

Potential Implementation of Augmented Reality Technology in Education

M. Brizar, D. Kažović

University of Applied Sciences Velika Gorica, Croatia
mato.brizar@vvg.hr, dkazovic@vvg.hr

Abstract - In today's age of development of science and technology, which is developing extremely fast, the way in which technology is implemented is also changing. One of the important technologies that is used in many areas of business, as well as education, is certainly AR technology, i.e. augmented reality technology. Numerous studies have shown great benefits of applying AR technology in all segments of education, from preschool education, elementary education, secondary education, higher education, as well as within the field of lifelong education. By using AR technology through augmented reality displays and 3D formats, it is possible to facilitate learning processes and experience of the material learned in all areas and segments of education. Scientific research will be carried out for the purposes of drafting this paper. The objectives of the research are to research the attitude towards augmented reality technology in learning and knowledge acquisition and to research the attitude towards the potential for improving educational processes using AR technology. The paper will present the results of research that will show the influence of previous experience with AR technology on the adoption of more positive attitudes towards the implementation of AR technology in learning and acquiring knowledge and will present the potential for the implementation of AR technology within the Croatian educational curriculum in the coming 5 years.

Keywords: *augmented reality, AR technology, education*

I. INTRODUCTION

Augmented reality (AR) is a technology that integrates digital information, such as text, images, videos and 3D objects, into the real world [1]. The term "augmented reality" was first proposed by Boeing employees in 1990 [1]. AR technology also supports seamless interaction between real and virtual environments and allows tangible interfaces to be used for object manipulation [2]. Augmented reality integrates digital information with the user's real-time environment through various electronic devices, such as head-up displays, holographic displays and hand-held devices such as smartphones and smart glasses [3]. In augmented reality, a computer uses sensors and algorithms to determine the position and orientation of the camera, and AR technology then displays 3D graphics of the object as it would appear in the camera's view, superimposing the computer-generated images over the user's view of the real world [4].

The application of augmented reality in education is significant in the field of robotics, animation and

programming basics since it enables the visualization of a complex 3D object, device scheme, technological process, etc. [5]. Although the real world is three-dimensional, we prefer to use two-dimensional media in education, which is very convenient, flexible, portable and cheap, however, such media is static and does not offer dynamic content, while the computer-generated three-dimensional virtual environment offered by augmented reality can be effectively used in education and make it more dynamic [6,7]. There are significant challenges in the potential implementation of AR technology in education for educators due to facing the increasing demands of students, institutions, industry and the expectations of society in general [8,9]. Therefore, educators also need to understand how to create educational content using augmented reality, and how to structure AR content at multiple points within the curriculum [8,10].

The usefulness and advantages of using AR technology in education have been recognized in many research studies [11-13]. AR technology as a tool for improving the educational process is applicable in all fields of education, from preschool education to higher education [13]. The motivation for introducing this technology varies from one application to another, but mostly it provides the user with additional information that the user cannot obtain using only his/her senses [12]. There are two principal ways of introducing AR technology in education - through smart glasses or AR headsets and through portable devices, such as mobile phones, tablets or laptops [10]. Augmented reality provides more enthusiasm for active learning, better understanding of object's appearance and features, as well as improving the ability to visualize an object in space [14-17].

The strategic framework for the digital maturity of schools and the education system in the Republic of Croatia (2030) contains a strategic area of support for learning and teaching using information and communication technology, in which the emphasis is on encouraging the development of digital educational content and teaching scenarios and supporting the culture of student creation using digital technology [18]. ICT technology is important in education and harmonizing educational materials and learning outcomes in accordance with constant changes in society [19]. The largest share of the use of modern technologies relates to the use of presentations in classes [20].

II. RESEARCH METHODOLOGY

The usefulness of applying AR technology in education has been recognized in scientific research. Considering insufficient research and insufficient implementation of AR technology in Croatia, any research effort related to the field of AR technology is quite significant. The research that was carried out for the purposes of writing this paper is focused on researching the extent to which AR technology can affect learning and knowledge acquisition, and what are the potentials of using AR technology to improve educational processes in Croatia.

