Features of implementation of modern AR technologies in the process of psychological and pedagogical support of children with autism spectrum disorders

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Abstract. The article deals with the actual issue of the specificity and algorithm of the introduction of innovative AR technologies in the process of psychological and pedagogical support of children with autism spectrum disorders (ASD). An innovative element of theoretical and methodological analysis of the problem and empirical research is the detection of vectors of a constructive combination of traditional psycho-correctional and psycho-diagnostic approaches with modern AR technologies. The analysis of publications on the role and possibilities of using AR technologies in the process of support children with ASD (autism spectrum disorder) and inclusive environment was generally conducted by surfing on the Internet platforms containing the theoretical bases for data publications of scientific journals and patents. The article also analyzes the priorities and potential outcomes of using AR technologies in psycho-correction and educational work with autistic children. According to the results of the analysis of scientific researches, Unified clinical protocol of primary, secondary (specialized), tertiary (highly specialized) medical care and medical rehabilitation "Autism spectrum disorders (disorders of general development)", approaches for correction, development and education of children with ASD, AR technologies were selected for further implementation in a comprehensive program of psychological and pedagogical support for children with ASD. The purpose of the empirical study is the search, analysis and implementation of multifunctional AR technologies in the psycho-correctional construct of psychological and pedagogical support of children with ASD. According to the results of the pilot study, the priorities and effectiveness of using AR technologies in the development of communicative, cognitive, emotional-volitional, mnemonic abilities of children and actualization of adaptive potential and adaptive, socially accepted behaviors are made. The possibilities and perspectives of using AR technologies as an element of inclusive environment, with regard to nosology and phenomenology, need further investigation.

Keywords: inclusion, autism spectrum disorders, AR technologies.

1 Introduction

1.1 The problem statement

The processes of reforming special education in Ukraine require interdisciplinary research and finding new optimal ways to develop and shape the personality of children with autism spectrum disorders. The organization of complete and timely care for children with general development disorders (F84 according to the International Classification of Diseases of ICD-10). The main purpose of helping children with autism is their habilitation. Habilitation is the creation of new opportunities, building social potential, i.e. the child's ability to be realized in this society [30; 34]. All social, psychological, informational and educational work should be aimed at enhancing the personal, cognitive and social status of such a child. The prevalence of autistic development disorders is, according to various data, from 6-17 to 57 per 10,000 children. According to foreign studies, with the timely organization of complex psychological and pedagogical support, 60% of autistic children get the opportunity to study under the program of general school, 30% – under the auxiliary program, almost all of them reach the level of socialization necessary for life in society. In cases where appropriate support is not provided, only 2-3% of autistic children can study in the education system, the rest do not reach the required level of intelligence and socialization. The analysis of psycho-corrective, therapeutic and developmental directions of organization of psychological and pedagogical support of a child with ASD (autism spectrum disorders) indicates the focus on the individual psychological features of the respective child, not focusing on the introduction of rehabilitation cases. Most programs also include elements of the child's direct communication lines with a specialist that may be a problem for children with ASD. The relevance of the study of the given problem is due to the search for integrative components of the organization of psychological and pedagogical support, focused on a complex combination of leading psychological and pedagogical approaches and innovative AR technologies in the process of habilitation and further integration of the child with ASD.

The aim of the study is to analyze the features and best practices of augmented reality technologies for the psychological and pedagogical support of children with autism spectrum disorders.

1.2 Literature review

Since the 1990s, special efforts have been made to study the specificity of the mental dysontogenesis of autistic children, to search for the natural causes and the logic of autistic development, which revealed the "pervasive" (cross-cutting or spectral) nature of this disorder [19]. More and more researchers are thinking that autism is affecting all levels of mental organization. It should be noted that at present there are no generally accepted theoretical and methodological grounds for studying the features of disorders of different structures and functions of the psyche in the case of autism, and also - the relationship between them [20; 21; 22]. Autism is a general (pervasive) developmental disorder that affects verbal and non-verbal communication and social interaction, and

complicates the formation of adaptation processes; Autism spectrum disorders generally occur at the age of three. Other characteristics that are often associated with autism: limited repetitive stereotyped movements, intolerance to environmental changes or everyday life, unusual reactions to sensory stimuli [26]. The researchers consider Autistic spectrum disorders as a violation of mental development, characterized by an intense lack of social interaction, the ability to communicate and cognition of the environment, loss of interest in reality. Generalization of symptomatic manifestations of autism spectrum disorders according to DSM-5 (Diagnostic and Statistical Manual of Mental Disorders, fifth edition) is presented in fig. 1 [24].

