2nd Basic and Applied Science Conference (BASC) 2022
Volume 2022
http://dx.doi.org/10.11594/nstp.2022.2501

NST PROCEEDINGS

OPEN ACCESS

Conference Paper

The Advantages and Applications of Augmented Reality in Science Education

Anggi Datiatur Rahmat[1], Heru Kuswanto*[2], Insih Wilujeng[1]

[1]Science Education Department, Faculty Mathematics and Natural Sciences, Universitas Negeri Yogyakarta
[2]Physics Education Department, Faculty Mathematics and Natural Sciences, Universitas Negeri Yogyakarta

*Corresponding author:
E-mail:
herukus61@uny.ac.id

ABSTRACT

Educational technologies can help students learn more interest and help the student to understand abstract concepts in science to become concrete with visuals in the learning process. The new technology in education is Augmented Reality (AR), which also has an excellent potential to make the learning process more enjoyable, coloring and helping students understand abstract concepts. The use of AR in science education has recently caught the attention of researchers and allowed students to gain real-world experience. Therefore, this study's concept is the paper review about AR research in science education. The review discusses the application in the science subjects, including Physics, Chemistry, and Biology. Also, this paper explains the advantages of AR technology in science education. The review also shows that AR in science education has great potential and benefits for adapting to science education and highlights AR's limitations for future research.

Keywords: Augmented reality, advantages, applications, science education

Introduction

In this era, technology in daily life is developing rapidly. In addition, the technology is also effective for use in education (Sahin & Yilmaz, 2020). Technology has positively impacted learning and teaching (Fidan & Tuncel, 2019; Karagozlu, 2018; Karagozlu & Ozdamli, 2017). Technology in science education can enhance the quality of the learning process, develop reasoning skills, help students acquire knowledge, improve problem-solving skills, and communicate situations. You are confusing in everyday life. Technology-assisted learning is a more efficient and innovative form of teaching and learning (Chang et al., 2018; Karagozlu & Ozdamli, 2017; Saidin et al., 2015).

Integrating technology tools in the curriculum becomes good content in teaching (Abdusselam & Karal, 2020; Fidan & Tuncel, 2018; Virtanen & Rasi, 2017). The rapid advances in technology in education are prompting researchers to integrate emerging technologies to support the learning process (Chang & Hwang, 2018; Fidan & Tuncel, 2019; Maulana et al., 2019). The integration of technology can improve student learning outcomes. Recent studies have shown that students better understand the learning process using multimedia, computer simulations, animation, and statistical software (Neumann et al., 2011; Yoon et al., 2018).

Previous studies have shown that the contribution of new technologies to the educational environment is increasing. The traditional learning environment can be transformed by using new educational techniques to enable extracurricular activities in the classroom (Karagozlu & Ozdamli, 2017). Augmented Reality (AR) is one of the new technologies used in learning sciences (Fidan & Tuncel, 2019; Sahin & Yilmaz, 2020; Wang & Chi, 2012). Much research has been done on AR, but little on education, especially mathematics and science. AR has been widely used in the various education sector. Most are used because they are efficiently used to represent a model that needs to be visualized to look real (Nóbrega & Correia, 2012; Sahin & Yilmaz, 2020; Singhal et al., 2012). Augmented reality is a technology that places virtual information in an actual image to create an

How to cite:
Rahmat, A. D., Kuswanto, H., & Wilujeng, I. (2022). The advantages and applications of augmented reality in science education. *2nd Basic and Applied Science Conference (BASC) 2022*. NST Proceedings. pages 1-7. doi: 10.11594/nstp.2022.2501

interactive space where users can explore, interact, and learn at the same time (Wang & Chi, 2012).

Background of the problem

In recent studies, students are bored when listening to the instructors before the lecturer. Students believed that integrated technology helped the learning process. Therefore, researchers have searched for integrated technologies in education in scientific issues. The following subsections describe how to use classes and science learning and technology such as AR to solve these problems.

