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VR in the treatment of dyslexia. Examples of applications and their possibilities

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The aim set by the authors of the text is to present examples of VR software, the possibilities of which enable the implementation of therapy through exercises in interactive forms. The first part of the text will present the current results of research on the use of educational technologies in preschool and early childhood education. The state and scope of teachers' use of software dedicated to the problems of dyslexic children will emerge from this area. In turn the features of the software intended for the treatment of dyslexic children will be discussed and examples of VR programs will be presented.

Educational technologies in preschool and early childhood education - research review

„Today's preschool children, unlike previous generations, are capable of handling increasingly complex Technologies". Educational technologies are understood here as, inter alia, technical equipment plus information and communication technology tools in teaching and learning (in educational process). When addressing the issue of the possibilities of using VR in preschool and early school education, it is worth taking a look at the state of equipment in kindergartens and the educational technology tools used by teachers. Research in this area was carried out in 2021 by Natalia Worach under the scientific guidance of Dorota Siemieniecka as part of her master's thesis entitled Rola multimediów w procesie edukacji małego dziecka w praktyce nauczycieli edukacji przedszkolnej (The role of multimedia in the process of educating a young child in the practice of preschool education teachers). The issues of the research carried out concerned what equipment and what multimedia resources were used by preschool education teachers, whether this software has an impact on the activation of the child in the learning process, and whether it affects educational effectiveness. The research used a questionnaire and included 59 teachers from all over Poland. The most numerous groups among the respondents were people aged 23-28, who accounted for 47% (28). 95% of the respondents use multimedia in teaching (56), only 5% of the respondents do not use them at work (3). The most

frequently used tools by teachers include: an audio player (54 people representing 96% of the group under research), a multimedia board (36 people representing 64% of the group), a multimedia computer enabling multimedia presentations (36 people representing 64% of the group), and a multimedia projector (26 people, 46% of the group), and projection screen (13 people, 23% of the group). Teachers use interactive floors / interactive rooms (10 people -18% of the group), robots (8 people - 14%), interactive toys (3 people - 5% of the group), digital cameras (6 people -11%), karaoke sets (4 people-7%). Teachers rarely use interactive boards (1), a tablet (1), a magic carpet (1), a touch screen (1) and a telephone (1). Teachers do not use the interactive sandbox, 3D visualizers, kinect, or touch monitors (1). One person does not use any aids at all. In the teaching practice, research most often uses educational games and activities (e.g. developing auditory perception, logical thinking, vocabulary, perceptiveness, and problem solving) (17 often, 29 sometimes), multimedia didactic software (e.g. for learning letters, numbers) (20 sometimes), utility programmes enabling the presentation of multimedia materials (film, graphic collections) (16 often, 34 sometimes). 39 people sometimes use teaching and exercise programmes (helping to acquire or consolidate knowledge), and 29 sometimes use testing programmes (checking the level of knowledge). Most often, teachers do not use multimedia encyclopaedias (36), 20 respondents use them sometimes. They rarely use therapeutic multimedia programmes (e.g. in Poland, eduSensus software packages are available - "Logopedia Pro", "Spektrum Autyzmu Pro", "Supporting Development Pro"; Eduterapeutica- "Logopedia", "Dyslexia"; PWN- "Oxygenation, training correct pronunciation, name programs","Ear training ", headphones with a microphone, etc.). They also rarely (44) use educational software (e.g. „MozaWeb", „Talent", „Przedszkole Bolka i Lolka", „ABC z Reksiem", „Moje przedszkole-literki i plastyka"), teaching packages (42) and APS mobile applications (e.g. "Pszczoła- Edukacja Ekologiczna", "Bing: Oglądaj, baw się i ucz", „Gry edukacyjne dla dzieci 2-4", "IK: Gry edukacyjne dla dzieci", „Edukacja z Plecaka Przedszkolaka"). Most often (I use and I often use) teachers use didactic aids such as radio plays (51), presentations (51), and films (50). They also use quizzes (41) and games (39). Teachers believe that the use of multimedia significantly influences the effectiveness of education (64). They also consider the time used in the lesson to be more effective (48). While preparing for classes, teachers use YouTube (10), Wor-

