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Integrating Augmented Reality (AR) in Education in the Era of Society 5.0: A Systematic Literature Review

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Abstract

The advent of the term Society 5.0 brings in a new concept of human-centered technology integration, education included. Augmented Reality (AR) provides an interactive and immersive learning experience. The objective of this research is to systematically examine the trends, advantages, challenges, and relevance of the use of AR in education within the context of Society 5.0. Through the application of the Systematic Literature Review (SLR) method, 46 research articles published on ScienceDirect between 2020 and 2025 were filtered through inclusion and exclusion criteria. The findings indicate that AR adoption is on the rise, specifically in higher education and in medical and engineering disciplines. Most studies cite the function of AR in aiding enhanced learning outcomes, student motivation, and interactive simulations. However, the use of AR must also navigate infrastructural limitations, teacher preparedness, and budget constraints. This study charts the deployment of AR in a human-centered education system and offers direction to subsequent research and development.

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INTRODUCTION

The development of digital technology has brought significant changes to various sectors of life, including education. Entering the Society 5.0 era, a concept of a human-centered society based on smart technology, education is expected to produce human resources who are adaptive, creative, and competent in facing the challenges of the 21st century. The human-centered approach places human needs and interests at the center of the process, shifting from technology-based progress to a primary focus on people and society. (Xu et al., 2021). Industry 5.0 goes beyond the production of goods and services

for profit, requiring all parties to think and act differently (Gürdür Broo et al., 2022). Industry 5.0 introduces technological innovations, including predictive maintenance, high levels of customization, and cyber-physical systems that merge the physical and digital worlds. It also introduces human-focused collaborative robots, or cobots.. (Khan et al., 2023). One real-world application of the human-centric approach in Industry 5.0 is the use of smart technologies such as AR and VR in education to create interactive, immersive, and learner-centered learning experiences.

Virtual Reality (VR) uses complex hardware to create a computer-generated three-dimensional world that interacts with the senses of the user and provides computer-generated experience and feedback. Users can interact with virtual worlds that are connected to the real world. AR and VR are different: AR still shows the real world, VR is completely virtual. VR needs a headset, AR just uses a cell phone. AR can add things to the real world, VR only to the virtual world (Fahim et al., 2022) Various engineering fields use AR technology as an interactive learning tool. This tool helps increase student motivation in the classroom (Chang et al., 2022). AR is an interactive tool used in technical education and helps increase students' learning motivation in the classroom (Kaur et al., 2020). AR/VR technology has revolutionized learning approaches through immersive digital experiences, interactive environments, simulations, and engagement (Al-Ansi et al., 2023). AR/VR has the potential to make science learning more engaging. However, it requires additional effort from education policymakers to provide the necessary tools and trained teachers (Alalwan et al., 2020). AR technology is used to enhance Computational Thinking (CT) or programming skills in various contexts (Theodoropoulos & Lepouras, 2021). Integration AR in education and dental surgery practices has significantly improved precision and interactivity in dental training and patient care (Lin et al., 2024). The application of AR and VR technology can make learning more interactive and immersive. The technology can offer learners varying interesting audio and visual stimulations, thus making them more interested in what they are learning. AR and VR also enable simulations and virtual worlds that make learning experiences more enjoyable and fun. (Al-Ansi et al., 2023). AR-assisted science teaching contributes positively to students' performance and attitudes toward the subject. Positive results can also be achieved through AR technology in various subjects (Sahin & Yilmaz, 2020). Learning through AR technology will help students understand learning content in a more creative way than before (Faqih & Jaradat, 2021).

The success of technical education in the industry 5.0 era will depend on 'collaborative learning' between humans and intelligent machines (Gürdür Broo et al., 2022). The core values of Industry 5.0, which emphasize human and social objectives in technology adoption, the reuse of knowledge plays a crucial role in empowering employees, promoting collaboration and adaptability, and fostering lifelong learning (Ariansyah et al., 2024). In this context, education must adapt to technologies like AR to create more personalized and effective learning. To identify trends, challenges, and the potential for implementing AR technology in education based on Society 5.0 principles, this study uses a Systematic Literature Review (SLR) approach. This approach was chosen because it can provide a comprehensive and structured synthesis of knowledge from various published empirical studies.