Reduce student's interest in science subject

Scientific company surveys are complex processes that include the identification of issues to inspect data collection methods and hypotheses and results for testing data collection methods (Fidan & Tuncel, 2019; Karagozlu, 2018; Sahin & Yilmaz, 2020; C. Wang & Chi, 2012). Participating in these processes makes students increasingly aware that science subjects are challenging subjects, allowing students to think critically at each step and achieve the best results (Chang & Hwang, 2018).

Much research has been done to teach students how to increase their interest in learning science. One suggestion to stimulate students' interest in scientific research is for teachers to provide subject-related context and make classroom activities more attractive (Fidan & Tuncel, 2019; Sahin & Yilmaz, 2020; Yilmaz, 2021). Students prefer to study in an interactive environment. Students are also less interested in science because they perceive science as an uninteresting subject with many abstract concepts. Therefore, you need to create scientific concepts more precisely by using a class of visuals.

Students' difficulties in visualizing abstract concepts in science subject

The students must struggle to understand complex abstract concepts fully (Sahin & Yilmaz, 2020). Students generally find the subject of science abstract. This requires deep understanding and visualization skills (Nóbrega & Correia, 2012; Sahin & Yilmaz, 2020). This can be a misconception when students struggle to understand the concept well. The selection of teaching methods plays an essential role in minimizing misunderstandings among students. (Ibisono et al., 2020; Syuhendri et al., 2019).

Visualization technology has the stimulating potential to promote understanding in the scientific field and avoid misunderstandings (Abdusselam & Karal, 2020; Matsumoto et al., 2015). Augmented reality can improve students' visualization skills by presenting various abstract visual images that allow them to manipulate and explore the pictures (Fidan & Tuncel, 2019). You can visualize abstract concepts using multiple available technologies (Lin et al., 2013; Wang et al., 2014). Examples of visualization techniques examined in previous studies include animations, virtual environments, and simulations. These visualization techniques help solve misunderstandings and help students better understand. According to students ' degree of understanding, AR technology plays a vital role in embodying and visualizing abstract concepts. It is possible to observe phenomena that cannot be encountered in real life.

Potential technology for visualizing abstract concepts

Much research has found practical uses for technology to visualize abstract concepts well. The importance of using technology to enhance visual and intellectual involvement, especially when describing abstract and complex concepts in a science subject. Technology makes students multidimensionally recognize phenomena in science lessons, better interpret information, and focus attention on lessons (Fidan & Tuncel, 2019; Karagozlu & Ozdamli, 2017; Sahin & Yilmaz, 2020; Wang & Chi, 2012). Augmented reality (AR) is one of the technologies with great potential in education today, especially in visualizing abstract concepts. Augmented reality is a new

technology that could affect education, especially in science classrooms. This statement from the 2010-2016 Horizontal Report describes AR technology that brings the virtual world into the real world like the human world (Wang & Chi, 2012). AR can be described as an interactive platform that can present a combination of objects in the virtual world and the real world (Fleck & Simon, 2013; İbili & Şahin, 2015; Singhal et al., 2012). When scanning using a camera, AR can make a virtual object to a certain point in the form of an image so that it interprets certain output programs in the form of objects in the real world (Arici et al., 2019; Küçük et al., 2014) AR consists of many virtual objects that are commonly used in education, especially 3D objects and graphics (Cai et al., 2014).

