The augmented reality portal and hints usage for assisting individuals with autism spectrum disorder, anxiety and cognitive disorders

Yulia Yu. Dyulicheva[1][0000-0003-1314-5367], Yekaterina A. Kosova[1][0000-0002-3263-9373] and Aleksandr D. Uchitel[2][0000-0002-9969-0149]

[1] V. I. Vernadsky Crimean Federal University, 4 Vernadsky Ave., Simferopol, 295007, Crimea
{dyulicheva, kosovakateryna}@gmail.com
[2] State University of Economics and Technology,
5 Stepana Tilhy Str., Kryvyi Rih, 50006, Ukraine
o.d.uchitel@i.ua

Abstract. The augmented reality applications are effectively applied in education and therapy for people with special needs. We propose to apply the augmented reality portal as a special tool for the teachers to interact with people at the moment when a panic attack or anxiety happens in education process. It is expected that applying the augmented reality portal in education will help students with ASD, ADHD and anxiety disorder to feel safe at discomfort moment and teachers can interact with them. Our application with the augmented reality portal has three modes: for teachers, parents, and users. It gives the ability to organize personalized content for students with special needs. We developed the augmented reality application aimed at people with cognitive disorders to enrich them with communication skills through associations understanding. Applying the augmented reality application and the portal discovers new perspectives for learning children with special needs. The AR portal creates illusion of transition to another environment. It is very important property for children with ADHD because they need in breaks at the learning process to change activity (for example, such children can interact with different 3D models in the augmented reality modes) or environment. The developed AR portal has been tested by a volunteer with ASD (male, 21 years old), who confirmed that the AR portal helps him to reduce anxiety, to feel calm down and relaxed, to switch attention from a problem situation.

Keywords: augmented reality, autism spectrum disorder, anxiety disorder, augmented reality portal, innovations in education.

1   Introduction

On 27 March 2020 the Centers for Disease Control and Prevention had published a report alleging that the number of people with autism spectrum disorder (ASD) diagnosis were increased and there were identified the ASD for 1 out of 54 eight-year old children from USA [4]. Besides, throughout the world the number of people with

anxiety disorders and panic attack is increased. For example, 25.1% of the children from USA between the ages 13 and 18 have anxiety disorders and 2.7% of the adult population from USA has panic disorders with twice as many women as men [3]. The development of methodologies and innovative technologies usage for assisting people with ASD and anxiety disorders are the pressing challenges.

1.1   The problem statement

The augmented reality technology (AR technology) is one of the innovative technologies in education and therapy and proved itself to work well in the different applied fields [17; 18; 26; 29; 34; 39; 47; 48]. In particular, it is being used successfully to support the education of persons with disabilities, including individuals with ASD and anxiety disorders [16; 31]. The AR technology usage fosters the social, physical and everyday skills to empower the persons with special needs to realize the educational purposes [5]. The AR application efficiency is achieved through the mixed environment use, where the real objects interact with virtual objects [8; 24].

The aim of the article is to develop a methodology based on the augmented reality portal usage for assisting individuals with ASD and anxiety disorders. This article offers the augmented reality portals usage as teachers support tool that allows students "to hide" at the moment of a panic attack, obsessive-compulsive disorder (OCD) and other negative reactions caused by anxiety disorders. AR application has been further developed to acquire the skills of the associative thought process for individuals with cognitive disorders.

1.2   Analysis of recent research and publications

The results of systematic review Quintero et al. [32] have shown that augmented reality usage leads to the development of social interaction (communication) skills (24% from analyzed publications, covering the period 2008-2018), to increasing of the interest, attention, motivation and academic performance for people with special needs (22%). Most of the studies devoted to AR technology are based on marker technology and geolocation detection. The Vuforia library (8%) and Aurasma (HP Reveal) (10%) are often used for AR application development. When the review [32] was published, the markerless technology was not studied. Approximately one-fifth of research (18%) was devoted to augmented reality usage for teaching individuals with ASD.

According to the International Statistical Classification of Diseases and Related Health Problems 10th Revision, ICD-10, ASD diagnosis involves the impairment in social interaction and communication models as well as a limited, stereotyped, repetitive scenario of the interests and actions [14].

