INNOVATIVE TECHNOLOGIES AS A MEANS OF OVERCOMING SPEECH DISORDERS IN PRESCHOOL CHILDREN

[a]ILONA DYCHKIVSKA, [b]NATALIIA RUDENKO, [c]OLEKSII YURCHUK, [d] TETIANA PAVLIUK, [e]NATALIYA FEDOROVA

[a]*Rivne State University of Humanities, Rivne, Ukraine. St. Bandery St., 12, Ukraine .*
[b]*Rivne State University of Humanities, Rivne, Ukraine. St. Bandery St., 12, Ukraine.*
[c]*Rivne State University of Humanities, Rivne, Ukraine. St. Bandery St., 12, Ukraine.*
[d]*Rivne State University of Humanities, Rivne, Ukraine. St. Bandery St., 12, Ukraine.*
[e]*Rivne State University of Humanities, Rivne, Ukraine. St. Bandery St., 12, Ukraine.*
E-mail: [a]*econometricsciences@meta.ua,*
[b]*Public.article@online.ua,* [c]*psychologyofarticle@meta.ua,*
[d]*StateArticle@online.ua,* [e]*StateArticle@online.ua*

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Abstract: The purpose of the present research is to evaluate innovative technologies in overcoming speech disorders in preschool children through the practice of using a mobile application as a tool for correcting speech defects. The research methodology is based on the concept of visual and phonological deficits in children with speech disorders. Individual and adaptive integrated approaches to reading and teaching children with speech disorders have been used. Corrective therapy has been conducted with application of interactive technologies in order to improve reading skills and perception of the material through better recognition. Meister Cody-Namagi - an adaptive multicomponent reading program, based on digital games, has been used in the research. The results demonstrate the difficulty in developing reading.

Keywords: children's speech disorder (disturbance), correction and therapy of speech disorders, digital environment of correction of disorders, innovative technologies of speech correction.

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1 Introduction

The health care and rehabilitation system requires the use of innovative technologies because of such problems, as: disability, aging, population growth, including children with various types of disorders that need correction. Despite the achievements of medicine in the sphere of the development of technologies for diagnosis and correction of defects in order to reduce the burden on medical staff and rehabilitologists, there is a shortage of language rehabilitologists who provide assistance to people with disabilities. The use of telemedicine technologies has partially solved this problem over the last ten years (Mashima & Doarn, 2008).

Innovative technologies are playing an increasingly important role in the development of new means of communication and language correction, especially for children with speech disturbances and disorders. Technological solutions provide a more effective organization of correctional work with children, ensuring the formation of new visual approaches and the use of alternative communication in order to improve everyday communication and integration of children into the society (Shane et al., 2012).

The integration of technologies into the correctional work of the teacher contributes to the formation of a new era of linguistic pathology, which will provide innovation and diversification of tools in the practical activities of the rehabilitation therapist. E-therapy resources and devices are increasing rapidly; consequently, they are making the therapeutic process more flexible and fun for children (Theodoros, 2012). Mobile applications as an element of e-therapy, a component of the mHealth concept and correction are increasingly used by teachers in their work with children with speech disorders. The basic problems faced by health care professionals include the lack of full knowledge of high-quality programs and technologies that provide the highest level of therapeutic benefit and effect. The dynamic growth of mHealth necessitates the development of effective systems for evaluating programs and their therapeutic benefits (Furlong et al., 2018).

The purpose of the present research is to evaluate innovative technologies in overcoming speech disorders in preschool children through the practice of using a mobile application as a tool for correcting speech defects.

2 Literature Review

The potential and effectiveness of technologies used in various strategies for the treatment and correction of children with speech disorders are actively discussed in the scientific literature. The following technologies should be highlighted, namely: Internet communities, robotics, assistive devices, interactive metronomes, automated instructions, video modeling, DVD instructions, and video instructions, biological probing, virtual reality, voice output devices, telecommunications, computer games, machine learning and algorithms for diagnosing children's speech disorders (Bölte et al., 2010). In the work of Chui et al. (2017), the issue of disease diagnosis through the tools of the intelligent health care system has been considered. Chui et al. (2017) identify new typical optimization algorithms and machine learning algorithms for the diagnosis of speech disorders (evolutionary, stochastic and combinatorial optimization) (2017).

