Augmented Reality in K-12 Education

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Contributor: Christina Volioti , Euclid Keramopoulos , Theodosios Sapounidis , Konstantinos Melisidis , Maria Zafeiropoulou , Charalampos Sotiriou , Vladimiros Spiridis

Augmented Reality (AR) could provide key benefits in education and create a richer user experience by increasing the motivation and engagement of the students. Initially, AR was used as a science-oriented tool, but after its acceptance by students and teachers, it evolved into a modern pedagogical tool that was adopted into the classroom to enhance the educational process. In summary, AR-based technology has become a popular topic in educational fields in the last decade as well as in educational research [26]. Taking into consideration various modern educational disciplines, technologies such as AR must be included in the learning environment in science education; otherwise, the absence of them could possibly negatively affect productivity and learning achievements [27]. However, the educational values of AR in the domain of physical science are not exclusively based on the use of AR technologies themselves. These educational values are more likely connected to how AR is designed, implemented and integrated into formal and informal learning settings [28].

augmented reality | game-based learning | usability | K-12 education

1. Introduction

Augmented Reality (AR) has become very popular in the last few years. It is estimated that, by 2024, there will be 1.7 billion mobile AR users worldwide [1]. Initially, AR was used as a science-oriented tool, but after its acceptance by students and teachers, it evolved into a modern pedagogical tool that was adopted into the classroom to enhance the educational process [2]. The main benefit of this evolution is that AR technology is fostering motivation in learning environments [3]. It is widely accepted, as well as pedagogically correct, that learning motivation is more likely to engage students and increase learning performance [4][5]. Apart from that, AR cultivates skills, such as problem solving, observation and exploration, and it also stimulates engagement [6]. Therefore, it aims to become an integral part of modern teaching methods.

Given the combination of interactivity and immediate feedback, AR has the potential to reshape some modern learning models, such as the student-centered learning model. It is important to note that plenty of educational AR-based tools use game-based design principles which are important for the learning process and, in addition, could influence students' motivation and knowledge [7][8][9]. AR technology has the potential to become a must-have aid tool for modern classrooms, due to providing learning experiences that are contextual and embodied [10], which can be achieved by overlaying the real world with virtual data, which is one of AR's most important features [11].

Therefore, AR may be an innovative teaching method that efficiently promotes learning, and this has led to a growing number of studies being conducted recently in the field of education.

2. AR in K-12 Education

Recently, several studies have been conducted to explore the use and benefits of AR in various domains. Particularly, in teaching English courses in secondary school, Kucuk et al. [12] conducted a study that examined the motivations, attitudes and achievements when using AR technology combined with traditional textbooks. The findings revealed that students have positive attitudes towards the combination of AR and traditional textbooks. Moreover, the combination increased learning motivation, improved learning performance, and finally, students exerted a lower amount of effort to conquer the knowledge. In the domain of visual art, Serio et al. [13] performed a related course and a study in which an AR-based tool helped to present images of art from the Italian Renaissance. The results showed that the attention, relevance, confidence and satisfaction of the students were enhanced in the AR approach in relation to the traditional learning environment. Additionally, Huang et al. [2] explored the feasibility of integrating AR technology in early art education. The outcomes indicated that AR applications, from the children's point of view, promoted their engagement, enjoyment and imagination, and from the teachers' point of view, it was a useful and motivating tool that improved the teaching process, as expressed by their willingness to use and adopt the AR application in their daily teaching.

It is known that AR has recently become popular in science, technology, engineering and mathematics (STEM), especially in K-12 education. The common mechanisms, design patterns and features of STEM applications are based on knowledge discovery through interaction with augmented 3D objects. More specifically, in mathematics education, historically the usage of physical objects such as rules was accepted by the plenary sessions of the class. Similarly, the AR-based tools were easily adopted in the learning environment. In geometry, for example, AR technologies can provide a plethora of features such as augmented 3D geometric shapes and objects, as well as real-time reshaping, thus enhancing participants' exploratory learning. Based on these concepts, Kaufmann and Schmalstieg [14] developed a 3D geometric construction tool called Construct3D, targeted at high school. Using a kinesthetic learning style, the AR tool is used to improve students' spatial skills, which is the main goal of geometry.

