Approaches to Speech Therapy for Children with Autism Spectrum Disorders (ASD)

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Abstract: *Background*: The article analyzes methods of correcting speech disorders in children with autism spectrum disorders (ASD). It is based on a literature review and practical cases on this issue.

Methods: The study used observation methods of behavior, speech, and communication of children with ASD, questionnaires from parents, educators, and correctional teachers, and experimental research based on the information obtained. The main methods of correction of speech disorders in children with ASD are highlighted, which include speech therapy, alternative and augmentative communication (AAC), therapy using games and imitation techniques, the use of behavioral techniques, and multisensory approaches. Traditional and innovative means for implementing the outlined methods of correction of speech disorders in children with autism spectrum disorders are outlined. A methodology for determining the effectiveness of the use of methods for the correction of speech disorders in children with autism spectrum disorders is proposed.

Results: Criteria and indicators for evaluating the outlined methods of correcting speech disorders have been developed. The main criteria include speech development, development of communication and social skills, reduction of stereotypical and repetitive forms of speech, emotional and behavioral regulation, use of alternative means of communication, and individual progress. Based on the developed criteria, a survey was conducted among parents, educators, and therapy specialists on the effectiveness of using the outlined methods of correcting speech disorders. The effectiveness of the use of traditional and innovative means of correction of speech disorders in the context of the implementation of the outlined methods of speech correction in children with ASD was experimentally tested. The effectiveness of the above methods was tested for different groups of children with ASD, including preschool, school, and adolescent age. In the course of the test, the control group used traditional means, and the experimental group used a combination of traditional and innovative means of correcting speech disorders in children with autism spectrum disorders (ASD).

Conclusion: The positive influence of the combination of traditional and innovative means of correction of speech disorders in children with autism spectrum disorders (ASD) on the development of language skills is noted.

Keywords*:* Speech disorders, autism spectrum disorders, correction methods, alternative communication, applied behavior analysis.

1. INTRODUCTION

Comprehensive rehabilitation and education of children with autism spectrum disorders (ASD) requires correction of speech disorders. Such disorders in children with ASD can be expressed to varying degrees, including a complete lack of speech and the use of stereotypical speech constructions. These speech disorders impact a child's life, social interaction, and learning ability. Autism spectrum disorders are characterized by communication deficits, limited social interaction, and a narrower range of interests, which makes dialogue with others difficult. ASDs are also accompanied by problems with understanding and expressing speech, difficulties in non-verbal communication, and a deficit in spontaneous speech.

Methods for correcting speech disorders in children with autism spectrum disorders will rely on individualizing the approach based on monitoring each

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child's progress or regression. Approaches to correcting speech disorders in children with ASD will include speech therapy and psychological and pedagogical sessions aimed at developing communication skills. Also, complex therapy based on alternative means of communication, behavioral techniques, and game-based learning forms positively reduces the degree of speech disorders.

The correction of speech disorders in children with autism spectrum disorders (ASD) is an important and complex task that requires an integrated approach. In order to determine the most effective methods of correction, the article analyses research and methods. The primary social communication skill negatively affected by ASD is joint attention, which affects the development of speech, cognitive, and social skills from childhood. An immersive computerized interaction system between a caregiver and a child is presented to help children with ASD practice initiating attention and developing speech [1]. It has been determined that the inclusion of children with ASD in the educational process together with normative children has a positive effect on the development of speech and communication skills [2].

Children with autism spectrum disorders have communication and language difficulties, which may also be associated with difficulty analyzing emotions. An optimized deep learning model with multimarker classification for ASD prediction based on emotion analysis was presented [3]. A study was conducted to identify anxiety states in children with ASD that affect speech correction [4]. The article discusses the problems of preparation for admission and education of students with ASD and the need to provide them with psychological support [5].

The means of academic and non-academic support for children with ASD are considered. The primary mission of educational institutions in this context is to focus on the development and availability of academic support and, in addition, to provide teachers and staff with effective professional development to address the stigma of seeking and using available support systems [6]. A study was conducted to predict the severity of ASD symptoms [7]. A deep learning model with multi-marker categorization is presented. The proposed model uses the Kaggle Convolutional Neural Network (I-CNN) dataset as an image dataset, and the images are used to classify people who have or do not have ASD. The proposed method correctly predicts six and four general emotions [8]. The robots were used in joint attention (JA) tasks with children with autism spectrum disorder (ASD). The study aims to investigate whether there are differences in responses to JA initiation between children with ASD and TD (normotypical children) with two interactive partners, an adult and a social robot (NAO), and to determine which characteristics of children with ASD predict their performance in JA tasks with a robot [9]. Gaze deficit is one of the characteristics of autism. It has been determined that machine learning and gaze-tracking technology can contribute to autism identification characteristics by identifying visually atypical people with ASD [10].