Therefore, it is important to systematically explore how Augmented Reality technology has been implemented in education and how this technology supports human-centered learning in the Society 5.0 era. To address these issues, this study formulates the following research questions: RQ1: What are the trends in the use of Augmented Reality (AR) in education over the past five years? RQ2: What are the benefits and challenges of implementing AR across different levels and fields of education? RQ3: How does the integration of AR support immersive, personalized, and human-centric learning in line with the principles of Society 5.0.

RESEARCH METHODS

This study employs the systematic literature review (SLR) method to examine the role of augmented reality (AR) in education during the Society 5.0 era. SLR was chosen because it provides a systematic and evidence-based synthesis of relevant scientific literature. Data was obtained using Publish or Perish (PoP) software with the ScienceDirect database. The search was conducted using the keyword "AR in education" for publications from 2020 to 2025, with the following criteria: English-language articles, peer-reviewed, full-text, and relevant to the context of education and Society 5.0. From the initial 100 articles, selection was based on inclusion criteria: discussing AR in education, in English, published between 2020 and 2025, peer-reviewed, full-text, and relevant to the values of Society 5.0, and exclusion criteria: only discussing VR, not related to education, not scientific articles, not full-text, or duplicates. This selection ensures the quality and relevance of the articles analyzed in this study.

RESULTS AND DISCUSSION

Trends in the Use of Augmented Reality (AR) Over the Last Five Years 2020-2025 (RQ 1)

Over the past five years (2020-2025), the trend of AR use in education has shown a significant increase at almost all levels of study. Out of the 46 studies reviewed, there has been an increase in the implementation of AR in elementary and secondary education, higher education, and medical education, with a primary focus on 3D visualization, simulation-based learning, and enhancing learning motivation. Most studies indicate that AR integration is predominant in science, technology, engineering, and mathematics (STEM) subjects, as well as in anatomy, chemistry, and engineering fields. Additionally, AR trends indicate that AR is beginning to be applied as a tool for distance learning and mobile learning, signalling a shift toward more flexible, technology-light learning.

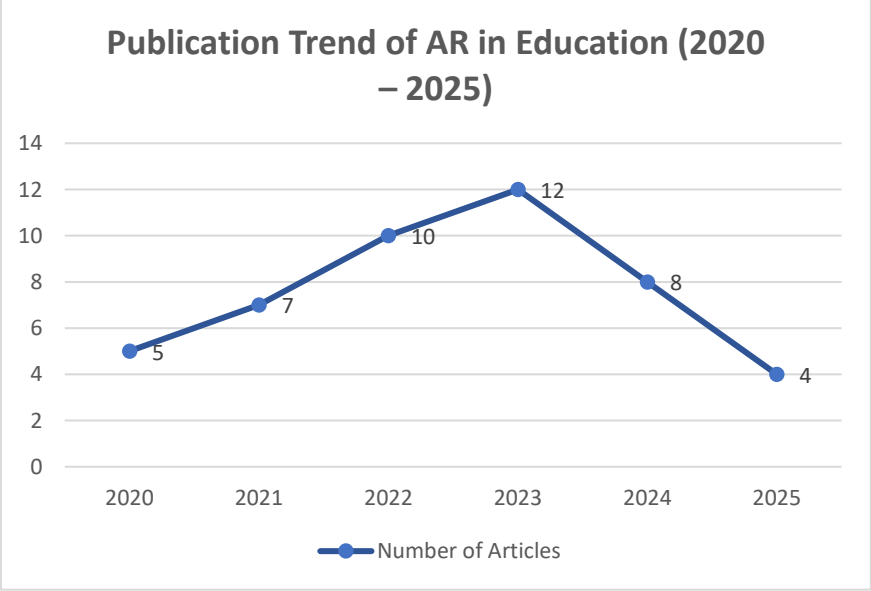

Figure 1. Publication Trend of AR in Education (2020-2025)

Figure 1 illustrates the trend of academic articles on the application of Augmented Reality (AR) technology in education from 2020 to 2025. There is a remarkable rise from 2020 (5 articles) to the highest point of 2023 (12 articles). This rise reflects increasing interest and concern among researchers regarding the utilization of AR as a new approach to learning, especially amidst education digitization in the perspective of Society 5.0. However, from 2023 and beyond, the publications decline, with just 8 papers in the year 2024 and 4 papers in the year 2025. This decline is probably a result of a change in research interest on other technologies or constraints on the extensive use of AR in schools.

Benefits and Challenges of Implementing AR in Various Levels and Fields of Education (RQ 2).