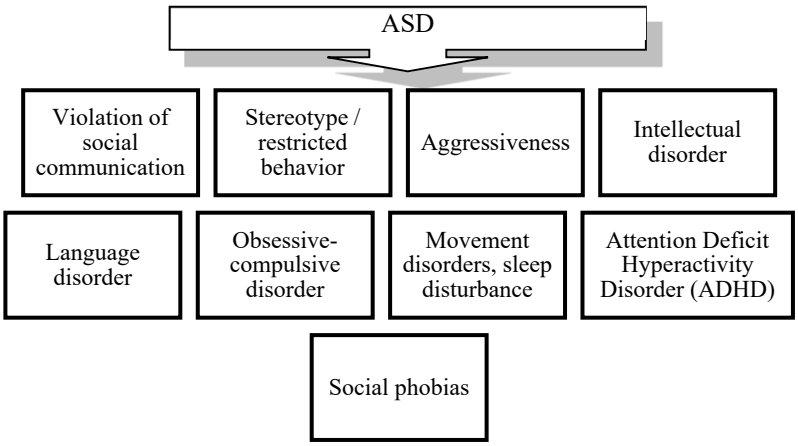


Fig. 1. Main DSM-5 autism symptoms and related problems.

Emphasizing on the phenomenological aspects and symptomatic manifestations of the autism spectrum disorder, recent studies have focused on the use of information, computer resources and modern AR technologies to improve the organization of psychological and pedagogical support and the development of adaptive capacity of children. Wedyan et al. [42] quite thoroughly discuss the use of augmented reality (AR) in the diagnosis and treatment of autistic children with a particular focus on the effectiveness of AR in assisting autistic children with communication, social, mood and attention deficit disorders. The authors identified the main design features that enable AR systems to achieve high levels of efficiency of autism therapy. The authors also classify different systems of AR technologies for corrective process support with children with ASD based on different criteria. Particularly valuable is the analysis of an empirical study of the implementation of a method for the diagnosis of autism in children, focused on the measurement of upper limbs movements [15]. The new method described by the authors used AR to create a virtual object to encourage children to move their hands. The system records all movements of children using the Microsoft Kinect sensor [23]. Thus, the key two components of the system are the AR game and the motion recorder.

In their turn, Marto et al. [32] conducted a systematic review of the use of augmented reality in patients with autism, considering not only the social and psychological

construct but also the medical aspect. In the era of information and improving the existence of vulnerable sections of the population, including children with ASD, Tang et al. [39] research on the use of a mobile application based on the main object recognition module implemented within the deep learning platform – TensorFlow, which promotes improved learning and communication skills in children with ASD. Chung et al. [10] offer to adjust the deficit of social interaction and the development of soft-skills using augmented reality (AR) technology for visual conceptualization of social stories. Interactive social stories are played with several tangible markers and AR technologies that mark the corresponding virtual images. Researchers also suggest the use of three-dimensional (3-D) animation to simulate emotional expressions on the face, which aims to develop the emotional spectrum and social skills of autistic adolescents. Lorenzo et al. [31] own research aimed at determining the effectiveness of augmented reality curriculum based on visual support for children with autism spectrum disorder to improve their social skills. Su Maw et al. [35] conducted a systematic review and meta-analysis of the effectiveness of cognitive, developmental, and behavioral interventions in the context of corrective effects on preschool children with ASD. Bai et al. [3] focusing on the deficit of symbolic thinking in children with ASD (autism spectrum disorder), suggested an interactive system that explores the potential of Augmented Reality (AR) technology to visually conceptualize image representation in an outdoor gaming environment. The results of an empirical study involving children with ASD aged 4 to 7 showed a significant improvement in interactive play [3]. Cai et al. [6] offered to integrate the classic Dolphin Therapy model with innovative AR technologies by developing an innovative Virtual Dolphinarium design for potential rehabilitation support for children with ASD. Instead of imitating dolphin swimming, a virtual dolphin interaction program will allow autistic children to train by the pool for dolphins and learn (non-verbal) communication with virtual dolphin gestures. Boccanfuso et al. [5] and Billard et al. [4] focus on the effective use of robotics in the process of psychological and pedagogical support for children with ASD.

Researchers empirically argue that the use of robots in the interactive game to promote the development of movement coordination in children with autism spectrum disorders and encourage the manifestation of verbal and non-verbal communication [13; 22]. According to the analysis of the existing scientific and practical tendencies and developments concerning the introduction of modern AR technologies into the complex system of psychological and pedagogical support of children with autism spectrum disorders [18], the question of finding vectors of the combination of traditional psychological and pedagogical approaches as well as modern approaches remains a far-reaching aim.

2 Results and discussion

Interdisciplinary research was carried out within the framework of the implementation of research work, which is performed at the expense of the General Fund of the state budget: “Development of methodology for psychological and pedagogical support of

families raising children with special needs" – the state registration number: 0119U002003, "Adaptive system for individualization and personalization of professional training of future specialists in blended learning" – the state registration number: 0120U101970 [30; 33] and with the support of the NGO "Special Parenthood. Protecting the Rights of Special Families". Methods used in the research process: method of theoretical analysis of literary sources, analysis of current experience of psychological and pedagogical support of the integrative process of adaptation and development of children with autism spectrum disorders, generalization and conceptualization of leading domestic and foreign studies, the introduction of VR technology / psychophysical development of a child with ASD, analysis of studies of the practical experience of triad interaction "specialists – parents – child with ASD" [15] in the process of development and integration child in society.

