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The technology of augmented and virtual reality in teaching children with ASD

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Abstract. The special feature of teaching children with special needs is the need to take into account their needs and abilities. An integral part of the process of teaching students with autism is the provision of communication, the development of social skills and academic (traditional) training. For the development and improvement of the system of IT support for the training of children with autism, the most promising directions are the technologies of an Augmented Reality (AR) and Virtual Reality (VR). The model of data flows in such support system allows determining its basic features and principles of operation in the system. To train *Social and household orientation* for students with autism, several social scenarios were proposed, using the VR and AR technologies.

Keywords: autism, ASD, education information technology, augmented reality, virtual reality, social skills, traditional learning

INTRODUCTION

Early detection of peculiarities of psychophysical development enables to improve the development of the child. It is of exceptional importance for children with disorders of the nervous system. Such disorders have a broad paradigm, which is reflected in the international classification of illnesses and health-related problems in Ukraine (ICD-10). This classification is used in world practice to ensure the convenience of preserving, collecting and analyzing medical data. In 2021, it is planned to start using the updated classification ICD-11. Such an updated classification, among others, will be more consistent with the DSM-5 [1] nosological system of psychiatric disorders, which is implemented in the USA. In the DSM-5, the American Psychiatric Association offers all autism-related diagnoses to replace the term *autism spectrum disorder* (ASD). An autism spectrum disorder is a common term used to group some disorders of the brain, including autistic disorders, Asperger's syndrome, children disintegration disorder, and other widespread developmental disorders, including intellectual.

An autistic disorder can be characterized by the complication of social communication and interaction, as well as limited and repetitive behavior. In Ukraine, among every 10,000 children, 4 to 26 are diagnosed with autism spectrum disorders. Over the past 10 years, the morbidity has increased by 273% [2]. In *Dovira* training and rehabilitation center (located in Lviv, the regional center of Ukraine) has over 200 students aged 6 years and older with ASD. Like other autistic experts [3], the specialists of this center claim that their students feel comfortable "communicating" with modern gadgets and other technological devices. That is, the application of modern information technology for the teaching of children with autism makes it possible to use modern developments in the IT industry to improve the processes of socialization of the person with autism.

RELATED WORKS

The role of modern information technologies in the education of students with special needs, including those with ASD, is described in [4-7]. For the IT-developers who design assistive software training of a person with special needs, it is important to take into account and apply the principles of accessibility and usability of web content. Such demands are stated, for example, in the ISO / IEC40500: 2012, a standard proposed by the World Wide Web Consortium (W3C) [8]. The application of the principles of universal design for learning (UDL) is appropriate in the case of additional visualization of educational content [9]. For example, the team at Cambridge University has developed an online toolkit to support universal design [10]. In addition, the technologies used by autistic children educators, should take into account the particular psychophysical development of such students. Also, the system of informational and technological support for the education of such children must be nationally-adapted and use the state language [26-28].

The technologies, designed to assist a student with ASD, can be classified according to the skills that these technologies are intended to develop or correct. In summary, we suggest using the classification of information and communication technologies to support the training of students with ASD in those who support communication skills, social communication and actually traditional (academic) education [11] (Fig. 1).

