Artificial Intelligence Applications (Fluency SIS, Articulation Station Pro, and Apraxia Farm) in the Psycholinguistic Development of Preschool Children with Speech Disorders

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***Abstract*—Speech disorders in preschool children have far-reaching consequences, affecting their communication abilities, social interaction, and overall development. This study aims to analyze the impact of artificial intelligence-based interventions on the psycholinguistic development of preschool children with speech disorders. To achieve this goal, the research included an experimental study conducted for five months. It rested on the intervention of AI tools and an assessment of progress. Participants were offered a program aimed at improving speech skills. The program included sessions with speech therapists and classes based on AI-based applications (Fluency SIS, Articulation Station Pro, and Apraxia Farm). Additional methods were semi-structured interviews in focus groups with parents and speech therapists, as well as statistical analysis of the obtained data. The study participants were 170 children aged 3−5 years with diagnosed speech disorders, as well as 20 parents and 6 independent speech therapists. The Shapiro-Wilk test measured the normality of the data obtained in the study. The result of this test was 0.97 (p = 0.23), which indicates a normal distribution of data. The moderate effect size (0.47) indicates a moderate difference between the scores of the two groups after the intervention. This result confirms the assumption that AI-based interventions contribute to significant improvement. The findings can become the basis for scientifically sound recommendations regarding the inclusion of AI interventions in preschool speech therapy practice. The study can aid in the development and revision of artificial intelligence applications according to the specific needs of this age group.**

***Keywords*—apraxia, mobile applications, special education, speech and language pathology, verbal fluency**

I. Introduction

Typically, children learn the basics of language and speech at an early preschool age. Language and speech skills play a key role in learning and social relationships. Delays in the early development of speech skills are widespread among the population. These disorders affect all areas of functioning: social interaction, academic achievements, cognitive development, emotion regulation, self-esteem and confidence, and so forth [1]. The treatment of speech disorders can significantly improve speech skills and reduce the functional impact of persistent disorders. Current research in the field of speech and language therapy rests on activity-oriented, child-oriented, neuropsychological, psycholinguistic, and synergetic approaches [2]. The psycholinguistic approach considers speech activity as an integral unity of linguistic and communicative components. Therefore, it allows for the most holistic and comprehensive diagnosis of speech disorders and related speech effects [3]. Research largely builds upon language education context. The latter, as a rule, neglects the psycholinguistic motivation for the development of speech units arising due to the child's need for communication.

Children with speech disorders constitute about 5% of all children in primary school [4]. They are not a homogeneous group, and there is disagreement as to whether speech disorders should be classified according to etiology or symptoms. One of the main issues in this discussion is the influence of risk factors on speech and language development [5]. The frequently reported risk factors are a family medical history, hearing impairment caused by damage to the middle ear, pre- and perinatal problems, including premature birth and low birth weight, and psychosocial factors [6]. Scientific studies of speech development in preschoolers mainly relate to 6-year-old children [7]. At the same time, the potential maturity of key linguistic and communicative paradigms forms in children aged 5. Their need for communicative interactions is maximal and stimulates the intensive development of the communicative aspect of speech activity [8]. However, in children with speech development disorders in this age group, speech activity undergoes the deforming influence of adverse factors. This influence leads to secondary communicative difficulties. Therefore, the identification of children with speech delays in the preschool period should be a priority for the pediatrician [9]. Artificial intelligence is one of the modern and progressive tools for detecting and working with speech disorders.

Artificial Intelligence in Education (AIEd) is a new interdisciplinary field that applies artificial intelligence technologies to transform educational design and student learning [10]. The use of artificial intelligence in the psycholinguistic development of preschool children with speech disorders is a new and potentially important area of research and practice. Speech disorders in children include a variety of conditions, such as articulation disorders, phonological disorders, apraxia, and so forth [11]. These disorders can significantly affect a child's ability to effectively communicate, interact with peers, and participate in learning activities.

