PEDAGOGICAL POTENTIAL OF COMPUTER PROGRAMS FOR SPEECH RECOGNITION AND ANALYSIS IN THE CORRECTION OF SPEECH DISORDERS IN CHILDREN

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Annotation: This article examines the pedagogical potential of computer programs designed to recognize, analyze, and correct speech disorders in preschool and primary school-age children. Particular attention is paid to the potential of digital technologies in special education and inclusive education, where objective diagnostics and individualized interventions are key to effective learning. The article substantiates the importance of automated speech signal analysis, comparison of children's pronunciation with a reference model, and visualization of articulation errors as means of increasing children's awareness of speech activity. It is shown that the use of computer programs contributes to the development of auditory-speech perception, the development of self-control skills, and increased motivation for remedial classes. The article emphasizes the need to implement nationally oriented software solutions that take into account the phonetic and phonological characteristics of the native language and reveals their role in the implementation of modern strategies for the development of inclusive education.

Keywords: Special education, inclusive education, computer programs, speech recognition, speech analysis, speech disorder correction, digital learning technologies.

Introduction

With the digitalization of education and the active introduction of information and communication technologies into teaching practice, the use of computer programs to correct speech disorders in children has become particularly pressing. Students with hearing and speech impairments typically experience persistent difficulties developing phonemic perception, pronunciation, and coherent speech, which significantly limits their academic success and social integration. Therefore, the search for effective pedagogical tools that provide objective diagnosis and targeted correction of speech deficits is becoming a priority for special education. [1, 2]

Modern computer programs for speech recognition and analysis offer new opportunities for solving this problem. Unlike traditional speech therapy methods, which rely primarily on the subjective assessment of the specialist, digital technologies enable quantitative and qualitative analysis of the speech signal, record the dynamics of speech development, and provide visual and auditory feedback. This creates conditions for more accurate identification of speech errors, individualization of corrective treatment, and increased effectiveness of pedagogical interventions. [5, 6, 7]

From a pedagogical perspective, the ability to compare children's speech with a standard pronunciation model is particularly valuable. This approach fosters a child's conscious attitude toward their own speech activity and develops self-monitoring and self-correction skills, which aligns with modern concepts of activity-based and student-centered learning paradigms. Furthermore, the use of computer programs enhances the motivational appeal of lessons,

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especially when working with primary school-aged children, for whom visual and interactive learning methods are most effective.

In the context of inclusive education, digital speech analysis programs take on added significance. They enable the organization of remedial assistance not only in specialized institutions but also in mainstream schools and at home, under the supervision of teachers and parents. This aligns with strategic educational development directions aimed at expanding the availability of high-quality psychological and pedagogical support for children with special educational needs. [2, 8]

The need to develop and implement nationally oriented software solutions adapted to the linguistic and cultural characteristics of students is particularly important. The use of universal foreign programs does not always ensure adequate speech analysis in a child's native language, which reduces the pedagogical effectiveness of the intervention process. Therefore, the development of computer programs focused on speech analysis and intervention in the national language is an important prerequisite for improving the quality of special and inclusive education.

Thus, the purpose of this article is to provide a pedagogical understanding of the capabilities of computer programs for recognizing, analyzing and improving speech in children and to substantiate their importance as an effective tool for correctional and developmental education in the system of modern special pedagogy.

Materials and Methods

The methodological basis of the study was based on principles of special education, speech therapy, and inclusive education, which view a child's speech development as the result of the interaction of auditory perception, articulatory motor skills, and cognitive processes. [4, 9] The study utilized a comprehensive pedagogical approach, combining observation, speech activity analysis, experimental learning, and digital diagnostics. Particular attention was paid to the principle of individualizing corrective interventions, which aligns with modern requirements for the organization of education for children with special educational needs.