dWall (5), and learningApps (3). Most often, Edtech tools are used in the first part of the day (10) or during the delivery of teaching activities (27). Teachers most often use the materials found on the Internet (46), they buy them themselves (28) or the school buys them (14). The fact that teachers most often use films and multimedia presentations in their work is confirmed by the results of nationwide research published in the report. Co zmieniło się w edukacji zdalnej podczas trwania pandemii (What has changed in distant education during the pandemic). Raport z badania marzec 2021 (Research report March 2021). Marlena Plebańska, Aleksandra Szyller, and Małgorzata Sieńczewska indicate that teachers "are still using videos (20.1%) and multimedia presentations (19%) most frequently. About 15.8% use online exercises, digital textbooks (15.7%) and interactive quizzes (12.9%). Less than 10% use mobile educational applications (7.9%), digital educational games (6.3%), or online experiments (2.4%)". The research conducted by Helena Marzec and Dorota Depczyńska shows that teachers prepare teaching materials on their own. In their teaching practice, they use 21 teaching charts (out of 33 respondents), worksheets (20), teaching games (18), textbooks (15), CDs with recordings and films (11), and encyclopaedias (8). 5 people prepare presentations for lessons. The technologization of educational institutions, devoid of reflection, may lead to what Zbigniew Łęski writes about, who believes that "by treating new media in the same way as teaching means present in teaching-learning so far, we doom ourselves to failure. It is necessary to adjust the concepts, curricula, and computer software used in teaching in such a way as to make from the relational nature of the human-computer contact a resource, and not - as is currently the case - a disturbing element". The point is that the tools of educational technology should help people achieve their intentions and activities. The essence of the teaching process is not only what tools teachers use, but also what activities children undertake, and whether the process is creative and enables problem-solving (computational thinking may be an example). Therefore, the theoretical proposal is complementary education as described by Maciej Tanaś and developed by Jakub J. Czarkowski. These authors pay attention to such an approach to educational technologies as enables the intentional complementation of real and digital reality. This applies to the cognition process, but also to the creation of content, curricula, and the organization of education. The research carried out by Jan Amos Jelinek describes the strategies and methods that children adop-

ted while learning during the course of working with the software. The author observed that computer programmes in their construction use teachers' strategies regarding educational goals, selection, and arrangement of tasks. They also have blockades that limit the intellectual effort of children. The author emphasizes that the effectiveness of computer programmes may be low. Among the elements essential for the process of effective work with the software, he mentions the structure of the programme, its framework (able students may get bored while completing tasks with a lower level of difficulty), while, e.g. children with a lower level of ability, in the case of tasks with too high difficulty level, may use their own learning strategies, e.g. based on escape („I leave the task because I can't do it"), they can solve problems that are too simple. Jelinek believes that it is important not only to use the programme, but also to test students while working and assess qualitatively their activities. Such assessment is usually not recorded by the programme, because the result is calculated on the basis of the number of completed tasks. The research carried out by this author concerned the use of a programme for teaching reading (the popular Polish program Klik Uczy Czytać (Klik Teaches to Read), also used in work with dyslexic children), 8-year-old children were covered. Students working with the software read only 160 words (735 phonemes) in 3 hours. However, the reading by a student of e. g. 400 words tells us nothing about the quality of his/her work. Jelinek writes that one word can be read over and over again. The research has shown that children who read a small number of words preferred tasks that required classifying letters, matching them into pairs and pointing to the correct letter (so-called preparatory tasks). Students with poor reading levels browsed the programme content and chose the easiest exercises. The research has shown a difference in the number of phonemes read by children when working with a computer programme. In the case of working with a computer, it was 735, while when using the educational package and books - 84,800. It is, therefore, important to pay attention to the content and forms of communication as well as the results of students' activities that require the application of the acquired knowledge. Educational technology tools such as VR are used to train cognitive skills, remembering, and the understanding of information. Katarzyna Mikołajczyk lists the areas that develop contact with software, which are: spatial and visual knowledge, psycho-motor skills, and the memory of objects. In the case of computer-based dyslexia therapy, it is

recommended to combine the child's natural curiosity with therapeutic measures by (e.g. in the case of visual perception) using puzzles, mosaics, searching for details in pictures, and recreating patterns (e.g. coloring book combined with letters and shapes recognition). The child's agency is important, as is his/her independence in performing the task while interacting with the software. However, it should be remembered that the role of therapist in a work with computer program and selection of software and its value belongs to the therapist.