Artificial intelligence technologies can be used in the development of speech recognition systems that accurately

analyze a child's speech patterns. These systems detect certain speech errors, incorrect pronunciation, and other phonological problems [12]. By providing real-time feedback, these systems can help children understand and correct their speech mistakes. Artificial intelligence also adapts to the unique needs and learning tempo of each child [13]. By analyzing a child's speech patterns and progress, artificial intelligence systems create personalized learning plans tailored to their specific speech difficulties. This individual approach increases the child's involvement and learning outcomes. AI-based applications provide interactive speech therapy exercises that are interesting for preschool children [14]. These applications may employ games, classes, and interactive exercises that encourage children to practice their speech by playing. This category of applications also includes virtual AI-based speech therapists assisting children on demand. They can guide children through speech exercises, simulate correct pronunciation, and provide immediate feedback [15]. These applications can be especially useful in conditions of limited access to speech therapy specialists.

Research into the use of artificial intelligence in child speech therapy can contribute to the development of artificial intelligence technologies [16]. Thus, studying the integration of AI into the psycholinguistic development of preschool children with speech disorders can make a significant breakthrough in speech therapy. AI expands access to interventions, increases engagement, and improves outcomes for a vulnerable group of children.

II. Literature Review

A. The Status of AI Algorithms in Inclusive Education

AI development is neither a positive nor a negative phenomenon. It is a consequence of the need to support information progress. To date, the released AI packages (for example, ChatGPT) are simple and designed to support a deeper study of AI. Through AI and machine learning, ChatGPT can provide students with a personalized learning experience tailored to their individual needs [17]. ChatGPT can help teachers create more engaging lessons. Natural language processing, computer vision, and other artificial intelligence technologies allow educators to better understand student behavior and preferences. Consequently, they make adaptive real-time changes based on feedback from their students [18]. For example, if a student has difficulty understanding a concept or is struggling with a task, ChatGPT may recommend additional resources or accordingly modify the lesson plan.

Researchers discussed potential problems in AI education, noting the issues of surveillance bias, autonomy, and privacy. Their implications can vary depending on the age and development level of students participating in an AI environment [19]. For instance, there is a privacy issue. Students may feel uncomfortable when a computer system collects and analyzes their personal data. Moreover, some artificial intelligence systems can analyze and detect patterns in student data, occasionally causing bias and limiting the perception of student performance. The disclosure of information about disability may aggravate ethical issues [20]. Therefore, it is crucial to begin an open discussion about AI and its consequences for people with disabilities.

In addition, there is a need to support teachers and students in creating an ethical learning environment based on AI for people with disabilities [21]. The main purpose of AI in an educational context is to assist students in learning. Artificial intelligence systems collect and analyze student data, such as academic performance, learning preferences, and social interaction. This multimodal data can provide personalized learning, increasing student engagement and, at the same time, improving academic performance [22].

Another ethical issue related to AI in inclusive classrooms is consent. While AI systems can potentially help students learn more effectively, students may not adequately understand the implications of this technology, for example, what data the AI system collects, how it is stored, and who has access to it [23]. Technology coordinators, administrators, special education teachers, and parents should ensure that students with disabilities understand the consequences of using technology. Students should learn about data privacy and cybersecurity to know the specifics of data collection, storage, and access to it [24].

Students, teachers, and parents should understand the potential risks associated with the use of AI, such as possible bias, discrimination, or data leakage. Parents should discuss ethical issues related to AI and make a family decision about whether an AI-enabled school is the most optimal option for their child. Special education teachers also need to realize their own beliefs and values to ensure that they use AI ethically [25]. Therefore, teachers need to assess potential risks by answering the following questions: Does the artificial intelligence system correspond to the individual student learning plan? How does it comply with the ethical standards of the school? Can an artificial intelligence system provide personalized learning while respecting students' different backgrounds and values? Is AI used to improve the quality of teaching or to replace a teacher? [26].