The World Association of Speech Therapists (The World Association of Speech Therapists (WASLP), 2020) defines speech therapy as a science that develops prevention, supervision, diagnosis and rehabilitation of voice problems in conversation and writing based on a balance of theory and practice. The main goal is the rehabilitation of language disorders and communication process, development of tools of communication and interaction. Speech and language therapist diagnoses, prevents, evaluates, treats and studies speech and communication disorders (comprehension processes, expression of spoken and written language, nonverbal communication). Speech and language therapy of developed countries has been using information and communication technologies (ICT) for over 30 years in the diagnosis and treatment of children with speech disorders (Knight et al., 2013). In the early 1990s, therapists and speech therapists used innovations in order to create their own computer programs based on the specifics of the language. Virtual reality is one of the basic innovative technologies, which have begun to develop since the 1990s, including for improving the quality of life of people with speech impairments (Wainer & Ingersoll, 2011). "Use of Augmentative and alternative communication (AAC) technology has been shown to enhance the highest quality of life (QOL) for children as young as 32 months, … 3,4 children with autism spectrum disorder… The evidence base indicates that the life experience of people who use AAC is determined by their ability to achieve the highest performance communication possible" (Hill, 2010).

The development of the Internet has led to the emergence of speech therapy platforms. Jatkowska (2020) studies the improvement of articulation of children with speech disorders based on technology in the practice of speech and language therapy. The conducted pedagogical experiment testifies to the effectiveness of such practice in speech therapy for children (Jatkowska, 2020). Along with this, Newbutt, Sung, Kuo & Leahy (Newbutt et al., 2017) highlight the following challenges of technology, namely: immersion, escape from reality, environmental soundness and ethics of technology use, transfer of technology from laboratories to the real context. Knight, McKissick & Saunders (Knight et al., 2013), based on the analysis of studies on the practice of using technology in the work of speech disorders for 1993-2012, pay attention to caution in the use of technology in the practice of rehabilitation therapists because of low quality of experimental researches on efficiency of this component of therapy. Ploog, Scharf, Nelson & Brooks (Ploog et al., 2013) draw similar conclusions based on the analysis of multimedia computer technologies as a tool for the treatment of speech disorders and communicative, linguistic, social development.

Consumers of technologies and programs for the correction of speech disorders face the problem of finding high-quality products in speech and language therapy for children. Furlong, Morris, Serry & Erickson (2018) have evaluated the quality of 5000 programs and found that only 3% of products meet the quality evaluation criteria. The main disadvantages are as follows: (i) the unavailability of logical operators and the ability to use only one search term when using the program; (ii) constant change of the order of applications' lists in the online store; (iii) software products in the online store are placed according to popularity, not efficiency; (iv) high cost and unavailability of the program with low therapeutic quality (Furlong et al., 2018).

Speech impairment commonly occurs in children with hearing and speech impairments, autism (Bölte et al., 2010) and Parkinson's disease (Ramig et al., 2007). This disorder requires a large amount of practice and speech therapy, different approaches to therapy (medical, surgical, behavioral). "The common perceptual features of reduced loudness (hypophonia), reduced pitch variation (monotone), breathy and hoarse voice quality and imprecise articulation, together with lessened facial expression (masked facies), contribute to limitations in communication in the vast majority of these individuals" (Ramig et al., 2007). As a result, the pressure on speech therapists and rehabilitation specialists increases and requires the use of tools that will simplify the treatment process. Involving children in the therapeutic process increases the stress and the need for additional rehabilitation tools. Consequently, games are often used in practice; they give an impetus to children's correction during the game. Automation of the game process of correction is one of the effective innovative tools of the therapist. In the study of Nasiri, Shirmohammadi & Rashed (2017), a serious game has been developed and practically implemented, in which children can learn to speak specific words that they, according to the expectations of speech therapists, should know by the age of 7. The game contains an avatar controlled by a child using a language that moves in the game environment, for which the user is credited with coins. The constant reward, integrated into the world of fantasy games, seems to be the most attractive for children with special learning needs (Ke & Abras, 2013). An avatar is controlled by voice commands (Go, Back, Forward, Right, Left). The game reduces the level of involvement of the therapist or a teacher through a series of automated actions. The practice of using the game indicates an increase in the amount of time for correcting speech disorders, compared with the clinical approach; it is more effective due to the limited time of a speech and language specialist, a therapist (Nasiri et al., 2017).