A multimodal diagnostic framework for ASD detection in children based on a typical deep learning algorithm is proposed. The experimental results of evaluating 40 children with ASD and 50 typically developing children showed that the proposed method achieved superior performance compared to two unimodal methods and a simple feature-level fusion method, which has promising potential to provide objective and accurate diagnosis to assist speech-language pathologists [11]. We evaluated the XGBoost method with different hyperparameter configurations and assessed its effectiveness in correctly categorizing and accessing groups of people with and without autism spectrum disorder (ASD). The proven accuracy of the model can help clinicians and researchers in the early identification and intervention of individuals at risk of ASD [12]. The research aims to create a supervised machine-learning model that can classify people with ASD in much less time and effort than current diagnostic procedures and help visualize the common causes that lead to it so that appropriate lifestyle changes can be made [13].

The work focuses on the use of AI and approaches based on neuroimaging and deep learning algorithms for the diagnosis of ASD [14]. The physiological and pathophysiological aspects of the functioning of the speech system in people with ASD are described [15]. The study compares speech disorders in children with genetically determined and unidentified autism spectrum disorder (ASD) and determines that early diagnosis can provide information for further monitoring and treatment of ASD-related conditions [16]. The study focuses on the issue of international mobility as a means of providing an inclusive space for students with ASD, and it is determined that meeting the needs of people with special needs is an essential aspect of the globalization and internationalization of education [17]. Teachers need support and knowledge development to

improve inclusive learning environments [18]. It is also essential to develop methodological and didactic support, especially in the context of inclusive education [19].

AI opens up new opportunities for educating people with disabilities, allowing the learning process to be personalized. A range of AI tools for correcting speech disorders in children with ASD has been outlined, and they are focused on providing personalized support and alleviating difficulties in reading, writing, and language learning [21]. The use of experimental inclusive monitoring has been shown to have positive effectiveness results in inclusive education. The positive impact of integrating experimental inclusive monitoring into the learning process has been experimentally proven [21]. The results showed a significant improvement in learning outcomes and perceptions of learning based on using augmented reality (AR) in inclusive education [22]. A round-the-clock online program for teaching behavior, lifestyle, and speech to children with ASD has been outlined [23]. Parental support is also an essential aspect of correcting speech disorders in children with ASD [24].

The study is devoted to analyzing methods of correcting speech disorders in children with autism spectrum disorders (ASD), proposing the optimal use and combination of these methods, and evaluating their effectiveness.

Study Objectives

1. To propose a methodology for determining the effectiveness of correcting speech disorders in children with autism spectrum disorders.
2. To develop criteria and indicators for evaluating the outlined methods of correcting speech disorders.
3. Based on the developed criteria, parents, educators, and therapy specialists were surveyed on the effectiveness of using the outlined methods of speech disorder correction.
4. To experimentally test the effectiveness of the use of traditional and innovative means of correcting speech disorders in the context of the implementation of the outlined methods of speech correction in children with ASD.

2. MATERIALS AND METHODS

Qualitative and quantitative research methods were used in the work. As a tool of data collection, questionnaires for parents and teachers and observation of behavior during classes were used. The methods of data collection were questionnaires and assessments before and after therapy.

Qualitative research was carried out by observing the behavior of a child with ASD, observing the child's speech, and functional assessment of communication. Observing the behavior of a child with ASD allows for assessing their communication skills, the spontaneity of speech, and reaction to interaction with other people. Observing the child’s speech to assess various aspects of language, such as pronunciation, grammar, vocabulary, dialogue ability, and comprehension. Functional assessment of communication to analyze verbal and non-verbal forms of communication: gestures, facial expressions, eye contact, and vocalization.

Quantitative research was implemented using questionnaires for parents, carers, and correctional teachers, and it was an experimental study. Questionnaires for parents, carers, and correctional teachers are structured by the identified criteria for assessing the effectiveness of correctional methods. Parents and teachers describe the child’s communication and language abilities to obtain information about how the child behaves in different contexts and how his/her behavior changes with the application of correctional methods. The study was conducted on the basis of a survey of parents and teachers for children of different age categories: preschool, school, and senior school age.

An experimental study will determine the effectiveness of correction methods based on data analysis obtained during the questionnaire stage. The experiment was conducted based on obtaining information about preschool, school, and adolescent children during the 2022-2023 academic year. The control group, in which 61 children with ASD were observed, used traditional means of correcting speech disorders. In contrast, the experimental group, in which 60 children with ASD were observed, used a combination of traditional and innovative methods.

A survey was conducted among parents, carers, and therapy specialists, the questionnaire is based on a 10-point scale, where 1 is no or insignificant result, and 10 is global progress. The scores were converted to a percentage scale. A study was conducted to assess the effectiveness of the methods for the correction of speech disorders in children with ASD based on a questionnaire. The children undergoing correction of speech disorders were divided by age.