At the beginning of the research, the research problem was defined, and scientific literature was extensively analysed. The research objectives were defined through literature analysis. A survey questionnaire was drafted for research implementation. Google Forms survey tool was used for drafting the questionnaire. The survey questionnaire could be completed between 16 January and 25 January 2023. The respondents voluntarily completed the questionnaire. The participation was anonymous.

Research participants: The participants were undergraduate students in Computer Systems Maintenance and graduate students in Information Systems at the University of Applied Sciences Velika Gorica. Participation in the research was voluntary. A total of 74 respondents participated, 87.8% of which were men and 12.2% were women. The age structure of the respondents was as follows: 74.3% between 18 and 25 years of age, 17.6% between 26 and 35 years of age, 5.4% between 36 and 45 years of age, 1.4% between 46 and 55 years of age and 1.4% over the age of 55. The type of completed secondary education by respondents is the following: 73% finished technical school, 10.8% finished grammar school and 16.2% finished other secondary schools.

Defining the problem: The research problem is to determine how much the application of AR technology in education can affect learning and knowledge acquisition and how much the implementation of AR technology could help improve educational processes. The scientific research problem is the potential of applying AR technology in education in Croatia.

Research goals: The research set two basic research goals: 1. Research the attitude on the application of AR technology in learning and knowledge acquisition and 2. Research the attitude on the potential for improving educational processes using AR technology.

Hypothesis 1 (H1). Respondents who have previous experience with augmented reality technology have more positive attitudes towards the implementation of AR technology in learning and knowledge acquisition.

Hypothesis (H2). Respondents who have a more positive attitude towards the implementation of AR technology in learning and knowledge acquisition will state a higher potential for the implementation of AR technology into education curricula in the coming 5 years.

Measuring instruments: The research used survey method. The Likert scale was used to determine the attitudes of respondents in the survey questionnaire. The statements used in the research were obtained based on the study of the literature on the implementation of AR technology in education.

III. RESEARCH RESULTS

Descriptive statistics showed great optimism among respondents in all areas, and it can be concluded that the respondents believe that the application of AR technology in classes can help them obtain more information on a subject or a field of study, that the application of AR technology can help to obtain information on a subject faster, that the implementation of AR technology can increase interest in subjects or a field of study, that the application of AR technology can increase knowledge acquisition efficiency, that the application of AR technology can improve the level of understanding. The majority of respondents believe that AR technology is easy to use and that applying AR technology in the educational process can be fun. Respondents do not feel nervous about using AR technology in class and are not insecure in their ability to use AR technology.

Principal component analysis with Oblimin rotation was performed to analyse the scale score. The results show that the two-component solution is optimal. The first component refers to the evaluation of usefulness, while the second component refers to the sense of concern. The analysis shows that variables: "The use of augmented reality (AR technology) can help me acquire more information on a subject or a field of study"; "The use of augmented reality (AR technology) can help me get information on a subject or a field of study faster"; "The use of augmented reality (AR technology) could increase my interest in subjects or fields of study"; "The use of augmented reality (AR technology) could increase knowledge acquisition efficiency"; "The use of augmented reality (AR technology) could improve my level of understanding" and "The use of augmented reality (AR technology) in education can be fun" fall under the first component. While the variables "I feel nervous (concerned) about the use of augmented reality (AR technology) within education curricula" and "I feel insecure about my ability to use augmented reality (AR technology)" fall under the second component. The analysis shows that the variable "I think augmented reality (AR technology) is easy to use" does not belong to any component.

Hypothesis 1 examines whether the respondents who have previous experience with augmented reality technology have more positive attitudes towards the application of AR technology in learning and knowledge acquisition. Pearson's correlation coefficient was used to analyse this hypothesis. At the level of scale results, there is no correlation between previous experience and the attitude towards the use of AR technology in education. It can be assumed that the participants show high trust in AR technologies regardless of previous experience, considering that, the assessment of usefulness is high and concern is low on average. Table I presents the details of the analysis. For a more detailed analysis, an analysis of

the correlations of individual variables with previous experience was performed. The correlation exists for the variable: “I think augmented reality (AR technology) is easy to use.” The results show that only the variable “I think augmented reality (AR technology) is easy to use” is positively related to previous experience, i.e. that the respondents who have more experience with the use of AR technology, simultaneously consider the technology easier to use. Table II presents the analysis details.

