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The Future Pedagogical Landscape: The Impact of Augmented Reality on the Development of Education and Teaching Methods

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Abstract: Modern digitization processess allow the use of augmented reality technology for pedagogical purposes. The practice of this tool, given its novelty, will require additional reasoning. The purpose was to study the future pedagogical landscape through the prism of the use of augmented reality. Methods: a mixed research design was used, attracting 50 teachers of different educational institutions who agreed to participate in the discussion. The sample provided a diversity according to various parameters: age, years of teaching experience, teaching of academic disciplines. The inclusion criteria: current teaching faculty with experience using digital and augmented reality technologies. Data collection was carried out during the first semester of the 2023-2024 academic year. The use of mixed research methods, analysis of collected data, and the identification of the main factors that influenced the successful implementation of these technologies into the educational process, made a unique contribution to this issue understanding. The results confirmed that the use of augmented reality technologies had numerous advantages in the educational process. They created an interactive environment, attracting students' attention and making learning interesting. The findings of the questionnaire of pedagogical staff testified to the widespread use of these technologies, with 40% of teachers who continuously used them, and 30% who used them 2-3 times a week. The obtained data analysis indicated the positive perception of augmented reality in the educational process and a high level of teacher satisfaction from their use. The positive feedback from educators regarding the effective integration of AR suggests a potential shift in teaching paradigms. This implication underscores the need for ongoing research to delve deeper into the long-term impact of AR on student learning. The exploration of the scalability of AR implementations across diverse educational settings and subjects for future studies, could provide valuable insights into its broader applicability.

Keywords: augmented reality, technology, efficiency, surveys, terms of use

Introduction

In today's ever-changing world of technology, the field of education is experiencing significant transformations as a result of the influence of augmented reality (AR). This technology opens up new perspectives and opportunities for education, creating an innovative learning environment. The relevance of the problem lies in the fact that AR provides an opportunity to interact with virtual objects in real-time and space, expanding the boundaries of traditional learning.

This technology creates unique opportunities for the pedagogical process, helps engaging students and enrich their experience. The use of AR in teaching methods can increase students' interest, promote their activity, and develop critical thinking. Thus, the study of the impact of augmented reality on education is a key area that opens up new horizons for the effective implementation of modern technologies in the educational process.

Modern researchers are interested in this topic mainly because of the possibilities of using modern educational technologies. The analysis of the scientific literature shows that the use of augmented reality technologies offers many advantages in various fields. In education, they create an interactive environment that attracts students' attention and makes learning fun (Ruiz-Ariza et al., 2020). Particularly, augmented laboratories allow for safe experiments, and virtual museums expand cultural experiences by providing opportunities to visit historical sites and study art (Lichty, 2020; Paramita et al., 2021; Saez-Lopez & Cozar-Gutierrez, 2020). According to Mladenovic (2020), in medicine, AR technologies are used to train future surgeons with surgical simulators and to visualise medical data, which facilitates the work with three-dimensional organ models. It is also important to note the

interactivity that AR technologies add to learning (Atanasyan et al., 2020). They create an environment where students can actively interact with materials and concepts, making the learning fun and engaging.

The visualisation of complex concepts is another significant advantage. Modern technology allows learners interacting with abstract ideas, making them easier for the understanding and memorisation (Harb, 2019; Keane et al., 2022; Vaughan, 2021). Hands-on learning that allows for experimentation and interaction in real-world scenarios is a key benefit, especially in the fields of science and medicine. These technologies also allow for individualised learning, adapting it to the needs and pace of each learner (Wolf et al., 2020). In general, it has been proven in scientific studies that modern technologies stimulated greater interest and development of personal skills. In addition, the use of interactive elements in technology increases the motivation of learners, which contributes to active and effective learning.

Research Problem

Even though there are a number of studies on this issue, certain aspects related to changes in learning conditions and the emergence of fundamentally new requirements for the educational process remain unresolved. Thus, it is necessary to rethink the teaching methods used to form a new image of a personality. In view of these changes, it becomes an important task to find effective mechanisms and modern approaches for the creation of conditions that conduct to the harmonious development of the individual in the context of modern reality. Given the innovative development of education in the future pedagogical landscape, modern digital technologies play a key role. Researchers point out that these technologies will become the main element in the training of specialists, not just an additional component (Kolbina & Oleksenko, 2020; Santoveña-Casal & FernándezPérez, 2020). At the same time, the choice of the main tools for creating an innovative personal learning environment is an individual task that depends on the specific learning objectives. The more diverse and richer the personal learning environment is, the more opportunities it opens up for the learner. Thus, it is recommended to constantly review and develop the learning environment, taking into account new technologies and their aptitudes. The introduction of a modern pedagogical landscape provides students with the opportunity to better understand their learning goals and choose appropriate learning tools.

Research Focus

The main focus of the study was to characterise the key aspects of the future pedagogical landscape based on the use of augmented reality technologies. They involved the introduction of a technological educational approach that combined the real world with the virtual world by adding computer-generated objects, information, or effects to the real environment. The main idea of AR is to expand or improve the user's perception of reality through visual, acoustic, or other sensors. Therefore, the main focus of this study was to empirically test the impact of augmented reality on the development of education and certain teaching methods.