Selouani, Sidi Yakoub & O'Shaughnessy (2009) have proposed speech support systems in the correction of French-speaking and English-speaking people with various speech disorders. The proposed supplementary systems are based on automatic speech recognition (ASR) and speech synthesis in order to improve the quality of communication. The systems are aimed at improving the intelligibility of pathological speech, providing maximum naturalness and closeness to the original voice of the person. New basic units, a new binding algorithm and grafting technique is used in the statements in order to correct feebly-marked phonemes. ASR responses are pronounced by applying a new speech synthesis system to convey a clear message to listeners. In order to confirm the effectiveness of this method, experiments have been performed with four American speakers with severe dysarthria and two Acadian French speakers with speech sound disorders (SSD). The experiment proves 5% improvement in Perceptual Speech Quality Score (PESQ); more than 20% improvement is achieved thanks to speech synthesis systems that deal with SSD and dysarthria (Selouani et al., 2009).

3 Methodology

The concepts of visual and phonological deficits in children with speech disorders have been used in the present academic paper. The concept of visual deficit explains the emergence of dyslexia with impaired visual synthesis and analysis, difficulties in spatial and visual perception and reduced efficiency and visual attention. The concept of phonological deficit explains disturbance of speech as a consequence of oral speech disorders. Within the framework of this concept, in dyslexia, the difficulties of separating words into sounds are distinguished. Dyslexia is also studied as an oral speech and visual deficit, due to which reading impairments occur as a result of imperfect processes of words' formation in row and speech formation in row. Along with this, the psychological component of the reading structure is often omitted in the scientific literature. In this case, Esposito, Esposito, Likforman-Sulem, Maldonato & Vinciarelli (Esposito et al., 2016) prove the influence of cognitive and psychomotor functions on speech disorders. For instance, the process of diagnosing speech disorders is selective; it takes into account certain components of speech disorders, which leads to gaps in the correction of writing and spoken language defects. Therefore, a comprehensive approach to the correction and treatment of children with speech disorders has been used in the present academic paper forasmuch as it takes into account not only the external manifestations of such disorders, but also the psychological and physiological characteristics of the child. Technologies are used as a tool of methodology for diagnosing and correcting disorders. Previous investigations on the effectiveness of interventions in the education of children with special needs, based on technology, emphasize that approaches to reading should be individual and adaptive (Jamshidifarsani et al., 2019; Perelmutter et al., 2017). This can be achieved by applying advanced technologies, such as smartphones and tablets, which have so far been largely neglected (Jamshidifarsani et al., 2019). According to Sweetser and Wyeth's proposed GameFlow model, engaging reading approaches for children with speech impairments should contain challenges, rewards, and visible signs of progress that need to be integrated, but not simply added to learning content (Jamshidifarsani et al., 2019).

Psycholinguistic approach takes into account the study of dyslexia in children, their physiological, neuropsychological, psycholinguistic features. This approach considers the structure of reading both in terms of the physiology of disorders (analysis system, nerve conduction pathways responsible for reading of the cerebral cortex area) and the psychology of disorders (psychological functions and operations). Psycholinguistic approach is the basis of a new technology for the correction of speech disorders in children and diagnoses the deep mechanism of disorders. The reading structure based on this approach has been used as a method of diagnosis and correction of disorders in the present research (Figure 1).