B. Speech Disorders and AI

Studies have shown that some risk factors (prenatal and perinatal problems, problems with ears, nose, and throat (ORL)) affect speech impairment. There are two modern classifications of speech disorders, both focus on functional (inorganic) disorders associated with development [27]. The first classification rests on etiological factors and distinguishes the following speech disorders: (1) unknown origin (possibly genetic), (2) verbal apraxia, and (3) psychological involvement [28]. Another approach centers on the symptoms [29]. The psycholinguistic defects underlying the speech processing algorithm become obvious after the analysis of surface error patterns (the number and type of speech errors). The mouth, jaw, tongue, lips, palate, and other articulators work together to produce human speech. The inability to move these parts appropriately affects speech intelligibility, leading to Speech Sound Disorders (SSD) [30]. There are various causes of SSD, including weakness of the oral musculature (dysarthria), structural disorders (cleft lip and palate), as well as the inability to correctly interpret and execute messages from the brain due to a neurological disorder (apraxia) [31].

The development of speech and language is decisive in the first years of a child's life. Early intervention in speech disorders is more likely to have better results. The young brain is more adaptable and can reorganize neural pathways. Many children with speech disorders face difficulties in

accessing a qualified speech therapist due to such factors as geographical location, limited resources, or high cost [32]. Artificial intelligence-based tools can bridge this gap by providing affordable measures that can be used at home or in educational institutions. AI can also process and analyze large amounts of data to gain insight into a child's speech patterns, progress, and problems. This data-driven approach can inform therapists, parents, and educators about the effectiveness of interventions and facilitate decision-making in the child's treatment plan [33].

Speech and communication problems can also be common among children with Autism Spectrum Disorders (ASD). These difficulties have different effects and may include problems with speech development, language comprehension, social communication, and pragmatic language skills. An example of an application for such children can be Proloquo2Go [34]. This application employs Language Environment Analysis based on artificial intelligence. It allows people with speech disorders to communicate using symbols, images, and synthesized speech. There are also AI-based virtual speech therapists. For example, Wizdy Diner is a virtual speech therapist controlled by artificial intelligence that offers children fascinating scenarios to train language skills and improve their speech [35]. Robot-Assisted Language Learning (RALL) systems use robots controlled by artificial intelligence to facilitate language learning through interactive conversations, vocabulary replenishment, and sentence construction [36]. Artificial intelligence algorithms can identify speech disorders at an early stage by analyzing a child's speech patterns and comparing them with developmental norms. Early detection allows for timely measures, which are crucial for effective treatment. Language ENvironment Analysis (LENA) uses artificial intelligence to analyze children's speech environment and provide information about language development and potential delays [37]. Studies have proved that both standardized language and cognitive indicators showed a positive correlation with some LENA indicators. Adults skillfully adapt their language according to the linguistic and cognitive levels of students. That is, students with lower language and cognitive abilities hear fewer complicated words because teachers use shorter phrases or sentences [38].

The purpose of this study is to investigate the impact of artificial intelligence-based interventions on the psycholinguistic development of preschool children with speech disorders. To achieve this goal, the study set the following tasks:

1) Assess how artificial intelligence-based interventions affect the speech and language skills of preschool children with speech disorders.
2) Compare the opinions of parents and speech therapists about the effectiveness and convenience of artificial intelligence tools for the psycholinguistic development of preschool children.
3) Determine whether AI-based applications are effective for the psycholinguistic development of children.

III. Materials and Methods

A. Research Design

The experimental study lasted for five months and employed the intervention of AI tools with an assessment of progress. The study took place in 2021−2022 in Almaty, Semey, Astana (Kazakhstan). Research base: kindergartens ("Er-Tan 1", "Aruzhan", "Ainalayyn", "Nursaule") and secondary schools (School No. 74, School No. 86, School No. 159, School No. 56, School No. 35, School No. 12).

The participants took a training program to improve their speech skills. The program included sessions with a speech therapist, as well as classes based on AI-driven applications. Additional methods were semi-structured interviews in focus groups with parents and speech therapists, as well as statistical analysis of the obtained data. Classes with children took place 4 times a week. The program integrated the following applications: Fluency SIS, Articulation Station Pro, and Apraxia Farm. The applications were chosen because they utilize technology to enhance traditional speech therapy methods. These platforms offer interactive and engaging tools that can complement in-person therapy sessions. The apps serve as supplementary resources that enhance traditional therapy methods and provide additional opportunities for practice and engagement.

