sciendo

AR Technology Potential for Facilitating Access to Advanced Education for Students with ASD

Ruxandra BEJINARU
Academy of Romanian Scientists, Ilfov, Romania
"Stefan cel Mare" University of Suceava, Suceava, Romania
ruxandrab@usm.ro

Marian-Vlăduț TOMA
Academy of Romanian Scientists, Ilfov, Romania
"Stefan cel Mare" University of Suceava, Suceava, Romania
vlad.toma@usm.ro

Abstract. *Facilitating access to advanced education and research is the mission of a proactive and future-oriented university. The university must also direct its attention to categories with disabilities such as students with ASD (Autism Spectrum Disorders). For this purpose, Augmented Reality (AR) can be used through applications that offer different types of support, as well as learning robotization processes. Students with ASD have diverse intellectual potential and can significantly contribute to scientific progress. It is important that universities recognize the intellectual potential and talent of students with ASD and provide appropriate support and accessibility to develop their skills and achieve their academic and research performance. Throughout this paper, we aimed to point out aspects of critical importance from these categories: conceptual and practical evolution, influencing factors, advantages and difficulties, perspectives but also risks regarding the lack of action in this direction. This work integrates qualitative literature review research with empirical research. The literature analysis section highlights the extent to which universities provide adaptation and orientation facilities in new spaces, taking into account the difficulty of people with ASD to adjust to unfamiliar spaces. We will present, both based on the literature and from the practice of the field at a global level, the technologies and platforms used in the development of AR applications for orientation in space. The research conclusions have an impact towards at least three directions: 1. Scientific impact, respectively enriching the specialized literature with new perspectives transmitted in a clear, concise and targeted manner; 2. Applicative impact, increasing the potential of implementing innovations in this field; as well as 3. Informative impact on the general public, which contributes to broadening the spectrum of knowledge but also to strengthening the image in the local community of the efforts made by researchers in this revolutionary field of AR.*

Keywords: AR technology, Autism Spectrum Disorder (ASD), advanced education, students' abilities, AR application, future-oriented university.

Introduction and problem statement

A forward-looking university should adopt a number of long-term strategic development directions to maintain its leading position in the field of education and to fulfil its mission of creating educational opportunities for students and the community (Bejinaru et al., 2018; Bratianu & Bejinaru, 2019; Neamtu et al., 2020). In tandem with global evolution, universities are forced to adapt to new technologies and integrate them into their learning and research processes (Bejinaru, 2019). For example, the use of Augmented Reality (AR) and Virtual Reality (VR) in the teaching and learning processes can improve the efficiency and quality of education. The university of the

DOI: 10.2478/picbe-2024-0155

future will be described by attributes such as: inclusive, integrated, innovative, based on advanced technology, digital, accessible, flexible, and especially global (Friedman, 2008; Linton, 2018; Kapetanaki et al., 2022).

We consider that for the educational system in Romania, advanced technology is a bold puspose that is difficult to achieve on a large scale and research on the issue of increasing access to education for vulnerable categories (such as people with disabilities, or ASD) through AR is almost non-existent, as we have not identified specific publications carried out in our country.

Concept and evolution of Augmented Reality (AR) technology

Augmented Reality (AR) is a technology that combines real-world elements with computer-generated virtual elements to create an enriched and interactive user experience. It superimposes layers of digital information, such as images, text, sound or video, over the real environment and allows interaction with these elements in real time (Azuma, 1997). The concept of AR was first introduced in the 1960s, but has gained popularity in recent years due to the development of mobile technologies and wearable devices such as smart phones and tablets. As seen in figure 1, the number of mobile AR active user devices worldwide increased considerably from 2019 and is expected to reach 1.73 billions in 2024, according to statista.com (2022) (https://www.statista.com/statistics/1098630/global-mobile-augmented-reality-ar-users/). These devices have sufficient cameras, sensors and processing power to facilitate AR experiences (Carmigniani et al., 2011).

