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TEACHING METHODS AND AIDS ASSISTING DYSLEXIC PUPILS IN LEARNING CHEMISTRY

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Abstract. *Some pupils (about 10% to 15% of population) exhibit specific difficulties in learning called dyslexia. They cannot work effectively in the traditional educational system. Despite their hard work they usually achieve worse results compared to the pupils without this dysfunction. Learning difficulties caused by dyslexia are also observed in learning chemistry. The studies were aimed at finding which methods and educational means can assist the learning process of chemistry by dyslexic pupils. Their main characteristics was the fact that they took into account the specification of the thinking processes in these pupils. The studies proved that there are methods which have a positive effect on the process of learning chemistry by dyslexic pupils.*
Key words: *chemistry education, teaching of dyslexic pupils.*

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Introduction

School should create conditions for the acquisition of the knowledge by all pupils and ensure assistance and understanding particularly for those, who despite the efforts, do not achieve expected results. This refers, among others, to the pupils, who despite good intellectual proficiency and over average intelligence, have some difficulties in reading and writing, which, in turn, causes some problems in the acquisition of basic knowledge and skills in various school subjects. These specific difficulties in learning are termed developmental dyslexy (Augur, 1997; Pumfrey & Reason, 1991).

The International Dyslexia Association uses the following definition: **Dyslexia is** a neurologically-based, often familial disorder which interferes with the acquisition of the language. Varying in degrees of severity, it is manifested by difficulties in receptive and expressive language, including phonological processing, in reading, writing, spelling, handwriting and sometimes arithmetic. Dyslexia is not the result of a lack of motivation, sensory impairment, inadequate instructional or environmental opportunities, but it may occur together with these conditions. Although dyslexia is life-long, individuals with dyslexia frequently respond successfully to timely and appropriate intervention (Orton Dyslexia Society, 1994; Lyon, 1995).

There are many studies on dyslexia. Besides the conception

analysing the causes of dyslexia in genetic and neurophysiology, the studies by psychologists play an important role. They paid their attention to dyslexic pupils' intellectual capacity. It was found that intelligence of 90% of them is within the standard for a given population and the others possess higher intelligence than the average (Bednarek, 1996; Hynd & Cohen, 1983). What follows from the data of the British Dyslexia Association is that about 10% of the population in the world exhibit symptoms of dyslexia (Pennington, 1991; Snowling, 2000, www.bdadyslexia.org.uk). There is not a "typical dyslexic" model. However, some symptoms typical of this disorder can be pointed to. They are:

- divergence between the level of intellectual development and that of reading,
- diminished ability of audiovisual analysis and synthesis
- poor short-term memory for words,
- language and speech difficulties,
- difficulties in element arrangement and sequence separation,
- lack of distinct hand lateralization,
- frequent spelling mistakes, worse graphical quality of handwriting
- time and space orientation disorder
- motorial development and manual efficiency disorder (The British Dyslexia Association; Fawcett, 2001)

Another problem worth mentioning as far as the learning process of dyslexic pupils is concerned is specific differences among the dyslexic affecting a differentiated approach to the contents taught in the same way. One difference on the individual level concerns cognitive processes like: perception, memorizing and reproduction. Taking these into account one can distinguish the following ways of learning by dyslexic pupils: a) visual–motion–visual / b) auditory–motion–visual / c) motion–visual–auditory (Dyrda, 2003). The above ways of learning show various possibilities of dyslexic pupils which should affect various teaching methods (http://www.ditt-online.org/index.html).

Taking into consideration the above characteristics manifesting themselves in dyslexic pupils and specificity of chemistry as a school subject one can assume some difficulties in their learning chemistry as a school subject. The papers already published dealing with education of the dyslexic, discuss mainly the first stage of education focusing on reading and writing problems. Their difficulties while learning chemistry and physics are discussed in very few papers (Ragkousis, 2000). They do not specify the type of difficulties and the way of assistance. The results point only to the differences in school achievement by dyslexic pupils and those without this dysfunction. Dyslexic pupils have, weaker achievement in both knowledge and skills. The greatest difficulties appear while learning qualitative and quantitative interpretation of symbols, molecular and structural formulae of chemical compounds, equations of chemical reactions and solution concentrations (Kamińska-Ostęp, Gulińska, 2003). Effectiveness and success of dyslexic pupils' chemical education should depend on teaching methods adjusted to specific needs. Special attention should be paid to acquisition of knowledge and skills which are of significant importance in successive stages of education.