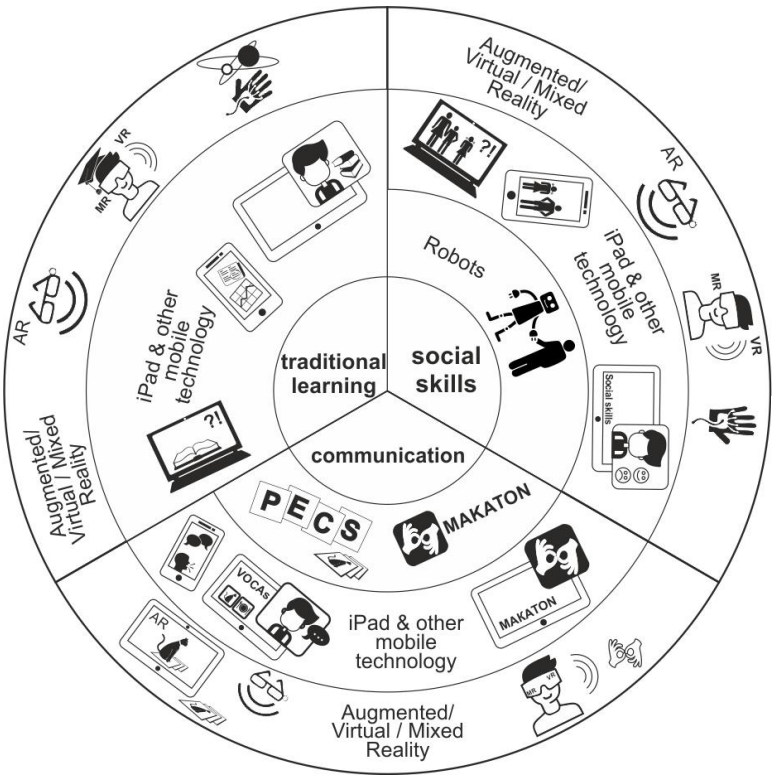

Fig. 1. Information assistive technologies for the education of children with ASD

An overview of the global developments in the field of educational information technologies to support the life and activity of the students with ASD has highlighted the main modern trends in the industry [11]. The most promising education information technologies are the augmented and virtual reality. These technologies are actively developing. For example, to improve the communication process for children with ASD and enable a better understanding of the task requirements, the virtual environments were developed [12, 13]. To develop social skills, a number of applications have also been developed using virtual and augmented reality tools to visualize learning or play [14-16], motivate for improving cognitive and social skills [14, 15, 17-20], improve social interaction with [19], etc. A wide range of applications for therapy, motivation, training, and support for students with ASD has been developed to accompany academic learning by means of virtual and augmented reality [21 - 25].

The augmented and virtual reality technologies are advanced and promising technologies, used to improve communicative processes, social skills and academic learning of students with ASD. That is why the collaboration of the authors of the article with the specialists of the *Dovira* training and rehabilitation center, where children with ASD study, is directed to create education information technologies on the basis of augmented and virtual reality technologies.

THE ASSISTIVE EDUCATION INFORMATION TECHNOLOGY FOR STUDENTS WITH ASD

To develop the education information technology for students with ASD, it is important to consider data flows between the components of such technology. The graphical representation of the data flows in such system is shown in Fig. 2. This diagram roughly specifies the interaction in the education information technology with external modules. At the next stages of the design, all relevant processes will be specified and detailed.

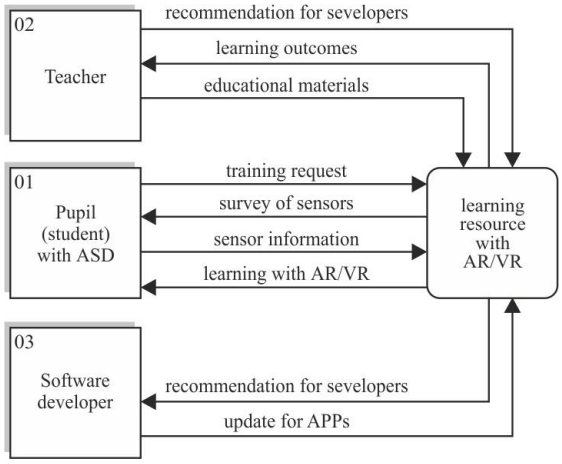

Fig. 2. Data flow diagram

The diagram (Fig. 2) has the following entities:

- **Pupil (Student) with ASD** is an external entity, which undergoes a training process, follows the recommendations of the avatar, and has appropriate testing, all with 3D scenes.

- **Teacher** is an external entity forms educational materials, fills in an educational resource, assess educational outcomes, collaborates with Developers by providing with recommendations.

- **Software Developers** is an external entity, develops specialized modules for the educational resource, both commercial and free.

- **Training Resource** is a complex of specialized applications for teaching children (students) with ASD based on AR/VR technology.

The training resource is realized as a specialized application based on the multi-platform *Unity* tool [29] designed to develop 2D and 3D applications and games, and *Vuforia* framework for the augmented reality realization [30]. *Vuforia* is a platform for developing augmented reality, virtual reality, and mixed reality (MR) applications, that provides robust tracking and performance on a range of hardware (including mobile devices and compatible home screen displays (HMDs) such as Microsoft HoloLens). *Unity's* integration with *Vuforia* allows creating applications and games for Android and iOS using the drag&drop process. The *Vuforia* AR+VR sample kit is available at the *Unity Asset Store* [31], with plenty of useful examples that demonstrate the most important features of the platform. *Vuforia* supports a variety of third-party devices (such as AR/MRs), as well as VR devices with rear panel cameras (for example, Gear VR).