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                        │               The structure of reading                  │
                        └─────────────────────────────────────────────────────────┘
          ┌──────────────────────────────────────────┐       ┌──────────────────────────────┐
          │ Correct identification of graphic units  │       │    Reading comprehension     │
          │            (letter, word)                │       │                              │
          └──────────────────────────────────────────┘       └──────────────────────────────┘
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| Visual analyzer | Speech-motor analyzer | Auditory analyzer | Lexical and grammatical structure of oral speech | Mental activity. Psychomotor and cognitive functions |

| Visual functions and operations (attention, perception, control, memory) based on the subject, abstract-logical material | Phonetic side of speech | Auditory functions and operations (attention, perception, control, memory) |

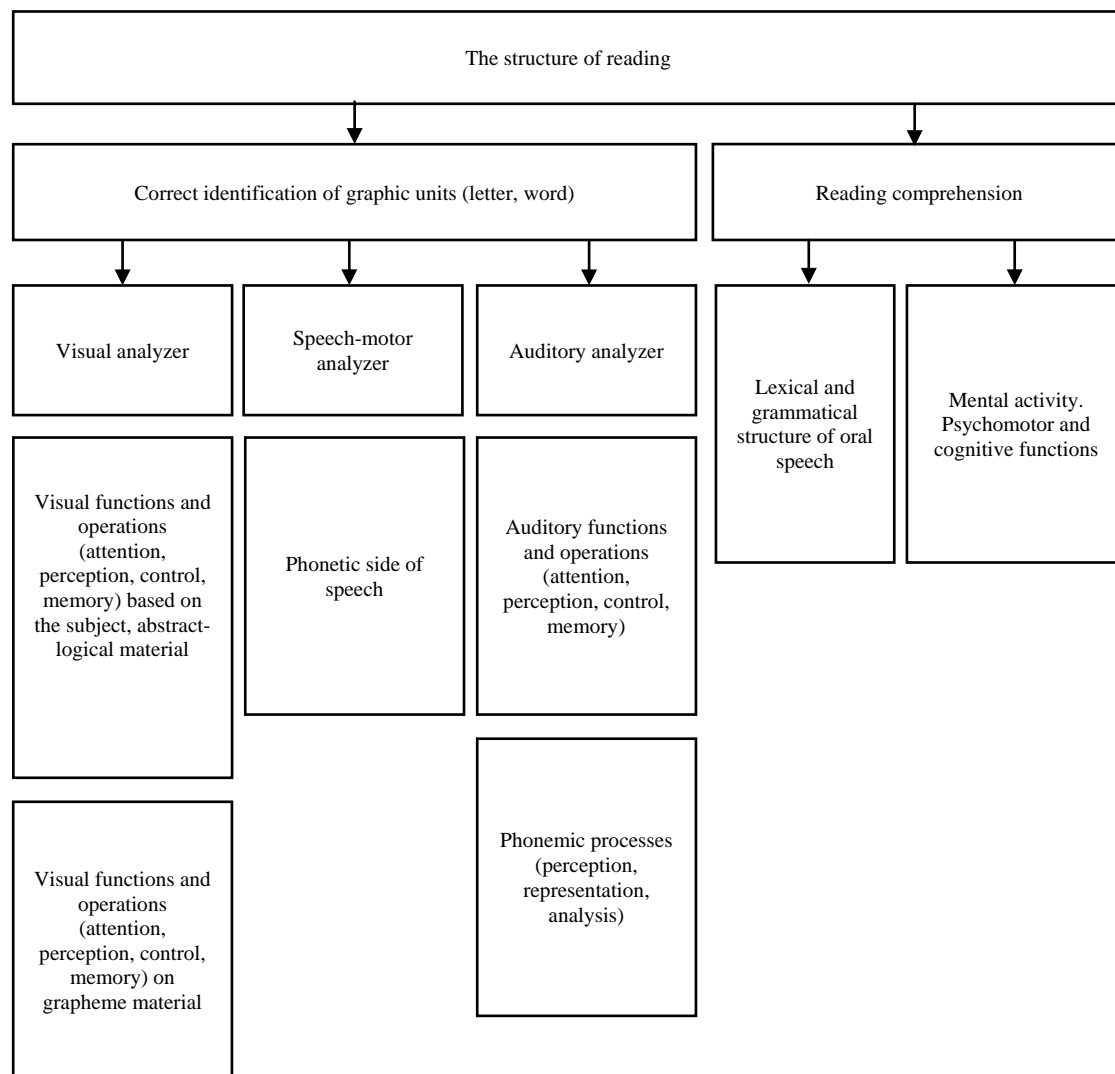| Visual functions and operations (attention, perception, control, memory) on grapheme material | | Phonemic processes (perception, representation, analysis) |

Figure 1. Psycholinguistic structure of reading
Source: compiled by the author.