The directions of the augmented reality usage for teaching individuals with ASD are extremely diverse. So, the methodology for learning content development for the people with ASD based on augmented reality is considered in the article Vullamparthi et al. [44]. The Android application allows capturing and images recognition of surrounding objects and set their connection with AR content (photo and video). The results of research Chen et al. [8] showed that augmented reality usage for individuals

with ASD to improve emotions recognition and to foster adequate feedback on emotional expressions of faces. Tentori et al. [40] conducted complex research devoted to smart environment usage based on augmented reality for therapy of the children with ASD. The results of experiment indicated that there exists a positive impact of new environment on motor skills development. To reduce the burden on teachers the AR environment MOBIS for enhanced visual support was developed by Escobedo et al. [9]. Experiments have found that environment MOBIS usage provided multi-tasking and helped teachers to work with individuals with ASD. The web-application AR Layar to facilitate the independent navigation in the unknown place is described in research McMahon et al. [23]. Lee et al. [19] showed experimentally that augmented reality technology jointly with a mental map was effective to learn children with ASD that had problems with social skills, especially, to answer on greetings from other people.

People with ASD prefer stability and familiar sequence in their activity and environment. The changing of routine habits provokes anxiety and can lead to inability to function [30]. Besides, ASD results in sensory hypersensitivity that also leads to increased anxiety and stress [2; 12; 13; 36]. It is recommended the sensory-neutral environments to use in teaching process for children with ASD [38]. Besides, the cognitive abilities are improved in the natural habitat compared to the extreme sensory stimuli of the urban environment [6]. It is necessary to provide quiet and peaceful places for students with ASD who are anxious due to increased sensory sensitivity on stage of training organization in the open educational space of an educational institution [38].

The people who have anxiety disorders not related to ASD also may need a calm environment. In case of phobic anxiety disorders (code F40 ICD-10), the main symptom is the fear of being in a certain situation, which, in fact, is not dangerous at a moment. Other anxiety disorders (code F41 ICD-10) are characterized by manifestations of anxiety that are not limited to and are not directly related to a specific situation. Anxiety disorders can provoke panic attacks, depressive episodes, obsessive symptoms and other negative reactions that limit a person's life [15].

The augmented reality applications can be useful in neutral, calm environments creation for people with ASD and anxiety disorders, and without the use of special expensive equipment.

1.3 The purpose of the article

On the basis of analysis of papers devoted by augmented reality application for people with special needs we propose to use the augmented reality portal as tool for teachers and parents to interact with students at the moment when panic attack or anxiety happens. We also propose to use the augmented reality application for children with cognitive disorders to enrich their associations knowledge about the real objects based on the hints in augmented reality mode.

2 Theoretical background

The augmented reality technology based on "aliving" and embedding content in real

environment helps people with ASD and anxiety disorders to feel ongoing concern and support. AR/VR/MR-applications help to improve the communicative, emotional and cognitive skills based on appearance of unexpected augmented reality content in real environment for test subject. Let's consider the brief review of AR/VR-applications aimed at learning of individuals with ASD and anxiety disorders to acquire the social and cognitive skills and to mitigate anxiety.

AR application to acquire the skill for orientation in a new environment. Using a mobile application HP Reveal, the teachers and parents can create audio and video content that will be displayed above the markers. The pictures as markers with the image of a favorite hero are placed in new environment. The individuals with ASD receive hints in the augmented reality mode that help to navigate in a new environment [10].

AR applications to acquire the social skills. The books with the games and elements in augmented reality mode contribute to the development of cognitive and social skills. The book involves the children to interact with AR character through the different scenarios of social behavior to learn the emotions recognition that they feel [7]. The AR RPG system aimed at participating in various role game to involve children with ASD in atmosphere of "miniature theatre" with the goal to create the game with virtual environments that reconstruct the child familiar environments to develop the behavioral skills in the classroom and in society based on scenarios. An improvement in the skills of behavior and understanding of gestures and expressions was observed for three children after AR RPG usage [20].