Table 1. Information on tools for exploring pervasive development.

Diagnostic area	List of psychodiagnostics tools
Screening procedures for development research	CHAT M-CHAT (age – 16-30 months) CASD (screening of children 1-16 years old) Questionnaire for children "CSBS DP™ Infant-Toddler Checklist" (screening of drawings) ASQ (screening of children and adults) CAST (screening of children 4-11 years old) ASDS (screening of children 5-18 years old) SCQ (screening of adults and children from 4 years old) CARS-2
Basic tools for the diagnosis and dynamics of autistic disorders	ADI-R ADOS CARS 2
Additional tools	
Cognitive functioning and school skills (quantitative assessment)	BSID-II WPPSI-IV SBT-4 MSEL KABC M-P-R
Cognitive functioning and school skills (qualitative assessment)	Development Profile II "Screening tools for assessing of general development" The well-being profile of prerequisites for development in children under 36 months of age, revised edition
Assessment of the level of social adaptation (adaptive behavior)	Assessment of the development level of adaptive behavior is one of the main tools of the clinical diagnostic program. VABS assessments may be conducted for this purpose. The scale is valid for children aged 0 to 18 years, adults – 19 to 99 years SIB-R ASQ: SE
Other additional tools of the clinical diagnostic program	
For assessment of behavior	BOS EOS

Diagnostic area	List of psychodiagnostics tools
For assessment of speech development	ROWPVT EOWPVT SICD-R PRE-CELF PLS RDLS
For assessment of sensory development and sensory disorders	Sensory profile for children aged 3-10 years old Sensory profile of toddlers Analysis of sensory behavior
Tools or special screening available in Ukraine	
ADI-R ADOS-2 The Modified Checklist for Autism in Toddlers (M-CHAT) Checklist for Autism in Toddlers –CHAT) CASD (screening of children from1to 16 years old) SCQ (screening of children and adults from 4 years old) STAT – The Screening Test for Autism in TwoYear-Olds WISC-IV International Performance Scale Leiter-3 PEP-3 Bayley Scales of Infant Development-II Mullen Scales of Early Learning) Conners-3	

Table 1 presents a thorough list of psychodiagnostics programs, clinical diagnostic programs and screening programs. The presented list of psychodiagnostics methods is presented in the unified clinical protocol of primary, secondary (specialized), tertiary (highly specialized) medical care and medical rehabilitation "Autism spectrum disorders (general developmental disorders)", developed taking into account modern requirements of evidence-based medicine and psychological care. The document considers the features of the diagnosis and treatment of autism spectrum disorders in Ukraine from the standpoint of ensuring the continuity of medical and psychological care. The relevant list of psychodiagnostics bases is developed on the basis of adapted clinical guidelines "Autism in children" and "Autism in adults", which are based on the principles of evidence-based medicine and psychological principles, taking into account modern international guidelines reflected in clinical guidelines:

1. NICE CG 128 – Autism: recognition, referral and diagnosis of children and young people on the autism spectrum (2011);
2. NICE CG 142 – Autism: recognition, referral, diagnosis and management of adults on the autism spectrum (2012);
3. Practice Parameter for the Assessment and Treatment of Children and Adolescents With Autism Spectrum Disorder, the American Academy of Child and Adolescent Psychiatry (AACAP) Committee on Quality Issues (2014);
4. Diagnostic criteria for research. The ICD-10 Classification of Mental and Behavioral Disorders, WHO, 1992. You can read the adapted clinical guidelines at link http://www.dec.gov.ua/mtd/reestr.html.

Diagnosis of ASD is based on medical history, clinical examination of the patient, standard psychological assessment, as well as interviews with the subject and caregivers. Clinical evaluation of the patient should be aimed at identifying disorders of social interaction, communication, limited repetitive behavior and stereotyped movements. The patient's age and level of development should be taken into account when choosing tools for the study of pervasive disorders of the client. The use of special standardized evaluation procedures (table 1) complements but does not replace clinical judgment. Psychologists and psychiatrists should consider ethnic, cultural, or socioeconomic factors that may influence assessment. They also coordinate appropriate multidisciplinary assessment of children with ASD. The purpose of the assessment is to standardize the detection of signs of ASD and compare them with the "Research Diagnostic Criteria" International Classification of Diseases – 10 and diagnostic criteria DSM-V. DSM-V diagnostic criteria are used as additional. This assessment provides a diagnosis of RAS from 2 years. Formalized assessment is performed using the Semi-Structured Parental Interview (ADI-R) and the Semi-Structured Assessment of Autistic Behavior (ADOS). Functional diagnosis of ASD includes assessment of cognitive levels functioning, speech functions, school skills, development of fine and gross motor skills, visual-motor coordination and the level of functioning of the child in the field of adaptive behavior with the use of tools for the study of pervasive disorders of client development. Diagnosis of autism is made according to certain criteria, in comparison with which a psychologist, correctional teacher, speech therapist, doctor can assess the behavior and condition of the child [24]. Early diagnosis and timely treatment and psychological and pedagogical assistance will improve the quality of life of a child with ASD [19]. Given the priority perspectives of the use of innovative computer technologies in psycho-diagnostic practice in the process of research of children with ASD, the use of a computer complex for psycho physiological testing is a priority - the HC- Psycho test. Today, there are a number of efficient approaches to constructively support children with ASD and the development of adaptive, sensory, emotional-volitionary and cognitive capabilities of the child [41].