Based on the proposed structure, an algorithm for identifying the mechanisms of dyslexic errors in children with speech disorders has been developed, namely:

1. Identification of errors, their amount, features of manifestation under different reading conditions.
2. Analysis of the detected errors according to the classification in the scientific literature.
3. Identification of different types of errors, the state of direct and inverse links.
4. Identification of the state of oral speech, taking into account the structure of defects in severe speech disorders, which are characterized by different levels of underlying pathology (primary disorder).
5. Analysis and investigation of features of analyzer systems' functioning which take part in reading through determining development of functions and operations of revealing.
6. Analysis of the status of the way of thinking.
7. Determining the level of correlation of dyslexic errors with the development of oral speech when comparing the specific manifestations of errors in reading and speaking.
8. Determining the level of correlation of dyslexic errors with the implementation of functions and operations of analyzer systems that provide reading processes based on the analysis of errors at different stages of the psychological structure of diagnostic tasks and comparison of the results obtained.

9. Identification of the complex structure of deviations as a mechanism of reading disorders in children with speech disorders.

Diagnosis of dyslexic errors and correction of speech disorders has been conducted based on methods of monitoring the learning process of children of 2-4 grades with various speech pathologies (dysarthria, alalia, rhinolalia, severe forms of stuttering). Children have been previously diagnosed with dyslexia, difficulties with reading skills. Quantitative and qualitative methods of statistical processing have been used to assess the effectiveness of correction by applying new therapy technology. Children have been divided into control (without speech and reading disorders) and experimental groups (with speech and reading disorders). The experiment was conducted at the boarding school №7 in Kyiv for children with speech disorders.

The object of research is the process of reading by junior students with severe speech disorders (SSD). The subject of the research is a methodical system of overcoming dyslexic errors in primary schoolchildren with SSD.

At the first stage of the research, children's speech disorders were studied, an experimental technique was formed, which included the identification of reading skills, reading errors, the nature of errors, stability and prevalence. Different reading conditions were used to identify a set of disorders, namely: with

the use of interactive technologies and without the use of interactive technologies. This affected the speed of reading, reading specially selected words in random and alphabetical order. The assessment of the quality of reading skills was carried out according to the criteria of awareness, correctness, speed, expressiveness, way of reading. At the second stage of the research, therapy was performed using interactive technologies in order to improve reading skills and perception of the material through better recognition. For this purpose, Meister Cody-Namagi program was used. It is an adaptive multicomponent digital game-based reading educational program developed by Meister Cody GmbH and the Dyslexia Research Group at the Department of Child and Adolescent Psychiatry, Psychosomatics and Psychotherapy, University Hospital LMU M, Germany. This software develops phonological awareness, phonemic and grapheme coherence and word reading skills in primary schoolchildren with speech impairments. The program consists of three different modules (phonological awareness, phonemic display and reading of words) with a total of 22 tasks. The first module (phonological awareness) focuses on exercises aimed at improving basic phonological skills (for instance, segmentation and counting of syllables, phoneme identification, mixing and segmentation of phonemes, and differentiation between long and short vowels). The second module aims to display phonemes-graphemes and grapheme-phonemes. The third module consists of exercises on reading accuracy (for example, lexical solutions and word building exercises), as well as reading speed (for example, semantic display of words and display of words - images for a limited time period).

The training consisted of 30 training sessions; herewith, each session consisted of three predefined exercises. In the first half of the training schedule, three exercises consisted of one exercise from each module (phonological awareness, phonemes-graphemes matching and word reading accuracy). The second half of the training schedule centered much more on word reading activities; therefore, each session consisted of one exercise of one or two modules and two exercises of a word reading module, including reading accuracy exercises and reading speed exercises.