B. Functioning of Applications

Fluency SIS is an application that speech therapists and students can use when working with stuttering children of preschool and school age. The program strategy encourages creativity and humor during intervention classes. Fluency SIS consists of four components (Smart Intervention Strategy) and includes various activities. The four components are a) Think Smart, Feel Smart, b) Cool Speech, c) Challenge the Dragons, and d) Into the 'Real' World. The intervention develops confidence in speech and acceptance of stuttering, avoiding focus on changes in the speech manner of a child. The goal is to become an effective and confident communicator. Creativity and humor are additional methods to help stuttering children "solve problems" and expand their perception to develop and maintain a positive attitude towards themselves and communication. The application uses a motivational cartoon character (Ah-ha Diamond) that encourages children during classes. Ah-ha Diamond guides the child on a journey to discover the joy and pleasure of conversation. Fig. 1 shows an example of a task from this application.

Fig. 1. A task from Fluency SIS.

Articulation Station Pro is a comprehensive articulation program offering practice at the level of words, sentences, and stories using 22 sounds. It offers a range of activities and exercises that target specific speech sound errors. The application provides audio and visual cues, along with interactive games and activities, to engage users and make

learning fun. It also allows for tracking progress and customization based on individual needs. In addition to the professional and clear design of the application, every action in Articulation Station is accompanied by real photos on a white background. This approach to visualization makes the photos easily recognizable. Fig. 2 shows examples.

Fig. 2. A task from Articulation Station Pro.

Another application is Apraxia Farm developed by certified speech therapists from Smarty Ears, a company known for creating educational applications for speech and language development. This AI-driven application aids children with speech apraxia (a motor speech disorder that affects the ability to plan and perform the precise movements necessary for speech). The application provides children with a playful and interactive environment for practicing speech sounds, words, and sentences. Apraxia Farm includes several levels that target both vowels and consonants (Fig. 3).

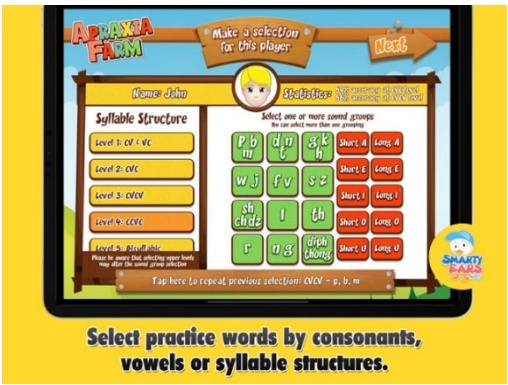

Fig. 3. A task from Apraxia Farm.

C. Sample

The study participants were 170 children aged 3–5 years with diagnosed speech disorders, as well as 20 parents and 6 independent speech therapists. They were randomly selected from 10 state institutions for the temporary stay of preschool children (kindergartens). The main sampling criterion was the anamnesis indicating a speech disorder and the age of 3–5 years. Parents received an invitation for participation via e-mail (the administrations of the institutions provided the addresses). All participants were guaranteed anonymity and confidentiality of information.

The study involved participants diagnosed with:

- articulation disorders (associated with difficulties in producing certain speech sounds);
- phonological disorder (includes patterns of speech sound errors that affect the entire sound system of speech);
- fluency disorders (stuttering);
- apraxia;
- dysarthria.

For the intervention at the first stage of the study, the children were randomly divided into two groups (control and experimental) with 85 participants each. The training in the control group included traditional classes with speech therapists in small groups according to individual programs. The control group employed the selected AI-based applications in classes. Thus, at each lesson, the speech therapist allocated 10–15 minutes for working with gamified applications. The children performed tasks under the supervision and recommendations of a speech therapist. During the training, students completed several tasks in one of the proposed applications, which alternated each time. Parents could also attend classes.

