



# Exploring Augmented Reality-Based Learning Media Implementation in Solar System Materials

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## ABSTRACT

**Objective:** This research aims to analyze the impact of using augmented reality (AR) based learning media on understanding Solar System material. The focus is on evaluating the effectiveness of AR in improving the learning process, particularly on Solar System materials. **Methods:** The research method used is a literature review by searching for related journals indexed by Scopus within the last five years, from 2018 to 2023. The selected literature was then analyzed to gain an in-depth understanding of the implementation of AR in Solar System learning. **Results:** Analysis of the literature shows that using AR technology as a learning medium positively impacts understanding of Solar System concepts. There is an increase in student engagement and learning effectiveness through AR. **Novelty:** This study reveals that using AR-based learning media on solar system material can improve understanding of Solar System concepts. This finding invites researchers, teachers, and the government to develop and consider the implementation of AR in the context of astronomy learning.

## INTRODUCTION

Natural science is one of the compulsory subjects found in secondary schools. The definition of natural science is a branch of science that studies real and abstract events in nature that must be proven by making observations, observations, and experiments. One of the materials considered difficult for students in Natural Sciences subjects is material about the solar system (Ardiyanti & Zuhdi, 2021). This material's complexity and abstract nature make it difficult for students to fully understand it, mainly due to their limited ability to observe astronomical objects and phenomena related to the solar system directly in everyday life (Nadzif et al., 2022). Therefore, the learning process on material about the solar system must be supported by the selection of appropriate learning media (Suwartiningsih, 2021) because learning media is an intermediary or introduction to excellent and pleasant communication between teachers and students (Fakhrudin & Kuswidyanarko, 2020).

Learning media means a set of tools or means used to channel and convey material or information in the form of material in learning activities so that the teaching and learning process can run effectively and the objectives of learning can be achieved perfectly (Zahwa & Syafi'i, 2022). The use of learning media not only makes it easier for teachers to deliver material to students (Melanda et al., 2023) but also increases their interest (Puspitarini & Hanif, 2019) and motivation to learn more interactively and proactively (Dewi et al., 2019). This can create a more lively classroom atmosphere (Pranoto & Suprayogi, 2021), where feedback between teachers and students can be established smoothly and the effectiveness of the learning process during teaching and

Learning activities can increase (Audie, 2019). The selection of learning media used by a teacher plays a crucial role in the success of the learning process to achieve the desired results (Indriyani, 2019). However, in reality, many teachers still need to understand and implement suitable learning media, relying only on using the blackboard as the learning media (Juhaeni et al., 2023). Therefore, a teacher must be innovative to create conducive learning conditions by designing excellent and fun learning for students (Putri et al., 2022).

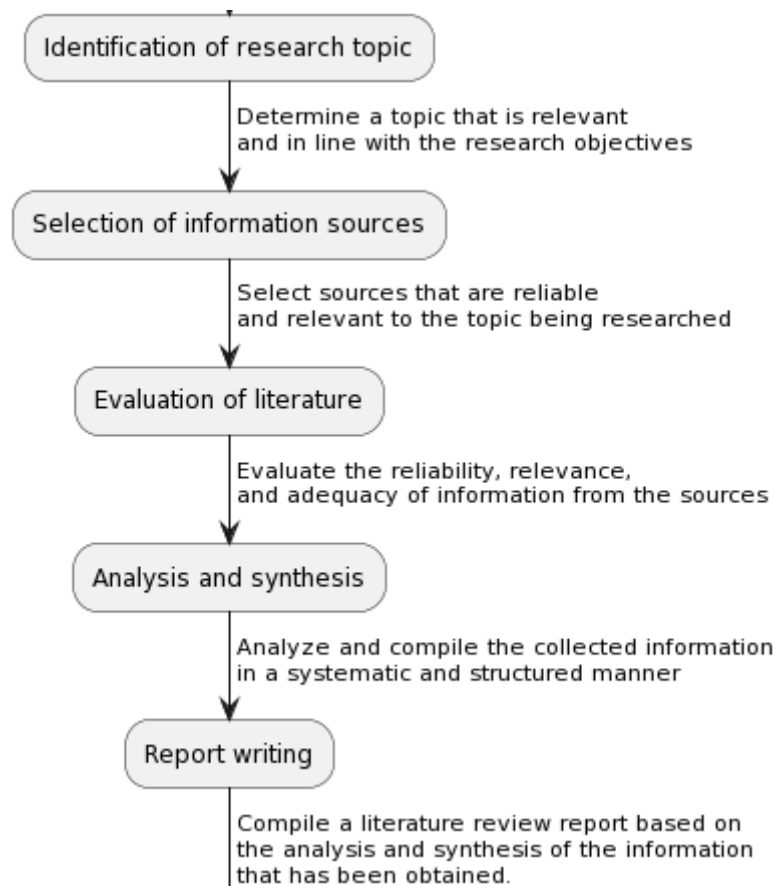
The development of information and communication technology (ICT) today has influenced various fields, especially in education and the learning process. The use of ICT in the learning process is no longer a foreign thing in this era of globalization (Akbar & Noviani, 2019). Learning media innovations that can be used in the classroom are also increasingly numerous and varied to increase students' interest in learning science (Ningrum et al., 2022). One of the learning media that is now starting to be widely used is augmented reality (AR) (Abdillah et al., 2020). AR is a modern technology-based instrument that combines virtual world objects, both two-dimensional (2D) and three-dimensional (3D), into the real world and then projects in real-time (Maulana et al., 2019). AR technology has been widely used in various sectors such as medicine, military, manufacturing, entertainment, museums, games, and others (Usmaedi et al., 2020). AR technology has also been applied in the education sector by utilizing devices such as smartphone cameras, which are currently widely used by the general public, including students (Rosa et al., 2019). The use of AR technology in the learning process can be a helpful learning medium for teachers in optimizing the delivery of subject matter (Saputra, 2020). This is because AR technology can bring 2D, 3D, video, audio, or text animation objects into learning media, so AR technology has great potential to increase effectiveness in the learning process (Eviyanti & Firmansyah, 2023).