Hypothesis 2 examines whether the respondents who have a more positive attitude towards the application of AR technology in learning and knowledge acquisition will estimate a greater potential for the implementation of AR technology within the education curriculum in the coming 5 years. The results show that the respondents who gave a higher grade to the usefulness of AR technology also gave a higher grade to the potential for implementing AR technology in education in the coming five years. Table III presents the analysis details. For a more detailed analysis, an analysis of the correlations of individual variables with previous experience was performed. Correlation exists for variables: “The use of augmented reality (AR technology) can help me acquire more information on a subject or a field of study”; “The use of augmented reality (AR technology) can help me get information on a subject or a field of study faster”; “The use of augmented reality (AR technology) could increase my interest in subjects or fields of study” and “I feel insecure about my ability to use augmented reality (AR technology). The results show that the respondents who gave a higher grade to the potential for implementing AR technology in education also believe that AR technology can help to obtain more information on a subject, that information can be obtained faster, and that AR technology can increase interest in a subject. At the same time, an unexpectedly positive correlation between the potential for implementation and the sense of uncertainty in one's own ability to use AR technology was discovered. It can be assumed that considering that most of the respondents are students up to 25 years of age and lack experience, that the previous reflects their uncertainty in the knowledge of creating content using AR technology and is expected of them. Table IV presents the analysis details.

TABLE I. HYPOTHESIS 1 ANALYSIS

No.	Variable	1	2
1	Do you have previous experience with Augmented Reality (AR) technology, either through personal or professional experience?	1	.032
2	The usefulness of AR technology in education	.032	1
3	Concerns regarding AR technology	-.071	-.066

TABLE II. ANALYSIS OF CORRELATIONS BETWEEN INDIVIDUAL VARIABLES WITH PREVIOUS EXPERIENCE

Variable	Correlation
The use of augmented reality (AR technology) can help me get more information on a subject or a field of study.	.122
The use of augmented reality (AR technology) can help me get information on a subject or a field of study faster.	-.113
The use of augmented reality (AR technology) could increase my interest in subjects or fields of study.	.130
The use of augmented reality (AR technology) could increase knowledge acquisition efficiency.	.088
The use of augmented reality (AR technology) could improve my level of understanding.	-.019
I think augmented reality (AR technology) is easy to use.	.252*
The use of augmented reality (AR technology) in education can be fun.	-.070
I feel nervous (concerned) about the use of augmented reality (AR technology) within education curricula.	-.070
I feel insecure about my ability to use augmented reality (AR technology).	-.055

* p < 0.05

TABLE III. HYPOTHESIS 2 ANALYSIS

No.	Variable	1	2
1	How realistic do you think is it that the educational system in the Republic of Croatia will implement AR technologies within education curriculum in the coming 5 years?	1	.256
2	Usefulness of AR technology in education	.256*	1
3	Concerns about AR technology	.214	-.066

* p < 0.05

TABLE IV. ANALYSIS OF CORRELATIONS BETWEEN INDIVIDUAL VARIABLES WITH A MORE POSITIVE ATTITUDE

Variable	Correlation
The use of augmented reality (AR technology) can help me get more information on a subject or a field of study.	.262*
The use of augmented reality (AR technology) can help me get information on a subject or a field of study faster.	.240*
The use of augmented reality (AR technology) could increase my interest in subjects or fields of study.	.261*
The use of augmented reality (AR technology) could increase knowledge acquisition efficiency.	.184
The use of augmented reality (AR technology) could improve my level of understanding.	.195
I think augmented reality (AR technology) is easy to use.	-.012
The use of augmented reality (AR technology) in education can be fun.	.035
I feel nervous (concerned) about the use of augmented reality (AR technology) within education curricula.	.127
I feel insecure about my ability to use augmented reality (AR technology).	.262*

* p < 0.05

IV. CONCLUSION

Through strategic documents, the Ministry of Science and Education emphasizes raising the quality of education and the achieved learning outcomes, mainly by developing new approaches and contents [18]. The entire society and everyday life are changing every day mainly due to the accelerated development of technology and the introduction of the use of technology [21]. Given the changes in society and life in general, changes in education are also inevitable, which also change the learning methods [22,23].