Methodology of Research

The studies are aimed at searching the effective methods of teaching, forms of work and educational means assisting dyslexic pupils in learning chemistry. Based on the available results of research there are some selected kinds of problems and difficulties in the acquired chemical knowledge choosing those most essential for continuation of chemical experiments, forming formulae and names for chemical compounds as well as writing chemical reaction equations. The obtained information from the research and analysis of literature was the starting point for choosing methods and educational means which should assist the learning chemistry contents by the dyslexic students using the ways which are efficient for them. Based on it there was formulated the main research problem: What is the educational efficiency of chosen methods and chemistry teaching means for dyslexic pupils?

Table 1. Comparison of chosen chemical contents and teaching methods and aids applied for their accomplishment.

No	Elements of chemical knowledge	Teaching methods and aids
1.	chemical computational tasks	A. proportion method used for calculations B. mathematical equations used for calculations
2.	chemical experiments	A. application of film instructions B. application of printed instructions
3.	formulae and nomenclature of inorganic compounds, chemical reaction equations	A. using educational computer games B. using educational board games
4.	formulae and nomenclature of organic compounds, chemical reaction equations	A. using computer animation B. using rod-ball models

The studies were carried out in three gymnasium schools-pupils aged 13-15. At this stage of education chemistry is taught as a separate subject. In each class under investigation about 20% of pupils were dyslexic having the certificate from the psychological and pedagogical clinic about specific difficulties in learning. The research was carried for three years (2002-2005) and was divided into four stages in relation to an element of chemical knowledge based on the assumptions in Table 1. Over 400 pupils took part in each stage of research (Table 2). The sample was sufficiently numerous to provide reliable results and at the same time provided possibility of efficient organization and carrying out research.

Table 2. Comparison of the number of pupils with and without dyslexia taking part in individual stages of research.

Research stages	Dyslexic pupils / without dyslexia	Total
1	93 / 395	488
2	93 / 395	488
3	89 / 336	425
4	93 / 361	454

The classes were divided into two groups in which one of the two teaching methods and aids accepted for a given element of chemical knowledge was applied. One set of classes used the methods designated A in Table 1 and the other B. It was theoretically assumed that the methods designated A in Table 1 should be taken into account specifically as well as the needs of the dyslexic pupils. It was used for the classes with chemistry knowledge being poor according to the pupils. Then pupils' knowledge was evaluated by the means of closed and open tasks. The results were statistically analysed using the variant method ANOVA. In the analysis the calculation sheet Microsoft Excel was. The achievements of the pupils without dysfunction were compared with those of the dyslexic enabling to draw additional conclusions.

Results of Research

Organization, course and results of the four stages of research can be presented as follows.

Stage One

The aim was to study the effect of application of the proportion method and the one consisting in transformation of the mathematical equation in order to solve mathematical tasks by dyslexic pupils. Both methods were used for solving the mathematical tasks of percentage concentration of solutions and solubility of substances while teaching the section "Water and Aqueous Solutions". The tasks required

the knowledge of preparation of solutions of a given concentration and ability of calculating suitable amounts of substances, using a solubility curve and calculating concentrations of solutions. For dyslexic pupils performing mathematical calculations and converting chemical units is a complicated activity. This is due to the limited memory capacity, particularly the short-term one and performing calculations. Solving chemical mathematical tasks require doing a large number of operations. Therefore one can assume that the proportion method is more effective here due to elimination of the factors making mathematical calculations and equation transformation is difficult. The efficiency of mathematical task solution was tested regarding the skills practiced during chemistry lessons. 488 pupils (93 dyslexic and 395 without dysfunction) took part in this stage of research. The group using the proportion method (PM) included 43 dyslexic pupils and 203 without dyslexia whereas that using the mathematical equation method (MEM) 46 dyslexic and 192 without dyslexia pupils.