Research Aim and Research Questions

The purpose of the study was to characterise the future pedagogical landscape with augmented reality technologies through the prism of an empirical study based on a survey and questionnaire among teachers and lecturers conducted during the first semester of the 2023-2024 academic year.

The research questions are as follows

1. The definition of the basic conditions for AR technologies use.

2. The characteristic of the impact of AR on the use of certain teaching methods and determining the effectiveness of this technology in general.

3. The analysis of the strengths and weaknesses of AR in the system of the modern innovative pedagogical landscape.

Research Methodology

General Background

A mixed-methods research design was used in order to collect a complete data set combining quantitative and qualitative data. A sequential approach began with quantitative data collection, followed by in-depth qualitative data collection to provide a detailed understanding of the effectiveness of AR in modern educational settings.

Sample / Participants

The study involved 50 teachers of different levels of educational institutions. Data collection took place from 1 September to 1 November, covering the first semester of the 2023-2024 academic year. The participants of this research experiment had to actively use augmented technologies in their professional activities during the specified period. The sample provided a diversity in various parameters: age, years of teaching experience, teaching disciplines.

Sampling Method. The sampling method used in this research was the purposeful sampling. The advantages of purposive sampling included the ability to select participants who are most relevant to the research question, ensuring that the study focused on individuals with specific characteristics or experiences related to the research topic.

The purposive sampling involved selecting participants based on specific criteria relevant to the research question or objectives. In this case, the researchers targeted teachers who actively used augmented technologies in their professional activities.

Criteria for inclusion and exclusion.

a. *Inclusion criteria*: (1) teachers with at least one academic year of experience in using digital technologies; (2) teachers and educators currently teaching at different levels of education; (3) teachers who have a clear understanding of the specifics of AR.

b. *Exclusion criteria*: (1) teachers who have not implemented digital technologies in their teaching methods; (2) teachers with less than one year of experience in using blended or distance learning.

Data Collection and Instruments

The data for the study was collected in stages, and different tools were used at each stage.

Collecting Quantitative Data. At this stage, a survey among teachers was used. The survey was sent by e-mail to those participants who previously agreed to participate. This survey was uploaded to Google Forms. The main questions in this survey focused on the integration of augmented reality, its perceived impact on teaching methods, and the overall effectiveness of this technology in the innovative pedagogical landscape. Therefore, the core inquired in this survey delved deeply into the seamless integration of augmented reality, aiming to understand its impact on various facets of

teaching methods. The focus extended to examining not only how augmented reality is perceived by educators but also its broader implications for instructional strategies and the transformative potential it holds within the innovative pedagogical landscape. In addition to assessing the perceived impact, the survey also sought to gauge the effectiveness of augmented reality in enhancing the educational experience. By exploring the multifaceted aspects of its integration, the research aimed to contribute comprehensive insights into how this technology is shaping the contemporary educational environment (see Table 1).

Table 1

Sample Survey

Section of the questionnaire	Question
Part 1 The use of technology.	1. Do you use augmented reality in your teaching? 2. What are the conditions for using these technologies? 3. How often do you implement augmented reality in your teaching? Rarely From time to time Often Always 4. What types of augmented reality technologies do you use?
Part 2 Evaluation of the impact and effectiveness	5. On a scale of 1 to 5, how would you rate the impact of augmented reality on your teaching methods? 1 (No impact) 2 3 4 5 (Significant impact) 6. Please describe the specific ways in which augmented reality influences your teaching methods. 7. Rate the effectiveness of augmented reality technologies from 1 to 5 1 (Not effective at all) 2 3 4 5 (Very effective)
Part 3 The gaps and challenges identification	What difficulties did you face when integrating augmented reality into your teaching?
Part 4 General results	How does augmented reality contribute to the overall learning experience of your students?

Source: Author's development.

Validity. The validity of this research hinged on the careful selection of participants and the alignment of research questions with the goals of the study. The inclusion of teachers actively using augmented technologies ensures the relevance of the findings to the targeted subject matter. Additionally, efforts to capture diversity in age, teaching experience, and disciplines enhance the

external validity, allowing for potential generalisations to a broader population of educators. The survey instruments and methodologies employed in data collection contribute to the internal validity, ensuring that the study effectively measures what it intends to explore in the realm of augmented reality in education.

Reliability. The reliability in this research was upheld through consistent and standardised data collection procedures. The utilised survey instruments were pre-tested or piloted to ensure clarity and reliability in responses. The defined timeframe for data collection (from September to November, covering the first semester) adds a temporal reliability element, ensuring that responses are reflective of a specific period. Moreover, the use of quantitative measures, such as Likert scales, enhanced the reliability of the gathered data by providing a structured and consistent format for participant responses.

Result Output. The result output of this research is presented in a tabular format, as evidenced by Tables. These tables detail the participants' ratings on the impact and effectiveness of augmented reality technologies. The distribution of ratings across categories allowed for a clear visualisation of the teachers' perceptions. The use of numerical values, such as the counts of participants in each rating category, added a quantitative dimension to the output. Such structured presentation facilitated straightforward interpretation and comparison of findings, providing a foundation for meaningful discussions and conclusions in the subsequent sections of the research report.