AR applications to acquire the cognitive skills. The AR technology is actively used for the formation and development of cognitive skills in various fields of knowledge. Thus, an experiment to check the effectiveness of using augmented reality for teaching the English alphabet showed the advantages of using the teaching based on augmented reality content over the traditional full-time methodology. The AR applications "AR Flashcards Animals-Alphabet" and "AR Alphabet Flashcards" available at AppStore were used for the research [37]. When pointing the smartphone's camera to the first letter the child can see the name of the pet or predator and three-dimensional picture of the studied letter, accompanied by the sound of the animal's cry and a small animation. The AR video game "Gremlings in my Mirror" was developed based on NyARToolkit and Unity3D to acquire logical skills for children with special needs [43]. By moving a pre-printed marker, the child must have time in the game situation to order the characters by size or to sort by color. As a result of comparing the game experience of two groups of children – with and without special needs – the same success indicators are obtained.

AR applications to acquire the skills for emotions and facial expression recognition. The Brain Power System is based on emotions recognition algorithms and special equipment usage such as Google Glass. A person with autism puts on glasses and begins to communicate with a teacher or mother in a playful way. There are two options for emoticons depicting the right and wrong emotions associated with the face in the augmented reality mode. The task for the child is to learn how to choose a smiley with the right emotion. Google Glasses have built-in special sensors that record the level of stress and anxiety. This kind of application in a playful way allows children with autism

to improve communication skills and understanding of emotions, establish eye contact in the communication process and increase self-confidence. The System efficacy results, described in [22], showed that for two boys during the experiment the decrease of autistic symptoms after using the Brain Power System was observed.

AR applications to reduce the anxiety. AR/VR/MR technologies are effectively used to combat various phobias, for example, arachnophobia [28], claustrophobia, etc. Claustrophobia belongs to the group of the anxiety disorders, manifested by unreasonable fear in enclosed spaces. One of the effective methods for the treatment of claustrophobia is the use of virtual reality technology.

It is used to immerse a patient with claustrophobia in a problematic situation at the time of the therapy under the supervision of a psychotherapist. For example, the "Claustrophobia Game" allows to move from an environment with worrying increase to a relaxation room in the virtual reality mode. According to experiments and estimates based on the Spielberger questionnaire, the level of apparent anxiety in 14 patients before and after using the game application was decreased [33].

3 Research methodology

To clarify the status of the problem and objectives of the study the scientific papers about the usage AR/VR/MR technologies for learning of the people with special needs such as individuals with ASD and anxiety disorders were analyzed, covering the period 2011-2019.

In the practical part of the research, the mobile applications were developed: the AR portal to reduce anxiety and the AR application to develop cognitive skills. To create the AR portals for people with ASD we used React Native framework with Viro AR and to create AR hints application for people with cognitive disorders we used ARKit and SpriteKit frameworks.

4 Results

In this section the results of the practical part of the study based on the development of mobile AR applications for people with ASD, hyperactivity and anxiety and the modern approaches to the design of immersive environments, in particular, AR portals are discussed.

4.1 About development of the augmented reality portals

Let's consider the possibility of the augmented reality portals usage to combat claustrophobia and anxiety disorders. AR portals create the illusion of a transition from one reality to another in order to decrease the anxiety and to feel safe. The studies demonstrate the effectiveness of anxiety therapy based on immerse to the virtual reality, but the use of such therapy is impossible without the special equipment. The results of our study can be used in problem situations associated with anxiety in the presence of

any gadget. Besides, there are no significant differences between virtual and augmented reality technologies to treat the induced anxiety. As shown in [46], the participants with induced anxiety feel almost the same discomfort, frequent heart rate and level of anxiety when immersed in an artificial environment using these two technologies during the experiment. So, we offer to use a methodology based on the augmented reality portal to help the teacher in case the students start to feel anxiety in the learning process.
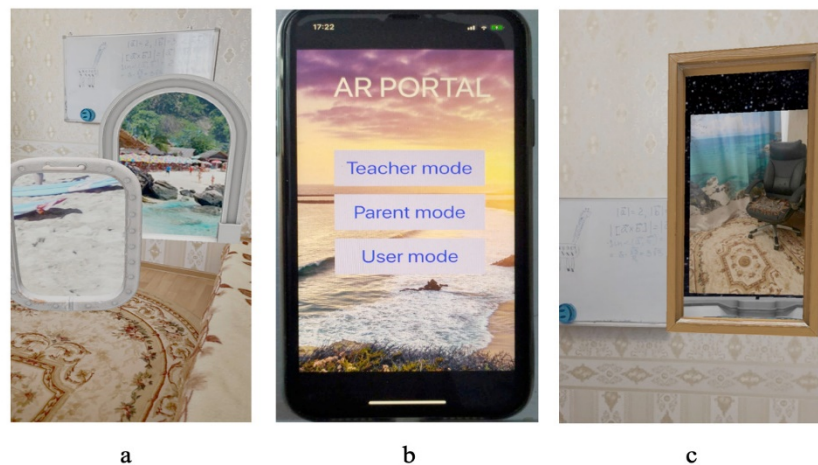
The approaches to the augmented reality portals development are considered.