Digitization of education in the Republic of Croatia started a long time ago, today we increasingly use smart boards and digital content in classes, students increasingly use computers and tablets, the use of e-learning tools has become a common practice at faculties, especially the Learning Management System for e-learning. All digitization of teaching thus far has been highly necessary, but it certainly cannot be final and must continue to develop rapidly. The above also applies to the technical equipment of schools and faculties, since the lack of equipment can often be a problem in the full implementation of IT technology. Today's modern technologies offer new possibilities that can shape new modern teaching aids and materials, among which AR technology is certainly very interesting. AR technology has proven its usefulness a long time ago and is today used successfully in all areas of business, from medicine, marketing, biology, mathematics, geography, engineering, etc. AR technology is still in development and offers new possibilities of use in different areas of society each day. AR technology provides significant help in teaching and better mastering the material and ultimately achieving better learning outcomes. For example, students can use AR technology to see information on the content on the screen in front of them, they can experience remote locations and different practical situations.

Through research, we aimed at finding out the students' attitudes towards AR technology and the implementation of AR technology in education. The research results certainly showed the great optimism of the respondents, and it can be concluded that the introduction of AR technology into everyday classes would be extremely useful for learning, knowledge acquisition and the final results achieved by the students. In addition to the usefulness of AR technology, a concern regarding the use of AR technology was recognized as a second factor, i.e. the respondents are confident in their knowledge and application of AR technology and do not feel worried about using AR technology.

The optimistic view on the application of AR technology can also be connected to the respondents' structure. Given that more than 70% of the respondents come from a technical profession, the assumption is that people with technical knowledge have a greater preference for modern IT technologies and are confident in the daily use of the AR technology.

It is interesting to point out the variable that shows that AR technology can be fun, which gives the conclusion that in today's era, in addition to teaching, an

educator should also work on motivating students for classes, class content, and all of the aforementioned can be achieved by providing a certain dose of entertainment during learning and imparting knowledge.

Although the usefulness of AR technology has been confirmed, what could pose a problem in its application in the development of education is certainly the lack of optimism regarding the application of AR technology in the education system in the Republic of Croatia in the coming 5 years. The results show that the application of AR technology in the coming 5 years is unlikely. The aforementioned is very worrying considering that changes happen every day and that monitoring new modern technologies and exploiting their possibilities in creating quality educational content and experiences should represent one of our strategic goals in the near future. Certain participants pointed out the problems of the slowness of changes in the education system and the problem of obsolescence of many teaching contents and methods. Therefore, it is certainly necessary to monitor the development of education at all levels, from the government, the Ministry, the economy, educational institutions to educators and students. It is necessary to find ways for efficient implementation of AR technology as an educational technology that should be used by both educators and students.

In addition to formal education, the application of AR technology should also find a place in informal education. The research participants pointed out that they would rather choose a course featuring AR technology compared to a course that does not use AR technology even if the content of the course is identical.

This paper is an introduction to the field of AR technology research in education. Therefore, it is planned to continue the research in this field, and the next step is to investigate the possibilities and attitudes on the application of AR technology by educators, education holders, their attitudes, their capabilities, actions that would motivate them to apply AR technology in everyday teaching and determine whether classrooms are equipped with amenities necessary for the introduction of AR technology.

REFERENCES

- [1] Y. Tan, W. Xu, S. Li, K. Chen, Augmented and Virtual Reality (AR/VR) for Education and Training in the AEC Industry: A Systematic Review of Research and Applications, Buildings, 2022. <https://doi.org/10.3390/buildings12101529>
- [2] N. F. Saidin, N. D. A. Halim, N. Yahaya, A Review of Research on Augmented Reality in Education: Advantages and Applications, International Education Studies, Vol. 8, No. 13, 2015. <http://dx.doi.org/10.5539/ies.v8n13p1>
- [3] J. Belda-Medina, V. Marrahi-Gomez, The Impact of Augmented Reality (AR) on Vocabulary Acquisition and Student Motivation, Electronics, 2023. <https://doi.org/10.3390/electronics12030749>
- [4] J. B. Cowin, Digital Worlds and Transformative Learning: Google Expeditions, Google Arts and Culture, and the Merge Cube, International Research and Review, Journal of Phi Beta Delta Honor Society for International Scholars, Vol. 10, Number 1, Fall, 2020.
- [5] D. Kozlitin, L. Kozak, T. Krystopchuk, D. Kochmar, The Application of Augmented Reality in Education and Development

