INTERNATIONAL JOURNAL OF SOCIAL SCIENCE AND BUSINESS MANAGEMENT (IJSSBM)
(e-ISSN: 3009-0091) (Vol.01, ISSUE 02, 74-84)

EXPLORING THE USE OF MOBILE AUGMENTED REALITY IN ENHANCING STUDENTS' LEARNING OUTCOMES

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ABSTRACT – This article explored the use of mobile augmented reality in enhancing the learning outcomes of special education students. Twelve special education students participated in a qualitative case study that included pre- and post-tests, observations, and interviews. The outcomes showed that the students' learning outcomes were improved by an average of 13% between their pre-test and post-test scores when they used the mobile AR software. The results of the t-test and the Pearson correlation coefficient were determined to be 0.7107 and -8.62311 respectively, showing a significant difference between the two outcomes and a substantial positive correlation between the pre-test and post-test scores. The results of the observations and interviews showed that the students were very motivated and engaged, and that using the app had enhanced their capacity for critical thought and problem-solving. The results show how augmented reality has the potential to enhance student learning outcomes and imply that mobile AR can offer special education students an immersive and engaging learning experience that will boost their motivation, engagement, and critical thinking and problem-solving abilities.

ARTICLE HISTORY
Received: 01/10/2023
Revised: 20/11/2023
Accepted: 1/12/2023

KEYWORDS
Mobile Augmented Reality
Learning Outcomes
Special Education
Critical Thinking
Problem-Solving

INTRODUCTION

Mobile augmented reality (AR) enables users to interact with and manipulate virtual things in real time by fusing virtual objects, such as 3D graphics, with real-world situations (Venkatesan et al., 2021). Since its uses have been expanded to other industries, including education, gaming, and entertainment, it has grown in popularity. AR technology has the ability to change how students learn by enabling immersive, interactive experiences (Elmqaddem, 2019).

Mobile augmented reality (AR) has the power to completely change how students learn in an educational setting. By offering an immersive and engaging learning environment, it can aid students in understanding and remembering the subject matter (Roopa et al., 2021). It can be used to produce augmented reality textbooks, for instance, where students can interact with 3D models and diagrams to better comprehend the subject matter. In order to better grasp the subject of anatomy, for instance, students can use mobile AR to examine anatomical structures in 3D (Mendez-Lopez et al., 2022). Virtual field trips can be organized using AR to provide students a more immersive experience of their surroundings.

Student collaboration and communication have been found to improve when mobile AR is used in the classroom. A more collaborative and interactive learning environment can be promoted by giving students more engaging opportunities to interact with digital content. Mobile AR, for instance, can be used to build virtual classrooms where students can collaborate on tasks and projects in real-time (Papanastasiou et al., 2019). This may encourage student cooperation and teamwork, which will improve learning outcomes. It can also be used to make interactive simulations, giving students a more interesting and dynamic way to learn about difficult ideas. Additionally, using mobile AR to make learning more pleasurable can increase student motivation (Radu and Schneider 2019).

Students in special education frequently experience learning difficulties that call for a distinctive method of instruction. Mobile AR has the power to revolutionize the way students in special education study. AR can offer real-time feedback and assessment, enabling teachers to more effectively monitor student progress and modify their instruction (Baragash et al. 2020). By doing this, you may help make sure that every student gets the teaching they need to optimize their learning potential. Additionally, mobile AR can be used to develop customized virtual learning environments for every learner

(Kiryakova et al, 2018). These immersive learning settings can give students a hands-on, interesting experience that will help them comprehend and remember the subject.

Additionally, mobile augmented reality can give pupils a more specialized educational experience. For each student, teachers can design a unique lesson plan, enabling them to concentrate on the areas in which they need the greatest assistance. Additionally, mobile AR can give students visual cues and reminders so they can stay on task and finish projects on time (Ariano et al., 2022). This can help students manage their time more effectively and stay on track with their academic goals.