Depending on the age group, children with ASD have different features of the manifestation of symptoms of speech disorders. Preschool children (3-6 years) struggle with socialization, stereotyped behavior, and speech delays. Children of primary school age (6-12 years) have difficulties with self-regulation and learning in the school environment. Adolescents (12-18 years) have emotional difficulties and difficulties with self-management and social interaction.

During the correctional classes with children with speech development disorders, they were divided into control and experimental groups. The control group used traditional correction methods for speech disorders during the experiment, while the experimental group used traditional and innovative correction methods. The control group consisted of 61 children with ASD, including 19 preschool children (PC), 22 school-age children (SAC), and 20 adolescents (A). The investigation's effectiveness was analyzed via a comparison of the indicators of the experimental and control groups, expressed in percentage terms.

3. RESULTS

Stereotypical behavioral patterns with repetitive actions or interests, impaired social interaction, communication, and speech characterize autism spectrum disorders (ASDs). These diseases can have a wide range of manifestations, which vary depending on the severity of ASD. These include the so-called classic autism, Asperger's syndrome, atypical autism, Rett syndrome, and Heller syndrome. The manifestations of ASD are characterized by communication problems, i.e., misunderstanding or incomplete understanding of gestures and facial expressions, impaired eye contact, and limited or inadequate use of language. Such disorders can also be expressed in stereotyped actions through repetitive movements and specific ways of performing actions, rejection of changes in schedule or daily routine, and excessive focus on a particular topic. Children with ASD also experience hypersensitivity or hypersensitivity to sensory stimuli: touch, light, and sound. The causes of this spectrum of diseases are still the subject of debate. However, the main factors today include genetic factors and negative influences in the early stages of brain development. Diagnosis is based on observing the child's behavior and assessing his or her communication skills.

Treatments for ASD include applied behavioral analysis and cognitive behavioral therapy, speech therapy, social skills development, sensory therapy, and medication to help manage co-occurring mental health disorders. ASDs can range from mild forms, when a person can lead an independent life, to more severe forms that require constant care.

Several methods are used to correct speech disorders in children with autism spectrum disorders, including speech therapy, alternative and augmentative communication, games and imitation techniques, behavioral methods of correction, and multisensory approaches. Figure **1** shows an analysis of traditional and innovative methods of correcting speech disorders in children with autism spectrum disorders. Systematic work on the correction and diagnosis of speech disorders in children with autism spectrum disorders allows for the development of communication skills and an increase in the level of social interaction.

Speech therapy aims to expand vocabulary, develop dialogic speech, improve comprehension and phrasing, and develop phonemic awareness and articulation. Let's look at traditional speech therapy tools. The Floortime method helps to promote emotional and social development through play. Through free play activities, speech therapists stimulate speech and communication based on the child's interests, which helps develop spontaneous speech interactions. Singing stimulates auditory perception and articulation. In the process of musical games, speech, and gestures are used, increasing the spontaneity of speech. Cognitive behavioral therapy (CBT) reduces stress during communication and motivates children to communicate in various social situations. Innovative speech therapy tools include AI (artificial intelligence) programs that improve speech skills, adapt to the child's level, and monitor progress. For example, Otsimo and AutisMate offer speech therapy exercises in a playful way.

Alternative and augmentative communication (AAC) uses gestures, cards, and non-verbal communication. One of the most common AAC methods is PECS (Picture Exchange Communication System), which is based on exchanging cards or images to express the needs of children with ASD who struggle with oral language. Alternative and augmentative communication (AAC) programs and applications are innovative AAC tools. Mobile applications such as Proloquo2Go, TouchChat, and Avaz help create sentences and phrases using pictures and symbols as a substitute for speech. Other innovative AAC tools include text-to-speech (TTS) technology. Programs