4 Results

The study of speech disorders in children indicates an insufficient level of established children's reading skills on all criteria of reading, namely: speed, type and correctness, intonation and expressiveness, perception of the material. Children with speech disorders are characterized by insufficient awareness and perception of the material, recognition and identification of words and images. From among children, 20,4% have read correctly, 44,9% have read 43% of the material with errors, 34,7% have made 80% of mistakes or omissions while reading.

Children with speech disorders are characterized by a slow pace of reading, mostly syllables and words, low intonation and high monotony, making errors during reading (replacement of letters, words, not reading all the phrases or words, adding letters, permutation of letters, semantic errors). The most pronounced disorders are replacements, additions or omissions, characterized by a small level of reduction.

In the course of the experiment it has been revealed a high level of correlation between the quality of reading comprehension and the number of the above mentioned errors; as a result, insufficient level of awareness of the written message is a consequence of incorrect reading. Situations of inaccurate recognition of individual printed characters, which have been recorded during the research, prove the insufficient level of the formed representation and relationships between graphemes and phonemes due to impaired speech development. Such reading skills of children with speech disorders require the development of an integrated method of correction.

Insufficient level of formed visual and auditory operations of children with speech disorders and dyslexia is closely correlated

with errors of different types during reading in accordance with disturbances of the analyzer system. Specific errors in dyslexia correspond to specific speech disorders.

Deficiencies in the functioning of speech and motor analyzers in some situations and in the presence of concomitant disorders, for instance, insufficient level of auditory control and phonemic processes, leads to the appearance of specific errors, which account for 14% of total dyslexic errors. Disorders of the articulatory system affect and cause approximately 58% of systematic specific errors during reading (when children concentrate on the sounds that are automated at this time, blocking of the sensory effect on the sounds nearby occurs, which is a mechanism of simultaneous heterosensory comparison). From among children, 28% with speech disorders have no pronunciation deficiencies. The analyzed dyslexic errors can be divided into the following three groups, namely: 1) directly related to sound disorders (high correlation); 2) indirectly related (average correlation); 3) have no connection with the pronunciation (no correlation).

Replacement of graphically similar phonemes during reading is due to lack of attention, visual perception and memory, control. Different levels of development of visual functions should be taken into account in the diagnosis and correctional therapy of children. The mechanisms of errors have been the basis for the division of children into two groups: the first group is characterized by a reduction in the quality of the visual analyzer system when performing tasks with application of easy-to-understand material; for the second group, the insufficient level of development of visual functions and operations has been observed at a higher level of perception (on the grapheme material). When analyzing these types of errors with basic speech disorders and pronunciation of sounds, the presence of such a mechanism in children with severe stuttering and clear phonetic speech has been revealed.

Impairments of sound and syllable analysis cause the replacement of acoustic-articulatory similar phonemes with the correct pronunciation at the time of the experiment. Additions or omissions in reading occur due to impaired sound and syllable analysis, reduced visual attention, control and memory to the provided grapheme material, which may be accompanied by reduced hearing control. Severe forms of stuttering and dysarthria in children most often cause these types of errors.

The feature of the dyslexia mechanism was found in younger schoolchildren, whose primary speech disorders were sensorimotor and motor alalia. The phonetic side of the oral speech of these pupils was characterized by a significant number of errors (replacement and distortion of sounds). During reading of primary schoolchildren with SSD, substitutions of letters were observed, the sounds of which were similar in acoustic-articulation characteristics, and letters that were graphically similar. The results of the research showed the so-called dual mechanism of disorder. On the one hand, the low level of auditory functions and operations prevents the formation of a sufficient level of phonemic processes, which causes replacements on the basis of acoustic articulation. On the other hand, this mechanism is complicated by a significant reduction in visual functions and operations (on types of material of various complexity), which leads to errors in graphic similarity.
Studying the features of the manifestation of dyslexic disorders during the performance of special tasks by pupils, developed taking into account the complex nature and interaction of visual, speech and auditory analyzers, complex psychological structure and level organization of phonemic functions, has made it possible to establish that different types of dyslexic errors may be based on different mechanisms. It should be noted that the most illustrative tasks that have been selected for processing by statistical methods can be used in practice by speech and language therapists as an express method of diagnostics of studying the disturbance mechanisms. The research has confirmed that the nature of dyslexic errors (replacements, omissions, additions) is connected with the lack of different levels of visual functions, auditory functions and phonemic

processes, the reduction and features of which reveal the peculiarities of dyslexia in younger schoolchildren with SSD. The author's corrective technique has been developed on the basis of the differentiated mechanisms of dyslexic errors revealed in young schoolchildren with SSD.