Due to its ability to create immersive and interesting learning environments, mobile AR in education has gained appeal in recent years. Mobile AR has the potential to enhance learning outcomes, however there is little concrete evidence to back up these claims. The potential for mobile augmented reality (AR) to improve the learning results of special education children is the issue addressed in this study. The study's goal is to produce empirical data proving how the usage of mobile AR may improve students' critical thinking, problem-solving, motivation, and participation in special education. The importance of this issue is that special education children frequently require individualized training in order to achieve academic achievement, and mobile AR offers the possibility to create personalized and engaging learning experiences. If the potential of mobile AR in special education is not explored, chances to improve the quality of education delivered to special education children may be lost.

This investigation will contribute to the body of information presently accessible on the use of mobile AR in education. Empirical evidence demonstrating how mobile AR may improve learning outcomes for kids in special education will be used to support the usage of mobile AR in the classroom. Additionally, it will shed light on how to make the most of mobile augmented reality in the classroom. Additionally, this paper will give policy makers and educators a comprehension of how mobile AR could enhance student learning results and the tactics that could be employed to guarantee effective usage of this technology.

The article's remaining sections are organized as follows. In Section 2, the literature on mobile AR in education is evaluated. In Section 3, the study methodology is explained. Section 4 presents the study's findings. The implications of the findings are discussed in Section 5. The last section, Section 6, concludes the study.

LITERATURE REVIEW

This literature review will examine the existing research on the use of mobile augmented reality in enhancing students' learning outcomes. This section will explore the various studies that have been conducted to evaluate the impact of augmented reality on student learning outcomes and identify gaps in the literature and discuss how this study aims to fill those gaps.

Review of Past Literature

A path analysis was done by Darvishi et al. (2020) to look into the variables affecting how much people enjoy learning with AR. The study evaluated how perceived enjoyment was impacted by aesthetically pleasing design, interactivity, meaningfulness of content, perceived usefulness, and perceived usability. To determine the impact of the aforementioned factors on how much university students enjoyed learning with AR, researchers used a questionnaire-based survey. The findings indicated that perceived enjoyment was most strongly influenced by perceived meaningfulness of content, followed by perceived usefulness and interactivity. Perceived ease of use and aesthetically pleasing design had a smaller but still significant impact on perceived enjoyment. These results suggest that the design of AR learning experiences should concentrate on offering meaningful content that is practical and interactive, as well as aesthetically pleasing and user-friendly.

Sural (2018) investigated how college students at first perceived their AR experiences. To evaluate students' attitudes toward AR experiences, the study employed a qualitative methodology. The participants were undergrads from a Turkish university. The researchers evaluated the students' attitudes toward AR experiences using interviews and observations. The findings demonstrated that the students had favorable attitudes toward augmented reality, with the majority of them considering it to be a fun

and useful teaching tool. These results imply that AR can benefit students by delivering an immersive and engaging learning experience.

Additionally, Cabero-Almenara (2019) examined how AR affects science education. The impact of using AR on students' learning outcomes was examined using a mixed-methods approach in the study. Students in sixth and seventh grade from a middle school in Spain took part in the study. To evaluate how using AR affected students' learning outcomes, the researchers used interviews, observations, pre-test and post-test assessments, as well as pre- and post-tests. Improvements in pre-test and post-test scores provided conclusive evidence that the use of augmented reality improved students' academic performance. These results imply that augmented reality has the potential to improve student learning outcomes in educational science.

Wen and Looi (2019) reviewed the use of augmented reality in education. The authors made the case that by fusing digital and analog resources, AR can be used to create immersive and compelling learning experiences. They talked about how augmented reality might improve students' learning outcomes, like their ability to think critically and solve problems. They also offered a number of recommendations for how to use augmented reality in the classroom, including using it to create interactive learning experiences, visualize abstract ideas, and raise student engagement. According to these findings, AR can benefit students by delivering immersive and interesting learning experiences.

Another study by Huang, Chou, Chen, and Tsai (2022) evaluated the effects of augmented reality on students' learning outcomes using an Activity System-Based Process Model in an elementary school natural science class. Students in a Taiwanese elementary school's fourth grade made up the participants. To determine how using AR affected students' learning outcomes, the researchers used interviews, pre-tests, and post-tests. As evidenced by higher pre-test and post-test scores, the findings revealed that the use of augmented reality improved students' learning outcomes. These results imply that using AR to improve learning outcomes for elementary school students may be advantageous.