Collecting Qualitative Data. During this period, in-depth interviews were conducted with 14 participants to gather qualitative insights. These participants agreed to be interviewed further. The interviews explored personal experiences, faced challenges, and observed benefits associated with the use of augmented reality in education.

Observation phase. Teachers were observed during actual teaching sessions using technology. The observed changes in teaching methods and student engagement were documented.

Data Analysis

In order to carry out the quantitative data analysis, statistical methods were used to analyse the main survey responses. Patterns and correlations in the quantitative data set were also examined to draw quantitative conclusions.

In order to analyse the qualitative data, a thematic analysis of the interview notes was used. Subsequently, the comparison method was also used to compare the results with the opinions of contemporary scholars. The conclusions of the study were based on the method of generalisation.

Results

The process of introducing augmented reality into educational institutions is a recent one. Initial hesitations arose from issues such as the prohibitive costs associated with hardware and content creation. However, as technology has evolved and become more affordable, there has been a gradual shift that has favoured the integration of AR into educational practice. Increased accessibility of technology has played a key role in overcoming barriers and increasing the availability of these tools for educational purposes (But & Panchenko, 2016). This change has been dramatic, allowing educators to use the immersive and interactive features of augmented and virtual reality to enhance the learning experience for students (Cobo & Rivas, 2023; Lazinski et al., 2021). Recognised as one of the most influential technologies, augmented reality has now become a prominent trend in the study of foreign languages, biology, chemistry, physics, history, and mathematics. This is underlined by the diverse

sample of respondents who have implemented AR technologies in their educational practice (see Table 2).

Table 2

What Areas Have AR Technologies Been Implemented in

Scope	% of participants
Social sciences and humanities (language, history, geography)	32% of respondents
Technical and natural sciences (physics, chemistry, biology and medicine)	38% of respondents
Formal sciences (logic and mathematics)	30% of respondents
Overall.	50 respondents

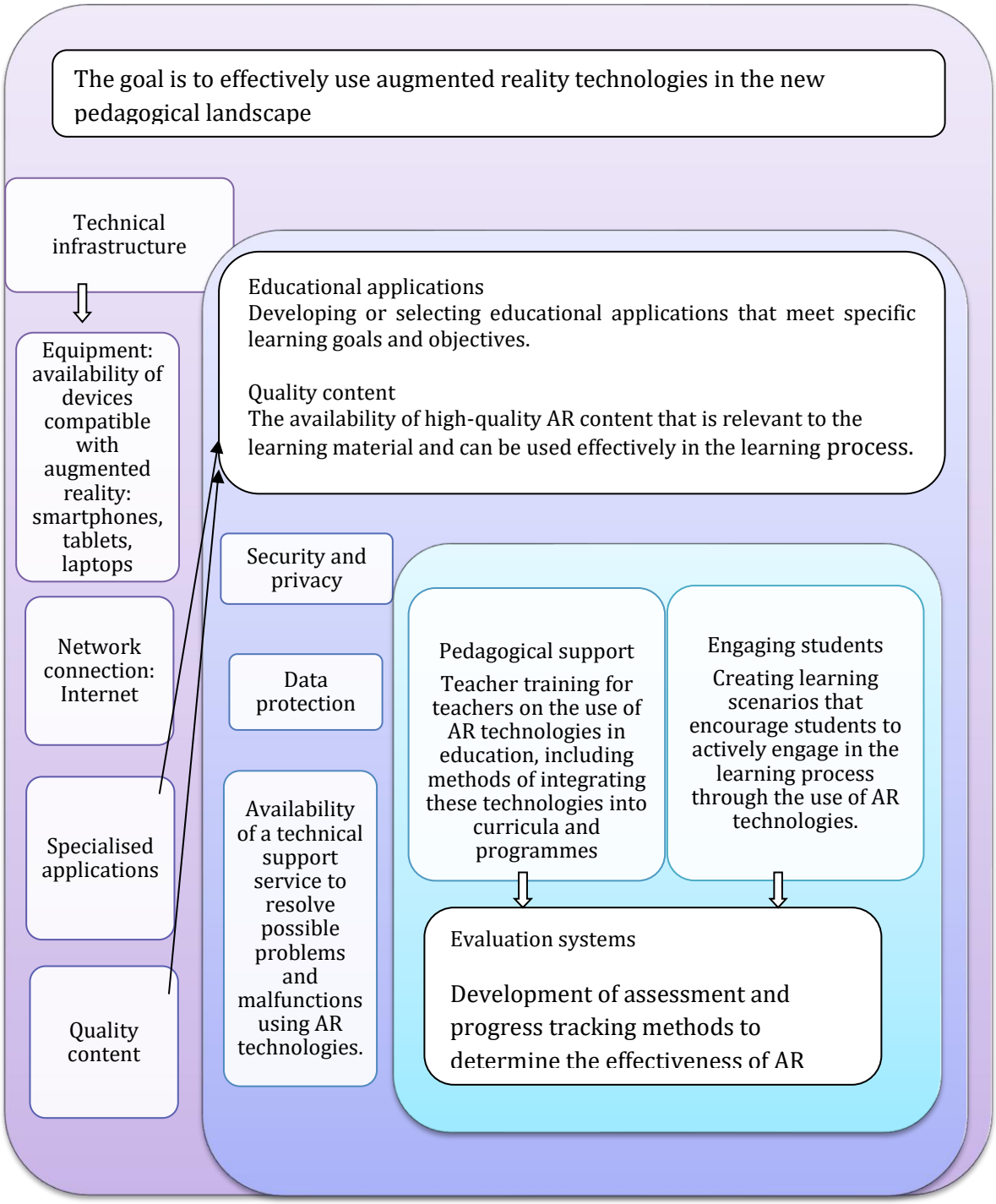
Source: Author's development.