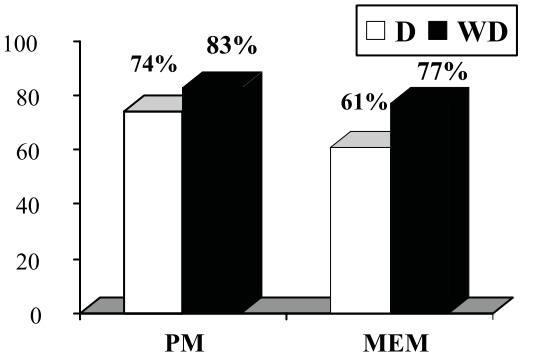

Figure 1. Percentage of correct answers for the dyslexic (D) and without dyslexy pupils (WD) in the group: PM–the proportion method and MEM–the mathematical equation method.

While using both methods dyslexic pupils' learning achievement was lower compared to those without this dysfunction. What follows from the data in the above figure that the proportion method is more effective for all pupils (both dyslexic and without dyslexy). The dyslexic obtained better results by 13% compared to those using the mathematical equation one which is the evidence for its effectiveness. As for the pupils without dysfunction the difference is smaller and is 6% in favour of the proportion method. What follows from the data, its application supports significantly teaching dyslexic pupils how to solve tasks and make their achievement closer to those of the pupils without dysfunction.

Stage Two

The aim was to study the effect of film and printed instructions on correctness of chemical experiments carried out by dyslexic pupils and the level of knowledge obtained by them. Unwillingness for reading and difficulties in reading cause that dyslexic pupils are not able to use the written sources of knowledge effectively.

They have also some difficulties in naming substances and chemical processes, laboratory equipment as well as expressing observations and conclusions based on chemical experiments. The printed instruction may not be efficient for proper performance of chemical experiment as well as for the expression of observations and conclusions due to specific difficulties for dyslexic pupils. However, owing to the possibility of frequent watching the experiment demonstration on the computer screen, the pupils should carry them out more efficiently and in a safer way, thus acquiring new knowledge. The choice of chemical experiments resulted from existence of recorded material in the form of film sequence and possibility of their performance by pupils.

1. Separation of heterogenous mixture of sand and water by the means of sedimentation, decantation and filtration

2. Calcination of sugar and identification of reaction products
3. Preparation of carbon (IV) oxide and its identification
4. Combustion of sulfur and magnesium in oxygen and air.

To check the efficiency of the instructions, there was a test of knowledge of the pupils acquired that performed the above mentioned chemical experiments. At the same time the pedagogical observations were made to evaluate correctness of their performance.

This stage of research was attended by 488 pupils (93 dyslexic and 395 without this disfunction). The group using the film instruction (FI) included 43 dyslexic and 203 without dyslexy pupils while, that using the printed instruction (PI) 46 dyslexic and 192 without dyslexy pupils.

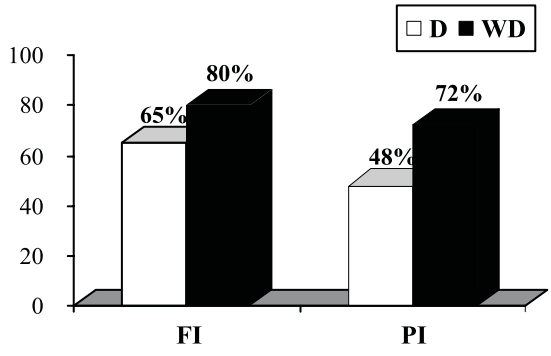

Figure 2. Percentage of correct answers obtained in the test for the dyslexic (D) and without dyslexy (WD) pupils in FI–the film instruction and PI–printed instruction groups.

Using both instructions dyslexic pupils obtained worse results compared to those without dysfunction. What follows from the data in the above figure the dyslexic ones and without dyslexy pupils using the film instruction while performing chemical experiments achieved better results than those working with the printed instructions. The number of correct answers by dyslexic pupils in the FI group is by 16% larger than in the PI group.

However, for the pupils without dyslexy the difference is only 8%. The better results in the dyslexic group using the film instructions indicate greater efficiency of this educational means.

As follows from the obtained data using the film instruction assists significantly teaching dyslexic pupils and their results are close to those obtained by pupils without this dysfunction.

During chemical experiments the teacher analyzed the pupils' actions using the observation card made earlier. From the obtained data it can be stated that the use of film instruction gives greater correctness of performing chemical experiments by dyslexic pupils than the use of printed instruction. Owing to the possibility of projecting the film showing the experiment many times, pupils can watch the activities, the course of the process and its effects.