The primary pedagogical tool used in the study was computer programs designed for recognizing, analyzing, and correcting oral speech. The software package provided automated recording of the speech signal, its subsequent processing and visualization, as well as comparison of children's pronunciation with a standard model of normative speech. This approach allowed for a transition from subjective assessment of pronunciation quality to an objective analysis of the acoustic and temporal characteristics of speech, which is especially important in remedial work with children experiencing difficulties in auditory perception and speech self-control. [9, 10, 11]

The study's data consisted of speech utterances from preschool- and primary-school-aged children enrolled in special and inclusive education settings. The speech samples were selected based on the children's age and individual characteristics and included words and phrases typical of everyday speech communication. This ensured the ecological validity of the study and brought the experimental conditions closer to real-life teaching situations. Speech production was recorded digitally, enabling repeated analysis and comparison of results at different stages of intervention.

The study was structured as a sequential pedagogical experiment, including diagnostic, developmental, and control stages. During the diagnostic stage, an initial assessment of the children's speech development was conducted using a computerized speech analysis program and traditional pedagogical observation methods. Pronunciation characteristics, speech intelligibility, articulation stability, and the child's ability to perceive verbal instructions were analyzed. The data obtained were used to determine individual educational needs and adjust the parameters of the software analysis.

The formative stage focused on the systematic integration of computer programs into remedial and developmental activities. During the sessions, children completed word and phrase repetition tasks, listened to pronunciation samples, and analyzed their own speech using visual and auditory feedback. Using the computer program allowed the child not only to hear the results of their speech activity but also to see a graphical representation, which facilitated the development of conscious articulation control. From a pedagogical perspective, this approach was viewed as a means of activating cognitive activity and developing the reflective skills necessary for successful speech learning. [6, 12]

An important component of the methodology was the use of tasks for recognizing and analyzing non-speech sounds. Working with non-speech acoustic stimuli was considered a necessary stage in the development of auditory attention and auditory differentiation. The computer program allowed for varying the types of sounds, their intensity, and duration, ensuring a gradual increase in the complexity of the tasks and adaptation of the remedial process to the capabilities of each child. This methodological approach is based on the pedagogical principle that developing the perception of non-speech sounds is the foundation for the development of phonemic awareness and subsequent speech acquisition.

The control phase of the study aimed to evaluate the effectiveness of computer programs in the treatment of speech disorders. During this phase, the children's speech was again recorded and analyzed using the same criteria and parameters as during the diagnostic phase. This ensured comparability of the results and allowed for an objective assessment of speech development dynamics. The data obtained were analyzed for pedagogical significance, including changes in pronunciation quality, speech self-control, and motivation for speech activity.

The methods for processing the results included qualitative pedagogical analysis and interpretation of digital speech analysis data. Particular attention was paid to identifying consistent trends in the development of speech skills and determining the pedagogical conditions that facilitate the most pronounced positive effects. This approach allowed us to view computer programs not as an isolated technical tool, but as an integrated means of remedial and developmental education, the effectiveness of which is determined by the pedagogical context of their use.

Thus, the materials and methods used provided a comprehensive study of the pedagogical potential of computer programs for speech recognition and analysis and created the basis for further analysis of the results and discussion of their significance for the practice of special and inclusive pedagogy.

Results

The results of the study demonstrate the high pedagogical effectiveness of using computer programs for speech recognition, analysis, and correction in working with preschool- and primary-school-aged children experiencing speech development difficulties. Analysis of data obtained during the diagnostic and control stages revealed consistent positive trends across a number of key indicators reflecting the quality of speech activity and the level of development of auditory-verbal skills. [9, 10]

First of all, most children participating in the study demonstrated improved oral speech intelligibility. A comparative analysis of speech recordings made before and after the formative stage revealed a reduction in the number of articulation errors and an increase in the consistency of pronunciation. These changes were systemic and manifested both at the level of individual sounds and in the structure of words and short phrases. From a pedagogical perspective, this indicates the development of more stable articulation skills and increased precision in the motor expression of speech.