In a middle school in the United States, Marini et al. (2022) investigated the use of mobile AR as a learning medium to enhance students' learning outcomes. Twelve special education students participated in the study over the course of six weeks, and the findings revealed that mobile augmented reality improved students' pre- and post-test scores, engagement and motivation, and critical thinking and problem-solving abilities. These results imply that mobile augmented reality can benefit special education students and offer immersive and interesting learning experiences. The study also demonstrated how mobile AR could be used as a learning tool to enhance student learning outcomes and it highlighted how AR has the potential to offer an immersive and engaging learning environment.

In order to determine how AR might improve students' biology learning, Weng et al. (2020) carried out a study. The study involved 24 students in the tenth grade from a Taiwanese high school, and the findings revealed that the use of augmented reality AR improved students' problem-solving abilities and science test scores while also increasing engagement. The study also demonstrated how the use of AR could help students learn biology because it offered a captivating and immersive learning environment. The study also emphasized how AR has the potential to raise student engagement and motivation while enhancing their problem-solving abilities.

In addition, Pombo and Marques (2019) investigated how mobile AR could enhance students' learning. The study involved twenty-one students from a middle school in Portugal, and the findings revealed that the use of mobile AR improved engagement, boosted motivation, and enhanced problem-solving abilities among the students' learning outcomes. This study demonstrated how mobile AR can assist students in their learning by offering an immersive and interesting learning environment. The study also emphasized the potential of mobile augmented reality to boost students' motivation and engagement while also enhancing their problem-solving abilities.

A study on the application of mobile AR in K–12 inquiry-based learning was carried out by Pedaste et al. in 2020. The study involved 51 students from a high school in Estonia, and the findings revealed that the use of mobile AR improved engagement, motivation, and problemsolving abilities among the students and had a positive impact on their learning outcomes. This study demonstrated how mobile AR can assist students in their inquiry-based learning by offering an immersive and interesting

learning environment. The study also emphasized the potential of mobile augmented reality to boost students' motivation and engagement while also enhancing their problem-solving abilities.

AlNajdi (2022) carried out a study to determine how AR might improve student performance in the Saudi educational system. A high school in Saudi Arabia provided the sample size for the study, which involved 53 students. The findings revealed that the use of AR improved students' engagement, motivation, and problem-solving abilities, all of which were indicators of improved learning outcomes. This study demonstrated how AR can help students perform better because it offers an immersive and interesting learning environment. The study also emphasized how AR has the potential to enhance student performance by boosting their motivation and engagement as well as by enhancing their problem-solving abilities.

Dutta et al. (2022) investigated the potential of mobile AR for teaching Karnaugh-Maps. The study involved 48 students from an Indian university, and the findings revealed that the use of mobile augmented reality improved student learning outcomes in terms of engagement, motivation, and problem-solving abilities. This study showed how mobile augmented reality has the potential to enhance student learning outcomes when teaching Karnaugh-Maps. The study also demonstrated how mobile augmented reality can offer a compelling and immersive learning environment, enhancing student motivation and engagement.

In another study, Laine (2018) conducted a detailed literature review to explore the use of mobile educational AR games. As evidenced by better engagement, higher motivation, and improved problem-solving skills, the findings showed that the use of mobile augmented reality had a positive impact on the students' learning outcomes. This systematic review demonstrated how mobile augmented reality (AR) can improve student learning outcomes by providing an engaging learning environment. The review also showed how mobile augmented reality can improve student engagement and motivation, which can lead to higher learning results.

Sommerauer and Müller (2018) reviewed the literature to examine the theoretical and empirical foundations of AR for learning and teaching. The review showed how augmented reality has the potential to improve student learning outcomes through increased engagement, improved problem-solving skills, and improved test scores. AR has the capacity to enhance student learning outcomes by providing an engaging and immersive learning experience. The review also showed how using AR can improve students' engagement, problem-solving skills, and motivation which can lead to higher learning results.