In the era of Society 5.0, where advanced technologies such as Artificial Intelligence (AI) and Augmented Reality (AR) have become part of everyday life, the world of education is required to adapt and become more dynamic. The use of AR in learning activities is not only a complement but also has the potential to be a transformative tool that can enhance the learning experience and make learning activities more interesting for students.

AR as an effective learning tool, AR not only provides audio and visual content but also offers a learning experience that can enhance students' understanding. AR makes learning more engaging; by directly involving students, AR can make learning more engaging by presenting interactive visualizations and immersive experiences. Enhancing student motivation, by making learning more engaging and enjoyable, AR can increase students' motivation to learn. Supporting self-directed and exploratory learning, AR enables students to learn at their own pace through simulations and interactions that can be conducted independently, thereby fostering greater autonomy in their learning activities.

Even though the incorporation of AR technology into learning has its advantages, there are also many difficulties that come along with it. The extensive obstacles that AR faces when being put into practice, such as the lack of sufficient resources when it comes to implementing AR as a widely used educational tool, reveal how AR still has a long way to go before it can seamlessly merge with education technology. Constraints on Certain Topics: Some lessons might be too advanced to be enhanced with AR technology. The advanced mathematics topics, especially complex calculations are a good example. Designing with Social Inclusion in Mind: Designing learning and teaching aids with respect to AR technology and robotics requires considerable finances for the development and maintenance of sophisticated educational equipment, and AR designs that include students with physical or cognitive challenges. Using Dual Augmented Reality & Virtual Reality (VR) Devices For Long Periods: Prolonged or continuous use of VR and AR tools may lead to motion sickness, which in turn diminishes focus for students. Lack of Familiarity with AR Technology: More control over students is needed when AR is integrated into teaching, which requires training for the teachers to be able to competently manage the learning environment.

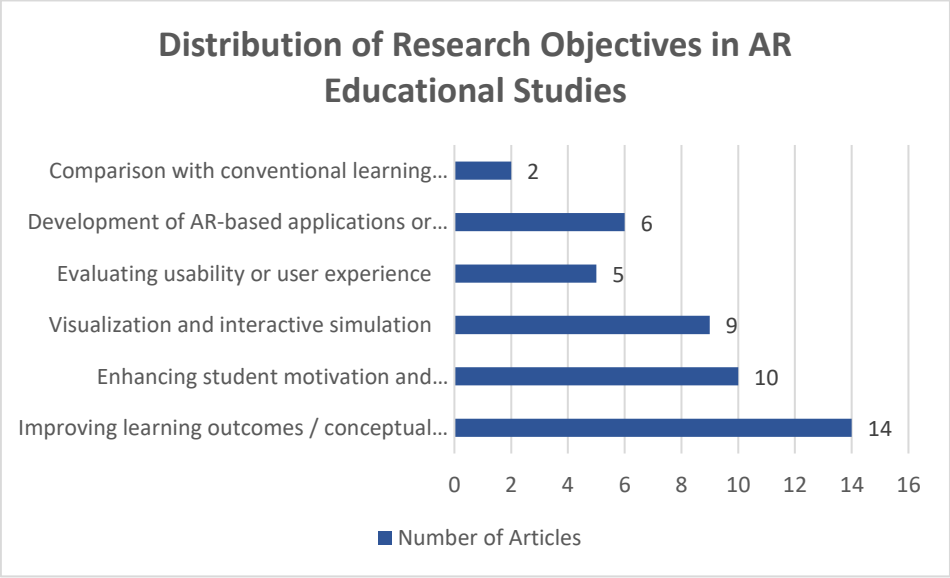

Figure 2. Distribution of Research Obectives in AR Educational Studies

Figure 2 shows that most AR research in education aims to improve learning outcomes and conceptual understanding (14 articles), followed by increasing student

motivation (10 articles), and interactive visualization and simulation (9 articles). Meanwhile, objectives such as application development, user evaluation, and comparison with conventional methods are still relatively few. This shows that the main focus of AR research is on pedagogical aspects and student learning experiences.

AR integration supports immersive, personalized, and human-centric learning in line with the principles of Society 5.0 (RQ 3).

The integration of AR in education shows great potential to support learning activities with a human-centric approach, as promoted by the principles of Society 5.0. This technology can enhance immersive, personalized learning experiences that are relevant to the needs and characteristics of users or students.