Table 2. Classification of approaches for correction, development and education of children with ASD.

Name of approach	General characteristics and areas
Behavioral approaches	
ABA – Applied behavior analysis (authors: Ivar Lovaas, Donald Baer, Sidney W. Bijou, Jim Hopkins, Jay Birnbrauer, Todd Risley, and Montrose Wolf)	The ABA method primarily focuses on positive reinforcement strategies, which are essential support for children in difficulty in learning or developing new skills. Also, ABA therapy deals with the correction of problem behavior, which impedes the normal functioning of the child, through the process of so-called "functional assessment of behavior". ABA therapy is used to improve language and communication skills, as well as attention, memory and academic skills.
VBA (Verbal behavior analysis)	The verbal-and-behavioral approach is based on studies related to the field of applied behavior analysis and the theory of behavioral scientist B. F. Skinner. The VBA develops the child's ability to learn a functional language.

Name of approach	General characteristics and areas
PRT – Pivotal Response Treatment (authors: Dr Lynn and Robert Koegle)	PRT is aimed at developing motivation, social initiative and ability to respond to multiple signals, self-government. It contributes to further facilitating the perception of educational information.
TEACCH – Treatment and Education of Autistic and Related Communication Handicapped Children (author: Eric Schopler)	1. Maximizing the independence of the child. 2. Helping the child to interact effectively with others 3. Increasing and developing intellectual skills, school skills and individual abilities 4. Stimulating generalization of skills (new skills the child will be able to use most often and effectively in different situations at home, in the garden, at school). 5. Developing feelings of self, understanding of self (development of emotional sphere). Work with children is in the following areas: imitation; perception; great motor skills; fine motor skills; coordination of eyes and hands; elementary cognitive activity; language; self-service; social relationships.
Developmental approaches	
Emotionally-meaningful approach (developed by experts of the Institute of Correctional Pedagogy of RAE)	This approach aims at normalizing the affective development of a child with ASD. The approach involves establishing emotional contact with the child and engaging him/her in interaction with her loved ones and making sense of what is happening. Development in emotional community with a close adult allows the child to become more enduring, active and interested, joint reflection and organization of life experience gives him/her greater freedom and constructiveness in contacts with the environment, opens the possibility of advancement in the development of the cognitive sphere.
DIR Floortime (author: Stanley Greenspan)	"Floortime" is a technique focused on the development of a child's initiative in play and social interaction. The concept of DIR and the "Floortime" technique are based on the assumption that by working with emotional or affective manifestations, we can have a beneficial effect on the basic capacities responsible for relationships, thinking and communication.
Son-Rise (authors: Barry and Samaria Kauffman)	The essence of the approach is to create a comfortable environment for the child, which includes both a positive psychological attitude to him/her from loved ones and willingness to contact him/her in accordance with his/her needs, interests and organization of environment, which contributes to the gradual, consistent development of the child's research and cognitive activity. The idea of the program is to develop relationships with the child through play therapy. The purpose of the program is to change the attitude of the parents towards their child from negative to positive, which is capable of changing himself/herself.
Daily life therapy (author: Kiyo Kitakhara)	The main purpose of this approach is to develop the necessary skills for children in everyday life, including communicative ones. Adaptive behavior training and correction of maladaptive behaviors are done through physical activity, emotional regulation, and academic skills in the group.

Name of approach	General characteristics and areas
RDI – The Interpersonal Relationship Development Program (authors: Stephen Gatstin and Rachelle Shealy)	RDI is a method of behavioral therapy based on a child's motivation for communication, interaction and friendship. The approach is based on studies of the human brain that confirm that the brain is able to adapt to any problem. People with disabilities can adapt and learn to function in a "normal" way. The purpose of the RDI technique is to complete a step-by-step accelerated path of development for a normally developed child.
Sensory-and-perceptual approaches	
Sensory integration (author: Gene Aires)	The method is aimed at stimulating the work of the sensory receptors in the coordination of different sensory systems. Sensory-and-integration therapy is a rigorously dosed and clearly constructed specific training system of impaired function in a specially organized therapeutic environment.
Tomatis therapy (author: Alfred Tomatis)	Tomatis therapy is a means of audio-vocal training. Tomatis therapy is a means of stimulating brain activity through the use of music based on any polyphonic sound.
Eclectic approaches	
Model SCERTS (authors: Barry M. Prizant, Amy M. Weatherby, Emily Rubin and Amy Laurent)	SCERTS is an innovative educational model for working with children with ASD and their families. It provides specific guidelines for helping your child become a competent and confident social communicator while preventing problematic behaviors that interfere with learning and relationship development. The approach also aims to help families, teachers, and therapists work together as a team, closely coordinated to make the most progress in supporting a child. The abbreviation "SCERTS" stands for: SC – Social Communication is development of spontaneous, functional communication, emotional expression, safe and trusting relationships with children and adults; ER – Emotional regulation is development of the ability to maintain a well-regulated emotional state to cope with daily stress and to be the most open to learning and interaction; TS – Transactional Support is development and implementation of support that helps partners respond to their child's needs and interests, change and adapt the environment, and provide tools to enhance learning (e.g., image sharing, writing schedules, and sensory support).
The Miller Method (author: Arnold Miller)	The method is based on a "cognitive-and-developmental systemic approach for children with ASD". Miller's method employs two basic strategies for the development process: one involves the transformation of behavioral systems that are abnormal, into functional behavior; the other – systematic and regular use in the process of developing occupations of certain activities involving objects and people.