The concept and definition of dyslexia

According to the definition, dyslexia is „specific difficulties in learning to read, write, and count, with at least parallel average intellectual abilities, which persist despite the use of the same educational and therapeutic methods, and growing up in comparable environmental conditions as other children". In the Polish literature on the subject, it is assumed that dyslexia is the most frequently reported cognitive development disorder in children. It is estimated that this problem affects 3% to 8% of children. Some diagnosticians even estimate that this value may even reach 12% (of all students in Polish schools), and four children out of a hundred are difficult cases. However, this problem concerns students, teachers, and therapists around the world. „Studies show that the number of dyslexic students is increasing, as it does the need of the appropriate learning techniques and methodologies increases as well. For the students with learning disability, generally and the dyslexic students specifically there aren't enough technologies that helps them in the learning process" .

Dyslexia includes problems of the visual, auditory, or mixed type. „The challenge that students with dyslexia face is that they find difficulties in processing and remembering information, so they need extra effort and time to learn". Additionally, as emphasized in specialist literature „children with dyslexia may exhibit deficits in both accuracy and speed during reading tasks. Usually, if a child reads slowly, he can make fewer mistakes. Besides, children with dyslexia may show poor phonological skills. Initially, this deficit may involve the pronunciation of words. Different expressions of phonological difficulty depend on different kinds of orthographies (consistent or less consistent orthographies)".

In Polish scientific literature, Marta Bogdanowicz has been preoccupied with dyslexia for many years. Among many approaches, she presents the

pedagogical understanding of the concept of specific difficulties in learning to read and write by combining them with special educational needs. In the literature, comparative approaches to the description of theories explaining the genesis of dyslexia can be found in the publications by the above-mentioned author and by Mateusz Rusiniak and Monika Lewandowska.

Specific difficulties in learning to read and write and the tools of educational technologies

The conducted research shows that the tools of educational technology prove themselves to be perfectly for therapeutic work, including that related to dyslexia. They help to present a problem in an interesting and valuable way. They enable the generation of various tasks on a selected topic in a short time, taking into account the skills and dysfunctions of the student. The research carried out by Kamila Majewska in 2020-2021, on a group of 570 students from the level of early childhood education, showed that children, having a choice of traditional, interactive classes with a multimedia board and tablets, as well as interactive lessons with VR goggles, choose the latter. The basis of the indication is:

- the nature of the materials that are highly interactive and make self-exploration possible. Students, even if instructed on what to pay attention to at a given moment, do it individually. They turn their head to the right, left, up, or down, in accordance with their own needs. It is mainly their interest that determines the time spent on analysing a given fragment of the presentation. The importance that cognitive processes are individualized and that each child attaches attention to other elements is evidenced by, for example, spontaneous comments in which students suggest what else is worth seeing, at the same time paying attention to various things,
- emotions accompanying the cognitive process, high-quality resources: graphics, sound, image and motion integrity, and the ability to manipulate various objects,
- the authenticity of the message, giving the impression that one is in the described place and that one has real contact with the object of cognition. Putting on the goggles creates a very credible illusion of immediate transfer to another reality".

Consequently, in working with children some therapists recommend the use of new technologies as tools accepted by children, as well as meeting the technical requirements of the designed exercises.

The literature pays attention to the areas that are important for the construction of multimedia and interactive material. Elisa Pedroli, Patrizia Padula, Andrea Guala, Maria Teresa Meardi, Giuseppe Riva and Giovanni Albani emphasize „The standard rehabilitation methods all use a classic paper and pencil training format but these exercises are boring and demanding for children who may have difficulty in completing the treatments. It is important to develop a new rehabilitation program that would help children in a funny and engaging way". Ewa Nowicka emphasizes that these programmes should be characterized by a wealth of exercises aimed at psychomotor disorders, should affect the emotional and motivational sphere, stimulate cognitive activity, interests, and activate the child. It is important that the software will make it possible for the therapist to carry out the corrective and compensatory work. The author emphasizes the importance of the poly sensor and interactive nature of the software and its possible applications at every stage of therapeutic activities. Nowicka writes about the trait described as "interactive dialogue" with the programme. The multimedial and interactive form of the exercises should consist of the same sets of exercises as are used in traditional therapy, as it is about achieving the assumed goals and the substantive value of the exercises (covering reading difficulties and forming reading and writing skills). The software should be graded in difficulty. It is important that the task makes the stimulation of visual-auditory perception possible. Interesting recommendations regarding the design of ICT tools (Information and Communication Technologies) in teaching a 3 to 6 years- old child were formulated by Michał Klichowski, Jacek Pyżalski, Kinga Kuszak, and Anna Klichowska. It should be noted that materials containing verbal messages should be linguistically correct and enable the activation of speech. The authors emphasize the importance of the linguistic function and the learning process. These materials should be based on simple vocabulary familiar to the child. However, it is emphasized that it is also important that information and communication technologies make it possible for the child to learn new vocabulary, and therefore, simple questions or verbal guesswork should be used. In terms of physical development, the child's activity with the tools should be as short as possible, it should be carried out taking into account the principles of safe computer work (the point is that the child should not remain in one body position for a longer period). Issues related to the threats posed by educational technologies are raised by