The ability of AR to create engaging and contextualised material for language, geography, chemistry, biology, and other disciplines has attracted attention in academic and educational circles. To facilitate the implementation of AR in educational contexts, a large number of apps are available on platforms such as the AppStore and GooglePlay. These apps offer a variety of content and functionalities suitable for both classroom and individual learning experiences. The accessibility of AR apps highlights their versatility and potential to transform education by providing immersive and dynamic learning opportunities (Lai et al., 2022).

In the interview respondents noted that an important element of the success of AR applications was the use of an intuitive and generally simple interface that did not require much time to learn or get used to. In general, the effective use of augmented reality technologies in education is determined by various conditions that take into account technical, pedagogical, and organisational aspects. Technical conditions include the availability of equipment, network connectivity, and the use of special applications and high-quality content. Pedagogical conditions include pedagogical support, engaging students, supporting their motivation, and using up-to-date assessment systems. Organisational conditions include security and confidentiality, data protection of all participants (see Figure 1).

Figure 1

Diagram of the Pedagogical Landscape Based on the Use of Augmented Reality Technologies (Based on the Main Conditions of Implementation)



Source: Compiled based on the analysis by (Lai et al., 2022; Wong et al., 2022; Yan et al., 2020).

Thus, these conditions help create a favourable landscape for the successful use of AR technologies in modern education.

The systematic use of digital technologies plays an important role in the new pedagogical landscape. When asked how often they used augmented reality technologies in the classroom, teachers

answered that 40% used them continuously, 30% used them 2-3 times a week, 18% used them several times a month, and 12% used them very rarely.

At the same time, the choice of specific AR technologies may depend on the subject, the teacher's tasks, and the specifics of the learning material (Antonioli et al., 2014). Table 3 shows some examples of technologies used in teaching a particular subject.

Table 3

Examples of AR Technologies Used in Specific Disciplines

Scope	Explanation
Mathematics	Didactic AR applications. Applications that use AR to display geometric shapes, solve maths problems, and interactively learn algebraic concepts. Geodetic AR applications. Apps that allow you to learn geometry and trigonometry in a real-world environment, for example, by measuring distances and angles using the device's camera.
History	AR tours. There are separate apps that allow you to create tours of historical places, events, and characters, adding context and visual elements to the real environment (Hart, 2020). Historical AR books. Apps that use AR to bring illustrations in textbooks or history books to life by telling additional stories and facts (Raghaw et al., 2018).
Chemistry	Applications that use AR to display three-dimensional models of molecules and chemical structures, contributing to a better understanding of chemical processes (Grunewald Nichele & do Nascimento, 2017; Irwansyah et al., 2020; Le & Nguyen, 2020). Chemical Laboratories Simulations of laboratory experiments where students can interact with chemical reactions and observe their results.
Languages	AR translators Applications that use AR to recognise text and provide real-time translation, helping to learn foreign languages (Kljun et al., 2020). Interactive Language Classes Applications that create interactive scenarios for language learning using augmented phrasebooks and real-life situations (Daling et al., 2020; Zhang et al., 2020).
Medicine, biology	Anatomical AR models. Virtual AR models of organs. Creating three-dimensional models of organs for a detailed study of their structure and interaction. Anatomy visualisation Use AR to design your own anatomical scenarios where students can explore different parts of the body. Medical Simulations Creating surgical scenarios where medical students can practice performing surgeries and doing practical exercises (Andersone, 2020; Campisi et al., 2020). Simulations of clinical scenarios to train healthcare professionals in real-life conditions using AR. Ecosystems

	Creating virtual ecosystems to study biological manipulation and understand ecological interactions between different species (Puspita et al., 2022).

Source: Compiled by the authors.

In general, the choice of AR technologies in teaching can vary depending on the teacher's goals, the nature of the subject, and the specific needs of the students. Such technologies can help making the learning more engaging and effective, as when assessing the impact of AR on teaching methods, the majority of teachers rated it as a 4 - 24 people, and 19 people rated it as a 5. At the same time, 7 teachers rated it as a 3. Furthermore, it's noteworthy that the survey probed into the specific ways in which teachers implemented augmented reality in their classrooms. Some educators utilised AR for interactive simulations and virtual experiments, enhancing students' practical understanding of complex concepts. Others leveraged AR to create immersive learning experiences, fostering a more dynamic and participatory classroom environment. The diversity in the application of AR technologies underscores its versatility as a pedagogical tool and the adaptability of teachers in tailoring their approaches to meet the unique demands of their subjects and students. (see Table 4).