1. *The AR portal development based on ARKit and SceneKit frameworks*. The stages of AR portal development include the detection and rendering of horizontal planes; the handle of session interruption and visual 3D objects placement on View based on SceneKit; the creation of three vertical planes for walls of portal and creation node for floor placement with the help of the objects from basic classes SCNNode и SCNBox; the determination of their position and angles of rotation, texture and transparency; the detection of doorway. For realistic portal creation it is needed to create light sources using objects from basic class SCNLight [35]. Another approach to AR portal developing is to use the Unity3D game engine in conjunction with the ARKit, ARCore, and ARFoundation frameworks.

2. *The AR portal development based on Figment AR application and using Snapchat Lens Studio*. The iOS Figment AR application is a convenient user application with the ability to create several augmented reality portals in a room and place your favorite 3D heroes in real environment. To create a portal, just select the type of portal door (hatch, door, arch) in the menu, determine the contents of the portal based on the 360 video and 360 photo templates and click on the smartphone screen to place it in the desired part of the room (Figure 1a). Snapchat Lens Studio allows you to create augmented reality applications based on predefined templates, for example, portal template.

3. *The AR portal development based on React Native and Viro AR*. The Viro AR platform is designed for the rapid development of augmented reality applications based on ARKit and ARCore and contains convenient components for developing an augmented reality portal: the <Viro3DObject> component for working with 3D objects, the <ViroPortal> and <ViroPortalScene> components for creating a portal and setting up scenes followed by adding to ARScene [27].

4.2   AR portal and AR hints for people with special needs

A mobile application for iOS has been developed. Three modes are available in application: a mode for a teacher, a mode for a parent, and a mode for a user. In teacher mode it is possible to create training content for AR portal based on 360^0 video and 360^0 image to acquire students with various ecosystems. The teacher in this mode can tag the content in the portals that caused to student discomfort. In parent mode, you can create 360^0 video and 360^0 image to fill the portals with content, which creates a student's safe and home environment. In this mode, the user can select content for augmented reality portals based on templates approved by teacher and parents. This application allows you to customize personalized content for individuals with special

needs. The menu of our application and portal loading with the home environment approved by parent are shown in the figure 1b, 1c. In addition to visualization, all three modes of the portal are provided with audio recordings such as relaxing music. As known the music therapy helps to reduce depression, stress, anxiety and nervousness [21; 42; 45].

a   b   c

Fig. 1. The augmented reality portals and app for people with special needs.

The augmented reality portal can be used by therapists and teachers as a sensory room to reduce the student's anxiety level. It has been shown that the safe space of sensory rooms helps children with ASD and emotional problems learn how to independently regulate their behavior, which helps to improve concentration on tasks in learning process [41].

Let's enumerate the target audience for the augmented reality portal usage:

1. people with ASD, faced with an unexpected situation for them, are pinched and try to find support in their environment. In such case, the augmented reality portal can serve as a transition to a protected space for them and can help to reduce the level of strain and anxiety with ability to continue interaction with student through the portal;
2. people with anxiety disorders can move to the augmented reality portal at the moment of panic attack or anxiety increasing through illusion of environment change;
3. people with ADHD feel significant difficulties in the learning process. Teachers need to create a special learning environment to exclude distractions; to control impulsive behavior; to redirect excessive physical activity to other activities; to provide an opportunity for movement (training individuals with ADHD requires breaks with the possibility of outdoor games and a change of scenarios); to promote positive social interaction in the learning process [1] and to develop interactive learning content. The augmented reality portal can help people with ADHD to change environment in the classroom.

