 7, 2022): 58–69, https://doi.org/10.53624/ptk.v3i1.119.

[10] Richi Rusli dkk., "Augmented Reality for Studying Hands on the Human Body for Elementary School Students," in *Procedia Computer Science*, vol. 216 (Elsevier B.V., 2023), 237–44, https://doi.org/10.1016/j.procs.2022.12.132.

digestive system can be presented through a more interesting and interactive method using AR.[11]

Some advantages of AR in learning are interaction that allows students to interact immediately with the material, effectiveness for improving conceptual understanding, flexibility during implementation to different topics, and progressively reduced expenses for development.[12] However, the implementation of AR endures difficulties especially regarding the availability of adequate devices and infrastructure.[13] Therefore, AR has an extremely significant opportunity to change the techniques that students learn. Through providing a more enjoyable and effective learning process, AR can optimize students' motivation, engagement, and academic achievement. However, to achieve its maximum potential, collaboration with multiple stakeholders is needed, including the government, schools, teachers, and technology developers.

Understanding of science concepts among elementary school students

The potential of students to understand and comprehend a subject extensively that they can explain and apply it to various situations, is called conceptual understanding.[14] A good conceptual understanding allows students to identify, classify, and present information correctly. The capability is extremely important in learning which becomes the foundation for students' academic success.[15]

An effective comprehension of concepts may improve students' learning motivation and make learners engage better in the learning process, as well as increase curiosity or enthusiasm for learning.[16] However, research findings indicate that many students have difficulty understanding concepts in sciences, mostly because of factors such as fewer diverse teaching methods and a lack of student interest.[17] This is correlated to additional supporting research that states that low conceptual understanding is frequently caused by a lack of reading habits, the predominance of lecture methods, and a lack of learning resources.[18] Therefore, there is a demand of learning media that allows students to actively explore and discover concepts independently.[19] In addition, the contribution of internal and external

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[11] Lilis Novia Santi, Nuriman, and Kendid Mahmudi, "Pengembangan Buku Ajar Berbasis Augmented Reality (AR) Menggunakan Assemblr Apps Pada Tema 9 Menjelajah Angkasa Luar Kelas VI Sekolah Dasar," *Sekolah Dasar: Kajian Teori Dan Praktik Pendidikan* 31, no. 2 (2022): 78–86.

[12] N. I. Zuniari dkk., "The Effectiveness of Implementation Learning Media Based on Augmented Reality in Elementary School in Improving Critical Thinking Skills in Solar System Course," in *Journal of Physics: Conference Series*, vol. 2392 (Institute of Physics, 2022), 1–13, https://doi.org/10.1088/1742-6596/2392/1/012010.

[13] N. Umamah dkk., "Development of Augmented Reality in Biotechnology Processes as a Supporting Media for Science Learning Modules in Elementary Schools," in *IOP Conference Series: Earth and Environmental Science*, vol. 485 (Institute of Physics Publishing, 2020), 1–5, https://doi.org/10.1088/1755-1315/485/1/012069.

[14] Nur Azizah, Moh Zmaroni, and Romi Ramdon Ginanjar, "Analisis Kesulitan Belajar Dalam Pemahaman Konsep Pembelajaran IPA Kelas IV Di MI Hidayaturrohman Kecamatan Teluknaga Kabupaten Tangerang," *Jurnal Pendidikan Dan Konseling* 4, no. 5 (2022): 2419–25.

[15] Linda Lestari, Candra Puspita Rini, and Aris Gumilar, "Analisis Pemahaman Konsep Dalam Pembelajaran IPA Pada Siswa Kelas IV SD," *Journal of Education Research* 5, no. 4 (2024): 4533–38.

[16] Lailatul Barkah, Candra Puspita Rini, and Aam Amaliyah, "Analisis Pemahaman Konsep Ipa Siswa Kelas IV Sdn Kalideres 09 Pagi," *Berajah Journal* 2, no. 2 (May 15, 2022): 287–92, https://doi.org/10.47353/bj.v2i2.91.

[17] Eko Bayu Gumilar, "Problematika Pembelajaran IPA Pada Kurikulum Merdeka di Sekolah Dasar / Madrasah Ibtidaiyah," *Jurnal Ilmiah Pedagogy* 2, no. 1 (2023): 129–45.

[18] Ni Kadek Erina Susanti, Asrin, and Baiq Niswatul Khair, "Analisis Tingkat Pemahaman Konsep IPA Siswa Kelas V SDN Gugus V Kecamatan Cakranegara," *Jurnal Ilmiah Profesi Pendidikan* 6, no. 4 (December 28, 2021): 686–90, https://doi.org/10.29303/jipp.v6i4.317.

