International Journal of Advanced Virtual Reality

Volume: 1, Issue: 1, Page: 20-25, Year: 2023
http://www.journals.leukolion.com

Augmented Reality as a Performance Enhancement Technology in Primary Education: A Systematic Review

Mani Das Runu[1] and J. V. Madhusudan[2]

[1] *University of Hyderabad, India, runumanidas123@gmail.com, ORCID: 0000-0003-0583-7603*
[2] *University of Hyderabad, India, madhusudanjv@uohyd.ac.in, ORCID: 0000-0002-6582-0152*

Article History:
Received: 16 Feb 2022
Revised: 21 Feb 2022
Accepted: 20 May 2022
Online: 21 Feb 2023

Keywords:
Augmented Reality
Augmented Reality Application
Primary Education
Systematic Review

Abstract
Augmented reality combines virtual objects into the real environment to enhance the performance of the real environment. In the educational field, augmented reality has been used to improve learner performance and make education advantageous. Especially in primary education, applications related to augmented reality have been developed to make education interesting and meaningful. However, only a few studies have analyzed and discussed the effectiveness of augmented reality on students' performance in primary education. In this context, the author seeks to find out the factors related to AR that enhances students' performance in primary school. Based on the previous studies, this study provides a systematic review of current knowledge and information. Mainly 14 research papers referred to the topic have been chosen to analyze the data which were published from 2018 to 2021. The result shows augmented reality applications have positive effects on learners' performance. The observation and results signify that augmented reality applications enhance the learners' motivation, interest, and academic performance of the learner.

Contents

How to Cite

Runu, M. D. and Madhusudan, J. V. (2023). Augmented Reality as a Performance Enhancement Technology in Primary Education: A Systematic Review. *International Journal of Advanced Virtual Reality*, 1(1), 20-25.

1. Introduction

In an educational setting, primary education is the first stage of formal education. It is the stage of learning basic concepts and acquiring basic information of formal education. Primary education mostly focused on playful learning for the development of the cognitive abilities of the learner in a joyful way. Therefore, teaching methods in primary education need to be modified and explore different aspects to enhance the learner's performance in primary education.

Integration of technology in the teaching-learning process is exploring new ways of enhancing students' performance. The use of ICT tools, virtual reality, mixed reality, digital games, etc. is the recent technological integration in the primary education system. Within these, augmented reality is also one of the enhanced technologies that have been developing an increasing interest in today's primary educational field.

In primary education, augmented reality effectively organizes the learner's learning habits by imposing AR applications and tools. The term augment has been derived from the Latin word **"augmentare"** which is indicated to enhance the real world with virtual aspects. Augmented reality (AR) produces a reality that is enhanced and augmented by bridging the virtual and real worlds (Wu et al., 2013). Real-world objects can be blended with virtual objects or superimposed information utilizing an augmented reality application. Subsequently, virtual items appear to cohabit with the real world in the same place (Bacca-Acosta et al., 2015).

AR apps run on mobile devices like smartphones and tablets and use built-in cameras, GPS sensors, and Internet connection to embed dynamic, context-aware, and interactive digital information in real-world (Chiang et al., 2014; Zhang et al., 2014). In primary education, Augmented Reality is used to make learning joyful and active. Considering the reviews, most studies focused on game-based learning applications in primary education. Therefore, the present study focuses on the positive effects of augmented reality applications in primary education, which enhances the learner's performance. This study also deals with the factors that depend on suitable teaching methods, learning environment of AR application that enhance learning in primary education. The research questions of our study are shaped and labelled as follows:

RQ1: What are the positive effects of augmented reality applications that enhance the performance of the learner in primary education published in between 2018-2021 research studies?

RQ2: What are the most suitable teaching methods and learning environments used to apply AR in the classroom in primary school to enhance learner performance published in between 2018-2021 research studies?

RQ3: What are the subjects that mostly used AR applications in primary school published in between 2018-2021 research studies?

RQ4: How factors of AR-enhanced performance of learners in primary school?