Another popular usage of AR in education belongs to the programming section, where there are plenty of AR-based tools whose main goal is to teach either procedural or object-oriented programming [15]. Fuste and Schmandt [16] developed an AR platform, called Hypercubes, to foster computational thinking and to improve the understanding of the procedural programming model. The combination of AR with paper cubes as AR marks enhanced students' spatial skills and successfully introduced them to the concepts of instructions and sequences. Regarding robotics, AR technology can help students to easily program robots and "see the unseen" when a robot operates. The students could "see" through the sensors of the robot, resulting in adapting their code depending on the robot's behavior [17].

Several studies have also been conducted in the field of science education (such as astronomy, chemistry and physics). More specifically, for teaching astronomy, Fleck and Simon [18] conducted an experiment in elementary school to help pupils to construct scientific knowledge about the solar system and to eliminate the usual misconceptions about fundamental astronomical concepts. This exploratory study was performed on inquiry-based science education principles, upon which pupils should learn by investigating and manipulating the concept to acquire knowledge. The experiment consists of the comparison of two 3D astronomical tangible models. One model was augmented with an AR model, whereas the other was a traditional physical model. The AR model was more acceptable by pupils than the old-school 3D model because they were able to virtually move the celestial bodies and manipulate them according to their perception. The findings showed that AR users mastered more of these scientific conceptions and improved their learning. Another approach on kinesthetic learning style was made by Zhang et al. [19], in which they constructed an AR-based mobile digital armillary sphere for astronomical observation. Despite the fact that astronomy is a difficult topic to implement inside the classroom due to various reasons (e.g., limited by location or time), the AR-based observation tool assisted astronomical observations in which fifth-grade pupils could manipulate and examine the astronomical concepts in order to identify constellations. The findings indicated that the participants cultivated scientific conceptions and learning motivations, and their learning experience and observation skills were improved.

For teaching chemistry, Cai et al. [20] implemented an AR simulation system targeted at junior high school students. The students could control and combine 3D models of micro-particles in a simulated micro-world, and they could conduct experiments and compose substances. This inquiry-based learning approach is capable of conquering the fundamentals of micro-worlds. The results showed that AR combined with inquiry-based learning approaches can provide improved learning outcomes and positive attitudes towards the concepts and can cultivate problem-solving skills.

Regarding the domain of physics, Enyedy et al. [21] created an integrated AR learning environment. They were primarily aimed at pupils between the ages of 6 and 8 years old, and they focused on Newtonian force and motion concepts. Throughout the study, students were required to predict how specific forces affected the movement of an object. The findings showed that, by using this embodied learning activity in which pupils played the role of the moving object, cognitive concepts were more easily assimilated. Additionally, researchers showed that most children made significant learning progress in the fundamental concepts of the specific forces. Significant improvement was also achieved as students engaged more with the augmented forces concepts because they explored and re-constructed their conceptual knowledge through two-way interactions with AR. Additionally, Cai et al. [22] conducted a convex imaging experiment containing complex physics concepts such as image distance and focal imaging, as well as abstract concepts such as what happens when an object approaches a lens. Eighth-grade students participated in the experiment, and the results showed that engagement with AR tools created a constructive connection between their responses and their knowledge. Moreover, students assimilated the content more easily with AR as the use of technology stimulated their interest. They also concluded that AR-based scenarios increase learning performance and promote students’ activity levels. Finally, Zafeiropoulou et al. [6] proposed an AR game-based learning system for teaching physics in the fifth grade of primary school. They developed a treasure hunt game for pupils to conduct physics experiments. The results, although preliminary, showed that the AR system was usable and interesting for both pupils and teachers.