D. Survey

The study included semi-structured interviews and focus group discussions with parents and speech therapists in both groups. These procedures aimed to collect qualitative data on perceptions, experiences, and problems associated with artificial intelligence-based interventions among preschoolers with speech disorders. The interview questions were designed to reveal the respondents' objective opinions while minimizing the influence of subjective factors. This procedure included clear and specific questions and avoided leading or biased ones. The interviews were structured in the form of a conversation and had only a general outline for the survey. Therefore, the respondents answered additional questions, when it was necessary. Data saturation was defined as the point where results consistently matched existing question topics and no contradictory or new information emerged. Below are examples of questions used in the interviews and discussions:

The questions from a semi-structured interview with parents:

1) What were your initial thoughts or expectations when you learned that your child would participate in speech therapy intervention based on artificial intelligence?
2) Can you describe your child's experience with AI-based interventions? How did they interact with the app and what was their reaction?
3) How did you notice changes or improvements in your child's speech and communication skills after using artificial intelligence?
4) What aspects of AI-based interventions did your child find most interesting or motivating? Were there any difficulties they faced?
5) How did AI intervention affect your child's willingness to engage in speech exercises at home? Have you noticed any changes in their confidence?

The questions from a semi-structured interview with speech therapists:

1) How have you integrated AI-based interventions into your

therapeutic approach? How did you manage to balance them with traditional methods?
2) According to your observations, how did children react to AI intervention during therapeutic sessions? Have there been any noticeable changes in engagement?
3) In your professional opinion, what are the strengths and weaknesses of AI-based interventions to solve problems with speech disorders in preschool children?
4) Have you noticed any differences in how children interacted with artificial intelligence compared to traditional therapeutic materials or methods?
5) In your experience, how can AI-based interventions and traditional therapies complement each other, providing comprehensive support to children with speech disorders?

E. Statistical Processing

To analyze quantitative data, the study used statistical methods, such as Cohen's d and ANCOVA. These methods allowed for comparing changes in speech and language outcomes between AI and traditional groups. The measurement of the effect size quantifies the difference between the mean values of the two groups in terms of standard deviations. To determine the intervention effects, the indicators of student performance were assessed. The results were compared by the mean value of the group.

F. Ethical Issues

AI promises successful integration into the psycholinguistic development of preschool children with speech disorders. Nevertheless, it requires careful consideration of ethical, confidential, and regulatory factors. The integration of AI into such sensitive domains requires scrutiny to ensure the well-being, privacy, and equitable treatment of the children involved. A balance between innovation and ethical responsibility is imperative for the successful and responsible implementation of AI in this context.

All the research processes that included the participation of people corresponded to the ethical standards of research. Before starting any screening procedures, the participants and their parents received detailed information about the study, its purpose, potential risks, and benefits. The parents of all participating children provided informed consent; ethical standards were not violated.

IV. Result and Discussion

A. The Effect of AI-Based Interventions on Improving Speech Performance

The Shapiro-Wilk test measured the normality of the data obtained in the study. The result of this test was 0.97 (p = 0.23), which indicates a normal distribution of data. In addition, Levene's test for uniformity of variance (F = 3.11, $p > 0.05$) indicates that the assumption is reasonable. It also shows that there were no significant differences in the variance between the two groups. The tests confirmed the uniformity of regression slopes, assuming the possibility of performing a one-factor ANCOVA (F = 0.26, $p > 0.05$).

To compare the intervention effects, the results of the control group (that received traditional therapy) and the experimental group (that received AI-based interventions) were analyzed. The mean score of the experimental group was 78; the mean score of the control group was 72. The standard deviation of the experimental group was 10; that of the control group −8. $\text{Combined standard deviation} = \sqrt{10^2 + 8^2} \approx 12.81$.

$$\text{Difference in mean values} = 78 - 72 = 6^{**}$$

$$\text{The effect size (Cohen's d)} = \frac{6}{12.81} \approx 0.47^{**}$$

**This means that there is a discernible difference between the groups is moderate.

As a result, the effect size (Cohen's d) is approximately 0.47. Cohen's interpretation of d varies, but as a rule, a value of 0.2 is a small effect, 0.5 represents a moderate effect, and 0.8 or higher is a large effect. A higher average score after the intervention in the experimental group suggests that AI-based interventions had a positive effect on improving speech and language skills compared to traditional therapy alone. The moderate effect size (0.47) indicates that the difference between the scores of the two groups after the intervention was moderate. This fact once again confirms the assumption that AI-based interventions contribute to significant improvement. The effect size may vary depending on such factors as the severity of the speech disorder, the type of AI intervention, and the level of participation in the intervention.