AR can be classified into several types depending on how virtual information is superimposed on the real environment. The two main categories are position-based AR and recognition-based AR. Position-based AR uses sensors and the Global Positioning System (GPS) to determine the user's location and overlay relevant information based on this location. Recognition-based AR uses image and object recognition technologies to identify objects and overlay relevant virtual information on top of them (Van Krevelen & Poelman, 2010).

At the moment, AR has a wide range of applications in various fields such as medicine, engineering, architecture, entertainment and education. In education, AR has been explored as a tool to enhance student learning, motivation and engagement, as well as to support the development of collaboration and communication skills.

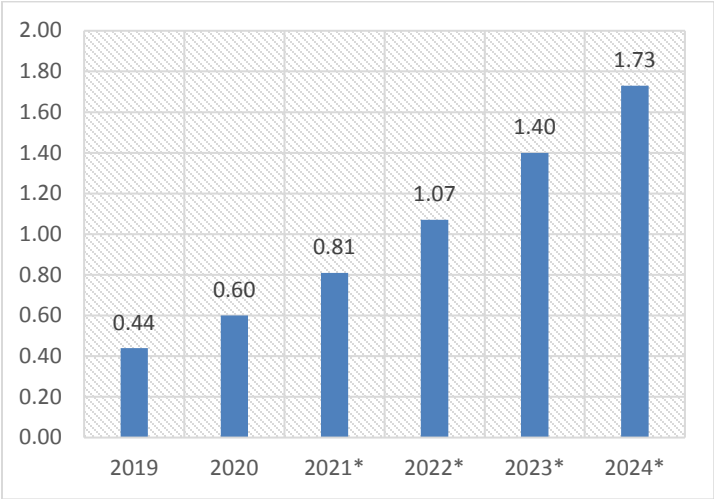

Figure 1. Number of mobile AR active users worldwide during 2019-2024

Source: Adapted from statista.com (2022).

Using Augmented Reality in Higher Education

Augmented Reality (AR) has undergone significant advancements in recent years, providing novel and stimulating learning opportunities in higher education. Its early experiments and applications in education were initiated in the 1990s and early 2000s, primarily in fields such as architecture, medicine, and engineering (Botden et al., 2007). However, the implementation of AR in higher education was restricted by the high costs and limited technology available at the time.

With the advent of accessible and affordable technology, mobile devices such as smartphones and tablets has played a pivotal role in enabling AR to be integrated into a broader range of educational settings. Concurrently, there has been a surge in the number and diversity of research and case studies on the incorporation of AR in higher education (Santos et al., 2014).

Augmented reality (AR) is also a promising technology that can be integrated into distance learning and online environments, offering innovative solutions to facilitate access to education and meet the needs of a diverse student population. One notable application of AR technology is the development of virtual laboratories, which enable students to engage in experimental activities and refine their skills in a secure and controlled setting (Ibanez et al., 2014). Additionally, AR has the potential to promote collaboration and communication among students and educators in virtual learning environments (Dunleavy & Dede, 2014).

Using Augmented Reality in education for students with ASD

In recent years, a considerable number of studies investigated the potential of AR technology to support the education of students with autism. Prior studies have primarily focused on examining how AR can be used to enhance the social and communication skills of students with autism, as well as to facilitate their academic learning (Kandalaft et al., 2013; Lahiri et al., 2013). While these studies have provided valuable insights, they have predominantly been conducted within the context of primary and secondary education. Consequently, research on the application of AR in higher education settings for students with autism is still limited.

Given that students with autism frequently encounter difficulties with communication and social interaction (American Psychiatric Association, 2013), AR offers a controlled and structured environment in which they can explore and learn at their own pace without feeling overwhelmed by real-world stimuli (Escobedo et al., 2012). Previous research has demonstrated that incorporating AR into interventions for students with autism can significantly improve their social skills, attention, and communication (Cheng et al., 2015).