Considering that some errors occur due to systemic impairment of auditory functions and operations in children, the method of correctional therapy is aimed at the formation of these functions and operations during the performance of specially designed tasks. The main feature of the work lay in the fact that the implementation of auditory functions and operations was a priority, and did not take place at the background level of therapy (as provided by traditional methods). Ensuring the formation of auditory functions is determined by the indicator of transition from the leading to the background level of training and correction. In cases of reduced level of vision as a fundamental disorder, correctional training has involved the implementation of tasks aimed at their development on a similar principle. The flexibility of the methodology was provided by the ability to start correction from the existing level of formation of the psychological structure's components of reading in each individual case.

Experimental and formative training contained three correctional stages (for each class). The content of the work on each stage was correlated with the gradual load (complication) and the relevant analyzers which were used as a leading support. The individual level of reading skills (according to the class) and the specific mechanism of dyslexia inherent in individual groups of pupils (each pupil) were taken into account). In case of difficulties, the teacher - speech therapist had the opportunity to repeat the task in subsequent lessons or individual lessons with the pupil, using other material aimed at developing those functions and operations that have not reached the required level. The content of the experimental methodology consisted of tasks that were divided into two directions, namely: the development of auditory functions and operations and visual functions and operations.

The first correctional stage involved performing tasks without reliance on the child's own speech as a prerequisite for the development of hearing and vision. The material consisting of letters and elements of letters was the main condition for the implementation of tasks for the development of auditory functions and operations and tasks for the development of functions and operations of vision. Corrective work was aimed at: hearing development - perception, attention, memory and control (at individual lessons, if possible, the speech therapist excluded words that contain sounds that are pronounced incorrectly by the child from the tasks); development of phonemic processes using the standard pronunciation of a speech therapist and software products (phonemic perception, analysis and synthesis); development of the general level of visual functions and operations on simple abstract logical pictorial material (perception, attention, memory, control); development of the highest level of visual functions and operations (perception, attention, memory, control) on the material of letters and their elements. At the second correctional stage (medium level of difficulty), the work was aimed at: the development of auditory functions and operations - perception, attention, memory, control (the material contained sounds that are pronounced incorrectly by the pupil); development of phonemic processes - perception (based on the reference pronunciation of the teacher), analysis and synthesis (based on the child's own pronunciation) and imagination; development of hierarchically higher level of visual functions and operations (perception, attention, memory, control) on the material of elements of words (syllables) and individual words with addition of reading aloud. At the third correctional stage (the highest level of complexity) work was carried out aimed at improving auditory functions and operations); improvement of phonemic processes - imagination, analysis and synthesis only by imagination (excluding auditory, articulatory analytical systems) and the development of visual functions and operations (perception, attention, memory,

control) on the material of phrases, sentences and passages from the text.

5 Discussion

In the course of the experiment, complications have been revealed in developing reading skills and differences between children, despite the positive effect of digital game. Children were characterized by different levels of success. In 52,8% of children, speech and reading correction provided the fastest results, no dyslexic errors were revealed. 33,3% of children were characterized by the success of correctional therapy, however, with the need to continue learning in a game-based environment. 13,9% of children with speech impairments, diagnosed with the need for correction of acoustic-articulatory disorders due to insufficient level of development of hearing functions, required the maximal time for learning. Similar graphic signs of the letter required more time to correct due to a decrease in the level of visual functions (perception, attention, memory). A particularly difficult task was to increase the level of these functions based on the graphic material.

Thus, the digital environment as a whole has significantly improved speech and reading disorders, however, 13,9% of children need to continue their training activities. Correction of dyslexic errors should begin with the tasks of visual and auditory perception. In this case, the game environment, which significantly improves the level of attention and perception, provides a high level of involvement and motivation.