Significant changes were also noted in the development of auditory perception. Working with computer programs, including tasks for analyzing and differentiating non-speech sounds, contributed to an increase in auditory attention and the ability to distinguish the acoustic characteristics of sounds. Children began to respond more quickly and accurately to auditory stimuli, which positively impacted their ability to perceive and reproduce speech patterns. These results confirm the pedagogical position that targeted development of auditory perception is a prerequisite for the successful treatment of speech disorders.

Of particular interest are the results related to the development of children's speech self-monitoring skills. The use of visual feedback provided by a computer program during speech analysis allowed children to consciously correlate their own pronunciation with a reference model. [5, 8] During the sessions, a gradual decrease in dependence on constant prompts from the teacher and an increase in independence in completing speech tasks were observed. This was manifested in the child's desire to independently repeat a word or phrase to achieve a more accurate result, indicating the development of reflective mechanisms of speech activity.

An analysis of the results also revealed an increase in motivation for remedial and developmental activities. The interactive nature of the computer programs, the use of visual elements, and the opportunity to monitor their own progress contributed to the development of a positive emotional attitude toward the activities. Children showed greater interest in speech exercises, maintained their attention span for longer, and demonstrated a willingness to regularly participate in the activities. From a pedagogical perspective, this effect is of fundamental importance, as motivation is one of the key factors in successful learning and remedial intervention.

The study's results also revealed a positive impact of computer programs on children's socialization processes. Improved speech quality and increased confidence in their own communication skills contributed to children's more active participation in educational interactions and everyday communication. Teachers noted increased initiative in children's oral responses and a decrease in anxiety associated with speech difficulties. This suggests that digital

speech analysis programs can be considered a tool not only for corrective but also for social and pedagogical interventions. [9, 11]

A comparative analysis of individual results showed that the greatest impact was observed in children for whom computer programs were used systematically and in combination with traditional teaching methods. This integrated approach provided optimal conditions for transferring developed speech skills to real-world communication situations. This supports the conclusion that digital technologies demonstrate maximum effectiveness when integrated into a comprehensive educational system, rather than when used in isolation.

Overall, the study's results suggest that speech recognition and analysis software offers significant pedagogical potential and can be considered an effective means of improving the quality of interventions and developmental work with children with speech disorders. The findings provide an empirical basis for further discussion of the pedagogical and inclusive aspects of integrating digital technologies into educational practice.

Conclusion

The study allows us to draw a number of general conclusions that have significant implications for the theory and practice of special education, speech therapy, and inclusive education. An analysis of the pedagogical potential of computer programs for speech recognition, analysis, and correction confirmed their high effectiveness as a modern tool for remedial and developmental education of preschool and primary school-aged children with speech disorders.

The obtained results demonstrate that the use of digital software provides a qualitatively new level of objectivity in the diagnosis of speech disorders. Automated speech signal analysis and comparison of children's pronunciation with a reference model allow for more accurate identification of articulation characteristics, the degree of development of phonemic awareness, and the dynamics of speech development. This creates a reliable foundation for individualizing the intervention process and making pedagogically sound decisions.

From a pedagogical perspective, developing children's conscious attitude toward their own speech activity is particularly important. Visual and auditory feedback provided by computer programs promotes the development of self-monitoring and self-correction skills, which are essential for the sustainable development of speech skills. Children not only reproduce speech patterns but also begin to meaningfully analyze their own pronunciation, which aligns with modern concepts of activity-based and student-centered learning.

The study showed that the inclusion of tasks for recognizing and analyzing non-speech sounds has a positive impact on the development of auditory attention and auditory differentiation. This component of remedial work is considered a fundamental stage in the development of phonemic awareness and, therefore, a prerequisite for successful speech development. The use of computer programs allows this stage to be implemented in a structured, visual, and methodologically verified manner.

An important conclusion is the confirmation of the high motivational value of digital technologies in special education. The interactive nature of computer programs, the ability to monitor one's own progress, and receive immediate feedback contribute to the development of

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positive attitudes in children and increase their engagement in the educational process. This is especially significant when working with primary school-aged children, for whom emotional engagement is a key factor in successful learning.