Furthermore, AR can facilitate collaboration and communication between students with autism and their peers, thereby supporting the development of social skills that are essential for success in higher education (Wainer et al., 2017). For instance, AR-based applications can create social scenarios and provide real-time feedback on the user's social behaviours, enabling them to improve their social interaction skills (Parsons et al., 2013). Chang et al. (2010) developed an AR-based instructional system that aimed to help students with autism learn complex tasks and enhance their communication and collaboration skills. The system was tested in a university-level engineering course and demonstrated promising results in improving the conceptual understanding and academic performance of students with autism. Parsons et al. (2013) examined the use of virtual and augmented reality environments to facilitate science learning for adolescents and young adults with autism. The study found that participants with autism were able to successfully navigate and interact in AR-based learning environments and that these environments can be used to support learning in higher education.

Radu (2014) also conducted a review of studies on the use of AR in education and identified several examples where AR has been used to support students with special needs, including those with ASD. Although not all research were specific to students with ASD, the review highlights the potential of AR to provide adaptations and personalised support for students with different learning needs.

Benefits and challenges of AR in educational context

The advantages and disadvantages of using AR in an educational context, particularly for students with ASD, may vary depending on the specific implementation and context. According to existing research, we extracted several advantages that include the following: -AR can boost the interest and motivation of students with ASD by providing them with engaging and interactive learning experiences; -AR provides opportunities for visual and contextual learning, which can be particularly effective for students with ASD, who often have strong visual abilities (Escobedo et al., 2012); -AR supports the development of social skills by helping students with ASD practice interactions and understand social behaviours (Kandalaft et al., 2013); -AR allows learning experiences to be tailored and personalised to the individual needs, enabling them to work at their own pace and focus on areas where they need more support (Akçayır & Akçayır, 2017); -AR can help students with ASD become familiar with new situations and develop self-confidence by giving them the opportunity to explore and experiment in a controlled and safe environment without the pressures and fears associated with new situations (Lorenzo et al., 2016).

Even if the list of benefits can go on, a series of difficulties, barriers, risks or limitations that are inevitable in a process of such scope should not be omitted. The implementation of such a strategy exposes the university to a series of risks and difficulties such as high costs, lack of material endowments and equipment, lack of highly specialized human resources, confidentiality and security issues, mentality and social culture in the sense of a possible negative perception of students without ASD (Merchant et al., 2020).

The costs associated with developing and purchasing AR apps and equipment can be high, which may limit access to this technology for some universities or students with ASD. Implementing AR in higher education can be difficult due to technical issues and the need to adapt content and teaching strategies to this technology (Bower et al., 2014). Another important challenge for some students with ASD, is that the use of AR can lead to sensory overload and increased anxiety. It is important that AR applications are appropriately tailored to take into account the individual needs and sensitivities of students with autism (Zydney & Warner, 2016). In order to effectively use AR in higher education for students with ASD, teachers may need additional training and support to become familiar with the technology and adapt teaching strategies to this new environment. Integrating AR into the university curriculum can be difficult, as it may require revising and adapting course materials and teaching strategies to accommodate this technology. This may require additional time, effort and resources from teaching staff and higher education institutions (Johnson et al., 2011). The use of AR in higher education involves the collection and storage of personal data and information about student performance, which can raise privacy and data security concerns. Educational institutions and AR app developers must implement appropriate security measures to protect this information (Villagran-Vizcarra et al., 2023).

The use of AR in higher education for students with ASD has both advantages and disadvantages. In order to benefit from the potential of this technology and mitigate the disadvantages, careful planning, adaptation of content and teaching strategies, and continuous

monitoring and evaluation of the impact on students are essential within a future-oriented university (Prelipcean & Bejinaru, 2018).

Research Methodology

Aim of research

Through this paper, we launch a detailed analysis of the subject regarding the facilitation of access to advanced education for students with ASD through AR technology in a higher education organization such as a university in Romania. The research methodology is mixed, which combines the qualitative methods of analysis and synthesis, with the empirical methods of developing and testing an AR application in a particular setting such as the "Stefan cel Mare" University in Suceava.

More systematically, the purpose of the research is to map the overall picture of the theme and to formulate solutions for realistic progress. There are several specific objectives, such as: -to identify the conceptual and practical evolution of the topic addressed, -to identify the influencing factors on the analysed topic, -to identify advantages and disadvantages arising in relation to the analysed topic, -to argue the positive perspectives as well as the risks that may arise for such a practical approach. As we mentioned, qualitative and empirical research methods complement each other. Regarding the results and impact of the research, we will present them in the following section while describing the research methods.