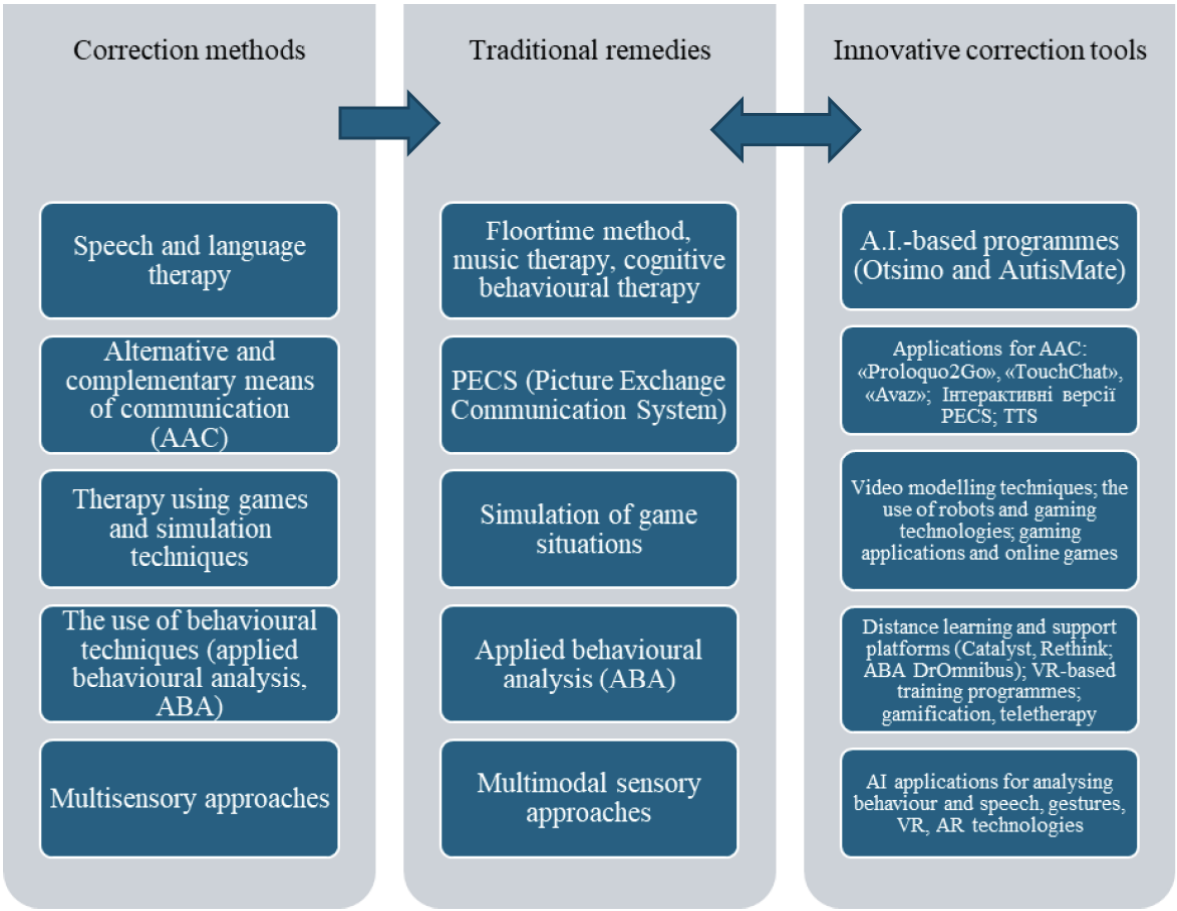

Figure 1: Methods and means of correction of speech disorders in children with Autism Spectrum Disorders. Source: developed by the author.

convert symbols into text or speech to express thoughts for children who do not speak. The advantage of this method is interactivity and adaptation to the individual needs of a child with ASD. Based on tablets or interactive whiteboards with images, modern interactive versions of the PECS method make communication convenient and visual.

Therapy using games and imitation techniques promotes the involvement of children in communication interaction through game and role-playing situations and modeling social scenarios. Based on the modeling of game situations and imitation of everyday scenarios (for example, a visit to a store or a catering establishment), scenarios of communicative interactions are worked out to use the worked-out models in everyday life. The video modeling method is based on showing videos with correct speech and social behavior patterns, such as greetings and dialogues. Robots and gaming technologies (NAO, Kaspar) have simple and predictable facial expressions, help children with ASD to develop speech and interaction skills, and act as partners in communication. Game apps and online games train speech and increase social interaction.

Behavioral techniques (Applied Behavioural Analysis, ABA) are based on encouraging appropriate speech behavior and minimizing maladaptive forms of communication. Applied Behavioural Analysis (ABA) is used to correct behavior and speech, encouraging correct speech patterns and communication skills. The method has a step-by-step structure, starting with simple phrases and gradually increasing in complexity. Distance learning and support platforms are designed to support and engage parents in therapeutic interaction, training, and sharing experiences. They include video courses, online consultations, chatbots, and webinars on implementing ABA methods at home. Digital platforms allow for tracking progress, structuring therapy sessions, and analysis of the behavior of a child with ASD. Rethinking provides tools for monitoring progress and implementing individual therapy plans. Catalyst is used to automate reports and monitor behavior. ABA DrOmnibus provides interactive games aimed at developing social and speech interaction.

Virtual reality (VR)-based training programs offer children with ASD pre-simulated social situations that mimic everyday situations and provide emotion management algorithms. These apps allow for marking progress and have reward systems to motivate children. Gamification of ABA therapy curricula also positively impacts the development of speech and social interaction. The Gamified ABA approach is based on incorporating game elements into therapy sessions. The TeachTown and Autism Learning Apps learning platforms provide educational games to improve communication and social skills. Teletherapy enables ABA therapy remotely and provides flexibility in the therapeutic process. SimplePractice and CentralReach are platforms that allow ABA sessions online.