AR technology can also be combined with other technologies, such as natural interaction technology, to produce even more attractive learning tools and content in physics. Using the motion-sensing device Kinect, Cai et al. [3] implemented an AR system to teach magnetic fields in eighth grade. Using a Kinect depth camera, the students could trigger the magnetic field by moving their hands in real time. The results showed that students' experiences were more nature-like than other flash-based computer-simulated programs. Furthermore, the authors supported the idea that the participants' learning was enhanced in a more intuitive way by obtaining real-time feedback on their actions. An increase in motivation was also observed through the whole time process. Finally, Pittman and LaViola [23] conducted a qualitative study to determine the effects and attitudes on potential AR utility in secondary physics courses. They created a prototype application, PhyAR, which was based on Unity3D and used a Microsoft HoloLens device. PhyAR provided self-contained demonstrations from secondary physics courses such as Coulomb's law, elastic collision, parallel circuits, volume, magnetic fields, and the Doppler ffect. The findings showed a clear desire for all new AR-based physics-oriented tools.

Leveraging the aforementioned studies, the use of AR technologies combined with pedagogical methods could provide an advantageous learning experience that can enhance learning outcomes. Nevertheless, these technologies pose some limitations due to the required technology literacy. According to Tobar-Muñoz et al. [24], there is usually a gap between the collaborated members (e.g., game developers and teachers) in using AR applications due to different expertise in creating learning experiences. Professional game developers are usually isolated from the real classroom environment, and they do not know the educational approaches in teaching. In addition, teachers usually lack the expertise and time to construct AR applications. These barriers, from the teachers' perspective, could result in their unwillingness to adopt AR in their class [25]. Therefore, it should be made clear that, in order to construct an appropriate pedagogical AR-based tool, all stakeholders should be trained on how to use and construct effective and efficient learning experiences.

In summary, AR-based technology has become a popular topic in educational fields in the last decade as well as in educational research [26]. Taking into consideration various modern educational disciplines, technologies such as AR must be included in the learning environment in science education; otherwise, the absence of them could possibly negatively affect productivity and learning achievements [27]. However, the educational values of AR in the domain of physical science are not exclusively based on the use of AR technologies themselves. These educational values are more likely connected to how AR is designed, implemented and integrated into formal and informal learning settings [28].

References

1. Number of Mobile Augmented Reality (AR) Active Users Worldwide from 2019 to 2024. Available online: https://www.statista.com/statistics/1098630/global-mobile-augmented-reality-ar-users/ (accessed on 6 January 2022).

2. Huang, Y.; Li, H.; Fong, R. Using Augmented Reality in early art education: A case study in Hong Kong kindergarten. Early Child Dev. Care 2016, 186, 879–894.
3. Cai, S.; Chiang, F.; Sun, Y.; Lin, C.; Lee, J. Applications of augmented reality-based natural interactive learning in magnetic field instruction. Interact. Learn. Environ. 2016, 25, 778–791.
4. Schmidt, J.T. Preparing Students for Success in Blended Learning Environments: Future Oriented Motivation and Self-Regulation. Ph.D. Thesis, University of Southampton, Southampton, UK, 2007.
5. Efklides, A.; Kuhl, J.; Sorrentino, R.M. Trends and Prospects in Motivation Research; Springer: Dordrecht, The Netherlands, 2001.
6. Zafeiropoulou, M.; Volioti, C.; Keramopoulos, E.; Sapounidis, T. Developing Physics Experiments Using Augmented Reality Game-Based Learning Approach: A Pilot Study in Primary School. Computers 2021, 10, 126.
7. Fotaris, P.; Pellas, N.; Kazanidis, I.; Smith, P. A systematic review of augmented reality game-based applications in primary education. In Proceedings of the 11th European Conference on Game-Based Learning, Graz, Austria, 5–6 October 2017.
8. Plass, J.L.; Homer, B.D.; Kinzer, C.K. Foundations of Game-Based Learning. Educ. Psychol. 2015, 50, 258–283.
9. Perrotta, C.; Featherstone, G.; Aston, H.; Houghton, E. Game-Based Learning: Latest Evidence and Future Directions (NFER Research Programme: Innovation in Education); NFER: Slough, UK, 2013.
10. Johnson, L.; Smith, R.; Willis, H.; Levine, A.; Haywood, K. The 2011 Horizon Report; The New Media Consortium: Austin, TX, USA, 2011.
11. Azuma, R.; Baillot, Y.; Behringer, R.; Feiner, S.; Julier, S.; MacIntyre, B. Recent advances in augmented reality. IEEE Comput. Graph. Appl. 2001, 21, 34–47.
12. Kucuk, S.; Yilmaz, R.; Goktas, Y. Augmented Reality for Learning English: Achievement, Attitude and Cognitive Load Levels of Students. Educ. Sci. 2014, 39, 393–404.
13. Di Serio, Á.; Ibáñez, M.B.; Kloos, C.D. Impact of an augmented reality system on students' motivation for a visual art course. Comput. Educ. 2013, 68, 586–596.
14. Kaufmann, H.; Schmalstieg, D. Mathematics And Geometry Education With Collaborative Augmented Reality. Comput. Graph. 2013, 27, 339–345.
15. Theodoropoulos, A.; Lepouras, G. Augmented Reality and programming education: A systematic review. Int. J. Child-Comput. Interact. 2021, 30, 100335.