Table 4

Assessing the Impact of Augmented Reality Technologies

Assessment	**Number of people**
5 points	19 people
4 points	24 people
3 points	7 people
2 points	0 people
1 point	0 people

Source: compiled by the authors.

Thus, the average assessment of the impact of augmented reality on teaching methods based on data from 50 teachers is approximately 4.24 on a scale of 1 to 5.

When assessing the effectiveness of augmented technologies, the teachers provided valuable insights through a range of ratings: 1 - 0 people, 2 - 0 people, 3 - 8 people, 4 - 17 people, 5 - 25 people (see Table 5). This distribution of ratings indicates a notable positive trend, with a significant number of educators expressing a high level of satisfaction and effectiveness in integrating augmented technologies into their teaching practices.

Table 5

Evaluating the Effectiveness of Augmented Technologies

Assessment	**Number of people**
5 points	25 people
4 points	17 people

3 points	8 people
2 points	0 people
1 point	0 people

Source: Compiled by the authors.

Thus, the average assessment of the effectiveness of augmented reality technologies according to the data from evaluators is approximately 4.09 on a scale of 1 to 5. The prevalence of top-tier rating suggests that, for a considerable majority, augmented reality has not only met but exceeded expectations in contributing to enhanced pedagogical outcomes. This underscores the promising potential of augmented technologies in fostering impactful and engaging educational experiences.

Despite its highly regarded effectiveness, the process of integrating augmented reality into teaching can cause a number of difficulties that should be taken into account. Firstly, technical problems may arise. It is worth considering the fact that it can be expensive and challenging to provide appropriate equipment for all students. In addition, the modern material and technical base of the educational institution must meet the basic technical requirements of AR. This, in turn, may entail additional costs for the institution.

On the other hand, respondents noted that an important nuance was the inconsistency of the curriculum with modern technologies. In addition, creating new teaching materials that use AR can be challenging for teachers. It is also worth considering that the use of these technologies may require changes to teaching methods. Another important challenge is that the collection and processing of data using AR may raise questions about the privacy and security of students.

Discussion

In the course of this study, the main theoretical and practical principles of the formation of the new pedagogical landscape based on the use of modern educational technologies were formed. The study confirmed the positive feedback of teachers regarding the use of technology. The study of the augmented reality impact on the formation of a new pedagogical landscape has confirmed the effectiveness of AR technologies in improving the teaching methods. In this context, the statement coincides with the opinion of Almås et al. (2021) and Nazarenko (2015) regarding the difficulties that teachers may face when adapting to new technologies. It is also important considering technical support (Salinas, 2017; Soberanes-Martín, 2021), security aspects, and financial costs (Peddie, 2017), as well as privacy and data security issues (Mozelius et al., 2020).

The findings of the study are in line with Rudnik (2023) that AR programmes provide a virtual experience, but the financial costs required for their implementation should be taken into account, which can be significant (Ducasse, 2020; Truitt & Ku, 2018). In addition, learners may experience difficulties in transitioning from traditional teaching methods to AR (Truitt & Ku, 2018). In the innovative education system, Rudnik (2023) recommends using AR for visual experiences, such as the GreatPaintings VR and TheOmniGallery apps. They not only provide an immersive experience but also have educational value (Rudnik, 2023). AR's educational capabilities can be particularly useful for subjects such as fine arts, history, and English. Apps like Discovery AR allow for the integration of teaching methods and improve interactivity, creating a more holistic learning environment.

However, Long and Bouck (2022) consider that the difficulties that teachers may face in adapting to new innovative technologies are somewhat exaggerated. At the same time, research by Almås et al. (2021) and Nazarenko (2015) points to the importance of providing adequate support and training for teachers to enable them to effectively implement AR in the educational process and interact with

students in this new context. The results do not contradict the opinion of these authors about the need to study and implement AR technologies in the educational process. Nevertheless, it is important paying attention to the individual needs of teachers and providing them with support in mastering these innovations.

In general, each of the above researchers emphasises the need to create an adaptive educational environment where teachers can improve their skills and implement AR with maximum efficiency. The adoption of these technologies requires not only technical readiness but also pedagogical support to make them an integral part of the educational process.

Also, most of these researchers point out that augmented reality technologies in education open up new opportunities for innovation and development (Nazarenko, 2015; Rudnik, 2023; Salinas, 2017; Soberanes-Martín, 2021), which generally coincides with the results of this study. However, for their effective implementation, it is important to provide support for teachers and students, as well as to take into account technical, organisational, and financial aspects. Therefore, AR technologies in education open up new opportunities for innovation and development, making learning more dynamic and effective: in this way, they contribute to the creation of a completely new pedagogical landscape that is interesting for students.