Multisensory approaches aim to improve speech development and information perception effectiveness, stimulating visual, tactile, and auditory sensory channels. Multimodal sensory approaches are aimed at working with disorders that affect speech development. Sensory stimuli, including sounds, visual elements, and tactile sensations, and their stimulation as a step of integration into speech therapy sessions contribute to developing speech skills. Virtual reality technologies facilitate training communication and speech skills in a controlled environment. Virtual scenarios correspond to various real-life social situations, such as visiting public places and interacting with other members of society. The benefits are reduced anxiety for children with ASD and the development of speech and communication skills through repetition in virtual situations. AR technologies offer interactive learning materials and communication applications that combine virtual elements with the real world.

An example is the identification of emotions by overlaying visual cues on faces in real time. AI applications for analyzing behavior and speech, gestures, facial expressions, and eye movements help parents understand how their child perceives the world and what approaches effectively improve speech and communication. AI-based applications also automa-

Table 1: Criteria for Evaluating the Effectiveness of Correction of Speech Disorders in Children with ASD

Criterion	Essence of the Criterion	Criterion Indicators
Speech development (K1)	Assessment of the level of expressive speech, level of speech understanding, use of non-verbal communication, compliance with age norms	Assessment of vocabulary and the ability to form sentences and use phrases.
		Assessment of the ability of a child with ASD to understand spoken language and follow instructions.
		Use nonverbal communication tools, such as gestures, facial expressions, and alternative communication tools (e.g., PECS cards).
		Comparison with the norms of speech development for a particular age.
Development of communication and social skills (K2)	Initiation of communication, assessment of the level of support for dialogue and speech in social situations, development of social interaction skills, and inclusion in communication	The ability to initiate communication on your own, not just answer questions.
		Ability to maintain interaction with the interlocutor and communication with others.
		Improving the ability to exchange information and share emotions.
		Participation in group activities, ability to follow the rules, and interaction with other participants.
Reducing stereotypical and repetitive forms of speech, emotional and behavioral regulation (K3)	Assessment of echolalia, reduction of speech stereotypes, presence of frustration during speech interaction, assessment of anxiety and behavior in stressful situations	Reducing the frequency of uncontrolled repetition of words or phrases.
		Reducing the number of speech patterns and automatisms.
		Ability to cope with communication difficulties without significant emotional outbursts and assess the child's comfort level in speech situations.
		Control over emotions and behavior in case of communication difficulties.
Use of alternative means of communication, individual progress (K4)	Effectiveness of using alternative means of communication (if necessary), ability to switch to verbal communication, monitoring the dynamics of changes, assessing the level of parental support in communication	If alternative means of communication are used (cards, communication devices), assess the level of awareness of their use.
		Assessing the possibility of switching to verbal communication.
		Assessment of progress against normative indicators for non-normative children and monitoring of individual progress against previous results.
		Using speech correction methods daily creates conditions for parents to practice speech and communication.

Source: compiled by the author.

tically generate communication prompts to help a child build phrases.

Traditional methods of correction of speech disorders in children with ASD are aimed at improving speech skills, cognitive development, and socialization. Innovative speech therapy methods are based on sensory integration, gamification, and personalization through digital technologies and software. In order to assess the effectiveness of the correction of speech disorders in children with ASD, criteria for evaluating the correction of these defects using the outlined methods have been developed. The criteria and their indicators are presented in Table **1**.

According to the developed criteria, a survey was conducted among parents, carers, and therapy specialists (Appendix 1). The questionnaire is based on a 10-point scale, where 1 is no or insignificant result, and 10 is global progress. The scores were converted to a percentage scale.

Table **2** presents the generalized results of using correction methods of speech disorders in children with autism spectrum disorders in percentage terms before the experiment.

Table **3** shows the generalized results of using methods of correcting speech disorders in children with autism spectrum disorders in percentage terms after the experiment.

Table **2** and **3** present the following conventions: K1, K2, K3, and K4—developed criteria for evaluating methods of correcting speech disorders in children with autism spectrum disorders (according to Table **1**); EG, CG – experimental and control groups; PC, SAC, and A – preschool, school, and adolescent age.

When comparing the data in Table **2** and **3**, it can be concluded that in the control group, the use of methods for the correction of speech disorders in children with autism spectrum disorders in infancy led to an improvement in results by 10%, in school and adolescence – by 9%. As for the experimental group, which received a combination of traditional and innovative correction methods, the results improved by more than 18% for children, 19% for schoolchildren, and 17% for adolescents. In other words, combining traditional and innovative methods for correcting speech disorders is more effective when comparing the results.

The main goal of the pedagogical experiment was to confirm the effectiveness of the outlined methods of correcting speech disorders in children with autism spectrum disorders. Figure **2** shows a general

Table 2: Results of Using Methods of Correction of Speech Disorders in Children with Autism Spectrum Disorders in Percentage Terms Before the Experiment

Criteria/Age	CG before the Experiment				EG before the Experiment			
	PC	SAC	A	Average	PC	SAC	A	Average
K1	23.2	22.7	24.1	23.33	25.4	24.8	23.1	24.43
K2	27.8	28	22.5	26.10	29.1	26.8	28.2	28.03
K3	31.8	28.7	32.5	31.00	31.6	30.1	37.5	33.07
K4	27.5	31.6	25.9	28.33	29.9	30.3	29.8	30.00

Source: compiled by the author.