The results of the experiment also confirm the effectiveness of an integrated approach and taking into account the psychological component for the correction of speech and reading disorders. The approach outlined ensures the consistency of the educational process and control of the learning process.

The results of the study correlate with the conclusions of German scientists concerning problems with children's reading skills: "around 4–8% of children do not master the challenge of learning to read adequately and are diagnosed with a reading disorder, typically characterized by deficits in reading accuracy, fluency and/or comprehension" (Görgen et al., 2020).

The main purpose of this research is to evaluate innovative technologies in overcoming speech disorders in preschool children through the practice of using a mobile application as a tool for correcting speech defects. Digital game-based training has significantly improved the reading skills of children with speech disorders.

The present research correlates with the conclusions of Ronimus et al. (2019), and the data confirm that children with reading disabilities receive a number of benefits and advantages from digital learning based on games. The results also show that training can be conducted independently at home. This is important because of the difficulty of refreshing reading skills in children with speech disorders (Galuschka et al., 2014; Ronimus et al., 2019). Our results confirm the effectiveness of a comprehensive approach to improving reading skills using digital games, which is also discussed in the study of Jamshidifarsani et al. (2019). Jamshidifarsani et al. (2019) use a holistic approach to reading; it combines various components identified as effective ones for improving reading skills through digital game-based learning. It is important that the training has ensured the success of learning, which has been confirmed experimentally with the help of a computerized test that displays images of words. This test shows an increase in the fluency of reading words by children with speech disorders. The effects of transfer to non-digital text materials can be partially confirmed. Although the skills of reading simple and short words did not differ significantly between the training and control group after training, skills of reading complex and long words improved significantly for children who use a digital game-based reading program compared to children in the control group. The difference between two groups of children can be explained by the fact that fluency in reading words for high-frequency short

words develops faster than fluency in reading for low-frequency words, which are less common (Berends & Reitsma, 2006). As a result, the influence of such simple and short words took place in both groups, regardless of training. Thus, it should be assumed that reading of simple words was already relatively free to learn, while there were more opportunities for improvement for complex and long words (Heikkila et al., 2013). Significant improvement in reading complex words is especially important, given that children with reading disabilities process complex language units less efficiently (Spinelli et al., 2005); consequently, such complex language units are more difficult to learn to read.

This research correlates with the results of Görgen, Huemer, Schulte-Körne, & Moll (2020) on the potential to support reading skills in children with speech disorders through technological tools. Digital game trainings are useful for children with special educational needs, which provide improved productivity of reading verbal material and transferring effects to previously untrained words. Digital games motivate children to do their homework, and the use of a multi-component approach together with the flow principle is the most effective. The use of advanced technological tools in a therapeutic or educational context is also known as edutainment, learning, based on digital games or serious games (Ramig et al., 2007), which means the integration of motivational game features for educational purposes. Digital games increase the level of attention, concentration, motivation and involvement of children in learning.

6 Conclusion

Despite the positive effect of digital game, the difficulty in developing reading skills and the differences between children has been proved in the study. It has been determined that the digital environment as a whole has provided a significant improvement in speech and reading disorders, however, 13,9% of children need to continue their training. The game environment significantly improves the level of attention and perception; it provides a high level of involvement and motivation. The results of the experiment also confirm the effectiveness of an integrated approach and taking into account the psychological component for the correction of speech and reading disorders. Such approach ensures the consistency of the educational process and control of the learning process. Digital game-based training has significantly improved the reading skills of children with speech disorders. Children with reading disabilities receive a number of benefits and advantages from digital learning based on games. The digital learning environment can be organized independently at home, which is important because of the difficulty of refreshing reading skills in children with speech disorders. The results confirm the effectiveness of an integrated approach to improving reading skills using digital games. A holistic approach to reading combines different components identified as effective for improving reading skills through digital game-based learning. Such approach ensured the success of training, which was confirmed experimentally with the help of a computerized test.

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Primary Paper Section: A

Secondary Paper Section: AN