The insights garnered from educators actively engaged in integrating augmented reality (AR) technologies into their teaching practices offer valuable guidance for both individual educators and educational institutions seeking to enhance their educational methodologies. Educators can leverage the positive feedback regarding the effectiveness and impact of AR technologies to inform their professional development initiatives. Targeted training programs can be designed to equip teachers with the necessary skills and knowledge to proficiently integrate AR into their lesson plans. Additionally, the identification of specific disciplines or teaching scenarios where AR has been particularly effective can guide educators in tailoring their strategies to suit the unique needs of their subjects.

Furthermore, educational institutions can use these findings to inform broader policy decisions. Investments in AR infrastructure, software, and training programs can be strategically aligned with the disciplines and contexts where AR has demonstrated significant benefits. Establishing a supportive environment that encourages experimentation and innovation with AR technologies can foster a culture of continuous improvement in teaching methodologies. Moreover, the research findings can be communicated to curriculum designers, helping them incorporate AR applications into educational materials. This ensures that the curricula are not only aligned with technological advancements but also capitalize on the immersive and engaging qualities of AR to enhance student learning experiences.

Put simply, this research has important practical applications that go beyond just individual classrooms. It provides guidance for teachers and schools on how to make the most of augmented reality in education. By taking advantage of these findings, everyone involved in education can work together to create a learning environment that is more technologically advanced and successful.

Conclusions and Implications

The results showed that in this small dataset, teachers consider AR technologies to be effective in improving teaching methods. The mean score was close to 4.09 out of a maximum of 5, indicating a positive perception of these technologies in the classroom. The high average score may indicate that many teachers considered the introduction of AR technologies to be an important and effective element of their teaching approach. Given that the maximum score was 5, the results also confirmed the high level of satisfaction of teachers with the use of these technologies in their work.

Respondents noted that the success of using AR applications in education depended on an intuitive and simple interface that did not require significant time to learn. The effective use of AR technologies was determined by technical, pedagogical, and organisational aspects. The systematic use of digital technologies played a key role in the new pedagogical landscape. Teachers' answered to the question about the frequency of using augmented reality technologies indicated their widespread use: 40% used them continuously, 30% – 2-3 times a week, 18% – several times a month, and only 12% used them very rarely.

However, it has been established that the introduction of augmented reality into education, despite its high effectiveness, can lead to difficulties. There may be technical problems and high equipment costs. Curriculum inconsistencies with modern technologies, the complexity of creating materials, and the need for changes in teaching methods are other potential problems. In addition, data security challenges can be a problem when using augmented reality in education. Therefore, further large-scale use of augmented reality technologies in the system of innovative pedagogical landscape will require addressing these issues.

Suggestions for Future Research

This study has provided a limited overview of the key components involved in integrating augmented reality into educational settings. While the findings offer valuable insights, the scarcity of data necessitates further research in several areas.

1. Consideration of different educational contexts.

A possible direction is to narrow the scope of the study to cover one specific educational institution: either from primary school or to analyse a higher education institution. In this context, it is worth comparing the feedback from teachers in different educational environments to understand how augmented reality technologies are perceived in different contexts.

2. Study of effectiveness in teaching various subjects.

A separate area is the analysis of the impact of augmented reality technologies on the teaching of specific subjects, such as mathematics, history, languages, and computer science. It is in this system that it is necessary to determine whether there are subjects where the introduction of AR is particularly effective.

3. Analysis of the impact on students

The study could be extended to focus not only on the opinions of teachers but also on the impressions and learning outcomes of students. In this context, it is worth investigating how the introduction of AR affects students' motivation, learning, and overall satisfaction. We also believe that it is worth considering how different groups of students (by age, level of study, etc.) react to the use of augmented reality technologies. Determine whether there are differences in perception among different categories of students.

4. Checking the long-term impact

In addition, given the limited period of the experiment, a separate area of research could be the long-term impact of the use of augmented reality technologies in education. This study should determine whether teachers' and students' positive attitudes towards AR remain over a long period of use.

5. Study of socio-cultural influence

There is a significant need for additional exploration in the field of investigating the socio-cultural consequences of augmented reality (AR) in education. This entails examining how cultural and societal aspects influence the acceptance and efficacy of AR technologies in various geographical areas. It is worth noting that the integration of AR in education requires an understanding of different cultural contexts. Cultural adaptation involves adapting the AR teaching process to align with the values, norms, and language of specific communities, ensuring that it resonates positively within a variety of cultural settings. In addition, it is worth considering that AR has the potential to create inclusive learning environments that respect cultural diversity. By incorporating content that reflects diverse perspectives, histories, and cultural practices, AR can contribute to more equitable representation in learning materials.

These areas can broaden the understanding of the impact of augmented reality technologies in education and contribute to further improvement of their use to improve the quality of learning and the educational process.