Table 2 constructively describes the main classical psychocorrectional and psychotherapeutic approaches that are actively used in the process of psychological and pedagogical support of children with ASD. Appropriate approaches are reflected in various correction programs, such as:

1. Programs and techniques for young children:

- "Early Bird" Program
- Denver Model for Early Intervention for Children with Autism – "Early Start Denver Model"
- ASSERT program
- "Carolina" program for infants and young children with special needs.

2. Programs and Methods for Preschool Children:

- "Behavior Modification in Autistic Children: A Guide for Parents and Professionals"
- Teaching Developmentally Disabled Children: "The Me Book" by Lovaas
- The program "Support for autistic and underdeveloped children. A compendium of exercises for professionals and parents under the TEACCH program" [18]

3. Programs and techniques for school-age children and children with functional autism:

- Orientation in the Social World – "Navigating the Social World" [41]
- "Mind Reading" Program – Teaching Children with Children's Autism Syndrome, Understanding Another Person)
- "Teach Me Language" Program – Teach Me To Speak

4. Programs and techniques for children with ASD who have communication problems:

- Picture exchange communication system (PECS)
- Facilitated communication

Integrated implementation of modern AR technologies, free software, unlike other means of psychological and pedagogical support, allows to realize aspects important for the rehabilitation process of children with ASD: first, differentiation, because there are no two identical children with ASD; second, the ability to work with meaning; third, the visibility [26]. Using tablets and special software is a good teaching and communication method for children with ASD who find it difficult to get in touch with others, and sometimes even with loved ones. With technique, a person with autism feels calmer, they do not need to worry about their behavior and fear questions that an autistic child does not know the answers to. It is believed that a child with ASD will not be able to talk to peers and adults after computer lessons.

An analysis of the research and theoretical and methodological reviews revealed four major components of the beneficial effects of AR technologies on the process of psychological and pedagogical support of children with autism spectrum disorders: cognitive, motivational, emotional and social ones. Computer training has seen an increase in speed and increased concentration of attention; improved learning, memorization, executive functions, creativity; problem solving skills appear. Motivational benefits include improved work efficiency and persistence. Emotional benefits are mood enhancement and adaptive regulation of negative emotions management strategies such as anger, anxiety, and depression. The introduction of AR

technologies is driving such positive social changes as enhancing cooperation, support, mutual assistance, and improving behavior and activity [38]. It is important for AR developers to support the learning of a child with ASD, taking into account and applying the principles of accessibility and ease of use of web content, as outlined, for example, in the ISO / IEC40500: 2012 standard offered by the World Wide Web Consortium (W3C). Considering the principles of universal design for correction and development support (Universal Design for Learning, UDL), it is advisable to further visualize the content. Accordingly, in the process of selecting AR technologies for the further implementation in the process of psychological and pedagogical support of children with ASD, we were guided by the following criteria: accessibility, instructiveness, understandability, visualization, complexity, availability of correction-developmental and psychological construct, logic, systematic, structural properties, available clear interface, the ability to implement an individual approach, and multi-functionality [21]. To summarize, we suggest dividing AR technologies of psychological and pedagogical support for people with autism spectrum disorders into those that will support communication skills, social communication and traditional ones themselves.