In the educational context, AR technology can provide interaction between the natural world and the virtual world so that it can increase student interest and motivation during the learning process (Fidan & Tuncel, 2019; Sahin & Yilmaz, 2020; Yen et al., 2013). The usefulness of AR in education is related to the ability of the technology to present complex information in a way that is easier to understand, explain events that cannot be seen directly, present phenomena that are dangerous if done in class, and visualize abstract concepts (Sahin & Yilmaz, 2020). AR can also reduce misunderstandings caused by students' inability to visualize abstract concepts. In addition, most studies conducted by AR show that students are excited and interested in learning with this technology. As highlighted in the horizon report, common points are expected to find that AR is most widely used in higher education in the medium term (Johnson et al., 2013). Especially in scientific education, AR was commonly used in education. A new dimension is brought to teaching, and creating a compatible interactive environment provides an opportunity to learn and educational processes (Karagozlu, 2018; Maulana et al., 2019). Thus, AR provides flexibility by providing a customizable interactive environment to a real-world environment. Several studies have integrated the results of previous studies. They have shown that AR applications have a positive impact on educational outcomes such as learning outcomes, attitudes, motivation, attention, and maintenance of learning processes (Fidan & Tuncel, 2019; Nincarean et al., 2013; Salmi et al., 2017). Table 1 shows the benefits of AR when used in science education. In addition, there are also benefits to integrating AR technology into the teaching and learning process.

Table 1. The advantages of using AR technology in science education

Author	Advantages
Singhal et al. (2012)	It supports object interaction between the real and virtual worlds so that it is possible to manipulate objects so that students easily understand them.
Burton et al. (2011)	Creating a learning experience where students are connected to a formal classroom enables students to learn outside class hours and school boundaries and can be done anywhere.
Sahin and Yilmaz (2020)	Use visuals in the classroom to help students understand the abstract concepts of science more concretely. Create a more engaging and interactive learning experience You can embody and visualize abstract concepts according to students' level of understanding and observe phenomena that cannot be encountered in real life.
Chen and Tsai, 2012).	AR technology enhances student interest and motivation through the interaction of the natural and virtual worlds.
Fidan and Tuncel (2019)	Presents complex information in an easy-to-understand manner, teaches subjects that cannot be observed directly, presents dangerous phenomena, and objectively presents abstract concepts.

The advantages of AR in education (highlighted in Table 1 above) show that it is possible to use AR in teaching and learning, especially for scientific subjects such as mathematics and science, where students need to visualize abstract concepts so that they are easy to understand. AR technology can increase students' interest and motivation in the learning process.

Application of AR Technology in Science Education

This section describes research on the application of AR in science education. This review deals with the application of AR technology in various fields of study in science education, including physics, biology, chemistry, and science. Reflections on the application of AR in this area will be reviewed to assess the potential use of AR in science education. Table 2 summarizes a meta-analysis of research related to AR in various areas of science education. The analysis includes the purpose of using AR and the study results. From this table, you can see how AR technology was implemented in each scope.

Material and Methods

This review aims to identify potential uses of AR in science education. The keyword used in literary studies was "augmented reality in science education." Second, research needs to map different domains to provide examples of AR use cases. Finally, the survey should emphasize the purpose of the AR technology used and the survey results.

Results and Discussion

The search of the literature was conducted using Google Scholar. The results are shown in Table 2.

Table 2. Meta-analysis of research on the use of AR in different scopes in science education

Author/s	Scope	Purposes of AR use	Result of the Study
Dilara Sahin (2020)	Science	Interactive 3D to simulate the solar system and create an AR learning environment	Students using AR in the learning process had higher learning outcomes and positive attitudes than students in the control group.
Abdusselam (2020)	Physics	AR for 3D simulation and Arduino as sensor technology. Combining AR and Arduino as a learning environment for experiments	Students who used a combination of AR and Arduino had higher learning outcomes than the control group. AR and Arduino teaching materials are considered complete, easier to understand, and students are more active in the learning process.
Bakri et al. (2020)	Physics	More attractive student worksheet with 3D simulation	Developing worksheets for students using AR technology is very suitable for learning tools in practicum activities