Research methods

The scientific literature analysis reveals lack of development of AR applications that can be tested and used in higher education, both for people with normal development and even more so, for people with ASD. Thus, we aim to develop an app for mobile devices (smartphone, tablet) using AR technology to support orientation on a school or university campus. Using GPS technology, built-in optical sensor and screen, the app will display complementary content in the form of graphic/text/audio & video creations when the camera is pointed at a specific target. This way, people with special needs such as those with ASD can be supported to orient themselves and get comfortable with new spaces, especially if they have a social skills deficit. The app can also be used to deliver guidance and additional information for people with normal development.

The app to be developed will run on a web server for easy access and use. Thus, the app does not require installation from a specialised app store such as the Play Store (Android) or Apple Store (iPhone) and does not take up local storage space. Because it’s cross-platform, it means that can be accessed from any device that has a browser installed. The app is accessed by simply scanning a QR code that links to the web server hosting it. The application flow chart is described in figure 2.

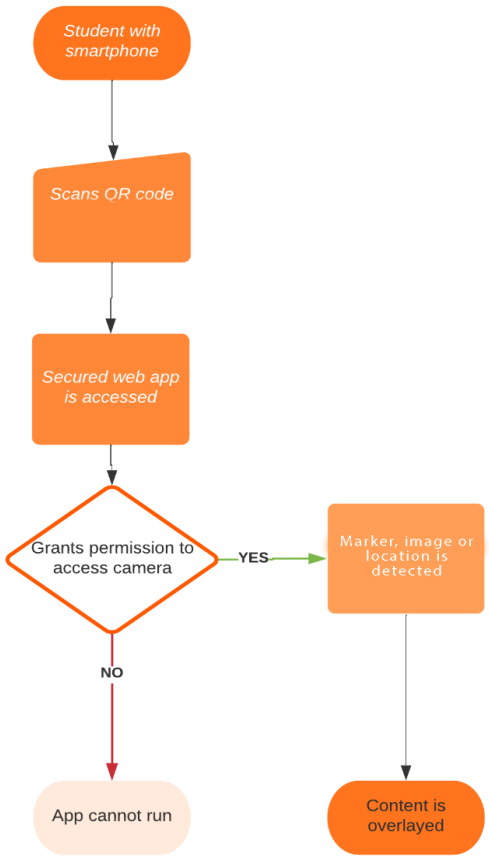

Figure 2. Application flow chart

Source: Authors own elaboration.

The application will be tested during the admissions process at "Stefan cel Mare" University in Suceava, both with potential students visiting the campus for the first time for the registration process and with voluntary people with ASD from the Help Autism Suceava Centre. To access the application, QR codes will be placed on a panel containing the name of each faculty, so that the student can scan the QR code for the faculty concerned and be directed to the web application, receiving guidance. On the first run, the users will be prompted to choose between standard assistance for orientation and special assistance (for people with ASD). The delivered content will be personalised depending on the chosen option.

Both during the university admissions period and in the first weeks of the semester, students can be disoriented and confused about the location of registration rooms for each faculty and later about the location of lecture halls and seminar lab rooms. Some find it difficult to socialise and ask for directions, especially because in a university study people from many different locations across the country and beyond.

The major limitations of the research methodology we can specify are lack of generalization and representativity, as the experiment will be developed in a specific framework, namely "Stefan cel Mare" University campus. Although this type of approach provides a certain control and predictiveness on the experiment and this could lead to further improvements.

Conclusions and expected results

Considering the potential of AR highlighted by both researchers and statistics on the trend of this technology adoption, it is expected that the proposed application will be a real success, with obvious advantages such as the use of a mobile device, as a smartphone, that most young people already own, running directly on a web browser without the need to install the application (thus eliminating resource consumption) and the valuable information it can provide by simply pointing the camera to various targets. Settling in and orienting to new spaces, especially those such as university campuses, can be difficult for both people with normal neurological development and people with special needs, such as those with autism spectrum disorders. Therefore, guidance can be very helpful. Based on the existing studies and applications that have been developed and tested, the need for a solution in terms of orientation on campus and by analysing the results obtained from previous research, it can be expected that the proposed application can make a real contribution.