This research brings novelty by focusing on using AR-based Learning Media in Solar System learning. The research findings show that using AR in this context can significantly improve students' understanding of Solar System concepts (Mashar et al., 2022). This novelty is an essential foundation for researchers, educators, and policy parties to explore the potential application of AR in astronomy learning more deeply. The relationship between AR, Solar System learning, and the results of improving student understanding can be further revealed through the literature review method. This study aims to descriptively describe and evaluate the effectiveness of using AR-based Learning Media on Solar System Materials by detailing the findings of various previous studies in the literature. Thus, this novelty not only brings innovation at the practical level of learning but also presents a stage for further reflection and understanding regarding the positive impacts of integrating AR technology in astronomy teaching.

## **RESEARCH METHOD**

The method used in this study is the qualitative literature review method. A literature review is defined as an investigation of scientific articles, books, and other sources related to specific problems, areas of research, or theories so that they can provide an overview, summary, and evaluation of scientific work (Danar et al., 2023). A literature review has a vital role as a foundation for various types of research because the results of literature review analysis can provide a deep understanding of the development of knowledge, as well as act as a trigger for the formation of new ideas, and are helpful as

a guide for research in a particular field (Snyder, 2019). The literature review is the leading choice for researchers because this method focuses on analyzing and investigating existing articles without requiring direct observation in the field (Sofiah et al., 2020). This literature research method identifies comparisons and outlines relevant references to enrich understanding (Saphira et al., 2023). This approach allows the researcher to systematically explore and integrate existing knowledge and organize it into a solid framework, which can then be used to support and extend further research (Marisana et al., 2023). Literature review research has several procedures that must be followed, as shown in Figure 1.



**Figure 1.** Stages of the literature review procedure (Socrates & Mufit, 2022)

Implementing AR-based Learning Media can be a solution to teaching material about the solar system to support effective learning (Zsalsabilla et al., 2022). This research methodology adopts a literature study to explore research problems (Karimah et al., 2023). The data type used is secondary, obtained through reading, studying, and understanding various literature sources, books, and scientific documents (Yusup et al., 2023). The selection of this method aims to gain in-depth insight into the incorporation of AR-Based Learning Media in the context of Solar System learning. The data collection approach was carried out by collecting literature related to the utilization of AR learning media in the context of solar system material. The literature collected includes Scopus-indexed publications in the last five years, from 2018 to 2023. The search was conducted using the keywords "AR," "solar system," and "learning."

## RESULTS AND DISCUSSION

### Results

This study was conducted to determine the use of AR-based learning media on solar system material. Researchers searched and reviewed literature related to the use of AR learning media in learning solar system material. The literature search and review results obtained ten pieces of literature data consisting of two international proceedings, one international journal, and seven reputable national journals. The literature data is presented in Table 1.