Several reviewed studies indicate facilitating experiential learning, where students can actively engage in direct interaction with 3D digital objects placed directly in the real world. Enhancing emotional and motivational aspects of learning, thereby fostering students' interest in making learning more contextual and meaningful. Supports personalized learning, as AR learning content can be tailored to users, allowing learning to adapt to the pace of learners. Integrates technology ethically and socially, providing educational solutions that are not only technologically advanced but also consider the needs of learners with disabilities or special needs.

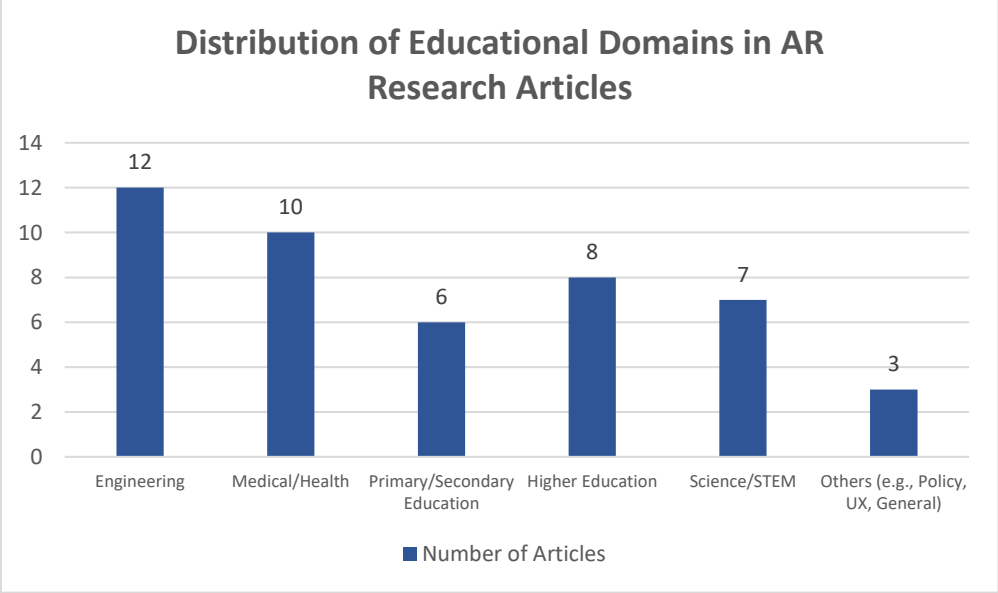

Figure 3. Distribution of Educational Domains in AR Research Articles

Figure 3 shows the distribution of educational domains from the AR research articles reviewed. Engineering dominates with 12 articles, followed by medicine/health (10 articles) and higher education (8 articles). Meanwhile, the fields of primary/secondary education (6 articles) and science/STEM (7 articles) still show moderate numbers. The "other" category, such as policy or user experience (UX), only includes 3 articles. This distribution indicates that AR adoption is still more prevalent in technical and professional fields, while implementation at the primary education level remains relatively limited.

Implication Research

Interpretation Of Findings

The results of this systematic review indicate that research related to Augmented Reality (AR) in education has increased from 2020 to 2023, with a peak occurring in 2022 to 2023, indicating that global attention to immersive learning technology, particularly for digital education transformation, occurred post-pandemic and shifted toward the Society 5.0 era. 0, with the majority focusing on higher education, engineering, and healthcare fields. This indicates that AR is most frequently applied in domains that heavily rely on spatial visualization and simulation-based learning.

Based on research objectives, some studies aim to enhance students' learning outcomes and conceptual understanding. Many research findings also show that AR use can increase student motivation and engagement. These findings align with learning objectives consistent with the Human-Centric values that form the core pillars of Society 5.0, namely personalized and inclusive learning.

Research GAP

Based on a Systematic Literature Review (SLR) conducted by De Lima et al. (2022), out of 196 articles analyzed, the majority of studies—123 studies—focused on the impact of Augmented Reality (AR) on learning outcomes. Meanwhile, 36 studies evaluated the functionality and effectiveness of AR technology, 21 studies examined users' perceptions of AR implementation, and 16 studies compared the use of AR with conventional learning methods. These findings indicate a dominant pedagogical focus in AR research, although challenges in long-term integration into educational systems remain a barrier.

This study confirms a similar distribution pattern but expands it by highlighting the direct link between AR utilization and Society 5.0 values. By emphasizing immersive, interactive, and learner-centered learning approaches, this study adds a human-centric dimension that has not been a major focus in previous reviews.

Figure 4 below visually illustrates the classification of these research objectives and shows that the dimension of improving learning outcomes remains the primary focus in AR studies in the field of education.