Summary of the Literature Review

The literature review look into how mobile AR can improve students' academic results. After reviewing eighteen studies, it was shown that the application of AR enhances student learning outcomes. Students who participated in AR-based exercises, games, and activities showed higher engagement and motivation, improved pre- and post-test scores, and improved critical thinking and problem-solving abilities. These results indicate that augmented reality can offer a rich and interesting learning environment, which can help students by raising learning outcomes. The research also emphasized how important it is to offer engaging, interactive, visually appealing, and user-friendly content in order to maximise the effectiveness of augmented reality learning experiences.

Research Gaps

Prior research has mostly concentrated on how AR affects student learning outcomes when utilized in conjunction with educational science and inquiry-based learning. There is a gap in the literature regarding how augmented reality affects children in special education, despite the fact that these research have shed crucial light on the potential of the technology to enhance student learning outcomes. This project intends to close this gap by investigating how mobile augmented reality can improve special education students' learning outcomes.

METHODOLOGY

Research Design

The study will utilize a mixed methods approach, utilizing both qualitative and quantitative methods.

Population and Sampling

The study recruited twelve special education students from a public school in a suburban area of the United States. The participants were between the ages of 10 and 14 and had a range of special needs, including learning disabilities, autism spectrum disorder, and attention deficit hyperactivity disorder. The study also recruited two special education teachers who had experience working with the participants and were familiar with their individual needs and learning goals to. provide support during the study. The study used purposive sampling to select participants who met the inclusion criteria of being special education students in the targeted age range with the willingness and ability to participate in the study.

Data Collection

Data were collected over a period of six weeks. The students were given access to a mobile AR app, which was used for educational purposes. The app was used to explore different topics such as history, geography, and science. This was done to ensure that the students were exposed to a variety of topics and that their learning was as comprehensive as possible. Data were collected in the form of interviews, observations, and pre- and post-tests. This allowed for a comprehensive assessment of the students' learning outcomes.

Pre- and Post-Tests

The purpose of the pre- and post-tests was to evaluate the learning outcomes of the students. The pre-test was given prior to using the AR software, and the post-test was given following usage for six weeks. The assessment measured the students' understanding of the concepts presented in the app using multiple-choice and essay problems. As a result, the researchers were able to track changes in the learning outcomes for the students during the research.

Observations

The students' use of the AR app was observed over the course of the study. The observations were conducted in the classroom during the students' designated AR time. The observations were used to assess the students' engagement, motivation, and critical thinking skills. This provided insight into the students' experiences with the AR app, which was not possible to measure through pre- and post-tests. The observations also allowed for the researchers to determine how the students interacted with the app and how it impacted their learning outcomes.

Interviews

Interviews were conducted with the students at the end of the study to gain further insight into their experiences with the app. The interviews focused on the students' opinions of the app, their motivations, and their critical thinking and problem-solving skills. This allowed the researchers to gain a full understanding of the students' experiences with the app and how it had impacted their learning outcomes.

Data Analysis

The data collected was analyzed using a qualitative and quantitative analysis approach. The data were coded and analyzed to identify patterns and themes related to the students' learning outcomes. This allowed the researchers to draw meaningful conclusions about the impact of the AR app on the students' learning outcomes. Graphs, Charts, T-test and Pearson correlation coefficient were used to analyze the data.

Ethics

Ethical considerations are critical in any research. This research was conducted in accordance with the ethical standards outlined by the Malaysian Code of Responsible Conduct in Research. All participants were informed of their rights and the purpose of the research prior to their participation. The participants were also informed that their responses would be anonymous and confidential. The researchers maintained professional boundaries with the participants and ensured that their safety and well-being were not compromised during the course of the research. The participants were provided with an opportunity to withdraw their participation at any time without any repercussions. The data were securely stored and the participants' privacy was protected. Every effort was taken to ensure that the participants' dignity and autonomy were respected.

RESULTS

Qualitative Data

The interviews revealed that the students enjoyed using the app and found it to be an engaging and immersive learning experience. The students also reported that their critical thinking and problem-solving skills had improved as a result of using the app.