16. Fuste, A.; Schmandt, C. HyperCubes: A Playful Introduction to Computational Thinking in Augmented Reality. In Extended Abstracts of the Annual Symposium on Computer-Human Interaction in Play Companion Extended Abstracts; Association for Computing Machinery: New York, NY, USA, 2019; pp. 379–387.
17. Cheli, M.; Sinapov, J.; Danahy, E.E.; Rogers, C. Towards an augmented reality framework for k-12 robotics education. In Proceedings of the 1st International Workshop on Virtual, Augmented, and Mixed Reality for HRI (VAM-HRI), Chicago, IL, USA, 5 March 2018.
18. Fleck, S.; Simon, G. An Augmented Reality Environment for Astronomy Learning in Elementary Grades: An Exploratory Study. In Proceedings of the 25th Conference on l'Interaction Homme-Machine, Talence, France, 12–15 November 2013.
19. Zhang, J.; Sung, Y.T.; Hou, H.T.; Chang, K.E. The development and evaluation of an augmented reality-based armillary sphere for astronomical observation instruction. Comput. Educ. 2014, 73, 178–188.
20. Cai, S.; Wang, X.; Chiang, F.K. A case study of augmented reality simulation system application in a chemistry course. Comput. Hum. Behav. 2014, 37, 31–40.
21. Enyedy, N.; Danish, J.A.; Delacruz, G.; Kumar, M. Learning physics through play in an augmented reality environment. Int. J. Comput. Support. Collab. Learn. 2012, 7, 347–378.
22. Cai, S.; Chiang, F.; Wang, X. Using the Augmented Reality 3D Technique for a Convex Imaging Experiment in a Physics Course. Int. J. Eng. Educ. 2013, 29, 856–865.
23. Pittman, C.; LaViola, J.J. PhyAR: Determining the Utility of Augmented Reality for Physics Education in the Classroom. In Proceedings of the 2020 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW), Atlanta, GA, USA, 22–26 March 2020; pp. 760–761.
24. Tobar-Muñoz, H.; Baldiris, S.; Fabregat, R. Co Design of Augmented Reality Game-Based Learning Games with Teachers Using Co-CreaARGBL Method. In Proceedings of the 16th International Conference on Advanced Learning Technologies (ICALT), Austin, TX, USA, 25–28 July 2016.
25. Li, H. Integrating ICT into the early childhood curriculum: Chinese principals' views of the challenges and opportunities. Early Educ. Dev. 2006, 17, 467–487.
26. Akçayır, M.; Akçayır, G. Advantages and challenges associated with augmented reality for education: A systematic review of the literature. Educ. Res. Rev. 2017, 20, 1–11.
27. Fidan, M.; Tuncel, M. Integrating augmented reality into problem based learning: The effects on learning achievement and attitude in physics education. Comput. Educ. 2019, 142, 103635.

28. Wu, H.-K.; Lee, S.W.-Y.; Chang, H.-Y.; Liang, J.-C. Current status, opportunities and challenges of augmented reality in education. Comput. Educ. 2013, 62, 41–49.

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