2. Literature Review

Research conducted by Dimitriadou et al. (2020) discussed the application of AR at the primary level to explain mathematical activities improve interactivity and students' interest. An investigation done by Safar et al. (2017) pointed out the use of augmented reality in primary school to increase English learning. Augmented reality uses 2D, 3D models, a live visual concept to connect the real world with a virtual object (Sáez-López et al., 2019). Fotaris et al. (2017) on a systematic review of augmented reality game-based learning in primary education has described the games that have been used to teach in primary education children. In total 17 studies from 2012 to 2017 have been covered in the study. The study has given importance to discussing verities of game-based applications that have been used in primary education. AbdulJabbar and Felicia (2015) in their systematic review of game play engagement and learning through games tried to find the impact of game features on cognitive and emotional levels. Another study by Bacca-Acosta et al. (2014) analyzed 32 studies between 2003 to 2013, concerned the scientific review of augmented reality trends in education discussed the challenges, attributes, and utilization of augmented reality in the educational process.

3. Materials and Methods

This research employs the "Systematic Review" method. A sort of literature review is a systematic review. The basic goal of a systematic review is to find all relevant subjects to a single topic. The systematic review method is used to analyze and evaluate a huge number of resources related to one particular field (Fotaris et al., 2017). Kitchenman proposed the idea of Systematic Review (Kitchenham and Charters, 2007) to utilize the previous literature systematically. Kitchenman's Systematic Review process includes three steps: Planning the Review, Administering the Review Process and Reporting the Review.

3.1 Planning the Review:

The first step is called Planning the Review and consists of the journal selection,criteria for inclusion and exclusion, categories of analysis.

3.1.1 Selection of Journal

In the initial stage, the appropriate journals are selected. The selection of journals process depends on the suitable method and scientifically relevant data. Initially, Google Scholar, ERIC, JSTOR, Springs abstracts, Research Gate articles have been chosen for journal selection of educational technology category. Journals such as the Asian Journal of university education, Journal of Computer Assisted Learning, Education and Information Technologies, Education Science, Research in Learning Technologies, etc. are selected for the present research topic.

3.1.2 Inclusion and Exclusion

Various researches have been conducted regarding augmented reality based on educational benefits. Especially use of AR in primary education has been considered as specific criteria and included in the study. Application of AR to enhance students' performance, a new application used to deliver information through AR, students active learning with AR have been included in the study.

Research that discusses the application of augmented reality in another educational setting such as secondary education, higher education has been excluded. Articles that are based on a comparison of AR, VR, and Mixed Reality, review-based articles, book chapters are excluded from the category.

3.1.3 Categories of analysis

Data are analyzed and categorized according to each research question are analyzed in group categories and subcategories. Augmented reality applications, subjects that are used for teaching augmented reality, teaching methods used for augmented reality are the category that has been discussed in the results and discussion part.

3.2 Administering the review process

The second step is called Administering the Review Process and consists of selection of study, extraction of data, synthesis of data, and coding of data

3.2.1 Selection of the study

The present study selected articles based on the application of augmented to teach different disciplines in primary school. Mainly, the method of the studies is based on experimental and quasi-experimental methods. In total 14 studies were selected between 2018-2021 for the present study.

3.2.2 Data extraction and data coding:

Data extraction and data coding have been completed after reading and understanding all the 14 review papers thoroughly. Data extraction and the coding process have been done by extracting main points and key terms from the studies and then coded as positive effects- enhance subject performance, enhance educational and cognitive values, active and joyful learning, etc. Factors coded as a teaching method, learning environment, suitable subject, teaching professional, etc. are the terms that have been selected from the reviews of augmented reality.

3.3 Reporting the Review

The third step is called Reporting the Review and consists of discussion and interpretation of the data. Table 1 shows the total studies with subjects, methods, findings of augmented reality applications in primary education. 4

Overall studies provide information regarding the effects of augmented reality applications, teaching methods used, and subjects that studies carried out.

4. Findings and Discussion

RQ1: What are the positive effects of augmented reality applications that enhance the performance of the learner in primary education published in between 2018-2021 research studies?

As per Table 1, most of the studies reported that augmented reality has positive effects on the performance of the learner. Augmented reality applications have potentially enhanced students' motivation, interest, subject performance, attitude, cognitive values, etc.

RQ2: What are the teaching methods and learning environments used to apply AR in the classroom in primary school to enhance learner performance published in between 2018-2021 research studies?

In the studies, as illustrated in Fig. 1, most of the experimental studies preferred indoor learning environments and used augmented reality game-based learning, ICT with the teacher-centered method, play and learn the method. On the other hand, few studies had conducted an experiment in outdoor learning environments that used the project method, outdoor games-sports.