[19] Irwandi Rahmat dkk., "Validitas Dan Praktikalitas Media Diorama Berbasis AR (Augmented Reality) Berbantuan Assembler Edu Pada Materi Siklus Air," *Jurnal Bioedukasi* 7, no. 1 (2024): 404–10.

factors can also influence students' conceptual understanding. Internal factors such as interest in learning, enthusiasm, and self-confidence, as well as external factors like methods and the learning environment, each element contributes to concept understanding.[20]

Therefore, conceptual understanding is an essential component to success in learning. Research shows that conceptual understanding, especially in science learning, is influenced by various factors both internal and external to the student. To improve students' conceptual understanding, collaboration from teachers, parents, and students is needed. The use of innovative learning media, the development of engaging teaching materials, and the creation of a conducive learning environment are important steps to achieve that goal.

The effectiveness of AR-based media to improve concept understanding

Augmented Reality (AR) provides an opportunity for enhancing the quality of learning, particularly in sciences. AR is capable of stirring interest and providing students with the freedom to conduct discoveries independently. Moreover, AR is very useful in science learning because it can visualize complex concepts that are difficult for students to understand.[21]

Riyanti, et al., presented concrete examples of using AR in learning about the water cycle. The researchers claim that AR could assist in making simpler to help learners to understand the principles of physics related to the water cycle.[22] Additionally, other researchers also support this finding through their research on the effectiveness of AR in learning about the solar system. Its study results show that the implementation of AR can significantly improve the quality of student learning.[23]

Teachers play an important role in assisting students in applying AR. Proper guidance can help students become actively involved in learning to get a correct understanding of concepts, which allows learners to more fully understand the benefits of what they have learned. AR also has an attraction aspect that can increase students' interest in learning, thereby rendering the learning process more enjoyable.[24]

Furthermore, based on various studies, it can be concluded that Augmented Reality (AR) has a very large potential for improving the understanding of science concepts for elementary school students. By visualizing abstract concepts, AR can produce exciting and interactive learning experiences. In addition, AR can increase students' learning motivation and encourage critical thinking. However, to achieve optimal results, the assistance of teachers must be provided to guide students in using AR effectively.

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[20] Azizah, Zmaroni, and Ginanjar, "Analisis Kesulitan Belajar Dalam Pemahaman Konsep Pembelajaran IPA Kelas IV Di MI Hidayaturrohman Kecamatan Teluknaga Kabupaten Tangerang."

[21] Ifa Safira, Abdurrachman Rahim, and Pricilia Indah Palangi, "Efektivitas Augmented Reality (AR) Pada Konsep Pembelajaran IPA Sekolah Dasar," *Klasikal: Journal of Education, Language Teaching and Science* 4, no. 3 (2022): 685–92.

[22] Aprillia Dewi Riyanti, Firman Wahyu Farudin, and Muwarni Dewi Wijayanti, "Pemanfaatan Teknologi Augmented Reality (AR) Sebagai Upaya Peningkatan Keterampilan Berpikir Kreatif Siswa Dalam Proses Pembelajaran IPA Siklus Air SDN 02 Sidayu Kelas V," Social, Humanities, and Educational Studies SHEs: Conference Series 7, no. 3 (2024): 672–78, https://jurnal.uns.ac.id/shes.

[23] Mohammad Haris Kurniawan and Julianto, "Pengembangan Media Pembelajaran Berbasis Ar 'Augmented Reality' Pada Materi Sistem Tata Surya Kelas 6 SD," *JPGSD* 10, no. 6 (2022): 1401–14.

[24] Bramianto Setiawan dkk., "Augmented Reality as Learning Media: The Effect on Elementary School Students' Science Processability in Terms of Cognitive Style," *Journal of Higher Education Theory and Practice* 23, no. 10 (2023): 60–71.

CONCLUSION

Based on the literature review that has been presented, it can be concluded that Augmented Reality-based media has an extremely significant opportunity to transform the learning process, particularly in science-related subjects. AR is capable of providing more interactive, enjoyable, and effective learning experiences, which improves motivation, engagement, and conceptual understanding. Research shows that AR may represent complicated ideas more effectively, rendering learning more valuable and encouraging students to think critically. To maximize the potential of AR in education, the following suggestions can be considered: AR needs to be systematically integrated into the curriculum, especially for subjects that are nature-based such as science.

Teachers need given properly training regarding how to effectively utilize AR technology in learning; there additionally needs to be sufficient infrastructure support, such as devices and internet connectivity, to ensure accessibility of AR technology for all students; and further research is needed to analyze various aspects that influence the implementation of AR in education. This research has several limitations, including the limited number of articles analyzed, which is only 20, and may not reflect the entirety of relevant research. Additionally, a limited emphasis on science subjects may restrict the understanding of AR applications in other disciplines. The important aspects of infrastructure and technology accessibility have not been extensively investigated, while the preparedness and skills of teachers in using AR are also crucial factors that have not been fully explored. Further, the methods used to measure students' conceptual understanding may not fully accurately reflect their critical and creative thinking abilities. These limitations suggest a requirement to conduct additional studies to obtain more comprehensive and relevant findings within the context of education.

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