B. Feedback from Parents and Therapists

The semi-structured interviews and focus group discussions showed the following trends:
1) Both parents and speech therapists expressed initial curiosity and interest in integrating artificial intelligence-based interventions into speech therapy classes.
2) The children interacted with artificial intelligence tools: animation, interactivity, and game functions increased their motivation to practice speech sounds.
3) The intervention produced positive results, including improved speech clarity, higher confidence, and increased willingness to practice speech exercises.
4) The adaptability and personalization of artificial intelligence tools allowed for individual exercises that complement traditional therapy approaches.
5) However, initially, parents had concerns about the ability of an artificial intelligence application to accurately understand their child's manner of speech and replace human guidance.
6) Speech therapists expressed concern about the need for detailed feedback when working with artificial intelligence tools and the importance of specific exercises that correspond to individual speech goals.
7) Some children encountered difficulties in accurately pronouncing certain words using the AI application; this fact indicates the need for individual guidance to solve some speech problems.
8) Both parents and speech therapists recognized the collaborative nature of using AI tools along with traditional therapies.
9) The features of adaptability and data tracking strengthened the material learned during personal lessons and ensured consistency in practice.

The following feedback from parents and speech therapists confirms the above conclusions:

Parent 1: "When I heard about artificial intelligence-based therapy, I was curious, but I was a little unsure. I was not sure

if the app could really replace traditional therapy."

Parent 2: "My child really enjoyed using the app. Colorful animation and interactive classes kept him interested and willing to practice."

Parent 3: "After using the app for a while, we noticed that my child's pronunciation became clearer and he became more confident in trying new words."

Parent 4: "The games and rewards in the app have turned the practice of speech into an exciting activity. However, sometimes it was a little difficult for my child to pronounce some words correctly."

Parent 5: "The app definitely motivated my child to study at home. We were looking forward to using it, and thanks to it, classes became less tedious."

Speech Therapist 1: "I was intrigued by the possibility of AI to attract children to therapy. I hoped it would improve their learning experience."

Speech Therapist 2: "Integrating artificial intelligence tools was a new experience, but the children seemed to be excited about interacting with them. The animation caught their attention."

Speech Therapist 3: "The children reacted positively. We noticed an improvement in the clarity of their speech sounds, and they enthusiastically started classes."

Speech Therapist 4: "The versatility of the AI app was helpful, but some children needed more personalized guidance to overcome certain speech problems."

Speech Therapist 5: "The children were interested in classes based on the app. It encouraged constant practice, which was sometimes a problem when using traditional methods. The artificial intelligence tools allowed children additional opportunities for practice. They complemented personal studies and supported the interest of children."

Speech Therapist 6: "I was concerned about the app's ability to provide detailed feedback. It is important to make sure that the technology understands different speech patterns. However, AI and traditional methods combine well, improving the learning process. Data tracking function also helped monitor progress."

Thus, the collaborative approach, in which AI tools complement traditional therapies, was positively evaluated. The conclusions drawn from these responses highlight the potential benefits of AI in supporting speech development. The results emphasize the importance of solving problems and improving the technology to better meet individual needs.

C. Description of the Progress for Each Specific Speech Disorder

At the same time, the monitoring of progress showed improvements in each of the disorders since the applications covered all speech problems of the participants. To describe the progress of children with various speech disorders in terms of articulation, pronunciation, stuttering, and other relevant aspects, it is necessary to assess their academic performance before and after the intervention. Below is the description of the progress for each specific speech disorder:

1) Articulation disorders

Before the intervention: Children with articulation disorders had difficulties with the formation of certain speech sounds. These difficulties led to inaccurate pronunciation and reduced speech clarity. After the intervention: The children demonstrated an improvement in the ability to accurately reproduce the target speech sounds. Pronunciation became clearer, increasing the overall intelligibility of speech.