Additionally, to the augmented reality portal we develop mobile application to help children with cognitive disorders. Persons with ASD perceive and process information in different manner than other people. Temple Grandin (2009) distinguishes three types of people's thinking: visual thinkers; verbal/logical thinkers; and musical/mathematical thinkers [11].

For visual thinkers, the process of the associations detection for the presented object is similar to photos recognition in a search engine. Moreover, the emerging associations are often not obvious to others, as they are associated with pictures from the past that are understandable only to people with ASD. As shown in [25], people with ASD have difficulties to form new categories. For the formation of skills to categorize data, it is important to enrich the visual associations knowledge [11]. The hypothesis of the research is an attempt to expand the category knowledge for children with ASD through photorealistic and sound associations in the augmented reality mode. Such augmented reality application will help children with ASD to interact with teachers, parents and peers, i.e. their communication skills.

The proposed mobile application allows children with ASD to see associations for selected object in augmented reality mode. The application was developed based on ARKit framework. As static learning content is ill-defined for children with ASD, we develop interactive augmented reality application that aimed at interest and motivation increasing in learning process. The augmented reality application with associations demonstrated as augmented reality hints is shown on figure 2. When child with ASD hover a smartphone screen on cat image, he can see popup hints with association, for example, mouse image and milk image. The augmented reality hints are considered as miracle by children with ASD and can be applied to decrease cognitive disorders.

Fig. 2. The mobile application to demonstrate the associations cards in the augmented reality mode.

5   Conclusions and prospects for further research

At the final stage of the project, the two experiments will be conducted:

1. to study the response of individuals with ASD and increased anxiety to the use of the new augmented reality portal;

2. to test the AR application that presents associations in augmented reality mode for categorization development and communication skills increasing for children with ASD.

As an experimental group, it is planned to attract children and adolescents with ASD that receive a special education at the center of correctional pedagogy and the students of secondary schools from Simferopol. The results of the experiments will be processed by methods of mathematical statistics, analyzed and published.

At the moment, the portal has been tested by a volunteer with ASD (male, 21 years old), who confirmed that the AR portal helps him to reduce anxiety, to feel calm down and relaxed, to switch attention from a problem situation. The effectiveness of the portal usage for people with ASD has been proved by the observer with pedagogical education and degree, certified in the use of information and communication technologies in the training of individuals with disabilities.

The beta-testing phase for AR application based on demonstration of association in augmented reality mode was completed. According to evaluations of the application prototype by specialists in the field of correctional pedagogy, the developed product can be used as a didactic game for children with cognitive disorders. Such application is recommended by educators that teach children with cognitive disorders and psychologists at the center of correctional pedagogy from Simferopol. So, the developed AR application is ready to approbation on target audience.

An analysis of the literature showed that the usage of AR / VR / MR technologies in education and quality life improvement for individuals with ASD is very perspective direction especially for people with special needs. It is no found the studies devoted by the augmented reality portal usage to reduce anxiety. We propose the augmented reality portal usage as tool to help teachers to interact with people with anxiety disorder, ASD and ADHD.

The proposed applications will be shared for free, without payment for use. They can be used by parents and teachers as the tool for effective interactive and teaching of people with special needs. It is expected that further introduction of AR portal and AR application in learning process for individuals with disabilities will allow to improve the quality of life and academic performance, to reduce anxiety in new learning environment and to improve cognitive skills.

References

1. Alberta Education: Focusing on Success: Teaching Students with Attention Deficit/Hyperactivity Disorder, grades 1 to 12. Alberta Education, Learning and Teaching Resources Branch, Edmonton. https://open.alberta.ca/dataset/e06f242f-eaf1-4567-a035-f56ef95a7435/resource/744e1402-d99d-46b0-b4e6-04f28073de29/download/2006-focusing-success-teaching-students-adhd.pdf (2006). Accessed 29 Nov 2019

2. Amos, G.A., Byrne, G., Chouinard, P.A., Godber, T.: Autism Traits, Sensory Over-Responsivity, Anxiety, and Stress: A Test of Explanatory Models. Journal of Autism and Developmental Disorders **49**(1), 98–112 (2019). doi:10.1007/s10803-018-3695-6