Natalia Bednarska, who draws attention to the noise generated by devices surrounding children (e.g. noise recordings), which may lead to disturbances in phonological processing. She also cites studies that show that the constant watching by children of TV broadcasts (10-15 hours a day) may result in problems with representing mental objects.

Among the recommendations regarding the use of educational technologies, M. Klichowski et.al. mentions fine motor stimulation, which consists in limiting complex and precise movements. These tools should „stimulate praxia by building activity that requires the planning of movement procedures". The exercises developed with the use of educational technologies „should enable frequent changes of movement (hand, finger, and/or hand position)". Expanding the child's environment through the tools of educational technology can stimulate perception, but in the literature we find indications that the child's work with the electronic medium should not exceed 30 minutes. Prolonged contact with the tools of the educational technology by a four-year-old child may weaken the processes of visual perception and reduce attention.

In the area of social development, it is propounded that the teacher should use educational technologies in order to create the possibility for the child to work independently in a group, focused on individual goals and cooperation without competition. EdTech tools "should give the adult the possibility of anticipatory interference in the child's activity - creating, transforming, and (physically and emotionally) securing this activity. The tools should be an element of the entire set of tools for the systematic development of pro-ecological attitudes, both in the sense of providing knowledge about the environment and transmitting positive values, e.g. related to nature protection, but also in the context of activating the child to act in and for the benefit of the environment. They should be constructed in such a way that various types of rewards are an element of the entire activity process, not only the result of its completion. They should be constructed in such a way as to enable the processing of emotions - the child should be able to try to understand the causes, dynamics, and meaning of experienced feelings (felt in oneself and observed in others, also in the characters of a given media message), and not only their registration (e.g. joy or sadness)" . Bronisław Siemieniecki lists the following principles that should be taken into account when designing applications intended for dyslexia therapy, which are: the principle of visua-

lization and multimedia (referring to multi-channel and multi-sensory interaction), the principle of diversity, the principle of evaluation, the principle of spatiality (the programme should enable its user to create spatial visual and auditory imagery), the principle of topicality (consisting in adapting the software to the individual needs of the recipient and creating new solutions), and the principle of ludicity (learning through play, involving the emotional, motivational, and mental sphere - enabling intellectual engagement). It is important to integrate visual and auditory stimuli that develop spatial orientation and memory. However, one should remember to take into account the child's individual perceptions and his/her developmental age. Iconic representation „causes rich associations, reaches into deeper structures of knowledge (...) visual images are richer with more differentiated features". Educational technologies make possible the individualization of the education process, learning at any time and place, and the individualization of the pace of learning. The teacher can choose the materials to suit the students' abilities (level of knowledge) and their learning styles. The software, expanded with expert systems, enables one to control learning outcomes and monitor educational progress. The literature also pays attention to an extremely important aspect of development, namely the children's ability to communicate. Computer systems can support communication and speech development, which is crucial for the social and intellectual development of children (especially those with intellectual disabilities of neurological origin). One can agree with the statement that „an important, if not the most important, goal of using educational technologies in rehabilitation and treatment is the optimization of man's psychophysical well-being and regaining the possibility of the best social functioning". Interesting research was carried out by Krzysztof Krejtz and colleagues, which indicates a decrease in cognitive involvement when reading a hypertext, which is explained by additional activities, such as: navigation and structuring of the processed information. Other studies have shown that reading from the iPod screen (2-3 words per line) improves the reading performance of adolescents with visual attention disorders (present in dyslexic problems). The traditional form of text is more effective for adolescents who do not have those disorders. Maciej Tanaś in his publications mentions other features of educational technologies: simulation and virtualization. Selected applications that can be used in working with dyslexic children are presented below.

Selected applications adapted to work with VR goggles

1) Type of problem: Indicating an item in noise (visual perception).