The AR technology was used to create an application that improves the **communication** during the training of students with ASD. The development procees using *Unity*, is shown at fig. 3. Figures 4-6 show a sketch of the character (avatar) and implemented a model with simplified texturing. The AR technology was used animate training lesson of the *Social and everyday orientation* course (for the training and rehabilitation center *Dovira)*. The workbook was animated for the Unit *Our school. A road to school* using is complemented by the *Little Owl* avatar. The same avatar was used to assist in **academic studies**.

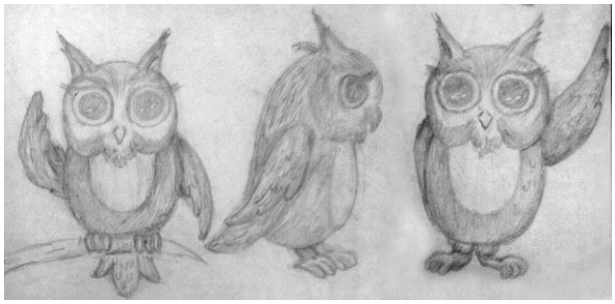

Fig. 4. The sketch of the *Little Owl* avatar

Fig. 5. The *Little Owl* avatar 3D model

Fig. 6. A fragment of a workbook with an avatar

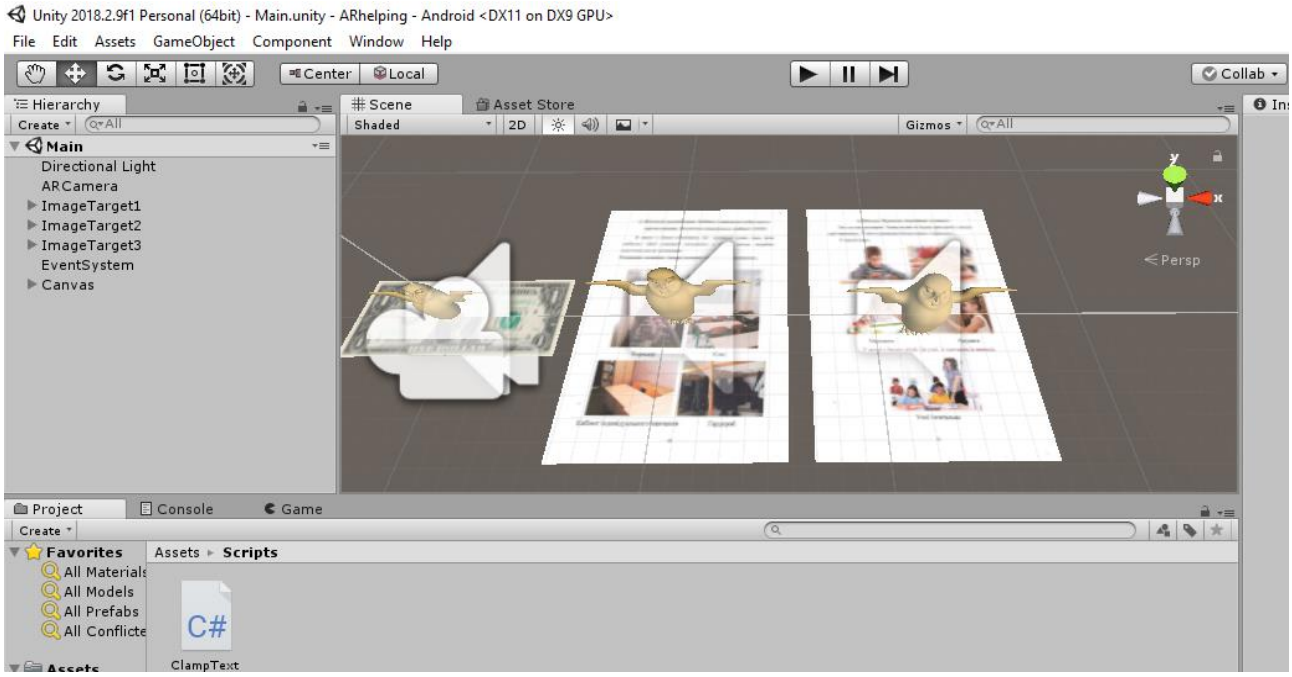

Fig. 3. *Unity* working window during development

The 3D avatar model is realized by means of 3DStudioMax (student version). The avatar`s animation controllers and materials and textures are being improved now. On *Dovitra*`s specialists' suggestion, another avatar, *Robot,* is being developed. It will allow selecting the avatar character during the first application running.