References

Almås, A. G., Bueie, A. A., & Aagaard, T. (2021). From digital competence to professional digital competence. *Nordic Journal of Comparative and International Education (NJCIE)*, *5*(4), 70–85. https://doi.org/10.7577/njcie.4233

Andersone, R. (2020). Innovations in the improved curriculum content of the competence approach: A case study in Latvia. *Rural Environment. Education. Personality (REEP), 13*, 213–218. https://doi.org/10.22616/reep.2020.025

Antonioli, M., Blake, C., & Sparks, K. (2014). Augmented reality applications in education. *The Journal of Technology Studies*, *40*(2), 96–107. https://doi.org/10.21061/jots.v40i2.a.4

Atanasyan, A., Kobelt, D., Goppold, M., Cichon, T., & Schluse, M. (2020). The FeDiNAR project: Using augmented reality to turn mistakes into learning opportunities. In V. Geroimenko (Ed.), *Augmented reality in education* (pp. 71–86). Springer. https://doi.org/10.1007/978-3-030-42156-4_5

But, V., & Panchenko, G. (2016). Implementation modern forms of lifelong learning in Ukraine. *Continuing Professional Education: Theory and Practice*, (3–4), 122–126. https://doi.org/10.28925/1609-8595.2016(3-4)122126

Campisi, C. A., Li, E. H., Jimenez, D. E., & Milanaik, R. L. (2020). Augmented reality in medical education and training: From physicians to patients. In V. Geroimenko (Ed.), *Augmented reality in education* (pp. 111–138). Springer. https://doi.org/10.1007/978-3-030-42156-4_7

Cobo, C., & Rivas, A. (2023). *The new digital education policy landscape: From education systems to platforms*. Taylor & Francis.

Daling, L., Kommetter, C., Abdelrazeq, A., Ebner, M., & Ebner, M. (2020). Mixed reality books: Applying augmented and virtual reality in mining engineering education. In V. Geroimenko (Ed.), *Augmented reality in education* (pp. 185–195). Springer. https://doi.org/10.1007/978-3-030-42156-4_10

Ducasse, J. (2020). Augmented reality for outdoor environmental education. In V. Geroimenko (Ed.), *Augmented reality in education* (pp. 329–352). Springer. https://doi.org/10.1007/978-3-030-42156-4_17

Irwansyah, F. S., Nur Asyiah, E., Maylawati, D. S., Farida, I., & Ramdhani, M. A. (2020). The development of augmented reality applications for chemistry learning. In V. Geroimenko (Ed.), *Augmented reality in education* (pp. 159–183). Springer. https://doi.org/10.1007/978-3-030-42156-4_9

Grunewald Nichele, A., & do Nascimento, G. (2017). Augmented reality in teaching chemistry. In *INTED2017 proceedings* (pp. 8736–8743). IATED. https://doi.org/10.21125/inted.2017.2069

Harb, G. (2019). Reshaping undergraduates research experience with station rotation learning model. *International Journal of Advanced Research*, *7*(11), 702–710. https://doi.org/10.21474/ijar01/10061

Hart, C. (2020). The romantic app: Augmented reality in fine art education. In V. Geroimenko (Ed.), *Augmented reality in education* (pp. 159–183). Springer. https://doi.org/10.1007/978-3-030-42156-4_16

Kljun, M., Geroimenko, V., & Čopič Pucihar, K. (2020). Augmented reality in education: Current status and advancement of the field. In V. Geroimenko (Ed.), *Augmented reality in education* (pp. 3–21). Springer. https://doi.org/10.1007/978-3-030-42156-4_1

Keane, T., Linden, T., Hernandez-Martinez, P., Molnar, A., & Blicblau, A. (2022). Digital technologies: Students' expectations and experiences during their transition from high school to university. *Education and Information Technologies*, *28*, 857–877. https://doi.org/10.1007/s10639-022-11184-4

Kolbina, T., & Oleksenko, O. (2020). Implementation of distance learning in Ukraine. *Educational Challenges*, *25*(1), 46–54. https://doi.org/10.34142/2709-7986.2020.25.1.04

Lazinski, M., Ross, L., Wolf, S., Finck, M., & Cherry, L. (2021). Interprofessional education at a distance: The hybrid interprofessional education model. *The Internet Journal of Allied Health Sciences and Practice, 19*(3), Article 15. https://doi.org/10.46743/1540-580x/2021.2011

Lai, Y., Saab, N., & Admiraal, W. (2022). Learning strategies in self-directed language learning using mobile technology in higher education: A systematic scoping review. *Education and Information Technologies, 27*, 7749–7780. https://doi.org/10.1007/s10639-022-10945-5

Le, H., & Nguyen, M. (2020). An online platform for enhancing learning experiences with web-based augmented reality and pictorial bar code. In V. Geroimenko (Ed.), *Augmented reality in education* (pp. 45–57). Springer. https://doi.org/10.1007/978-3-030-42156-4_3

Lichty, P. (2020). Making inside the augment: Augmented reality and art/design education. In V. Geroimenko (Ed.), *Augmented reality in education* (pp. 261–278). Springer. https://doi.org/10.1007/978-3-030-42156-4_15

Long, H. M., & Bouck, E. C. (2022). Calculators and online games: Supporting students with learning disabilities in mathematics. *Intervention in School and Clinic, 58*(4), 280–286. https://doi.org/10.1177/10534512221093787