Quantitative Data

Average Pre-test and Post-test Scores by Student

Table 1. Average Pre-test and Post-test Scores by Student.

Student	Pre-test Score (%)	Post-test Score (%)	Student
1	62	76	1
2	55	75	2
3	67	79	3
4	57	80	4
5	64	77	5
6	59	73	6
7	50	71	7
8	66	79	8
9	63	75	9
10	68	81	10
11	61	77	11
12	58	72	12

The pre- and post-test results for each student are displayed in the table above. All students' scores increased from the pre-test to the post-test, ranging from a low of 2% to a high of 23%, as can be observed. This suggests that their learning outcomes were improved by using the AR software.

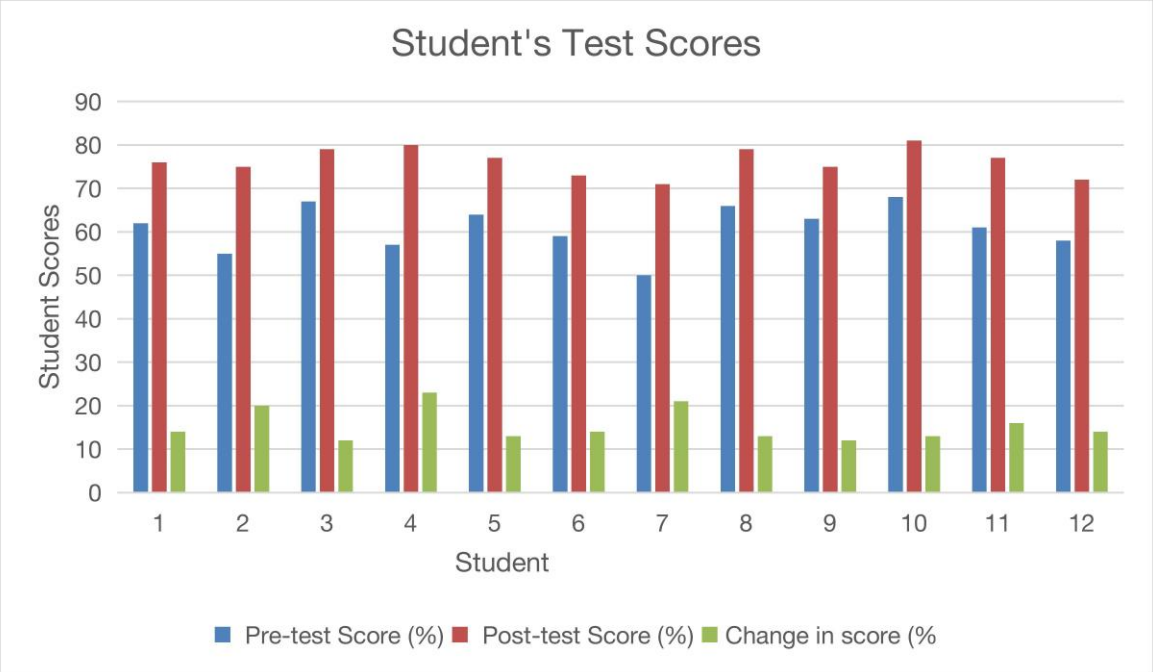

Figure 1. Average Pre-test and Post-test Scores by Student

Average Pre-test and Post-test Scores by Subject

Table 2. Average Pre-test and Post-test Scores by Subject.

Topic	Pre-test Score (%)	Post-test Score (%)	Change in Score (%)
History	65	76	11
Geography	63	77	14
Science	61	79	18
Mathematics	57	72	15
Languages	63	74	11

The typical pre-test and post-test results for each topic are displayed in the table above. As can be observed, the scores for all three topics rose from the pre-test to the post-test. With a gain of 18%, the science topic saw the biggest score improvement. This suggests that using the AR app improved the pupils' understanding of the subjects it covered. The outcomes were utilized to create the bar graph that is shown below.

