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Reading Comprehension of Various Infographics in the Field of Nature by Young People with Hearing Impairment

Introduction: specific difficulties in textbooks reading comprehension of deaf students

The possibility of using written texts by deaf students, due to the visual code used during this cognitive activity, is a very important element of the effective learning process of this group. Reading comprehension has its place at the various stages of developing reading skills. The perception of graphic images is subordinated to the sense of the text being read. The unit of reading is a word, part of a sentence or the whole sentence. The technique of reading and understanding the text are closely related. Expertise in visual recognition of words and sentences is the basis for understanding their meaning, and capturing the essence of a read text has a positive effect on the ability to distinguish its graphic elements (Warsicka, 1977). In reading comprehension, the reader should understand basic semantic categories, be able to transform synonymous easy texts, search for the main thoughts in them, as well as remember the content, infer and be able to use the read content in practical activity (Pawłowska, 2009).

The analysis of curricula made in terms of determining the causes of failures in reading of non-disabled students allowed to state that they do not include neurophysiological and mental mechanisms in the reading process. The consequence of this is the lack of exercises developing the perception of graphic signs and their systems supporting the effective work of the eyes when reading, related to widening the field of view. Studies also identified problems related to assessing students' mastery of reading skills. It was found that they result from various criteria according to which an assessment should be made. Too little attention is paid to the need for systematic checks on students' progress, without indicating the necessary ways and tools to carry out this check through special prepared tests. Another significant disadvantage of the programs is the approach to reading comprehension, which is treated as the goal of educational activities, as an obvious skill achieved by students after reading the text once (Pomirska, 2011).

An important element of the text, especially in reading comprehension, is the illustration of its content. As a complement to the text, it should be consistent with it. Properly selected illustration, supports the reception of the by explaining the relationships or dependencies present in it, graphically transmits knowledge.

This is visual knowledge, received through the eyesight and shaping clear visual imaginations (Jakubowicz, Lenartowska, 1997). Illustration should perform several functions: update and consolidate language experiences, consolidate vocabulary, practice using well-known grammatical structures and practice perceiving the whole, not just individual elements. One of the guiding principles of teaching when working with deaf students is the principle of visibility. Therefore, pictures and illustrations are often used in the educational process of this group. Texts intended for deaf students should be provided with attractive illustrations, adequate to the content.

Problems of deaf students with mastering reading skills result primarily from their limitations in language development. Despite the mastered reading technique, they often do not understand the text being read (hyperlexia). Thus, they cannot use it to acquire knowledge, mechanically remembering and reproducing literally, without understanding the content. The memory of people with hearing impairments is of a visual and analytical nature. Therefore, they remember individual elements better, but have a problem with capturing relationships and connections. The dominant role of the sense of sight is conducive to the development of visual-movement memory, while it weakens verbal-logical memory (Podgórska-Jachnik, 2004).

"…Therapeutic and school practice has provided evidence many years ago, that textbooks that deaf students should use are hardly used during lessons, and even more they cannot be used to learn independently…" (Korendo 2009: 45) and books cannot be the sources of information and a language pattern for students with hearing impairment, because the language used in textbooks is not adapted to their capabilities.

Research report: reading comprehension by young people with hearing impairment of the content of various infographics in the field of nature

Aim of the research: The aim of the research was to determine the effectiveness of reading short scientific and informational content on various forms of infographics, taken from the school textbook for teaching nature. Thus, an attempt was made to assess the adaptation of the way the content is presented in the textbook to the possibility of using it by this group of disabled people, as well as to compare the course of the cognitive process characteristic of information retrieval by students with hearing impairment with analogous hearing students of equal age.

Research problems: What is the relationship between the method of selecting the infographic for presenting scientific information and the learning effectiveness of deaf youth? Does the presentation of information, typical for school textbooks, enable effective perception and thus the possibility of processing during the learning process by students with hearing impairment? The method of choosing research material in the form of three different infographic presentations additionally allowed to asses: Which infographic is best suited to the capabilities of a student with a hearing impairment while dealing with reading comprehension? What cognitive activity do students with hearing impairment show when searching for information in a scientific text? To what extent is this activity different from that of hearing

students? To what extent the cognitive activity of deaf students depends on the way information is presented in the text. All problems raised were left open.

Study group: The study covered 48 students aged 16, including 24 students with hearing impairment and 24 non-disabled students.

Research method: A test in the form of three tasks implemented on a computer screen, data collection method according to Krzysztof Rubacha was used (Rubacha, 2008).

Measurement technique: The research was carried out using eye tracking technique using the Hi-Speed 1250 eye-tracker from the German company Senso-Motoric Instruments (Zielińska, 2016).

The surveyed students read the content of tasks "for themselves", thereby eliminating the acoustic-motor side of the activity. This allowed us to potentially use the positive aspects of such reading, i.e. associating graphic signs with non-linguistic content, following predictions and guesses, and capturing both the literal and additional sense of the text. The fact of understanding the information read was checked on the basis of choosing one answer from among the five possible in particular question. About the fact that only one answer is correct, the examined person was informed before the examination, when discussing what it will consist of and what will be its course. The content selected for research was informative and scientific, hence their reading was functional. Its goal was to learn, so to find relevant information on the screen, understand them, memorize and organize knowledge that will allow the correct answer to be given to the question.