AR technologies to improve communication skills. According to recent scientific studies, about 25% of children with ASD are non-verbal, i.e. they have limited or do not use speech to communicate. The Makaton Charity is a language program that enables people with disabilities to communicate. It is a unique language program using gestures, symbols and oral speech that helps to communicate people with communicative difficulties. The use of gestures makes communication possible for people who do not speak or their speech is indistinct. Symbols can help communicate with those who are unable to gesture or prefer graphic expression. With the exception of verbal language, all communication is considered Assistive and Augmentative / Alternative Communication (AAC) [9; 27; 36; 37; 38; 40]. Therefore, when a child with ASD has severe verbal problems, supportive and alternative communication strategies may be able to express themselves. The complexity of communication has a significant impact on the quality of life, education, development of social relations. The use of appropriate AR technology makes communication possible for people who do not speak or their speech is indistinct. Symbols help communicate to those who cannot gesture or prefer graphic expression. The program also teaches children to communicate with adults and peers, hear and understand others, inform about their needs and desires. Gesticulation stimulates the lingual areas of the brain, which promotes the development of the child's articulation apparatus [35]. As a result, the emergence of a form of communication in the child's life leads to social development and reduces the manifestation of behavioral disorders. It can be used by preschool teachers, teachers, speech therapists, psychologists and other specialists. A support of alternative communication covers advanced technologies and may be low-tech, such as the Picture Exchange Communication System (PECS) or high-tech, such as Voice Output Communication Aids (VOCAs) [11]. VOCAs are portable electronic devices that can produce a synthetic language for the user and can be used with graphic symbols as well as text. VOCAs can be used effectively by ASD children. Chien Hsu Chen [10]

described the effectiveness of this technology and focused on the design features of such AR technologies in the psycho-pedagogical support.

The most popular alternative online communication tools for Apps are SceneSpeak, which creates interactive displays and stories with voices and text broadcasts added to stories and devices using the Milo language to help children develop communication skills by creating an interactive history journal. In turn, it should be said that there are hundreds and thousands of developments, both online and mobile, so it is urgent to choose the best application for the user. One way to get a more informed view of the available AR technologies is to explore web resources that look at developments and applications for people with ASD. For example, DART (Development Autism Research Technology) reviews about 100 programs and has its own 5-point rating scale. DART also offers a very useful wheel of applications for selecting the proper Apps for PWD (Sue Fletcher-Watson researcher) [14]. Examples and comparisons of some well-known developments in communication technology by The University of Bath, one of the UK's leading universities, are SMART-ASD: Matching Autistic People with Technology Resources [42]. An even greater level of visualization can be achieved with the example of PECs using the augmented reality technology suggested by Taryadi and Kurniawan [18]. This technology offers a new system for developing communication skills, a sensory system, and an emotional-volitional sphere that uses augmented reality technology for PECS training techniques. This helps teach kids how to use new images or objects with the proper keywords or phrases, resulting in faster engagement and better social adaptation.

AR technologies for stimulating the development of social skills. Learning technologies based on the iPad and other mobile technologies are common to acquire social skills. Kolomoiets [28], Brandão [25] and other researchers offer the use of augmented reality technology in support of children with ASD to increase their motivation and involvement in interactive learning activities to improve their cognitive and social skills. Particular attention is paid to the use of augmented reality for learning and reproducing social skills, but with a minimal number of "dangerous" environments that can be carefully designed and controlled, and support more realistic and less didactic interactions. The Internet and Multimedia Technology Innovation Center (AIM Tech Center) at Hong Kong City University has developed a training program to study the effectiveness of virtual reality technology for teaching emotional and social skills. The program has six augmented reality scenarios depicting the everyday lives of typical Hong Kong children, research described by Yuan et al. [43] of the University of Kansas created the augmented reality technology, "Animated Visual Amplifiers for Social Skills" (AViSSS). This system has enabled people with ASD to work on social skills using different environments and situations. The participants should simulate behavior or select specific objects. This platform has given them the opportunity to deal with various social situations without tension or anxiety related to the real world. In the context of the analysis of modern mobile and computer applications based on augmented reality use, the most common and accessible ones should be identified. In 2013, Autism Soft was founded, which develops specialized software for people with ASD, mainly for tablets. The developers emphasize that their programs are built on the needs of future users. At the moment, the company has introduced two software

products: Autism Communicator and Visual Schedule. Autism Communicator is an application for children with autism that provides non-verbal communication with other people through cards. Visual Schedule is the first planner for children with ASD. All the events in it are complemented by vivid illustrations: drawings, photographs, etc. This form of timetable gives a clear structure of the sequence of events, removes the anxiety of the child in the future, and takes his activity to a new level. Both applications run on the iOS platform, but in late July 2015, Autism Communicator migrated to the Android platform. Appropriate technologies can be actively used in conjunction with behavioral approaches [29] within the framework of psychological and pedagogical support for a child with ASD, namely as an element of the ABA, Pivotal Response Treatment, TEACCH (Treatment and Education of Autistic and Related Communication Handicapped Children) method, and as a component of the SCERTS model. The implementation of ABA Math, an application-based behavioral analysis technique developed by Loveas [42], helps autistic children to learn arithmetic mechanically. For each example (for example, 1 + 2 = 3), the program creates different situations for the child in discrete tests until the student is able to cope with the task. Appropriate technology is an important mechanism for the development of mnemonic abilities of the child, facilitates the learning process. The ABA Math program is a synergistic factor in the complex implementation of eclectic approaches in the process of accompanying a child with ASD, namely, as a component of the SCERTS model, Miller method, as a multifunctional component of the development of the cognitive and emotional-and-volitional spheres of the personality. It is quite innovative to use special training programs developed by Palito [42] in training and psychological support of children with ASD, which completely eliminated the mouse and keyboard, leaving only the space bar command. Children can manage their own learning. The programs are divided into topics. For example, the Colors! is devoted to the study of color, its differentiation. Children learn to understand what colors some objects have, what colors are the main ones, which are derived.