2) Phonological disorders

Before the intervention: Children with phonological disorders demonstrated patterns of speech sound errors. These problems affected the entire sound system of the language and the ability to convey the intended messages. After the intervention: The children showed progress in correcting phonological errors. Their sound characteristics of speech better corresponded to age norms, which implies the improvement of communication skills.

3) Fluency disorders (stuttering)

Before the intervention: Children with fluency disorders had impaired speech flow disorders characterized by repetitions, elongations, and blocks in speech. After the intervention: Intervention efforts improved fluency. The children demonstrated fewer repetitions, and their speech flow became smoother, leading to more fluent and confident communication.

4) Apraxia

Before the intervention: Children with speech apraxia had difficulty planning and performing the precise movements necessary for speech reproduction. The reproduction of speech sounds was inconsistent. After the intervention: the planning and execution of movements developed. The children demonstrated increased consistency in pronouncing purposeful speech sounds and improved the sequence of sounds in words, producing clearer speech.

5) Dysarthria

Before the intervention: children with dysarthria experienced problems related to muscle control and coordination of speech. These difficulties complicated articulation and caused problems with speech volume and intelligibility. After the intervention: Muscle control and coordination of speech improved. The children demonstrated clearer articulation, increased speech volume, and overall intelligibility of speech.

Nevertheless, speech therapists noted that many participants need further work on their speech, depending on the type of disorder. They also reported that regular classes with AI applications would continue to contribute to progress among children. The research studied not only the impact on speech skills but also the potential impact on broader psycholinguistic development. This development includes improving vocabulary, expressive speech abilities, phonological awareness, and general communicative competence. Table 1 presents the results of psycholinguistic development.

In conclusion, the results of this study indicate a positive effect of AI-based interventions on the psycholinguistic development of preschool children with speech disorders. Interventions demonstrated effectiveness in improving articulation, pronunciation, fluency, and general communication skills. This finding supports the idea that AI tools can adapt to specific speech therapy goals, contributing to a more personalized and effective therapeutic experience. The feedback from parents and therapists emphasizes the collaborative nature of using AI tools alongside traditional

therapies. Continuous improvement in technology, guided by ongoing feedback and collaboration between developers, researchers, therapists, and parents, is crucial for optimizing the effectiveness of AI-based interventions.

Table 1. The impact of intervention on the psycholinguistic development of children

Speech disorder	Psycholinguistic profile before the intervention	Psycholinguistic profile after the intervention	The impact of the intervention on psycholinguistic development
Articulation	Limited speech sound production, indistinct articulation	Improved accuracy of sound, speech and articulation clarity	Improved ability to pronounce target speech sounds
Phonology	Constant speech sound errors affecting communication	The reduction of phonological errors, improved intelligibility	Increased clarity and accuracy of communication
Fluency (stuttering)	Frequent repetitions and blocks in the speech flow	Smoother speech flow, reduced speech gaps	Increased fluency and confidence in speech
Apraxia	Inconsistent sound production of speech, difficulties with the sequence of sounds	More stable sound reproduction, improved consistency	Improved ability to plan and perform speech movements
Dysarthria	Impaired muscle control, unclear articulation	Improved muscle control, clearer articulation	Improved the clarity and general intelligibility of speech

Speech disorders in preschool children have far-reaching consequences, affecting their communication abilities, social interaction, and overall development. Early intervention plays a key role in solving these problems and ensuring optimal psycholinguistic development [39]. In recent years, advances in technology, in particular artificial intelligence, have opened up new opportunities for improving speech therapy. Speech disorders in children affect their fluency and intelligibility. Delay in diagnosis and treatment increases the risk of social disorders and learning disabilities [40]. In conditions of acute shortage of Speech-Language Pathologists (SLP), interest in Computer-Assisted Speech Therapy (CAST) is growing. The results of this study revealed the positive impact of artificial intelligence-based interventions on the articulation and pronunciation of children with various speech disorders. The participants who took part in the interventions demonstrated increased speech fidelity and clearer articulation. This result is consistent with previous research showing that technological interventions can provide targeted practice and feedback to effectively address problems related to articulation and pronunciation [41].