Sometimes children have a problem with pointing to an image or a sign in a graphic with many elements. The game can help one practice this skill is Knight Castle Hidden Objects VR. „Knight Castle Hidden Objects VR is a new hidden object adventure game that will take you to the times when knights went on secret quests and important missions. (…) This is a virtual reality game in which you're inside of a medieval castle with mystery rooms filled with hidden objects and user quest is to find them all! Hidden items are scattered all over the place".

An alternative application is Find Toma VR game, consisting in finding a hidden cat. The time to complete the task is 2 minutes. The authors of the program note that:

- You can use your smartphone or VR-glasses: 4DUD, Google cardboard VR, Samsung Gear VR, Carl Zeiss VR.
- Choose the mode: with glasses / no glasses.
- Focus on the red arrows to move around the apartment.
- Hovers over the doors, cabinet doors to open it.
- Keep track of time.
- Rotate and tilt the device to "No glasses" mode to see all around.
- Just turn his head in the right direction in the "With glasses" mode".

The therapist can also benefit from the game Oddbods Hot & Cold VR game.

Figure 1. Oddbods Hot & Cold VR game.

Source: https://play.google.com/store/apps/details?id=com.maysalward.oddbodsvr&hl=pl&gl=US.

The objective in each level is finding lost things, like as: umbrella, frying pan, clock... Items are presented on list (located on the upper part of your screen) in each room. The game has three levels. In each level the player has to find 3 to 7 objects within the time limit. User can choose, if he wants to play with time limit. Application can also prompt the user. Hot means user are getting closer to a hidden object. Cold means he are moving away from a hidden object.

The above applications make it possible to practise: perceptiveness, sear-

ching the field of view, efficiency of visual attention, and omitting irrelevant elements.

1. Type of problem: Difficulties in conceptual differentiation.

The above type of difficulty applies to children who cannot cope with the differentiating of colours, shapes, and sizes. Recommended tasks include activities of sorting out or pointing to items that meet specific conditions.

The aquatic environment is an interesting and recommendable environment for grouping. Application VR Ocean Aquarium 3D (HYGAMES).

Figure 2. VR Ocean Aquarium 3D.

Source: https://play.google.com/store/apps/details?id=com.sculfa.vroceanaquarium&hl=pl&gl=US.

Application allows explore a new world by diving into the deep ocean. User can learn the fish species and look them closely. When user approach a fish, the movement is slower so that you can closely examine the details. The student may work with very beautiful graphics and realistic ocean environment. He can observe 107 different types of fishes. This is an opportunity to search for the same species of fish and selecting the same units that differ in size or direction of movements.

2. Type of problem: Difficulty fixing a repetitive shape.

When discussing the problem of dyslexia, speech therapists often mention the problem related to the inability to repeat the shape of letters and numbers. In the context of this dysfunction, it is recommended to learn copying in terms of gross motor skills, drawing circles, lines, parallel lines, and mapping.

An interesting alternative to traditional exercises carried out on a piece of paper may be working with the application Graffiti Paint VR (TN. Interactive). Applicaton allow to spray graffiti in virtual reality. Features game:

- Color picker which lets user pick any color you want.
- Possibility choose the spray size.
- Possibility choose the spray radius.
- User can save and load earlier images.
- User can export images.

Gross motor skills can also be practised in a Star Wars setting using the application VR Wars that makes it possible to fight with a light sword.

3. Type of problem: Difficulty remembering the appearance of a sign, the

shape of a figure, and frequent checking when copying (visual memory).

Students with the above difficulties often fail in rewriting, redrawing, and repeating activities with the teacher. In this situation, therapists recommend the use of games aimed at repeating commands, playing the memorrha, puzzles, memory games - what was here and what has disappeared.

In the context of the above disturbance and the VR space, it is worth paying attention to the VR Puzzle application (PicoPlanet Developing).

Figure 3. VR Puzzle.

Source: https://play.google.com/store/apps/details?id=com.PicoPlanetDev.PuzzleVR&hl=en_US&gl=US.

In Puzzle VR, user can visually train their brain to remember all sorts of patterns. Puzzle are created, as 3 by 3 or 4 by 4 grid. When user is ready, application will briefly display a random and every time different - pattern to memorize. The task of the user is recreated the pattern by clicking on each of the tiles. User can easily change the difficulty of application (size and the amount of time allotted for you to memorize the pattern). He can also to pick a theme from a list. After solve the puzzle, on the screen can be seen result. User can regenerate the puzzle to play again.

The above exercises successfully diversify the traditional process of diagnostics and therapy.

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