Table 3: Results of Using Methods of Correction of Speech Disorders in Children with Autism Spectrum Disorders in Percentage Terms after the Experiment

Criteria/Age	CG after the Experiment				EG after the Experiment			
	PC	SAC	A	Average	PC	SAC	A	Average
K1	31.7	30.1	32.4	31.4	45.7	43.7	43.7	44.37
K2	39.8	38.6	32.8	37.07	48.8	44.8	46.1	46.57
K3	41.8	38.8	42.4	41.00	49.9	49.8	48.1	49.27
K4	36.9	39.1	34.8	36.93	46.7	49.8	47.1	47.87
Average	37.55	36.65	35.6	36.6	47.78	47.03	46.25	47.02

Source: compiled by the author.

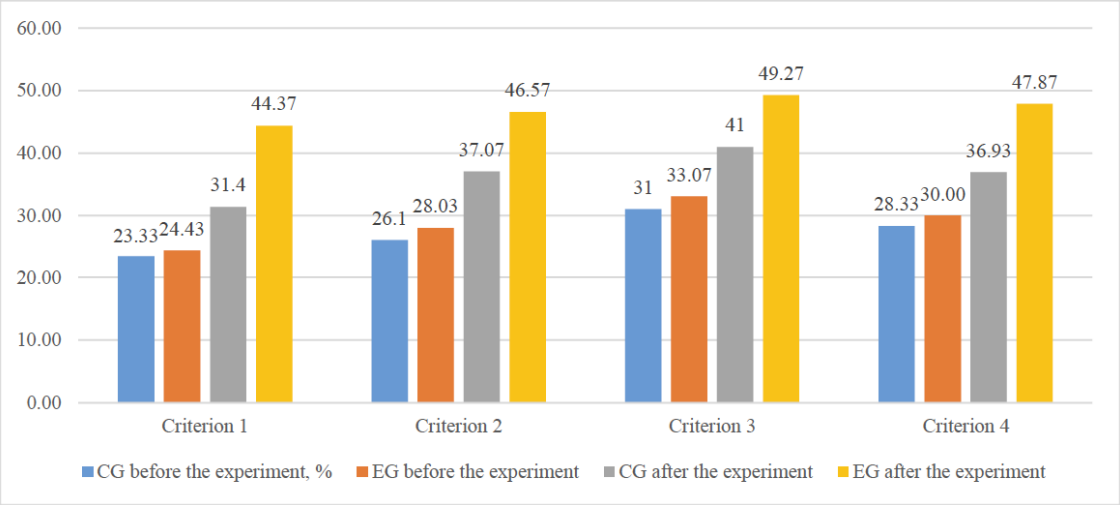

Figure 2: General visualisation of the effectiveness of correction of speech disorders in children with Autism Spectrum Disorders according to the developed criteria. Source: developed by the author.

visualization of the effectiveness of speech disorder correction in children with autism spectrum disorders in accordance with the developed criteria.

According to criterion 1, which describes speech development before the experiment, the control and experimental groups have insignificant differences. In contrast, the comparison of the control and experimental groups after the experiment has differences of 13%. The differences in the results of the control and experimental groups according to criterion 2 (development of communication and social skills) before the experiment were 3%, while after the experiment, this figure was almost 19%. Criterion 3, which characterizes the reduction of stereotypical and repetitive forms of speech and emotional and behavioral regulation before the experiment in control and experimental groups, has insignificant differences. In contrast, the comparison of the control and experimental groups after the experiment has differences of 10%. The differences in the results of the control and experimental groups according to criterion 4 (use of alternative means of communication, individual progress) before the experiment were 2%, while after the experiment, this figure was almost 10%. According to the experimental work, it can be concluded that the methods of correction of speech disorders in children with ASD, in particular the use of a combination of traditional and innovative methods, are effective.

This research did not involve animal subjects or any material that requires ethical approval. Although the research included human participants, there are some limitations. The study took into account time and ethical and practical constraints. Speech disorders can improve slowly, which requires long-term studies to obtain reliable data, so the study was long-term. In implementing practical constraints, a detailed study protocol was developed, which includes the justification of the methods, time frames, and expected results. The next step was to organize a meeting with the parents to explain all aspects of the study. Ethical aspects of the study were also taken into account. Consent to use speech therapy research methods was obtained from the parents or legal representatives of the child (Appendix 1). Confidentiality was also maintained, and the participants' personal data was protected.