3. Anxiety and Depression Association of America. https://adaa.org/about-adaa/press-room/facts-statistics (2020). Accessed 13 May 2020

4. Autism Society. https://www.autism-society.org/releases/cdc-releases-new-prevalence-rates-of-people-with-autism-spectrum-disorder (2020). Accessed 13 May 2020

5. Baragash, R., Al-Samarraie, H., Alzahrani, A., Alfarraj, O.: Augmented Reality and Functional Skills Acquisition Among Individuals With Special Needs: A Meta-Analysis of Group Design Studies. European Journal of Special Needs Education **35**(3), 382–397 (2019). doi:10.1080/08856257.2019.1703548

6. Berman, M.G., Jonides, J., Kaplan, S.: The cognitive benefits of interacting with nature. Psychological Science **19**(12), 1207–1212 (2008). doi:10.1111/j.1467-9280.2008.02225.x

7. Brandão, J., Cunha, P., Vasconcelos, J., Carvalho, V., Soares, F.: An Augmented Reality Gamebook for Children with Autism Spectrum Disorders. In: The International Conference on E-Learning in the Workplace, 2015 June 10th-12th, New York, pp. 123–127 (2015)

8. Chen, C.-H., Lee, I.-J., Lin, L.-Y.: Augmented reality-based self-facial modeling to promote the emotional expression and social skills of adolescents with autism spectrum disorders. Research in Developmental Disabilities **36**, 396–403 (2015). doi:10.1016/j.ridd.2014.10.015

9. Escobedo, L., Tentori, M.: Mobile Augmented Reality to Support Teachers of Children with Autism. In: Hervás, R., Lee, S., Nugent, C., Bravo, J. (eds.) Ubiquitous Computing and Ambient Intelligence. Personalisation and User Adapted Services. UCAmI. Lecture Notes in Computer Science, vol. 8867, pp. 60–67. Springer, Cham (2014). doi:10.1007/978-3-319-13102-3_12

10. Geroimenko, V., El-Seoud, S., Halabi, O.: An Augmented Reality-Based Framework for Assisting Individuals with Autism and Cognitive Disorders. International Journal of Information and Education Technology **8**(12), 904–907 (2018). doi:10.18178/ijiet.2018.8.12.1160

11. Grandin, T.: How does visual thinking work in the mind of a person with autism? A personal account. Philosophical Transactions of the Royal Society B: Biological Sciences **364**(1522), 1437–1442 (2009). doi:10.1098/rstb.2008.0297

12. Green, S.A., Ben-Sasson, A., Soto, T.W., Carter, A.S.: Anxiety and sensory over-responsivity in toddlers with autism spectrum disorders: Bidirectional effects across time. Journal of Autism and Developmental Disorders **42**(6), 1112–1119 (2012). doi:10.1007/s10803-011-1361-3

13. Horder, J., Wilson, C.E., Mendez, M.A., Murphy, D.G.: Autistic traits and abnormal sensory experiences in adults. Journal of Autism and Developmental Disorders **44**(6), 1461–1469 (2014). doi:10.1007/s10803-013-2012-7

14. ICD-10 Version:2019: F84 Pervasive developmental disorders. https://icd.who.int/browse10/2019/en#/F84 (2020). Accessed 19 April 2020

15. ICD-10 Version:2019: Neurotic, stress-related and somatoform disorders (F40-F48). https://icd.who.int/browse10/2019/en#/F40-F48 (2020). Accessed 13 May 2020

16. Kolomoiets, T.H., Kassim, D.A.: Using the Augmented Reality to Teach of Global Reading of Preschoolers with Autism Spectrum Disorders. CEUR Workshop Proceedings **2257**, 237–246 (2018)

17. Kramarenko, T.H., Pylypenko, O.S., Zaselskiy, V.I.: Prospects of using the augmented reality application in STEM-based Mathematics teaching. CEUR Workshop Proceedings **2547**, 130–144 (2020)

18. Lavrentieva, O.O., Arkhypov, I.O., Kuchma, O.I., Uchitel, A.D.: Use of simulators together with virtual and augmented reality in the system of welders' vocational training: past, present, and future. CEUR Workshop Proceedings **2547**, 201–216 (2020)

19. Lee, I.-J., Chen, C.-H., Wang, C.-P., Chung, C.-H.: Augmented Reality Plus Concept Map Technique to Teach Children with ASD to Use Social Cues When Meeting and Greeting.