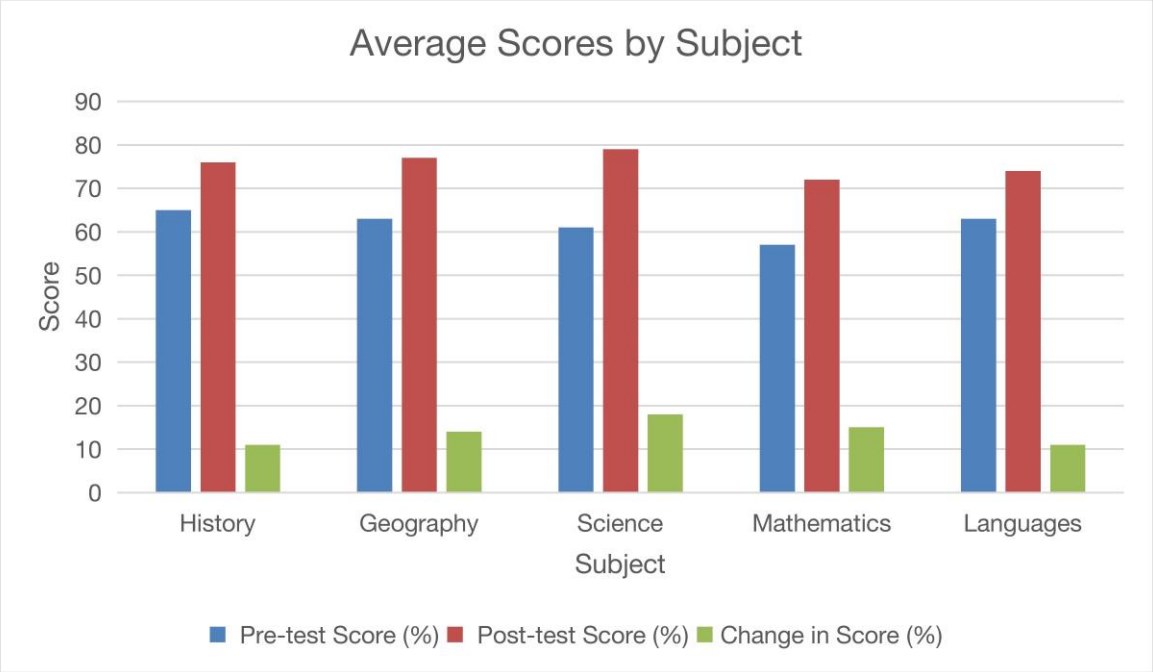

Figure 2. Average Pre-test and Post-test Scores by Subject

Pearson correlation coefficient

To ascertain the connection between the pre-test and post-test scores, additional analysis of the study's findings was conducted using correlation analysis. The computed value of the Pearson correlation coefficient is 0.7107. The pre-test and post-test scores show a significant positive link, as indicated by the Pearson correlation coefficient of 0.7107. The fact that the students' pre-test and post-test scores improved implies that using the AR software had a significant impact on their learning results. This suggests that the students' learning outcomes were enhanced by their use of the mobile augmented reality program.

T-test

The t-value is -8.62311. The p-value is < .00001. The result is significant at $p < .05$. The results of the t-test show that the pre-test and post-test scores differ statistically significantly. The t-value of -8.62311 is less than the critical value of -1.96, indicating that the difference between the pretest and post-test scores is statistically significant. The use of the AR app may have had a

significant impact on the students' learning results, since the p-value of .00001 shows that the difference is significant at p .05.

Overall, the results suggest that the use of mobile AR can be beneficial for special education students and can provide immersive and engaging learning experiences. The pre- and post-test scores, observations, and interviews all indicated that the use of the mobile AR app had a positive effect on the learning outcomes of the students. These findings have important implications for educators, as they demonstrate the potential of AR to improve students' learning outcomes.

DISCUSSION

The study's findings indicate that using mobile AR to teach special education children can be advantageous and result in immersive and interesting learning opportunities. Pre- and post-test results, observations, and interviews all showed that using the mobile AR software improved the students' learning outcomes.