Developmental Language Disorder (DLD) affects children's understanding and reproduction of spoken language. The early detection of DLD is vital. Several studies have examined predictors of DLD to identify children in need of further diagnostic testing. Most of these measures can be problematic for young children and bilingual children [42]. Another study analyzed how advanced information technologies can collect non-linguistic indicators of rhythmic anticipation and used them to identify children at risk of DLD [43]. The researchers developed MARS, a web-based tool for gamified data collection and analysis based on machine learning. The analysis of the sound features in the rhythmic vocal performances of the participants highlights various patterns in the two groups. This result, although preliminary, suggests that MARS may be a valuable tool for the early diagnosis of DLD. The current study used available applications to assess and work with the above-mentioned problems in children. One of the notable advantages of AI-based interventions is their ability to provide customized and adaptive exercises. Interventions can adapt to the individual needs of each child, allowing for a personalized approach to solve specific speech problems.

It is possible to use machine learning to classify children receiving language services in school settings. These approaches can identify those factors that best distinguish children with and without language disorders from a clinical point of view [44]. The variables that most contributed to the accurate classification of receiving language therapy were cognitive impairment, age, gender, as well as communication, social, and literacy skills reported by teachers and parents [45]. In the current study, the main variables were prenatal and perinatal problems and ear, nose, and throat disorders. Although AI in this case cannot accurately diagnose speech disorders in children, it can improve their results. A moderate effect size (0.47) indicates a moderate difference between the scores of the two groups after the intervention. This result once again confirms that AI-based interventions contribute to a significant improvement.

Schools designed for special children still have limited resources and facilities. Consequently, it is very difficult to provide individual care for each child with special needs. The children remain under sublimated care and education. Studies proved that computer-assisted education is on the way to solving these problems [46]. In another study, the researchers pre-processed sound and then transmitted it to a convolutional neural network to extract signs of disorders [14]. This procedure aimed to classify communication disorders. The authors used the Tensorflow model deployed on Android.

This study has several limitations. The first implies that the children received their diagnoses before the study (from their doctors). This factor could affect the objectivity and reliability of the results since diagnoses cannot be fully verified. In addition, speech disorders in participating children varied in severity and manifestation. All of them had individual intervention and treatment plans. Therefore, the effect of the intervention may be stronger or weaker in certain cases. The sample of the study may insufficiently reflect the diverse population of preschool children with speech disorders.

V. Conclusion

Overall, the study's main contributions lie in its exploration of AI-based interventions in a speech therapy context. The paper provides a comprehensive assessment of speech disorders and psycholinguistic development and combines quantitative and qualitative analyses. The findings suggest positive effects of AI interventions on the speech and language skills of preschool children. When comparing the effects of the intervention, the mean score after the intervention for the experimental group was 78, while the mean score for the control group was 72. For the experimental group, the standard deviation was 10; for the control group, it was 8. The calculated combined standard deviation was

approximately 12.81. It was used to calculate the effect size using Cohen's d, which gave an effect size of approximately 0.47. This result suggests that AI-based interventions significantly improved speech performance compared to traditional therapy. The positive feedback from parents and speech therapists indicates initial success and acceptance of AI-based interventions. Thus, there are implications for the broader adoption of such technologies in speech therapy. AI demonstrated the potential to enhance engagement and motivation among children. The study's focus on psycholinguistic development, including vocabulary, expressive speech abilities, and general communicative competence, underscores the holistic impact of AI-based interventions.

These results give insights into the potential benefits and challenges of integrating AI into speech therapy for preschool children with speech disorders. They can become the basis for evidence-based recommendations for the inclusion of AI interventions in preschool speech therapy practice. In addition, these findings can facilitate the development and revision of artificial intelligence applications according to the specific needs of this age group.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

All authors contributed to the study's conception and design. Conceptualization: NZ. Material preparation, data collection, and analysis were performed by LA and OT. The first draft of the manuscript was written by AU and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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