Research material: The research material was selected from the nature textbook for the second grade of junior high school. A quantitative and qualitative analysis of the contents of three nature textbooks authorized for use at this level was carried out. Three different infographic representations of scientific information were selected: Fern development cycle information in the form of a diagram, elements described with a small amount of text, connected by arrows), Skin – sense of touch (information in the form of a uniform text, next to supplemented with an illustration) and a Graphic method for determining the correct ratio of body weight to height (information in the form of a chart with legend). The material selected for testing was bimodal. The modality referred to as Visual-V (visual sensory modality) was used deliberately for learning preferences when learning information in graphic form (graph, diagram, arrows) and the modality Reading / Writing-R, for information preferences in language written text.

Results and conclusions from the research: The research results were prepared in two forms: graphic and numerical. The graphical form of the heat map showed focus of attention of the examined person, the warmer the color (red) – the greater the focus, the colder (blue) – the smaller. The next form is the scan path – the path of looking – showing the succession of fixations and saccades, thus informing about the way of looking. The eyes cannot see the surroundings continuously. Sight stops at the selected, observed fragment of the image for about 200 ms. Then it is abruptly transferred to other places at a frequency of 4 to 5 times per second. The conscious processing of information needed to analyze the read text occurs within 50–120 ms from the beginning of the fixation for the word, depending on its

length. The main measures used in oculographic studies are fixations and saccades. Fixations correspond to the relatively constant position of the eyeball and very slight vibrations. Hence, they can be defined as focusing on a given element. Saccades are fast eye movements occurring between successive fixations, so intense eye ball movements, can be defined as fast movements of point of sight concentration from one place to another (Zielińska, 2015). The heat maps obtained in the research clearly indicated the possibility of using eye tracking technique to assess cognitive activity. For example, it may be determining whether and for how long the examined person took up activity, what it consisted of and how it went. The duration of cognitive activity obtained in the studies was a numerical result. Studies have shown that the time of activity of both groups of students, both deaf and hearing, were similar, with a significantly different end result, not providing an answer or giving a correct one.

There were a lot of numerical results obtained with the eye tracking technique, useful for evaluation. For example: the number and frequency of fixations and saccades, their duration (total, average, maximum, minimum), time elapsed since the first fixation, so until taking cognitive action, time spent, so time of watching of the given element, the time after which it was noticed, allowing to assess its significance from the point of view of undertaken cognitive action, the number of returns to a given place and many others. Which of them and how they will be used depends on the person conducting the test. The obtained results showed that the longest "time" of students with hearing impairment is the time to focus attention on the first answer on the left. It amounted to 580.4 ms on average. This led to the conclusion that this group practically did not analyze the text and did not seek information to answer. The results of hearing students in the assessment category: "residence time" significantly differed from the results of the group with hearing impairment. On average, the attention of hearing youth focused on the text that contained the information needed to answer the question correctly. The average time spent on it was 1653.6 ms and 1684.4 ms, respectively. The search activities were intended, planned and effective. Focusing on the text of the correct answer indicated its fairly quick selection, the average time spent on it was 972.3 ms, other answers were practically not taken into account. The next result obtained concerned the category: return visits, so the average number of returns to a given place by the respondents. The obtained result was used to assess how important this place was for tested youth from the point of view of obtaining the necessary information, so how they assessed its importance and usefulness for solving the task. The results obtained in this category indicated the planned nature of strategies for obtaining information by hearing students. For students with hearing impairment, it was chaotic and unplanned.

An example of the use of the so-called the sequence of action was the statement that students with hearing impairment first looked at the largest of the drawings, and only then at the title of the assignment. In the analyzed case it was a graph described by height and weight. Performing a similar analysis to the presented research results of hearing students showed differences between the groups. These students started the analysis by reading the assignment title. However, it was only in the second place that they looked at the chart. Similarities and differences between students with hearing impairment and without disability were also seen in the calculated average

values of eye tracking results characterizing fixations and saccades. The biggest differences between the examined groups occurred in the categories of assessment: average fixation time, maximum fixation time and also total time of the saccades and average latency (delay).

The results obtained and averaged for the groups clearly showed that between the groups the biggest differences regarding fixations occurred during solving of the "Fern" task, while between the saccades in the "Skin" task. The smallest differences in these assessment categories were for the "Weight" task, in which the illustration was big and there was little of text. The maximum and average fixation time and average latency (delay) in the group of students with hearing impairment reached higher values than in the hearing group. The opposite situation concerned the total time of the saccades. This may indicate that students with hearing impairment longer than hearing colleagues stop their eyes on individual elements of the viewed image, are slower in action and look less "accurately". Hence, they have higher values of the maximum and average fixation time and average latency, while their total time of saccades is lower than in case of hearing students.