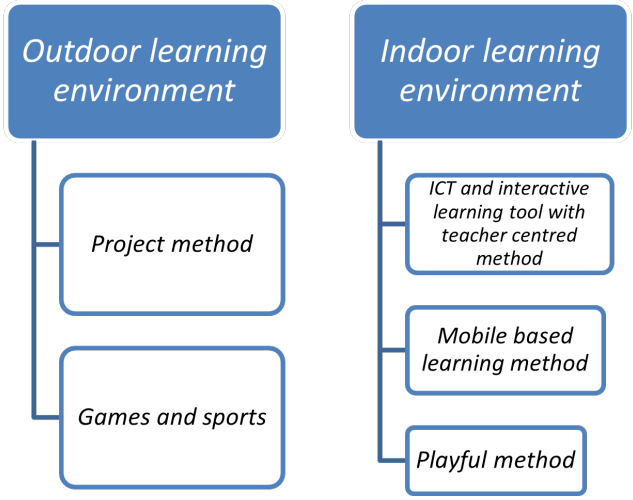

Figure 1. Teaching methods and learning environment for AR technology

RQ3: What are the subjects that mostly used AR applications in primary school published in between 2018-2021 research studies?

In a total of 14 studies, as illustrated in Fig. 2, half of the studies conducted research on science subjects i.e., 50%, whereas 35% shows that language subjects used AR to improve the language skills of primary school learners. Along with these, social science and physical education consist of 14% respectively.

RQ4: How factors of AR enhance the performance of learners in primary school?

Table 1. An Overall outline of Scientific Research in Primary Education

Research Studies	Types of Application	The subject of the study	Research Method	Results and Observation
Lu et al. (2018)	AR embedded physical puzzle game	Evaluation of AR embedded physical puzzle game on students' learning achievement and motivation on elementary natural science	Quasi-experimental design	Enhances specific knowledge in natural science
Pombo and Marques (2019)	EduPARK	The potential educational value of mobile augmented reality games: the case of EduPARK app	Mixed-method approach	Enhance educational values, interest and promote learning
Lubis and Nur Wangid (2019)	A-R Assisted Pictorial Story Book	AR-assisted pictorial storybook:media to enhance discipline character of primary school students	Quantitative Approach	Enhanced disciplinary character of the learner
Sáez-López et al. (2019)	WallaMe- An Ambiquitious Game	Application of the ubiquitous game with augmented reality in primary education	Quasi-experimental Design	Improvement in the academic performance and competence in information search and analysis of the subject, developed motivation and enjoyment, level of fun, information search skill and collaboration.
Lozada et al. (2019)	KARLMS	Augmented Reality-MS kinect in the learning of basic mathematics: KARMLS case	Quantitative approach	KARMLS has an important effect on the students. The positive effect of using computer-supported AR-based technology
Wu (2019)	Pokemon Go	The applications and effects of learning English through augmented reality: a case study of pokemon Go	Experimental method	Significant in learning performance and promote learning attitude, satisfaction and, achievement
Kumpulainen et al. (2020)	MyAR Julle	Children's augmented storying in with, and for nature	Narrative study	Improved cognitive learning, joyful and active learning
Baran et al. (2020)	Mobile Augmented Visual Reality	Application of Mobile Augmented Visual Reality (MAVR) for vocabulary learning in the ESL classroom	Repeated Measure Experimental Design	Students' vocabulary managed to be improved and AVR helps to develop motivation and interest among learner
López-Faican and Jaen (2020)	EmoFindAR Application	EmoFindAR: evaluation of a mobile multiplayer augmented reality game for primary school chidren	Experimental design	Satisfy learner with constructive empathy such as happiness, fun, and inquisitiveness which improves learner's performance
Wen (2020)	AR-Supported Chinies Character Learning Game	Augmented reality enhanced cognitive engagement: designing classroom based collaborative learning activities for young language learners	Mixed method	In the AR supported learning improve cognitive and rational engagement of the students
Jalaluddin et al. (2021)	Mobile Augmented Visual Reality	Application of Mobile Augmented Visual Reality (MAVR) for vocabulary learning in the ESL classroom	Experimental method	Students vocabulary managed to be improved and AVR helps to develop motivation and interest among learner
Midak et al. (2020)	AR-Technology in Lico.STEM Mobile App	Augmented reality technology within studying natural subjects in primary schools	Experimental method	Results show that students developed interest, curiosity, cognitive motivation, etc.
Midak et al. (2021)	AR technology in Lico.STEM Mobile App	AR technology to study the astronomic subject in primary school	Experimental method	Improve critical thinking, motivation, understanding the concept, power of memorization.
Safar et al. (2017)	AR smart flashcard application	Basic geometry shapes, creative thinking and motivation	Quasi-experimental method	Enhance geometry learning, enhance academic performance, creative thinking, positive relationship between augmented manipulative and creative skills, motivation has been found in the study.