Mladenovic, R. (2020). The usage of augmented reality in dental education. In V. Geroimenko (Ed.), *Augmented reality in education* (pp. 139–157). Springer. https://doi.org/10.1007/978-3-030-42156-4_8

Mozelius, P., Jaldemark, J., Eriksson Bergström, S., & Sundgren, M. (2020). The concept of 'Bringing your own device' in scaffolded and augmented education. In V. Geroimenko (Ed.), *Augmented reality in education* (pp. 59–70). Springer. https://doi.org/10.1007/978-3-030-42156-4_4

Nazarenko, A. L. (2015). Blended learning vs traditional learning: What works? (A case study research). *Procedia – Social and Behavioral Sciences*, *200*, 77–82. https://doi.org/10.1016/j.sbspro.2015.08.018

Paramita, A., Yulia, C., & Nikmawati, E. E. (2021). Augmented reality in nutrition education. *IOP Conference Series: Materials Science and Engineering*, *1098*, Article 022108. https://doi.org/10.1088/1757-899x/1098/2/022108

Peddie, J. (2017). Types of augmented reality. In *Augmented reality* (pp. 29–46). Springer. https://doi.org/10.1007/978-3-319-54502-8_2

Puspita, A., Bahri, A., & Latif, R. (2022). Bleanded learning dengan model pembelajaran maraja. *Biology Teaching and Learning*, *5*(2), 175–188. https://doi.org/10.35580/btl.v5i2.37770

Raghaw, M., Paulose, J., & Goswami, B. (2018). Augmented reality for history education. *International Journal of Engineering & Technology*, *7*(2.6), 121–125. https://doi.org/10.14419/ijet.v7i2.6.10136

Rudnik, Y. (2023). The use of augmented reality and virtual reality technologies in teaching foreign languages. *Educological Discourse*, *43*(1), 165–183. https://doi.org/10.28925/2312-5829.2023.110

Ruiz-Ariza, A., López-Serrano, S., Suárez-Manzano, S., & Martínez-López, E. J. (2020). The educational use of the 'Harry Potter: Wizards Unite' augmented reality application. In V. Geroimenko (Ed.), *Augmented reality in education* (pp. 247–259). Springer. https://doi.org/10.1007/978-3-030-42156-4_14

Saez-Lopez, J.-M., & Cozar-Gutierrez, R. (2020). Iberian cultures and augmented reality: Studies in elementary school education and initial teacher training. In V. Geroimenko (Ed.), *Augmented reality in education* (pp. 235–245). Springer. https://doi.org/10.1007/978-3-030-42156-4_13

Salinas, P. (2017). Augmented reality: Opportunity for developing spatial visualization and learning calculus. In G. Kurubacak & H. Altinpulluk (Eds.), *Mobile technologies and augmented reality in open education* (pp. 54–76). IGI Global. https://doi.org/10.4018/978-1-5225-2110-5.ch003

Santoveña-Casal, S., & Fernández Pérez, M. D. (2020). Sustainable distance education: Comparison of digital pedagogical models. *Sustainability*, *12*(21), Article 9067. https://doi.org/10.3390/su12219067

Soberanes-Martín, A. (2021). Augmented reality: An educational resource for the nursing graduate. In I. Management Association (Ed.), *Research anthology on nursing education and overcoming challenges in the workplace* (pp. 150–170). IGI Global. https://doi.org/10.4018/978-1-7998-9161-1.ch010

Truitt, A. A., & Ku, H.-Y. (2018). A case study of third grade students' perceptions of the station rotation blended learning model in the United States. *Educational Media International*, *55*(2), 153–169. https://doi.org/10.1080/09523987.2018.1484042

Vaughan, N. D. (2021). Blended Learning and Shared Metacognition. In A. G. Picciano, C. D. Dziuban, C. R. Graham, & P. D. Moskal (Eds.), *Blended learning: Research perspectives, Volume 3* (pp. 282–299). Routledge. https://doi.org/10.4324/9781003037736-23

Wolf, M., Söbke, H., & Baalsrud Hauge, J. (2020). Designing augmented reality applications as learning activity. In V. Geroimenko (Ed.), *Augmented reality in education* (pp. 23–43). Springer. https://doi.org/10.1007/978-3-030-42156-4_2

Wong, S. F., Mahmud, M. M., & Wong, S. S. (2022). Blackboard and virtual station rotation model: Effectiveness of learning calculus. In *ICIEI '22: Proceedings of the 7th international conference on information and education innovations* (pp. 35–40). ACM. https://doi.org/10.1145/3535735.3535741

Yan, L., Colleni, M., & Litts, B. K. (2020). Interacting across contexts: Augmented reality applications for developing the understanding of the Anthropocene. In V. Geroimenko (Ed.), *Augmented reality in education* (pp. 367–385). Springer. https://doi.org/10.1007/978-3-030-42156-4_19

Zhang, D., Wang, M., & Wu, J. G. (2020). Design and implementation of augmented reality for English language education. In V. Geroimenko (Ed.), *Augmented reality in education* (pp. 217–234). Springer. https://doi.org/10.1007/978-3-030-42156-4_12