Within the implementation of AR technologies, appropriate developments can be effectively used in the development of Emotional-Meaning Approach (DIR Floortime, Daily life therapy), Sensory-Perceptual Approach (Sensory Integration) and Behavioral Approach (TEACCH (Treatment and Education of Autistic). These programs are focused not only on the development of competence, cognitive and mnemonic functions in a child with ASD, but also on the development of emotional-and-volitional regulation, self-organization, self-control, and the formation of constructive adaptive mechanisms of interaction with others [16].

Autistic children think of images, poorly memorize the sequence, so to teach them it is necessary to correlate the word and the subject and record the sequence. For this purpose, it is very convenient to use a computer. It is much easier for them to correlate a word with a picture if they see a word and a picture printed on the screen. Some do not understand abstract drawings, so we recommend that you first work with real objects or photos [17]. Educational games in the “Logo” environment are addressed to children of primary and secondary school age. Many different programs have been developed for autistic children using ABA therapy and high-quality imaging. But, as a rule, they are designed for iOS devices. For example, Autism Emotion is a free and useful program for autistic toddlers to train them to recognize emotions. This program

can be actively used in the process of correctional and developmental work with a child with ASD. An appropriate program promotes the development of positive motivation, the correction of emotional rigidity, the formation of elements of empathy and the skills of establishing cause-and-effect and causal relationships between the relevant case and the life situation that a child with ASD is facing.

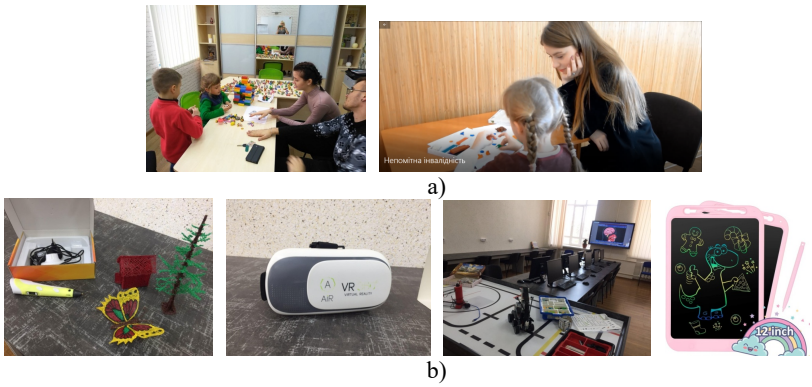
The use of Smart Board in psycho-correction work with children with ASD is seen as an augmented reality platform for empowering autistic children to play with their siblings, classmates, and friends, and building the communication process [7]. Children with autism are often described as thinking with visual images, so by embodying the imaginary image with augmented reality, it can help them understand the concept of imagination and effective engagement, and expand their personal social experience. The open play environment and augmented reality system work as a playground for imaginary play to help children with ASD visualize a particular activity algorithm in their mind. The use of modern AR technologies gives an opportunity to take into account the individual characteristics and capabilities of each child with ASD (for example: individual pace of activity, methods of learning knowledge, interests, etc.); to save personal resources; to correct developmental disabilities. The use of computer programs and augmented reality technologies promotes effective interaction, formation of positive motivation; development of intellectual and creative abilities, cognitive abilities [29].

An interdisciplinary pilot study aimed at the implementation of AR technologies in the concept of traditional psycho-correction effects on a child with ASD has developed and tested a psycho-correction program based on the SCERTS model and augmented reality elements at each session. The corresponding research was carried out in the process of cooperation with parents who raise children with ASD and are members of the Special Parenthood PO “Protecting the Rights of Special Families”. In the course of the research, a preliminary theoretical and methodological analysis of the effectiveness of the introduction of psycho-correction programs and elements of augmented reality in the process of supporting a child with a disorder of the autism spectrum was used. The following techniques were used in the psycho-diagnostic unit:

“C.A.R.S Autism Rating Scale”, “Routine Interview “, “M. Durand Behavioral Motivation Survey Scale”, “The Communication Matrix”. The total number of participants in the psycho-correction program is 29 children. As a result of the distribution, two groups were formed: soft and moderate autistic manifestations had 17 children (62.7%) belonging to Group 1, severe autistic manifestations – 10 children (37.3%) belonging to Group 2. The psycho-correction program consisted of four units, and an element of augmented reality was introduced into the structure of each lesson:

1. Developing parental competence: understanding the signals of the child, recommendations for the development of social and everyday skills and communication, developing attention, the ability to structure their space and activity.
2. Updating the adaptive capacity of the child with ASD, development of social skills.
3. Adaptive behavior training and correction of maladaptive behaviors.
4. Teaching children the skills of additional and alternative communication in subgroups.