In general, a future-oriented university must be inclusive and flexible towards all students, regardless of their special needs. By providing individualized support and creating an inclusive academic environment, universities can contribute to the development and success of all students, including those with ASD.

In conclusion, the paper proposes an adapted research model, which will be realized in an original (new) experiment through the intelligent mobile application based on AR. The paper argues the relevance of introducing AR technology for a specific problem such as access to advanced education for students with ASD. The implementation of this experiment has the potential to identify - both functionalities and dysfunctionalities and brings to light possible future approaches. A conclusion section is required. Conclusions should provide a synthesis of the main contributions of the paper, discussing the importance of the work, and/or suggest possible applications and extensions of the research. Also, the author should indicate some major limitations of the present research.

Acknowledgment

The present paper has been financially supported by the Academy of Romanian Scientists, within the program AOSR-TEAMS II EDITION 2023-2024, DIGITAL TRANSFORMATION IN SCIENCES, allocated to the project entitled "Facilitating access to education through Augmented Reality and stimulating dynamic learning in business through microlearning".

References

Akçayır, M., & Akçayır, G. (2017). Advantages and challenges associated with augmented reality for education: A systematic review of the literature. *Educational Research Review, 20,* pp. 1-11.

Azuma, R. T. (1997). A survey of augmented reality. *Presence: Teleoperators & Virtual Environments, 6(4),* pp. 355-385.

Bejinaru, R., Hapenciuc, C. V., Condratov, I. & Stanciu, P. (2018). The university role in developing the human capital for a sustainable bioeconomy. *Amfiteatru Economic, 20(49),* pp. 583-598. DOI: 10.24818/EA/2018/49/583

Bejinaru, R. (2019). Impact of digitalization in the knowledge economy, *Management Dynamics in the Knowledge Economy, 7(3),* pp.367-380.

Botden, S. M., Jakimowicz, J. J., & Goossens, R. H. (2007). Augmented reality in minimally invasive laparoscopic surgery: a review. *Surgical Endoscopy, 21(6),* pp. 844-852.

Bower, M., Howe, C., McCredie, N., Robinson, A., & Grover, D. (2014). Augmented reality in education–cases, places and potentials. *Journal of Educational Technology & Society, 17(2),* pp. 64-71.

Bratianu, C. & Bejinaru, R. (2019). Intellectual capital of the cultural heritage ecosystems: A knowledge dynamics approach. In: Handzic, M. & Carlucci, D. (Eds.). *Knowledge management, arts, and humanities. Interdisciplinary approaches and the benefits of collaboration*. Springer, Cham, pp. 215-238.

Carmigniani, J., Furht, B., Anisetti, M., Ceravolo, P., Damiani, E., & Ivkovic, M. (2011). Augmented reality technologies, systems and applications. *Multimedia Tools and Applications, 51(1),* pp. 341-377.

Chang, G., Morreale, P., & Medicherla, P. (2010). Applications of augmented reality systems in education. In *Proceedings of Society for Information Technology & Teacher Education International Conference*, pp. 1380-1385.

Cheng, Y., Ye, J., & Zhu, L. (2015). An augmented reality-based training system for autism spectrum disorder. In *Proceedings of the IEEE 15th International Conference on Advanced Learning Technologies (ICALT),* pp. 409-413.

Dunleavy, M., & Dede, C. (2014). *Augmented reality teaching and learning*. In Handbook of research on educational communications and technology, pp.735-745. Springer, New York, NY.

Escobedo, L., Nguyen, D. H., Boyd, L., Hirano, S., Rangel, A., Garcia-Rosas, D., Tentori, M., & Hayes, G. (2012). MOSOCO: A mobile assistive tool to support children with autism practicing social skills in real-life situations. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pp. 2589-2598.