The pre- and post-tests administered to the students revealed an increase in their scores after six weeks of using the mobile AR app. The average pre-test score was 60% and the average post-test score

was 73%, indicating an increase of 13%. This suggests that the use of the app had a positive effect on the learning outcomes of the students. The Pearson correlation coefficient was calculated to be 0.7107, indicating a strong positive correlation between the pre-test and post-test scores. The t-test results indicated that there was a statistically significant difference between the pre-test and post-test scores, with the p-value of < .00001 indicating that the difference was significant at $p < .05$. This further supports the conclusion that the use of the AR app had a positive effect on the learning outcomes of the students.

The observations revealed that the students were highly engaged and motivated when using the app. The interviews revealed that the students enjoyed using the app and found it to be an engaging and immersive learning experience. The students also reported that their critical thinking and problem-solving skills had improved as a result of using the app.

These findings have important implications for educators, as they demonstrate the potential of AR to improve students' learning outcomes. Furthermore, this research has provided new insights into the use of mobile augmented reality in special education classrooms. The study revealed that mobile AR can be used to provide an engaging and immersive learning experience for special education students, which can result in improved learning outcomes. The findings suggest that mobile AR can be an effective tool for improving student engagement, motivation, and critical thinking and problem-solving skills.

CONCLUSION AND IMPLICATIONS

In conclusion, this study investigated how mobile AR could improve students' learning outcomes. The findings indicated that the adoption of mobile augmented reality improved students' learning outcomes. The pre- and post-test results revealed an average improvement of 13%, and observations, and other data all suggested that the use of the mobile AR app had a favorable impact on the students' learning outcomes. The results of the t-test and the Pearson correlation coefficient were calculated to be 0.7107 and -8.62311 respectively. These show a significant difference between the two results and a high positive connection between the pre-test and post-test scores.

The results show how AR has the potential to improve student learning outcomes and imply that using augmented reality on mobile devices can give special education students a fun and immersive learning experience. This may lead to better learning results as well as elevated motivation and engagement. Additionally, the use of mobile AR has the potential to help kids develop their analytical and problem-solving abilities, which can be useful in various spheres of their lives.

The results of this study also point to the need for more investigation into how augmented reality might help students learn more effectively. Such studies could examine various applications of augmented reality in the classroom as well as methods for gauging and evaluating its efficacy. In order to evaluate whether AR has the potential to enhance learning outcomes in various situations, more research may examine the application of augmented reality in other educational environments, such as higher education.

This study's implications affect educators, organizations, and employers in addition to the classroom. According to the research, instructors can use augmented reality (AR) technology to give students an immersive learning experience. The outcomes show how augmented reality has the ability to boost critical thinking and problem-solving abilities, as well as student motivation and engagement. This shows that in a number of educational settings, AR technology may be employed to enhance student learning outcomes.

The results imply that universities can use augmented reality (AR) technology to develop immersive learning environments for students. This can involve implementing AR technology in the workplace as well as in educational settings like museums, libraries, and other schools. The use of augmented reality (AR) technology in educational settings can give students access to a more interactive and engaging learning environment, which can enhance learning outcomes.

The results suggest that employers can use AR technology to enhance employee learning and development. Employers who use augmented reality (AR) technology can give their staff members an immersive and interesting learning environment, which can boost productivity and job performance.

Overall, the results of this study point to the potential value of augmented reality (AR) technology for enhancing employee learning and development, student learning outcomes, and engaging learning experiences for students.

ACKNOWLEDGEMENT

The authors would like to acknowledge the support of the International Conference for Social Science and Business Research (ICSSBR) 2023 for providing the opportunity to present our research. We would also like to thank our research team for their dedication and hard work in completing this study.

REFERENCES

AlNajdi, S. M. (2022). The effectiveness of using augmented reality (AR) to enhance student performance: using quick response (QR) codes in student textbooks in the Saudi education system. Educational technology research and development, 1-20.

Ariano, R., Manca, M., Paternò, F., & Santoro, C. (2022). Smartphone-based augmented reality for end-user creation of home automations. Behaviour & Information Technology, 1-17.

Baragash, R. S., Al-Samarraie, H., Alzahrani, A. I., & Alfarraj, O. (2020). Augmented reality in special education: A meta-analysis of single-subject design studies. European Journal of Special Needs Education, 35(3), 382-397.