4. DISCUSSION

Analyzing methods of correcting speech disorders determined that ABA therapy includes improving communication skills through structured training. This type of therapy has a positive effect not only on the development of speech but also on the development of other aspects of behavior. However, this method requires a significant investment of time, and its effectiveness depends on the child's perception. The PECS card exchange system uses cards to express the child's needs. This facilitates communication in children with no or limited verbal language. However, this method does not directly contribute to verbal language development (although it can be a bridge to speech).

Logorhythmics is a set of exercises that includes music, movement, and speech elements. It combines motor activity with speech stimulation. However, this method requires the presence of a specialist to perform

the exercises correctly. Alternative and assistive communication (AAC) involves the use of various devices (electronic or visual) to improve communication in children with ASD. It allows for practical expression of thoughts even in the absence of verbal language, but some children find it difficult to move on to developing verbal speech. Sensory integration can improve the child's overall condition, increasing readiness for language learning, but it is not a direct method of language correction but rather a supportive one. DIR/Floortime therapy involves play-based work based on the child's interests, emphasizing developing interaction and communication, but requires high involvement from parents and professionals.

Autism spectrum disorders are usually detected by observing children's behavioral activity. This method of diagnosis is time-consuming and not suitable for early detection. This article focuses on using a machine-learning model to diagnose autism at an early stage. Machine learning algorithms are characterized by greater prediction accuracy than other models and can be used to improve autism detection methods and develop effective interventions [25].

Speech and language disorders are often associated with autism spectrum disorders (ASD). Some are obvious and immediately detectable, while others require additional diagnosis. The development of automated algorithms that can acquire and quantify language features unique to children with ASD is valuable for assessing each child's initial condition and development over time [26].

Mild forms of ASD can go unnoticed in preschool age but can manifest themselves in school age through more significant opportunities for social activity. The development relies on virtual reality technology combined with sensor technology. Physiological signals and game performance data are collected during user training and integrated with several rating scales. The statistical analysis of these data can be used to conclude the severity and correction strategies for speech disorders. In other words, the presented technology combines games, training, and therapy [27].

We present the development of a system designed to facilitate learning for children with ASD. It is an Arduino-based game with standard components such as a touch sensor, MP3 player, and LEDs to increase playability. Early intervention based on game elements has been shown to improve the cognitive skills of children with ASD [28]. Classical methods of correcting speech disorders in children with ASD are more focused on the behavioral development of children. Telemedicine platforms are tools to support parents, and the study identified their features and classified modules according to the criteria outlined to correct the behavioral, communicative, and educational aspects of children with ASD [29].

Artificially created VR environments help provide children with ASD with individualized tasks to achieve specific goals and objectives. A project to develop a VR-based application that can improve understanding and communication skills in children with autism and help them interact with society and the environment is presented [30].

The most effective approach combines several methods that provide comprehensive speech support. For example, ABA is used to teach specific language skills, while PECS or AAC helps to support communication in the early stages. However, using innovative means of correcting speech disorders complements traditional ones. It is essential to individualize programs, adjust them based on observations of the child's progress, and integrate the methods into the child's daily life.

An important aspect of implementing speech therapy approaches for children with autism spectrum disorders is focusing on individual needs, this may be the need for speech development or social communication. The introduction of screening questionnaires at the state level into the practice of pediatricians and child neurologists will help identify the risks of developing ASD at an early stage.

It is also necessary to select correctional tools according to the individual needs of a child with autism spectrum disorders because although ABA, Floortime/DIR and TEACSN methods have proven effective, they cause discussions and contradictions during application. For example, ABA is effective for teaching basic speech skills, and Floortime is used to develop social interaction. In particular, ABA is often criticized for being too structured, which, according to critics, can limit the natural development of the child, while other children with autism spectrum disorders need a more playful approach, as in the case of using the Floortime/DIR method. Therefore, specialists should assess the individual pace of development of the child and his needs and apply a combination of methods depending on the situation.

The work of a speech therapist is only part of a comprehensive solution to the problem, so cooperation

with psychologists to stabilize the emotional state, speech therapists, and sensory therapists is important since each team member is responsible for his area of work. The key to successful therapy is the integration of various speech therapy approaches, the flexibility of speech therapy technologies, individualization of approaches, and cooperation with the family and specialists.

5. CONCLUSION

Correction of speech disorders in children with ASD requires a comprehensive approach that includes both traditional and innovative means. Timely and early correction of speech disorders significantly improves a child's communication skills. The article outlines the methods of correction of speech disorders in children with ASD, which include speech therapy, alternative and augmentative communication (AAC), therapy using games and imitation techniques, the use of behavioral techniques, and multisensory approaches. According to each method, traditional and innovative means for their implementation are identified. The traditional means of correction are the Floortime method, music therapy, CBT, PECS (Picture Exchange Communication System), game simulation, applied behavioral analysis (ABA), and multimodal sensory approaches. Innovative correctional tools are also considered, including AI-based programs (Otsimo and AutisMate), AAC applications (Proloquo2Go, TouchChat, Avaz; interactive versions of PECS; TTS), video modeling, the use of robots and gaming technologies; gaming applications and online games; distance learning and support platforms (Catalyst, Rethink; ABA DrOmnibus); VR-based training programs; gamification, teletherapy, AI applications for analyzing behavior and speech, gestures, VR, AR technologies.