To be continued…

Fidan and Tuncel (2019)	Physics	AR learning environment with experimental tools to create augmented mobile reality, including augmented video, 3D simulation, AR as a learning environment	Augmented reality technology combined with PBL (Problem Based Learning) can be a possible and practical way to increase students' positive attitudes in the practicum learning process. AR embedded in PBL has higher learning outcomes than the control group.
Sung et al. (2019)	Physics	AR learning environment in experiment tools	The AR technology in this study is equipped with software and real-time simulators to help create more realistic simulation results and is considered to be highly effective in the physics learning process.
Chang and Hwang (2018)	Science	3D simulation of a flipped book Interactive 3D simulation	Augmented reality-based flipbooks can increase student motivation, critical thinking skills, and group self-efficacy.
Damla Karagozlu (2018)		Interactive 3D simulation	Using AR can improve student achievement and problem-solving skills.
Georgiou & Kyza (2018)	Biology	Interactive 3D anatomy pictures	The study results positively show motivation—furthermore, interest in learning positive concepts with a degree of immersion.
Chang & Yu (2018)	Biology	Interactive 3D anatomy pictures and AR learning environment in the laboratory	By integrating AR technology into teaching, students can adopt a more positive attitude toward self-learning. Students can gain an introduction to the biology lab through interactive and collaborative virtual learning.
Hung, Chen, & Huang (2017)	Biology	Interactive 3D anatomy of bacteria and AR as a learning guide experiment	AR integrated books provide a practical way for students to explore and study bacteria virtually. This is an effective aid compared to other forms of assistance.
Crandall et al. (2015)	Chemistry	AR technology for Simulation of the models using 3D	AR games can give students a variety of learning perspectives. Initiation of learning transfer from virtual world-based games to the real world.

To be continued…

Singal et al. (2012)	Chemistry	AR technology for exhibiting the models	AR is a new technology that has an effective way of representing and interacting with molecules resulting in a better understanding of the spatial relationships between molecules with this technology.

As Table 2 above shows, AR technology is adapted and applied to education and learning in science education. Most of the studies showing positive feedback from participants are related to AR technology. There are obvious benefits for students and teachers, so further research is needed to integrate AR into education and learning. The use of AR technology improves the education of Visual Science Course.

Limitations and recommendations for future augmented reality research

There are many aspects of AR technology that need to be placed where there will be many aspects related to this new technology in the future. This technology still has some limitations. Students who use AR in learning agree that AR is excellent and helps the learning process, but most participants do not consider the tool as effective when reading textbooks (Hsu & Huang, 2011).

In addition, research is also necessary to explore the latest technology, namely Mobile Augmented Reality (MAR), where smartphone applications are integrated with augmented reality. This new form of AR technology provides a formal classroom-based learning experience that supports students to learn outside the classroom or outside of school, anytime and anywhere (Fidan & Tuncel, 2019; Wang & Chi, 2012). These limitations review problems related to the technical aspects of using AR in the learning process. For AR technology to be widely applied in education, these technical matters need to be improved. Increasing internet access will support students to use AR via smartphones (Arici et al., 2019; Sahin & Yilmaz, 2020). This can make AR a powerful learning tool to help students acquire and retain knowledge through interaction with activities on smartphones.

Conclusion

A review of science education research shows that AR technology can be developed in education. The benefits of the extended reality function and practical applications use students in the learning process and help improve their visualization function. The parts are well explained to help you understand the students. AR technology is interested in aggressive feedback from students and their learning process for AR use. These appropriate answers are essential as students actively participate through the AR tools through AR tools. AR is a new technology in education. Therefore, there are still some restrictions. However, based on the research report, it is known that most of the limitations are related to technical problems. Over time, these limitations can be overcome as research integrating AR into education is enhanced. Where if the potential use of AR technology is explored further, the valuable features of AR can be widely applied in all fields of education and can increase the effectiveness of the teaching and learning process.