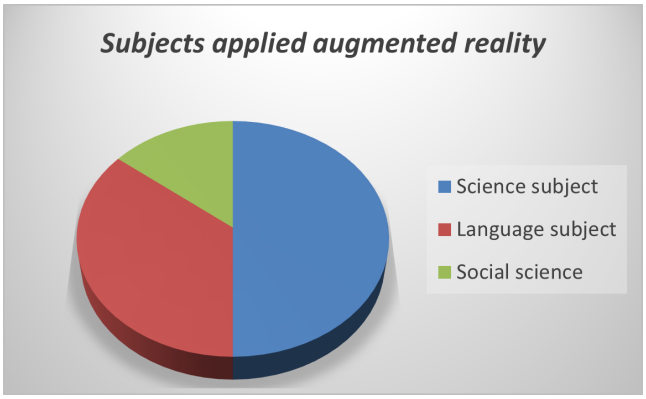

Figure 2. Subjects used to apply augmented reality

Teachers' teaching style, technology awareness, training in technology, learning environment, a suitable subject for AR application are the factors that improve the performance of the learner. The above Table 1 discussed the importance of the availability of teaching staff, ICT tools, trained professionals, internet connectivity, mobile phones/computer to support AR learning in the classroom. Overall, learners' performance depends on the factors of AR application to enhance students' performance in an educational setting.

Overall, the study discloses that a) augmented reality applications have positive effects on learners performance since findings show that learner develops motivation, subject interest, cognitive value, learning interest with the use of augmented reality application in primary education b) Science, STEM are the subjects that AR applications have been used mostly, c) Mobile learning with teacher center method, project method, laboratory, group discussion are the teaching methods that AR used to enhance the performance of the learner d) Teaching method, learning environment, subjects, professional expert are the principal factors of AR enhancement learning.

5. Conclusion

In conclusion, the present review is designed to bring light to different factors of augmented reality application in primary education which enhances the learning performance of the learner. The result of the study may incorporate new knowledge and ideas about the enhancement of primary education by applying augmented reality applications. The study shows the positive effects of augmented reality applications in primary education to enhance the performance of the learner. The positive effects of augmented reality applications help learners to develop a positive attitude, motivation, interest to learn interestingly. Factors of AR applications need to be considered while applying AR technology in the educational system. Teaching methods, professional experts, subjects, internet connectivity, technological tools, mobile, and computer should be available in the educational settings to apply AR technology. However, remote areas, poor internet connectivity in the school, lack of trained teachers are the aspects of the hindrance of using AR in an educational setting. This review has focused only on the factors and positive effects of AR applications in primary education which enhances the performance of the learner. Although, game-based learning with AR, the negative impact of AR application in psycho-social learning needs to be considered as an important aspect while applying AR-based technology in primary education.

Acknowledgments

We would like to inform our reader that some findings of our study are presented in the 3rd International Conference on Virtual Reality, November, 15-16, 2021, Şanlıurfa, Türkiye.

References

AbdulJabbar, A. I. and Felicia, P. (2015). Gameplay engagement and learning in game-based learning: A systematic review. *Review of Educational Research*, 85(4):740–779.

Bacca-Acosta, J., Baldiris, S., Fabregat, R., Graf, S., and Kinshuk, D. (2014). Augmented reality trends in education: A systematic review of research and applications. *Educational Technology and Society*, 17:133–149.

Bacca-Acosta, J., Baldiris, S., Fabregat, R., Kinshuk, D., and Graf, S. (2015). Mobile augmented reality in vocational education and training. *Procedia Computer Science*, 75:49–58.