To improve the **social skills**, the AR and VR technologies were used. In cooperation with *Dovira* specialists', for two Units of *Social and everyday orientation* were created social scenarios, realized with AR and VR technologies. It is planned interactive 3D scenes will create a safe environment to teach students with ASD certain social behavior. The algorithm of social story realization is presented at Fig. 7.

Such social stories can be illustrated with two scenarios, for example, *The behavior in a computer class* and *A road to school. Crossing the street*. The fragments of such scenarios implementation, using VR technology, are shown in Figures 8-12.

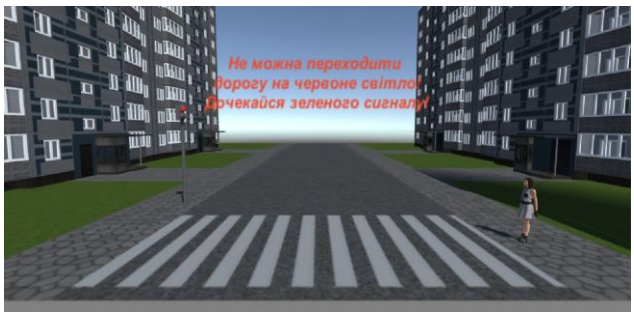

Fig. 8. A fragment of a social story *A road to school. Crossing the street* (red light signal)

Fig. 9. A fragment of a social story *A road to school. Crossing the street* (green light signal)

Fig. 10. A fragment of social story *The behavior in a computer class*

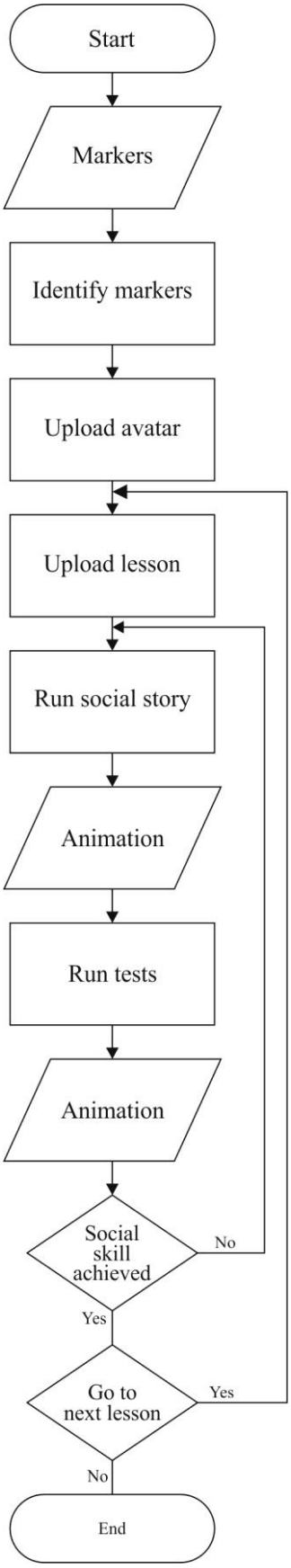

Fig. 7. The diagram of the social story realization with AR and VR technology

Fig. 11. A fragment of a social story *The behavior in a computer class*

Fig. 12. A fragment of a social story *The behavior in a computer class*

The implementation of such assistive technology with social stories will allow students with ASD to practice different types of social behavior and interaction. In the future, it is planned to expand and diversify the visual base for the *A road to school* story. Also, the social story *Behavior in a computer class* is the first in a set of stories that will describe the behavior in the training and rehabilitation center *Dovira* in the course *Social and everyday orientation*.

CONCLUSIONS

The development and application of education information technologies for the learning needs of people with ASD should take into account the peculiarities of the process of such training. At the same time, it is necessary to implement the official national language (languages) of the country, as well as the compliance with information technology requirements for people with autism (special needs). The latter also includes the need to take into account the difficulties in the development of social relationships and the inability to communicate for a student with ASD.

The most promising technologies for supporting the teaching of children with ASD are the technologies of augmented and virtual reality. Such technologies make it possible to create environments where students with ASD can study and re-perform various tasks in a comfortable communication environment. It is also useful and important to interact with the avatars, developed in such technologies, to recreate various social situations. Another promising opportunity in VR is a study with a virtual teacher. Another sufficient option of qualitative educational technology development is the cooperation with specialists of educational institutions, where children with ASD. The next stage of cooperation with the training and rehabilitation center for people with ASD will be the improvement of the described application prototypes. It is planned to develop a virtual environment for improving the communication of students with ASD. Each instance of the developed technology must meet the requirements for software for people with autism, in particular, and the requirements of universal design, in general.

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