**Table 1.** Literature review results.

No	Year	Research Author(s)	Finding
1	2023	Latif et al. (2023)	The Virtual Planetarium is an AR-based application designed using the Systems Development Life Cycle method to facilitate children's learning about the solar system. The app allows users to access 3D AR objects by selecting them from a list and provides information cards about the chosen object. Tested and functioning well, the user-friendly interface prioritizes ease of navigation, catering to the needs and comfort of children without requiring socialization. The app ensures factual data presentation, displaying the Sun and planets in the correct solar system order. The primary goal is to provide an engaging and educational experience for children to learn about the solar system through interactive virtual content on their smartphones.
2	2023	Rahmat et al. (2023)	The study found that students in class A who used mobile AR in the implementation study had higher learning achievement criteria than students in class B who used textbooks. According to students, mobile AR technology in physics learning makes the learning environment more enjoyable, facilitates abstract concepts to be concrete by adding visual 3D simulations, creates a pleasant learning environment, helps students more easily understand concepts, and affects learning achievement.
3	2023	De Moraes Rossetto et al. (2023)	Concerning its impact on the teaching process, evaluating responses in the pretest and post-test questionnaires indicates that the application significantly facilitated effective learning. Notably, the post-test results revealed a noticeable increase in the number of correct answers, highlighting the efficacy of the VR module. Additionally, student feedback indicated a preference for the VR experience's immersive and interactive nature while acknowledging the AR experience's intuitive

No	Year	Research Author(s)	Finding
4	2022	Zuniari et al. (2022)	quality. The study's conclusion shows that using AR as a learning medium, primarily through the ARLOOPA application, effectively facilitates understanding solar system materials. This allows for more tangible visualization for students and stimulates their curiosity, which enhances critical thinking skills through active participation in discussions.
5	2021	Gumilar et al. (2021)	Using learning media based on AR technology is an effective alternative to teaching the concept of solar system motion in physics learning. AR media facilitates learning and can increase children's motivation and concentration on solar system motion material in science learning.
6	2021	Taufiq et al. (2021)	Solar system learning media based on Merge Cube AR positively impacts students' problem-solving skills by allowing them to explore the subject independently. This interactive learning tool combines virtual and real worlds, enhancing students' imagination and critical thinking abilities. AR-based educational media provides flexibility, enabling students to learn anytime and anywhere, making it a valuable resource for their learning journey.
7	2020	Septiani et al. (2020)	The Android-based interactive learning media that uses AR in Science Theme 9 about the Solar System has proven to provide convenience for teachers and students in the learning process at Elementary School Pondok Rumpit, Bogor City. In general, this learning media is considered an appropriate and effective tool for supporting learning activities, especially in explaining the characteristics of the eight planets in the solar system.
8	2020	Muali et al. (2020)	Utilizing mobile AR can enhance students' comprehension of ideas, and it was found that self-regulated learning played a vital role in strengthening the connection between mobile AR and students' grasp of concepts. Educators suggested incorporating mobile AR and encouraging self-regulated learning in their teaching methods to enhance students' conceptual understanding.
9	2019	Kirikkaya & Başgöl (2019)	Integrating AR applications into science education substantially enhances student achievement and motivation. This study, which focused on the Solar System and Beyond, highlights the invaluable potential of AR technology in bolstering science lessons and profoundly impacting students' academic

No	Year	Research Author(s)	Finding
10	2019	Tresnawati et al. (2019)	performance in science. This research aims to utilize AR technology with Unity and Vuforia to create a learning media for introducing the Solar System in the Science subject of grade VI Elementary School based on the 2013 curriculum. The test results show that this application functions as an interactive learning media by receiving positive assessments from students and increasing students' interest in understanding the Solar System introduction material during the learning process.

Learning media, which has long been known in the world of education, is one of the essential components that serves as a messenger in the form of material, attitudes, and skills expected to be achieved by students. In education, there are already various types of learning media known, from learning media that utilize the surrounding nature to those that use technology. This development was triggered by changes in the world that also influenced and encouraged educational changes (Leliavia, 2023). One of the technology-based learning media is AR.

### *Discussion*

Based on the ten pieces of literature analysis, using AR technology as a learning medium positively impacts the learning process, especially in the context of solar system material. Learning media is one of the critical elements in the learning process (Fikram et al., 2023). Learning media is a device or tool that facilitates the learning process (Sanjaya et al., 2021). Learning media can also be interpreted as stimulating thoughts, abilities, and skills to encourage learning (Sulfemi & Mayasari, 2019). Learning media as a tool in the learning process cannot be separated. It aims to improve student understanding and help increase learning effectiveness to improve learning motivation (Junaidi et al., 2022).