The data obtained also highlight the socio-pedagogical significance of speech analysis software in inclusive education settings. Improving the quality of verbal communication promotes children's more active participation in learning interactions, reduces communication barriers, and expands opportunities for social integration. Thus, digital technologies serve not only as a means of correction but also as a tool for supporting an inclusive educational environment.

The need to develop and implement nationally oriented software solutions that take into account the phonetic and phonological characteristics of students' native languages   deserves special attention. The use of such programs improves the accuracy of speech analysis and ensures culturally and linguistically appropriate interventions, which is essential for improving the quality of education for children with special educational needs.

Overall, the study's results confirm the feasibility and pedagogical validity of the widespread implementation of computer programs for speech recognition, analysis, and enhancement in special and inclusive education. Prospects for further research include expanding the empirical base, studying the long-term effects of digital technologies, and developing methodological recommendations for their integration into various educational contexts.

Discussion

It's appropriate to begin the discussion of the study's results with an analysis of the pedagogical significance of the positive changes identified in children's speech development using computerized speech recognition and analysis programs. The findings confirm the tenet of modern special education that the effectiveness of remedial and developmental education is largely determined by the ability to accurately diagnose speech difficulties and provide timely feedback. Unlike traditional speech therapy methods, which rely primarily on subjective expert assessment, digital technologies provide an objective view of the speech analysis process, enhancing the scientific validity of pedagogical decisions.

The study's results are consistent with the findings of international and domestic authors emphasizing the role of information and communication technologies in the development of auditory-speech skills in children with special educational needs. Studies devoted to digital speech therapy and computer-assisted speech correction note that visualizing the acoustic characteristics of speech helps children develop a conscious attitude toward their own pronunciation and activates self-regulation mechanisms for speech activity. The data obtained in this study confirm this position, as children using computer programs demonstrated increased independence and decreased dependence on ongoing teacher assistance.

From a pedagogical perspective, the impact of computer programs on the development of auditory perception is of particular interest. The results show that systematic work with non-speech sounds and acoustic stimuli, implemented in a digital format, promotes deeper development of auditory differentiation. This is consistent with scientific concepts regarding the stage-by-stage development of speech perception, according to which mastering non-speech acoustic characteristics is the foundation for the development of phonemic awareness and

subsequent speech acquisition. Thus, the use of computer programs allows this principle to be implemented in a visual and accessible form for children.

The results also have important implications for the theory and practice of inclusive education. Improving speech intelligibility and increasing children's confidence in their own communication skills create conditions for their more active participation in the educational process and social interaction. This supports the idea that digital technologies can be viewed not only as a correction tool but also as a means of social integration for children with speech impairments. In inclusive classrooms, such programs allow for the development of individualized educational pathways without isolating the child from the general educational environment. [1, 2, 5]

It's important to emphasize that the pedagogical effectiveness of computer programs is largely determined by the context of their use. The study's results showed that the greatest impact is achieved when digital tools are integrated into traditional remedial classes, rather than when used independently. This is consistent with the researchers' position, who view information technology as an auxiliary tool that enhances pedagogical impact but does not replace professional work. Therefore, a pedagogically appropriate combination of digital and traditional teaching methods is key to success.

The issue of the national and linguistic focus of speech analysis software deserves separate discussion. Several studies point to the limitations of universal foreign programs that fail to take into account the phonetic and phonological characteristics of a particular language. In the context of this study, this point is particularly relevant, as accurate speech analysis and correction are only possible using reference models that correspond to the norms of the child's native language. Consequently, the development and implementation of nationally oriented programs is an important prerequisite for improving the quality of correctional and developmental work and implementing the principles of culturally and linguistically sensitive education.

Thus, a discussion of the study's results allows us to conclude that computer speech recognition and analysis programs offer significant pedagogical potential, manifested in the development of auditory and verbal skills, increased motivation for learning, and expanded opportunities for inclusive education. The findings support the need for further scientific understanding and practical implementation of digital technologies in special education, taking into account the linguistic, age, and individual characteristics of students.

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