- of Students Cognitive Activity, Vol I: Main Conference, PhD Symposium, Posters and Demonstrations, Kherson, Ukraine, 2021.
- [6] K. Mehmet, Y. Ozarslan, Augmented Reality in Education: Current Technologies and the Potential for Education, Article in Procedia - Social and Behavioral Sciences. December, 2012.
- [7] D. Holley, M. Hobbs, Augmented Reality For Education, Bournemouth University, Bournemouth, Dorset, 2017.
- [8] K. Dutta, Augmented Reality for E-Learning, RWTH Aachen University, Conference Paper, February, 2015.
- [9] J.A. Sicaru, C. G. Ciocianu, C.A. Boiangiu, A survey on augmented reality, Polytechnic University of Bucharest, Article, December, 2017.
- [10] S. Ribadiya, A Survey: Virtual, Augmented and Mixed Reality in Education. International Journal of Engineering Research & Technology (IJERT), Vol. 9, Issue 05, May-2020. Published by: <http://www.ijert.org>
- [11] Augmented and virtual reality survey report, Industry insights into the future of immersive technology, Vol. 3, March, 2019. <https://www.perkinscoe.com/images/content/2/1/v4/218679/2019-VR-AR-Survey-Digital-v1.pdf>
- [12] J. C. G. Vargas, R. Fabregat, A. Carrillo-Ramos, T. Jové, Survey: Using Augmented Reality to Improve Learning Motivation in Cultural Heritage Studies, Appl. Sci. 2020. doi:10.3390/app10030897
- [13] M. A. Mundy, J. Hernandez, M. Green, Perceptions of the Effects of Augmented Reality in the Classroom, Journal of Instructional Pedagogies, Vol. 22, <https://www.semanticscholar.org/paper/Perceptions-of-the-Effects-of-Augmented-Reality-in-Mundy-Hernandez%20Green/bdf9ba0417f2a0ae962f86d3d41501020a52d1f8>
- [14] O. Huerta, A. Kus, E. Unver, R. Arslan, M. Dawood, M. Kofoğlu, V. Ivanov, A Design-based Approach to Enhancing Technical Drawing Skills in Design and Engineering Education using VR and AR Tools, Conference Paper, February, 2019.
- [15] O. Çolak, L. Yünlü, A review on augmented reality and virtual reality in engineering education, Article, February, 2018. <https://www.researchgate.net/publication/327793245>
- [16] L. Ding, V. Chau, Construction of Interactive Higher Education Model Based on “VR+Internet”, Wireless Communications and Mobile Computing, 2022. <https://doi.org/10.1155/2022/6444864>
- [17] H. Batool, Augmented reality applications as a digital learning innovation in response to the pandemic, doi: 10.3389/feduc.2022.937074
- [18] Ministry of science and education, Strateški okvir za digitalno sazrijevanje škola i školskog sustava u Republici Hrvatskoj (2030), Zagreb, 2020.
- [19] I. Smiljcic, I. Livaja, J. Acalin, ICT u obrazovanju, Zbornik Veleučilišta u Šibeniku, 3-4, Šibenik, 2017, pp 157-170
- [20] T. Povic, K. Veleglavac, M. Carapina, T. Jagust, I. Boticki, Primjena informacijsko-komunikacijske tehnologije u osnovnim i srednjim školama u Republici Hrvatskoj // Proceedings of the Carnet User Conference 2015 (CUC2015), Zagreb: Carnet, 2015. 19, 26.
- [21] KA. Abutayeh, OM Kraishan, EQ. Kraishan, The use of virtual and augmented reality in science and math education in Arab countries: A survey of previous research studies, doi: 10.3389/feduc.2022.979291
- [22] I. Cicek, A. Bernik, I. Tomicic, Student Thoughts on Virtual Reality in Higher Education—A Survey Questionnaire. Information 2021. <https://doi.org/10.3390/info12040151>
- [23] M. E. C. Santos, A. Chen, T. Taketomi, G. Yamamoto, J. Miyazaki, H. Kato, Augmented Reality Learning Experiences: Survey of Prototype Design and Evaluation, IEEE transactions on learning technologies, Vol. 0, 2000.