References

Abdusselam, M. S., & Karal, H. (2020). The effect of using augmented reality and sensing technology to teach magnetism in high school physics. *Technology, Pedagogy and Education*, *29*(4), 407–424. https://doi.org/10.1080/1475939X.2020.1766550

Arici, F., Yildirim, P., Caliklar, Ş., & Yilmaz, R. M. (2019). Research trends in the use of augmented reality in science education: Content and bibliometric mapping analysis. *Computers & Education*, *142*, 103647.

Cai, S., Wang, X., & Chiang, F.-K. (2014). A case study of augmented reality simulation system application in a chemistry course. *Computers in Human Behavior*, *37*, 31–40.

Chang, S. C., & Hwang, G. J. (2018). Impacts of an augmented reality-based flipped learning guiding approach on students' scientific project performance and perceptions. *Computers and Education*, *125*, 226–239. https://doi.org/10.1016/j.compedu.2018.06.007

Chang, S. C., Hwang, G. J., Yoon, S. A., Anderson, E., Park, M., Elinich, K., Lin, J., Cheng, K. H., Cai, S., Chiang, F. K., Sun, Y., Lin, C., & Lee, J. J. (2018). Surveying students' conceptions of learning science by augmented reality and their scientific epistemic beliefs. *Interactive Learning Environments*, *25*(6), 226–239. https://doi.org/10.1080/02635143.2017.1386645

Fidan, M., & Tuncel, M. (2018). Augmented reality in education researches (2012-2017): A content analysis. *Cypriot Journal of Educational Sciences*, *13*(4), 577–589. https://doi.org/10.18844/cjes.v13i4.3487

Fidan, M., & Tuncel, M. (2019). Integrating augmented reality into problem based learning: The effects on learning achievement and attitude in physics education. *Computers and Education*, *142*(May), 103635. https://doi.org/10.1016/j.compedu.2019.103635

Fleck, S., & Simon, G. (2013). An augmented reality environment for astronomy learning in elementary grades: an exploratory study. *Proceedings of the 25th Conference on l'Interaction Homme-Machine*, 14–22.

Hsu, J.-L., & Huang, Y.-H. (2011). The Advent of Augmented-Learning: A Combination of Augmented Reality and Cloud Computing. *E-Learn: World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education*, 1328–1333.

İbili, E., & Şahin, S. (2015). Investigation of the effects on computer attitudes and computer self-efficacy to use of augmented reality in geometry teaching. *Necatibey Faculty of Education Electronic Journal of Science & Mathematics Education*, *9*(1), 1-.5

Ibisono, H. S., Achmadi, H. R., Fisika, J., Surabaya, U. N., & Reality, A. (2020). *Efektivitas buku saku berbasis augmented reality pada materi gerak planet untuk meningkatkan prestasi belajar peserta didik SMA Handal Setyo Ibisono , Hainur Rasid Achmadi , Nadi Suprapto*. *09*(02), 200–206.

Johnson, L., Adams Becker, S., Cummins, M., Estrada, V., Freeman, A., & Hall, C. (2013). NMC Horizon report: higher education edition. *Report. The New Media Consortium*.

Karagozlu, D. (2018). Determination of the impact of augmented reality application on the success and problem-solving skills of students. *Quality and Quantity*, *52*(5), 2393–2402. https://doi.org/10.1007/s11135-017-0674-5

Karagozlu, D., & Ozdamli, F. (2017). Student opinions on mobile augmented reality application and developed content in science class. *TEM Journal*, *6*(4), 660.

Küçük, S., Yilmaz, R., Baydas, Ö., & Göktas, Y. (2014). Augmented reality applications attitude scale in secondary schools: Validity and reliability study. *Egitim ve Bilim*, *39*(176).

Lin, T.-J., Duh, H. B.-L., Li, N., Wang, H.-Y., & Tsai, C.-C. (2013). An investigation of learners' collaborative knowledge construction performances and behavior patterns in an augmented reality simulation system. *Computers & Education*, *68*, 314–321.