The Asia-Pacific Education Researcher **27**(3), 227–243 (2018). doi:10.1007/s40299-018-0382-5

20. Lee, I.-J., Lin, L.-Y., Chen, C.-H., Chung, C.-H.: How to Create Suitable Augmented Reality Application to Teach Social Skills for Children with ASD. In: Mohamudally, N. (ed.) State of the Art Virtual Reality and Augmented Reality Knowhow. IntechOpen (2018). doi:10.5772/intechopen.76476

21. Leubner, D., Hinterberger, T.: Reviewing the Effectiveness of Music Interventions in Treating Depression. Frontiers in Psychology **8**, 1109 (2017). doi:10.3389/fpsyg.2017.01109

22. Liu, R., Salisbury, J.P., Vahabzadeh, A., Sahin, N.T.: Feasibility of an Autism-Focused Augmented Reality Smartglasses System for Social Communication and Behavioral Coaching. Frontiers in Pediatrics **5**(145) (2017). doi:10.3389/fped.2017.00145

23. McMahon, D., Cihak, D.F., Wright, R.: Augmented Reality as a navigation tool to employment opportunities for postsecondary education students with intellectual disabilities and Autism. Journal of Research on Technology in Education **47**(3), 157–172 (2015). doi:10.1080/15391523.2015.1047698

24. Midak, L.Ya., Kravets, I.V., Kuzyshyn, O.V., Pahomov, J.D., Lutsyshyn, V.M., Uchitel, A.D.: Augmented reality technology within studying natural subjects in primary school. CEUR Workshop Proceedings **2547**, 251–261 (2020)

25. Minshew, N.J., Meyer, J., Goldstein, G.: Abstract reasoning in autism – a disassociation between concept formation and concept identification. Neuropsychology **16**, 327–334 (2002). doi:10.1037/0894-4105.16.3.327

26. Mintii, I.S., Soloviev, V.N.: Augmented Reality: Ukrainian Present Business and Future Education. CEUR Workshop Proceedings **2257**, 227–231 (2018)

27. Moon, D.: How to build AR Portals in 5 mins w/ React Native & Viro AR. https://blog.viromedia.com/how-to-build-ar-portals-in-5-mins-w-react-native-viro-ar-b939850def94 (2017). Accessed 12 May 2020

28. Musalek, M., Vasek, L.: Possibilities of Using Realityas a Means for Therapy from Fear of Spiders. MATEC Web of Conference **292**(3), 01041 (2019). doi:10.1051/matecconf/201929201041

29. Nechypurenko, P.P., Stoliarenko, V.G., Starova, T.V., Selivanova, T.V., Markova, O.M., Modlo, Ye.O., Shmeltser, E.O.: Development and implementation of educational resources in chemistry with elements of augmented reality. CEUR Workshop Proceedings **2547**, 156–167 (2020)

30. Nicolaidis, C., Kripke, C.C., Raymaker, D.: Primary Care for Adults on the Autism Spectrum. The Medical Clinics of North America **98**(5), 1169–1191 (2016). doi:10.1016/j.mcna.2014.06.011

31. Osadchyi, V.V., Varina, H.B., Osadcha, K.P., Prokofieva, O.O., Kovalova, O.V., Kiv, A.E.: Features of implementation of modern AR technologies in the process of psychological and pedagogical support of children with autism spectrum disorders. In: Burov, O.Yu., Kiv, A.E. (eds.) Proceedings of the 3rd International Workshop on Augmented Reality in Education (AREdu 2020), Kryvyi Rih, Ukraine, May 13, 2020, CEUR-WS.org, online (2020, in press)

32. Quintero, J., Baldiris, S., Rubira, R., Cerón, J., Velez, G.: Augmented Reality in Educational Inclusion. A Systematic Review on the Last Decade. Frontiers in Psychology **20**, 1836 (2019). doi:10.3389/fpsyg.2019.01835