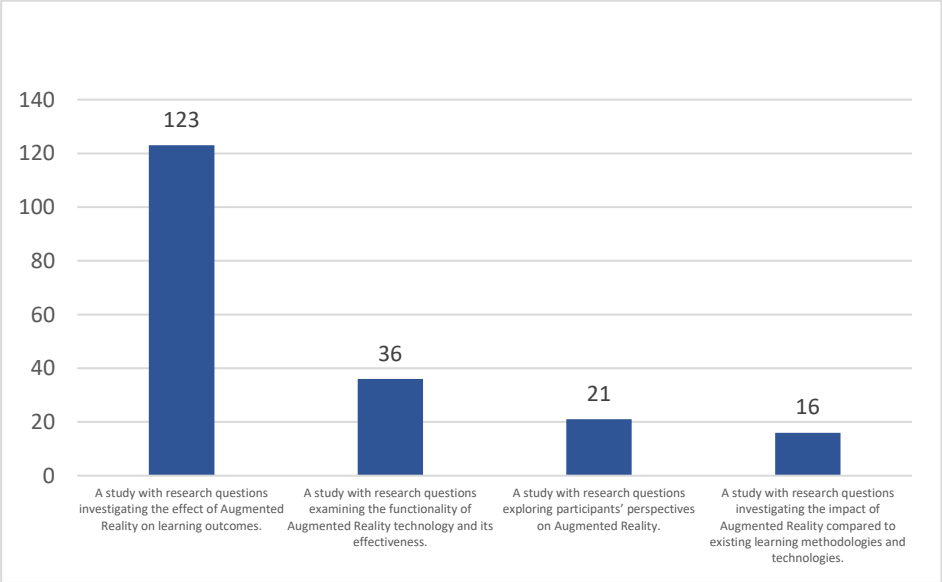

Figure 4. Distribution of research objective categories related to AR in education based on the review by De Lima et al. (2022).

Future Research Directions

Further research should explore the long-term impact of AR use on learning outcomes and 21st-century skills, particularly at the primary education level and in non-STEM fields that remain under-explored. Additionally, studies should be conducted on the sustainability and cost-effectiveness of AR implementation in real educational settings. Researchers are also encouraged to develop an evaluation framework that measures the extent to which AR use supports the principles of Society 5.0, such as personalized, inclusive, and human-centric learning.

CONCLUSIONS AND SUGGESTIONS

Conclusion

This research seeks to systematically analyze the use of Augmented Reality (AR) technology in education within the framework of Society 5.0. Through content analysis of 46 chosen scientific articles from 2020 to 2025, this research managed to determine

trends, strengths, and shortcomings of the utilization of AR at different levels and branches of education. The findings indicate that AR has developed significantly in educational environments in the past five years, focusing primarily on higher education, engineering, and medicine. Most of the studies aim to enhance learning outcomes and conceptual understanding among learners, as well as visualize intangible complex materials. AR technology has been proved to facilitate immersive, interactive, and student-centered learning—principles, which are aligned with the Society 5.0 phenomenon, where human beings are focused as the drivers of innovation. Nevertheless, utilization of AR is still characterized by numerous challenges, which span from infrastructure constrains, poor capacity development among teachers, and adoption differences by regions and levels of education.

Based on these findings, this research contributes to formulating a roadmap for integrating AR into a human-centric future education system. The study also opens opportunities for further research to explore the long-term effectiveness of AR, as well as how this technology can be used inclusively and sustainably in formal learning.

Suggestion

From the discussions and findings in this research, future researchers are suggested to extend the scope to the application of Augmented Reality (AR) in secondary and primary education, which is currently low in adoption relative to technical or medical applications and higher education. Additional research should also cover more situated and personalized approaches to learning, taking into account the human-oriented elements which are at the foundation of Society 5.0. Specialized evaluation tools also need to be developed in order to assess the contribution of AR technology from an integrative point of view, covering cognitive, affective, and technical dimensions. The direct participation of instructors and teachers in the planning, design, and piloting of AR apps in actual classroom settings should be given priority in order to make sure that the use of this technology is not just experimental, but also practical and sustainable. It is also suggested that there should be an interdisciplinary team of teachers, technologists, and policymakers working together in a way that guarantees the use of AR actually supports 21st-century learning goals and helps deliver an inclusive, intelligent, and adaptive education system in alignment with the trajectory of Society 5.0 transformation.

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