Matsumoto, Y., Takahashi, H., Murai, T., & Takahashi, H. (2015). Visual processing and social cognition in schizophrenia: Relationships among eye movements, biological motion perception, and empathy. *Neuroscience Research*, *90*, 95–100. https://doi.org/10.1016/j.neures.2014.10.011

Maulana, I., Suryani, N., & Asrowi, A. (2019). Augmented Reality: Solusi Pembelajaran IPA di Era Revolusi Industri 4.0. *Proceedings of the ICECRS*, *2*(1), 19. https://doi.org/10.21070/picecrs.v2i1.2399

Neumann, D. L., Neumann, M. M., & Hood, M. (2011). Evaluating computer-based simulations, multimedia and animations that help integrate blended learning with lectures in first year statistics. *Australasian Journal of Educational Technology*, *27*(2).

Nincarean, D., Alia, M. B., Halim, N. D. A., & Rahman, M. H. A. (2013). Mobile Augmented Reality: the potential for education. *Procedia-Social and Behavioral Sciences*, *103*, 657–664.

Nóbrega, R., & Correia, N. (2012). Magnetic augmented reality: virtual objects in your space. *Proceedings of the International Working Conference on Advanced Visual Interfaces*, 332–335.

Sahin, D., & Yilmaz, R. M. (2020). The effect of Augmented Reality Technology on middle school students' achievements and attitudes towards science education. *Computers & Education*, *144*, 103710.

Saidin, N. F., Halim, N. D. A., & Yahaya, N. (2015). A review of research on augmented reality in education: Advantages and applications. *International Education Studies*, *13*, 1–8. https://doi.org/10.5539/ies.v8n13p1

Salmi, H., Thuneberg, H., & Vainikainen, M. P. (2017). Making the invisible observable by Augmented Reality in informal science education context. *International Journal of Science Education, Part B: Communication and Public Engagement*, *7*(3), 253–268. https://doi.org/10.1080/21548455.2016.1254358

Singhal, S., Bagga, S., Goyal, P., & Saxena, V. (2012). Augmented chemistry: Interactive education system. *International Journal of Computer Applications*, *49*(15).

Syuhendri, S., Andriani, N., & Saparini, S. (2019). Understanding the concept and misconception of student teacher in kepler's laws. *Jurnal Kependidikan: Penelitian Inovasi Pembelajaran*, *3*(2), 261–275.

Virtanen, J., & Rasi, P. (2017). Integrating web 2.0 technologies into face-to-face PBL to support producing, storing, and sharing content in a higher education course. *Interdisciplinary Journal of Problem-Based Learning*, *11*(1), 5-10.

Wang, C., & Chi, P. (2012). Applying augmented reality in teaching fundamental earth science in junior high schools. In *Computer applications for database, education, and ubiquitous computing* (pp. 23–30). Springer.

Wang, H.-Y., Duh, H. B.-L., Li, N., Lin, T.-J., & Tsai, C.-C. (2014). An investigation of university students' collaborative inquiry learning behaviors in an augmented reality simulation and a traditional simulation. *Journal of Science Education and Technology*, *23*(5), 682–691.

Yen, J.-C., Tsai, C.-H., & Wu, M. (2013). Augmented reality in the higher education: Students' science concept learning and academic achievement in astronomy. *Procedia-Social and Behavioral Sciences*, *103*, 165–173.

Yilmaz, O. (2021). Augmented Reality in Science Education: An Application in Higher Education. *Shanlax International Journal of Education*, *9*(3), 136–148. https://doi.org/10.34293/education.v9i3.3907

Yoon, S. A., Anderson, E., Park, M., Elinich, K., Lin, J., & Cheng, K. H. (2018). How augmented reality, textual, and collaborative scaffolds work synergistically to improve learning in a science museum. *Eurasia Journal of Mathematics, Science and Technology Education*, *36*(4), 261–281. https://doi.org/10.1080/02635143.2017.1386645