Criteria for evaluating the effectiveness of methods of correction of speech disorders in children with ASD are developed, namely: speech development, development of communication and social skills, reduction of stereotypical and repetitive forms of speech, emotional and behavioral regulation, use of alternative means of communication, and individual progress. For each of the criteria, indicators of its implementation are outlined. Based on the criteria and their indicators, a survey was conducted among parents, educators, and correctional teachers on the effectiveness of these methods. The children with ASD who were surveyed were divided into two groups: a control group, in which the correction of speech disorders was performed using traditional means, and an experimental group, in which the correction was carried out using a combination of traditional and innovative means. The indicators of the experimental group showed a reasonably high increase, which indicates the effectiveness of combining traditional and innovative means of correcting speech disorders in children with ASD.

CONFLICT OF INTEREST

The authors affirm that they have no conflicts of interest to disclose.

FUNDING

No funds, grants, or other support was received.

ETHICS STATEMENT

This study involved the use of a questionnaire as a research tool. All participants provided informed consent for the use of the data collected. The study adhered to ethical standards to ensure the confidentiality and voluntary participation of all individuals involved.

INFORMED CONSENT STATEMENT

This study did not involve human participants, and therefore, informed consent was not required.

USE OF ARTIFICIAL INTELLIGENCE

The authors confirm that they did not use artificial intelligence technologies when creating the current work.

DATA AVAILABILITY

The manuscript has no associated data.

APPENDIX 1

Questionnaire for self-assessment of the effectiveness of methods of correction of speech disorders in children with ASD

Participation in the study is voluntary, and you have the right to withdraw at any stage without any negative consequences. The survey is anonymous, and the data obtained will be used solely in aggregate form to prepare recommendations and improve services. if you agree to participate in the survey, check this box ☐

K1. Speech Development

Please rate from 1 to 10 your vocabulary and ability to form sentences and use phrases.

1	2	3	4	5	6	7	8	9	10

Rate from 1 to 10 understanding of spoken language and following instructions.

1	2	3	4	5	6	7	8	9	10

Rate from 1 to 10 the use of non-verbal communication tools: gestures, facial expressions, and alternative means of communication.

1	2	3	4	5	6	7	8	9	10

Rate from 1 to 10 the progress of speech about the start of therapy according to the child's age. Where 1 is no progress, 10 is significant progress.

1	2	3	4	5	6	7	8	9	10

K2. Development of Communication and Social Skills

Please rate from 1 to 10 your ability to start a conversation independently and not just answer questions.

1	2	3	4	5	6	7	8	9	10

Rate from 1 to 10 the child's ability to maintain interaction with the interlocutor and communication with others.

1	2	3	4	5	6	7	8	9	10

Rate from 1 to 10 the improvement in the child's ability to communicate and share emotions.

1	2	3	4	5	6	7	8	9	10

Please rate the child's participation in group activities, ability to follow rules, and interaction with other participants from 1 to 10.

1	2	3	4	5	6	7	8	9	10

K3. Reduction of Stereotypical and Repetitive Forms of Speech, Emotional and Behavioral Regulation

Please rate from 1 to 10 the frequency of uncontrolled repetition of words or phrases you hear, where 1 is frequent, and 10 is rare.

1	2	3	4	5	6	7	8	9	10

Please rate the number of speech patterns and automatisms from 1 to 10, where 1 is frequent and 10 is almost nonexistent.

1	2	3	4	5	6	7	8	9	10

Please rate from 1 to 10 the ability to cope with communication difficulties without significant emotional outbursts and assess the child's comfort level in speech situations.

1	2	3	4	5	6	7	8	9	10

Please rate from 1 to 10 the level of control over emotions and behavior in communication difficulties.

1	2	3	4	5	6	7	8	9	10

K4. Use of Alternative Means of Communication, Individual Progress

If you use alternative means of communication (cards, communication devices), please assess the level of awareness of their use. Please rate from 1 to 10.

1	2	3	4	5	6	7	8	9	10

Rate from 1 to 10 the possibility of switching to verbal communication.

1	2	3	4	5	6	7	8	9	10

Score from 1 to 10 progress on normative indicators for abnormal children and monitor individual progress against previous results.

1	2	3	4	5	6	7	8	9	10

Please rate from 1 to 10 the use of speech correction methods in everyday life, creating conditions for parents to practice speech and communication.

1	2	3	4	5	6	7	8	9	10

Additional Comments

If you have anything else you would like to add or emphasize about the use of methods for the correction of speech disorders in a child with ASD, please indicate it here.

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