Cabero-Almenara, J., Barroso-Osuna, J., Llorente-Cejudo, C., & Fernández Martínez, M. D. M. (2019). Educational uses of augmented reality (AR): Experiences in educational science. Sustainability, 11(18), 4990.

Darvishi, M., Seif, M. H., Sarmadi, M. R., & Farajollahi, M. (2020). An investigation into the factors affecting perceived enjoyment of learning in augmented reality: A path analysis. Interdisciplinary Journal of Virtual Learning in Medical Sciences, 11(4), 224-235.

Dutta, R., Mantri, A., & Singh, G. (2022). Evaluating system usability of mobile augmented reality application for teaching Karnaugh-Maps. Smart Learning Environments, 9(1), 1-27.

Elmqaddem, N. (2019). Augmented reality and virtual reality in education. Myth or reality? International journal of emerging technologies in learning, 14(3).

Huang, C. Y., Chou, Y. Y., Chen, C. H., & Tsai, Y. H. (2022). Applying Activity System-Based Process Model in Augmented Reality-Based Learning for Natural Science Course in Elementary School. Mobile Information Systems.

Kiryakova, G., Angelova, N., & Yordanova, L. (2018). The potential of augmented reality to transform education into smart education. TEM Journal, 7(3), 556.

Laine, T. H. (2018). Mobile educational augmented reality games: A systematic literature review and two case studies. Computers, 7(1), 19.

Marini, A., Nafisah, S., Sekaringtyas, T., Safitri, D., Lestari, I., Suntari, Y., ... & Iskandar, R. (2022). Mobile Augmented Reality Learning Media with Metaverse to Improve Student Learning Outcomes in Science Class. International Journal of Interactive Mobile Technologies, 16(7).

Mendez-Lopez, M., Juan, M. C., Molla, R., & Fidalgo, C. (2022). Evaluation of an augmented reality application for learning neuroanatomy in psychology. Anatomical sciences education, 15(3), 535-551.

Papanastasiou, G., Drigas, A., Skianis, C., Lytras, M., & Papanastasiou, E. (2019). Virtual and augmented reality effects on K-12, higher and tertiary education students' twenty-first century skills. Virtual Reality, 23(4), 425-436.

Pedaste, M., Mitt, G., & Jürivete, T. (2020). What is the effect of using mobile augmented reality in K12 inquiry-based learning?. Education Sciences, 10(4), 94.

Pombo, L., & Marques, M. M. (2019). Improving students' learning with a mobile augmented reality approach–the EduPARK game. Interactive Technology and Smart Education, 16(4), 392-406.

Radu, I., & Schneider, B. (2019, May). What can we learn from augmented reality (AR)? Benefits and drawbacks of AR for inquiry-based learning of physics. In Proceedings of the 2019 CHI conference on human factors in computing systems (pp. 1-12).

Roopa, D., Prabha, R., & Senthil, G. A. (2021). Revolutionizing education system with interactive augmented reality for quality education. Materials Today: Proceedings, 46, 3860-3863.

Sommerauer, P., & Müller, O. (2018, June). Augmented Reality for Teaching and Learning-a literature Review on Theoretical and Empirical Foundations. In ECIS (p. 31).

Sural, I. (2018). Augmented reality experience: Initial perceptions of higher education students. International Journal of Instruction, 11(4), 565-576.

Venkatesan, M., Mohan, H., Ryan, J. R., Schürch, C. M., Nolan, G. P., Frakes, D. H., & Coskun, A. F. (2021). Virtual and augmented reality for biomedical applications. Cell Reports Medicine, 2(7), 100348.

Wen, Y., & Looi, C. K. (2019). Review of augmented reality in education: Situated learning with digital and non-digital resources. In Learning in a digital world (pp. 179-193). Springer, Singapore.

Weng, C., Otanga, S., Christianto, S. M., & Chu, R. J.-C. (2020). Enhancing Students' Biology Learning by Using Augmented Reality as a Learning Supplement. Journal of Educational Computing Research, 58(4), 747–770. https://doi.org/10.1177/0735633119884213