33. Rahani, V.K., Vard, A., Majafi, M.: Claustrophobia Game: Design and Development of a New Virtual Reality Game for Treatment of Claustrophobia. Journal of Medical Signals & Sensors **8**(4), 231–237 (2018). doi:10.4103/jmss.JMSS_27_18

34. Rashevska, N.V., Soloviev, V.N.: Augmented Reality and the Prospects for Applying Its in the Training of Future Engineers. CEUR Workshop Proceedings **2257**, 192–197 (2018)

35. raywenderlich.com Tutorial Team, Language, C., Bandekar, N., Bello, A., Coron, T.: ARKit by Tutorials: Building Augmented Reality Apps in Swift 4. Razeware LLC (2018)

36. Robertson, A.E., Simmons, D.R.: The relationship between sensory sensitivity and autistic traits in the general population. Journal of Autism and Developmental Disorders **43**(4), 775–784 (2013). doi:10.1007/s10803-012-1608-7

37. Safar, A.H., Al-Jafar, A.A., Al-Yousefi, Z.H.: The Effectiveness of Using Augmented Reality Apps in Teaching the English Alphabet to Kindergarten Children: A Case Study in the State of Kuwait. EURASIA Journal of Mathematics Science and Technology Education **13**(2), 417–440 (2016). doi:10.12973/eurasia.2017.00624a

38. Shield, B., Greenland, E., Dockrell, J.: Noise in open plan classrooms in primary schools: A review. Noise and Health **12**(49), 225–234 (2010)

39. Striuk, A.M., Rassovytska, M.V., Shokaliuk, S.V.: Using Blippar Augmented Reality Browser in the Practical Training of Mechanical Engineers. CEUR Workshop Proceedings **2104**, 412–419 (2018)

40. Tentori, M., Escobedo, L., Balderas, G.: A smart environment for children with autism.: IEEE Pervasive Computing **14**(2), 42–50 (2015). doi:10.1109/MPRV.2015.22

41. The Benefits of Sensory Rooms for Children with Autism and Social/Emotional Challenges. https://www.asd-1817.org/news-story?pk=1102483# (2019). Accessed 12 May 2020

42. Thoma, M.V., La Marca, R., Brönnimann, R., Finkel, L., Ehlert, U., Nater, U.V.: The Effect of Music on the Human Stress Response. PLoS One **8**(8) (2013). doi:10.1371/journal.pone.0070156

43. Tobar-Muñoz, H., Fabregat, R., Baldiris, S.: Augmented Reality Game-Based Learning for Mathematics Skills Training in Inclusive Contexts. IE Comunicaciones: Revista Iberoamericana de Informática Educativa **21**, 39–51 (2015)

44. Vullamparthi, A.J., Nelaturu, S.C.B.; Mallaya, D.D.; Chandrasekhar, S.: Assistive Learning for Children with Autism Using Augmented Reality. In: IEEE Fifth International Conference on Technology for Education (t4e 2013), 18-20 Dec. 2013, Kharagpur, India, pp. 43–46. IEEE (2013). doi:10.1109/T4E.2013.18

45. Witte, M., Spruit, A., Hooren, S., Moonen, X., Stams, G.: Effects of music interventions on stress-related outcomes: a systematic review and two meta-analyses. Health Psychology Review **14**(2), 294–324 (2020). doi:10.1080/17437199.2019.1627897

46. Yeh, S.-C., Li, Y.-Y., Zhou, C., Chiu, P.-H., Chen, J.-W.: Effects of Virtual Reality and Augmented Reality on Induced Anxiety. IEEE Transactions on Neural Systems and Rehabilitation Engineering **26**(7), 1345–1352 (2018). doi:10.1109/TNSRE.2018.2844083

47. Zelinska, S.O., Azaryan, A.A., Azaryan, V.A.: Investigation of Opportunities of the Practical Application of the Augmented Reality Technologies in the Information and Educative Environment for Mining Engineers Training in the Higher Education Establishment. CEUR Workshop Proceedings **2257**, 204–214 (2018)

48. Zinonos, N.O., Vihrova, E.V., Pikilnyak, A.V.: Prospects of Using the Augmented Reality for Training Foreign Students at the Preparatory Departments of Universities in Ukraine. CEUR Workshop Proceedings **2257**, 87–92 (2018)