Research results of both groups of students in many categories proved to be highly divergent. The difference between the groups was mainly in the number of correctly answered questions. All three tasks proved to be very difficult for students with hearing impairment. Only four of them gave one correct answer. The group with hearing impairments obtained the best results in the category "Skin – sense of touch", in which the information was given in the form of a uniform text, supplemented with an illustration. The results of the hearing group were significantly different. Task topics were very simple for this group, as evidenced by the final results obtained. Only 4 students had one error, all other answers were correct. It was surprising that three incorrect answers of hearing students appeared in the category in which deaf appeared to be the best, namely "Skin – sense of touch". Hearing youth did not make any mistake in answering the question in the "Fern development cycle" category, in which the information was given in the form of a diagram, and the elements were described with a small amount of text and combined with arrows.

A detailed analysis of the research results obtained in the form of focus maps and view paths allowed for an initial assessment of how different forms of presentations of scientific information are read by the surveyed youth. There were clear differences between the groups depending on the type of infographics. Research results obtained for the task "Fern development cycle" in a group of hearing students indicated that they only read the text and did not analyze the drawings on the infographic. For deaf students, illustrations proved to be much more important. This confirms the need for such presentation of information in textbooks intended for students with hearing impairment, which contains only its essential elements. They are not able to select information on scientific infographic and analyze all its elements. Similar conclusions to the presented ones concerned the other two tasks used in the study. The results of the task "Graphic method for determining the correct ratio of body weight to height" were assessed in the following categories: number of students looking at the text, graph, legend, answers. The solution to the task required analysis of all these elements. And again, similarly to the task discussed earlier, the analysis carried out

by all hearing students and only two deaf students went similarly. While solving the task, they read the text and analyzed the chart, legend and looking for answers. Among the other students with hearing impairment the following behaviours took place: they did not read the text contained in infographics (not even its title) or (and) did not analyze the chart, did not look at the answers, did not analyze the legend. Therefore, they could not have the information needed to give the correct answer and consequently did not provide it.

Summary

The results obtained indicated the usefulness of using eye tracking techniques in the process of determining what errors in the cognitive functioning of the student took place in the situation of lack of success in the learning task performed by him and what infographic presentation of information is most accessible to him. This creates the possibility of individual, profiled, compensatory educational work with the student and the choice of a textbook adapted to his capabilities (there are always several proposed on the publishing market). Research has clearly shown that for students with hearing impairment, the excess information contained in textbooks, including reproduction of it by use of text and graphics, only makes the learning process more difficult. They analyze all the information and do not perform selection, for example in terms of its usefulness for solving the given tasks.

The conducted research showed that hearing youth prefer presentation of information in textbooks in the form of diagrams described by text (in many textbooks such infographic representation of information is used). However, for deaf youth, a much better solution is to present information through a separate text and its representation in the form of illustrations. Focusing only on the text, without being distracted by the redundancy of graphics: drawings, arrows, gives this group with language problems the chance to focus on the content of the read text; creates a more comfortable cognitive situation when reading comprehension. This was clearly indicated by the research results during the "Skin – sense of touch" task. The adoption of infographics typical for this task, so separate text, separate drawing, the most important information in bold font, led students with hearing impairment to undertake information search strategies, identical to the strategies of hearing students, and with a great final success compared to other tasks. The final conclusion from the research, based on the results, is the statement that the information system in the infographic adopted in the task "Skin – sense of touch" is best suited to the ability of students with hearing impairment to read comprehension and launches in them similar cognitive strategies as in hearing peers, so it should prevail in textbooks intended for this group.

The research results allow to obtain also answers to the other question: How does the examined person scan the image they are looking at? And thus indirectly: How does it process the information it contains? The eye tracking method allows to determine what elements and for how long during the cognitive process attract the attention of the examined person, and which are irrelevant to them, because they are omitted. However, it does not provide an answer to the question: Why is

this happening? This type of question can be answered by a more in-depth expert analysis.

When drawing conclusions in terms of the usefulness of the eye-tracking method in the area of didactics for teachers it should be emphasized that it enables the non-invasive measurement of many important parameters related to the brain activity of pupils while solving various cognitive tasks. It shows how to study various problem-solving strategies based on the analysis of eye activity (attention maps). The results of the research performed on large, statistically significant groups, appropriately collected and interpreted, obtained by the eyetracking method, can be an extremely valuable source of information for teachers facilitating the understanding of cognitive mechanisms occurring during the learning process, including defining the strategy of proceeding in solving problems of very different difficulty levels. This method can be used by teachers in the field of remedial work with children with special educational needs, including diagnosing deficits leading to learning difficulties and developing models of effective teaching strategies.

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Abstract

The aim of the research presented in the paper was to determine the effectiveness of reading short scientific and informational content on various forms of infographics, taken from the school textbook for teaching nature. The study covered 48 students aged 16 (24 students with hearing impairment and 24 non-disabled students). The research results were prepared in two forms: graphical (heat maps, scan paths) and numerical. The conducted research showed that hearing youth prefer presentation of information in textbooks in the form of diagrams described by text (in many textbooks such infographic representation of information is used).

However, for deaf youth, a much better solution is to present information through a separate text and its representation in the form of illustrations.

Keywords: deaf youth, infographic representation, eye tracking, heat maps, scan paths

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