One of the materials in science subjects is solar system material. The solar system stands out as a highly intricate subject primarily because it delves into the exploration of all the planets within our solar system. Moreover, it encompasses discussions about their respective satellites and additional celestial entities, including meteors, comets, asteroids, and other space objects (Arum et al., 2019). However, in the solar system material learning process, today's learning media are still limited to textbooks and PowerPoint presentations. The use of these media is considered not fully effective and efficient in delivering material to students, especially when the material involves abstract and complex concepts, such as solar system material (Seviana et al., 2022). One solution that can overcome this limitation is the use of AR.

AR as a learning medium is a new approach that can help students understand the concepts taught more efficiently, even if they have never seen the object before (Rahmat et al., 2023). Although this technology is still relatively new, today's children are very familiar with mobile devices and are used to using them. Students can explore the material independently using AR-based solar system learning media. Thus, AR learning media allows flexible learning that can be accessed anywhere and anytime according to students' wishes (Taufiq et al., 2021). AR technology makes a significant contribution to

overcoming challenges related to the visualization of abstract concepts, such as astronomical phenomena, which are often difficult to understand in conventional classrooms (Arzak & Prahani, 2023; Hamid et al., 2020; Ngurah & Laksana, 2020; Prahani et al., 2022; Suryasa et al., 2020). By enabling three-dimensional visualization and connecting concepts spatially, AR applications provide an immersive and comprehensive learning experience for students (Siqueira, 2019). The integration of AR applications in teaching complex and abstract topics in the science curriculum has the potential to improve student understanding and motivation (Alzahrani, 2020; Cai et al., 2021; Chen, 2020; Jesionkowska et al., 2020; Liono et al., 2021). AR has also proven effective in helping students understand the characteristics of planets in the solar system (Septiani et al., 2020) and solar system motion material (Gumilar et al., 2021) by providing more realistic visualizations. In addition, using AR can stimulate students' curiosity, improving their critical thinking skills (Zuniari et al., 2022). This is supported by the findings of Muali (2020), which show that learning with AR media significantly impacts students' concept understanding and critical thinking skills. Comparison between the experimental group using AR and the control group using conventional learning showed higher concept understanding scores and critical thinking skills in the experimental group (Astuti et al., 2020; Faridi et al., 2021; Giri & Paily, 2020; Ikhsan et al., 2020; Ramdani et al., 2021; Sidiq et al., 2021). This shows that AR can be an effective tool in improving the quality of learning.

AR-based learning media received a very positive assessment from students and succeeded in increasing students' interest in understanding solar system introduction material during the learning process (Tresnawati et al., 2019). AR technology offers virtual educational content about the solar system in the real world on smartphones so that children can learn about it while actively interacting with their surroundings (Latif et al., 2023). AR applications in the learning process can attract student interest because of the novelty and wonder associated with AR technology. The positive impact of this interest is an increase in student academic success (Monita et al., 2019). Moreover, the integration of AR applications in teaching provides an interactive and engaging environment, encourages active learning, increases student engagement, and facilitates a better understanding of complex subjects (Li & Liu, 2023; Mystakidis et al., 2022; Tuma, 2021; Wen, 2021). With AR technology, learning becomes informative and motivates students to actively participate in the learning process (Kirikkaya & Başgöl, 2019). The application of AR technology in education can increase the attractiveness of learning, especially for students in remote areas (Alalwan et al., 2020; Baabdullah et al., 2022; Iqbal et al., 2022; Muhammad et al., 2021; Schaffernak et al., 2020). It has the potential to overcome the challenges of student absenteeism and lack of motivation to attend school. With interactive elements and a more exciting learning experience through AR, students are expected to be more motivated and excited to follow the learning process. AR technology brings innovations that can enrich students' learning experiences, even in educational environments that may be limited (de Moraes Rossetto et al., 2023).

## CONCLUSION

**Fundamental Finding:** This technology not only stimulates students' curiosity, strengthening critical thinking skills, but also enhances creativity, observation skills, analysis, communication, self-confidence, and responsibility individually and in group work. Furthermore, the use of AR also strengthens the collaborative relationship

between teachers and students, creating a closer and more interactive learning environment. Thus, AR technology can offer promising opportunities to improve learning outcomes and students' overall learning experience. **Implication:** AR as a solar system learning media shows many benefits and positive impacts. In addition to overcoming the limitations of teaching aids, AR technology can provide a deeper understanding of solar system material, encourage interest in learning, and make the learning process more enjoyable, effective, and meaningful for students. **Limitation:** This study has limitations, primarily related to the literature sources. Most of the literature sources still come from national journals, so it does not include reputable international literature that can provide a broader view. **Future Research:** Further research needs to be conducted to overcome the limitations of this study and increase the diversity of research findings. Future research should also enrich its references by referring to literature sources published in reputable international journals to increase the validity of the overall research findings.

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