Baran, B., Yecan, E., Kaptan, B., and Paşayiğit, O. (2020). Using augmented reality to teach fifth grade students about electrical circuits. *Education and Information Technologies*, 25.

Chiang, T., Yang, S., and Hwang, G.-J. (2014). An augmented reality-based mobile learning system to improve students' learning achievements and motivations in natural science inquiry activities. *Educational Technology and Society*, 17:352–365.

Dimitriadou, E., Stavroulia, K.-E., and Lanitis, A. (2020). Comparative evaluation of virtual and augmented reality for teaching mathematics in primary education. *Education and Information Technologies*, 25.

Fotaris, P., Pellas, N., Kazanidis, I., and Smith, P. (2017). A systematic review of augmented reality game-based

applications in primary education. In *11th European Conference on Games Based Learning (ECGBL)*, pages 181–191.

Jalaluddin, I., Darmi, R., and Ismail, L. (2021). Application of mobile augmented visual reality (mavr) for vocabulary learning in the esl classroom. *Asian Journal of University Education*, 17(3):162–173.

Kitchenham, B. A. and Charters, S. (2007). Guidelines for performing systematic literature reviews in software engineering. Technical Report EBSE 2007-001, Keele University and Durham University Joint Report.

Kumpulainen, K., Byman, J., Renlund, J., and Wong, C.-C. (2020). Children's augmented storying in, with and for nature. *Education Sciences*, 10:149.

Lozada, R., La-Serna-Palomino, N., and Molina, F. (2019). Augmented reality and ms-kinect in the learning of basic mathematics: Karmls case. *International Education Studies*, 12:54.

Lu, S.-J., Liu, Y.-C., Chen, P.-J., and Hsieh, M.-R. (2018). Evaluation of ar embedded physical puzzle game on students' learning achievement and motivation on elementary natural science. *Interactive Learning Environments*, 28(4):451–463.

Lubis, A. and Nur Wangid, M. (2019). Augmented reality-assisted pictorial storybook: Media to enhance discipline character of primary school students. *Mimbar Sekolah Dasar*, 6:11.

López-Faican, L. and Jaen, J. (2020). Emofindar: Evaluation of a mobile multiplayer augmented reality game for primary school children. *Computers & Education*, 149:103814.

Midak, L., Kravets, I., Kuzyshyn, O., Berladyniuk, K., Buzhdyhan, K., Baziuk, L., and Uchitel, A. D. (2021). Augmented reality in process of studying astronomic concepts in primary school. pages 239–250.

Midak, L., Pahomov, J., Lutsyshyn, V., Uchitel, A., and Rih, K. (2020). Augmented reality technology within studying natural subjects in primary school. In *CEUR Workshop Proceedings*.

Pombo, L. and Marques, M. M. (2019). Learning with the augmented reality edupark game-like app: Its usability and educational value for primary education. In Arai, K., Bhatia, R., and Kapoor, S., editors, *Intelligent Computing*, pages 113–125, Cham. Springer International Publishing.

Safar, A., Al-Jafer, A., and Al-Yousefi, Z. (2017). The effectiveness of using augmented reality apps in teaching the english alphabet to kindergarten children: A case study in the state of kuwait. *EURASIA Journal of Mathematics, Science and Technology Education*, 13(02):417–440.

Sáez-López, J.-M., Sevillano-García-García, M., and Pascual Sevillano, M. A. (2019). Application of the ubiquitous game with augmented reality in primary education. *Comunicar*, 27.

Wen, Y. (2020). Augmented reality enhanced cognitive engagement: designing classroom-based collaborative learning activities for young language learners. *Educational Technology Research and Development*, 69(02):843–860.

Wu, H.-K., Lee, S. W.-Y., Chang, H.-Y., and Liang, J.-C. (2013). Current status, opportunities and challenges of augmented reality in education. *Computers & Education*, 62:41–49.

Wu, M.-H. (2019). The applications and effects of learning english through augmented reality: a case study of pokémon go. *Computer Assisted Language Learning*, 34:1–35.

Zhang, J., Sung, Y.-T., Hou, H.-T., and Chang, K. (2014). The development and evaluation of an augmented reality-based armillary sphere for astronomical observation instruction. *Computers & Education*, 73:178–188.