Classes with children with ASD were held at the Laboratory of Psychology of Health of the Department of Psychology and the STEAM-Laboratory of the Department of Informatics and Cybernetics, Bohdan Khmelnytsky Melitopol State Pedagogical University (fig. 2).



a)

b)

Fig. 2. Elements of implementation of complex psycho-correction program using AR technologies (*a* – traditional psycho-correction techniques and methods; *b* – means of introduction of elements of AR technologies in psycho-correction process).

Observation of the behavior of children during the lessons showed that the multimedia computer program and AR technologies contribute to the emergence of motivational effect in children with ASD (the main task in teaching children with ASD is the development of social motivation). The data of the results of primary and secondary psycho diagnostic procedures were processed and accumulated in table 3.

Table 3. Psycho-diagnostic results before and after psycho-correctional exposure using AR technologies.

Subgroups of subjects	**Prior to correctional impact**	**After correctional impact**
Group 1	1. Domination of the fourth and fifth levels of communication (78.6%) 2. Manifestations of atypical stereotypical behavior (75.8%) 3. Behavioral hazards (Auto Aggression) (11.8%) 4. Most children demonstrated "achievement" as the predominant type of behavioral motivation (52.3%) 5. Attention motivation behavior (19.3%) 6. The manifestations of atypical behavior of children were motivated by insufficiency or excess of sensory feelings (14.1%)	1. The number of children with manifestations of atypical, stereotypical behavior decreased by 39.6% 2. Completely managed to overcome behaviors that were dangerous to themselves (auto aggression) 3. Children learned to use PECS cards and information resources, which helped to increase their communication level by 12.6% 4. After the psycho-correction program, the children had gestures of "congratulations," "goodbye," "give," "yes," "no." The group learned how to use a visual interactive schedule and developed own communication cards

Subgroups of subjects	Prior to correctional impact	After correctional impact
Group 2	1. Domination of the first and second levels of communication (85.6%) 2. Manifestations of atypical stereotypical behavior that impedes task accomplishment (98%) 3. Behavioral hazards (auto aggression) (44.1%) 4. Only 9.7% of respondents showed motivation for "achievement" 5. Attention motivation behavior (4.8%) 6. The manifestations of atypical behavior of children were motivated by insufficiency or excess sensory sensations (30.7%)	1. The number of children with manifestations of atypical, stereotypical behavior decreased by 48.6% ($p \leq 0.05$) 2. It was completely possible to overcome the manifestations of behavior that was dangerous (auto aggression) 3. After corrective actions, 54.70% of the children in this group reached the third level of communication 4. Children learned to use the gesture system, they used the following gestures: "greetings", "goodbyes". They learned to use the subject interactive timetable. A "give" gesture and pointing gesture, as well as functional gestures, were formed

As a result of such correctional work, children learned how to use PECS cards and gestures, use visual timetables and AR technologies to explain and express their emotional states, improve interaction with loved ones, expand social interaction experiences and instrumental skills in adaptive living and independent living skills. Prior to the corrective program, most children had atypical behaviors. After the corrective interventions, the number of children with atypical behavior in both groups decreased. Through a comprehensive integrative psycho-correction program using AR technologies, we were able to completely overcome behaviors that were dangerous to ourselves or others. In both groups the level of communication interaction increased significantly.

3 Conclusions and prospects for further research

In the process of employing AR technologies, autistic children learn to overcome difficulties, control their activities, evaluate results. When deciding on a computer-programmed case-study, the child strives for positive results, subordinates his actions to the goal. Thus, the use of modern AR technologies in the process of implementation of psychological and pedagogical support of a child with ASD helps to develop such strong-willed qualities as independence, alertness, concentration, personal control. The results of the pilot empirical research aimed at integrating the combination of traditional psychological-pedagogical methods and AR technologies in the process of psycho-corrective work with children with ASD, confirmed the need to introduce a component of additional reality in the process of supporting such children. According to the results of psycho-correcting influence and complex use in each lesson an element of augmented reality in children increased motivation, significantly developed communication skills, social skills and ability of organizing and self-regulation of their own actions and emotional reactions, and a manifestation of atypical, even auto-aggressive behavior has decreased. Combining AR technologies and traditional approaches achieves individuality and maximizes the effectiveness of corrective action.

Educational and corrective work should be directed mainly to the development of emotional contact and interaction of the child with adults and with the environment, affective development, the formation of internal adaptive mechanisms of behavior, which in turn, increases the overall social adaptation of the autistic child. Thus, the use of AR technologies in psychological and pedagogical support allows children with ASD to feel confident in themselves, helps them to adapt, promotes general socialization; develops skills of constructive interpersonal and communicative interaction. Prospects for further research are the development and testing of a comprehensive model of implementation of AR technologies in the psychological and pedagogical construct of accompanying children with disorders of the autism spectrum according to the nature and degree of disorders of interaction with the external environment, as well as the type of autism itself and individual characteristics of the child.

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