Friedman, T.L. (2008). Hot, flat and crowded: why we need a green revolution – and how we can renew our global future. London: Penguin.

https://www.statista.com/statistics/1098630/global-mobile-augmented-reality-ar-users/, accessed on 1.05.2023

Ibanez, M. B., Di Serio, Á., & Delgado-Kloos, C. (2014). Gamification for engaging computer science students in learning activities: A case study. *IEEE Transactions on Learning Technologies, 7(3)*, pp. 291-301.

Johnson, L., Smith, R., Willis, H., Levine, A., & Haywood, K. (2011). *The 2011 horizon report. Austin*, Texas: The New Media Consortium.

Kandalaft, M., Didehbani, N., Krawczyk, D., Allen, T., & Chapman, B. (2013). Virtual reality social cognition training for young adults with high-functioning autism. *Journal of Autism and Developmental Disorders, 43(1),* pp. 34-44.

Kapetanaki, A., Krouska, A., Troussas, C., Sgouropoulou, C. (2022). Exploiting Augmented Reality Technology in Special Education: A Systematic Review. *Computers*, 11, 143.

Lahiri, U., Bekele, E., Dohrmann, E., Warren, Z., & Sarkar, N. (2013). Design of a virtual reality based adaptive response technology for children with autism. *IEEE Transactions on Neural Systems and Rehabilitation Engineering, 22(1),* pp. 55-67.

Linton, J. D. (2018). DNA of the Triple Helix: Introduction to the Special Issue. Technovation, 21, 76-77: 1–2.

Lorenzo, G., Lledó, A., Pomares, J., & Roig, R. (2016). Design and application of an immersive virtual reality system to enhance emotional skills for children with autism spectrum disorders. Computers & Education, 98, pp. 192-205.

Merchant, W., Read, S., D'Evelyn, S. et al. (2020). The insider view: tackling disabling practices in higher education institutions. *Higher Education, 80,* 273–287.

Neamțu, D.M, Bejinaru, R., Hapenciuc, C.V., Condratov, C. & Stanciu, P. (2020). Analysis and modelling of influence factors in the configuration of a sustainable university. Case study: "Ștefan cel Mare" University of Suceava. *Amfiteatru Economic, 22(54),* pp. 391-410.

Parsons, S., Cobb, S., & Patel, H. (2013). Virtual environments for social skills training for students with ASD: A review of the research. In M. A. Williams White, S. W. Keonig, & L. A. Scahill (Eds.), *Social Skills Training for Children with Autism*. Springer.

Prelipcean, G. & Bejinaru, R. (2018). University agenda for developing students' skills in the knowledge economy, *Strategica –International Conference – Sixth Edition, "Challenging the Status Quo in Management and Economics"*, Bucharest: 11th -12th October, pp.600-610.

Radu, I. (2014). Augmented reality in education: a meta-review and cross-media analysis. *Personal and Ubiquitous Computing, 18(6),* pp. 1533-1543.

Santos, M. E. C., Chen, A., Taketomi, T., Yamamoto, G., Miyazaki, J., & Kato, H. (2014). Augmented reality learning experiences: Survey of prototype design and evaluation. *IEEE Transactions on Learning Technologies, 7(1),* pp. 38-56.

Van Krevelen, D. W. F., & Poelman, R. (2010). A survey of augmented reality technologies, applications and limitations. *International Journal of Virtual Reality, 9(2),* pp. 1-20.

Villagran-Vizcarra, D. C., Luviano-Cruz, D., Pérez-Domínguez, L. A., Méndez-González, L. C. & Garcia-Luna, F. (2023). Applications Analyses, Challenges and Development of Augmented Reality in Education, Industry, Marketing, Medicine, and Entertainment, *Applied Sciences, 13(5),* p. 2766.

Wainer, A. L., Ingersoll, B. R., & Hopwood, C. J. (2017). The structure and nature of the broader autism phenotype in a non-clinical sample. *Journal of Psychopathology and Behavioral Assessment, 29(2),* pp. 177-186.

Zydney, J. M., & Warner, Z. (2016). Mobile apps for science learning: Review of research. *Computers & Education, 94*, pp. 1-17.