Stage Three

The aim of this part research was to analyse the effect of computer and board chemical games to create skills of formula formation, reaction, equations and nomenclature of inorganic compounds writing by dyslexic pupils.

The course of this part of research was different from the others due to the function performed by educational games. They were no the means for acquisition of new knowledge by pupils but their aim was to consolidate the acquired chemical knowledge. After the course on "Acids, hydroxides and salts", the pupils wrote a test in which non-dyslexic pupils achieved higher scores than the dyslexic in each skill under consideration. The percentage of their correct answers was 63% whereas for the dyslexic 47%. The obtained results confirmed the fact that the dyslexic find it more difficult to assign the molecular

(model, structural) formula to the name of chemical compound and to read and write chemical reaction equations qualitatively and quantitatively.

Therefore the suggestion was made to use educational games in order to practice and consolidate knowledge and to create skills of formula formation, reaction equations and nomenclature of inorganic compounds writing. Part of class used computer games and the other part used board games. Application of computer games enables revision and practice of the same skill in an attractive way. It does not require concentration on one activity which is important for dyslexic pupils who have concentration problems. Computer chemical games promote memorization according to the rule that something which is attractive is easier to remember.

Application of computer games enables individualization of work which should lead to efficient learning by the dyslexic. In order to check their efficiency knowledge of nomenclature, molecular and structural formulae, reactions of obtaining acids, hydroxides and salts and their ionic dissociation was tested. 423 pupils (87 dyslexic and 336 without this dysfunction) participated in this part of research. The group using computer games (CG) consisted of 46 dyslexic and 181 without dysfunction pupils and that using board games (BG) included 41 dyslexic and 155 without dysfunction pupils.

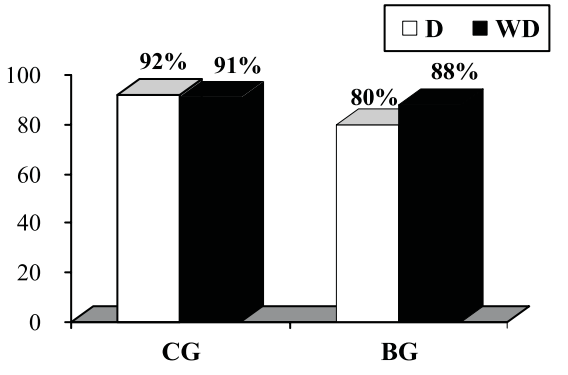

Figure 3. **Percentage of correct answers by the dyslexic (D) and without dyslexy (WD) pupils in the computer game CG and board game BG groups.**

What follows from the data in the figure application of computer games for both dyslexic and without dyslexy pupils gives better results. The dyslexic pupils' result was by 12% better than that obtained using board games. Thus this educational means is more efficient.

However, the difference is 3% for the pupils without dyslexy. The dyslexic obtained better results using computer games than the pupils without dysfunction. They enabled repetition of the same actions leading to better command, good rate of work and its individualization. Owing to their amusing character they resulted in engagement and cognitive activity. Comparing the results of the initial test where the differences between both groups were large, the achievements of both groups were similar after the use of computer games.

Stage four

The aim of this part was to study the effects of computer and ball-rod models on solving training–problem tasks by dyslexic pupils. Organization and course of the pedagogical experiment consisted in using both methods mentioned above models while teaching "Hydrocarbons and their derivatives". The training–problem tasks solved during the lessons included nomenclature, molecular and structural formulae and characteristic reactions of hydrocarbons and their derivatives. These skills are difficult to master by the dyslexic which is caused by some problems connected with nomenclature association, memorizing complex names, complicated structures due to limited operational memory

capacity. Models visualize chemical problems facilitating transition from specific to abstract concepts. This also facilitates in formation of representations corresponding to the structure of matter and then using them in reasoning. It was believed that the employment of computer facilitates learning difficult problems by dyslexic pupils. Compared to manual models they allow to represent the structure of organic compound molecules in an attractive way by a frequent repetition and training, difficult skills sustaining concentration for a long period of time. To check the efficiency of both models, the skills trained during the chemistry lessons were tested. 454 pupils (93 dyslexic and 361 without dyslexy) participated in this part of research. The group using rod-ball models (RBM) included 45 dyslexic and 173 without dyslexy pupils and that using computer simulations (CS) included 48 dyslexic and 188 without dyslexy pupils.

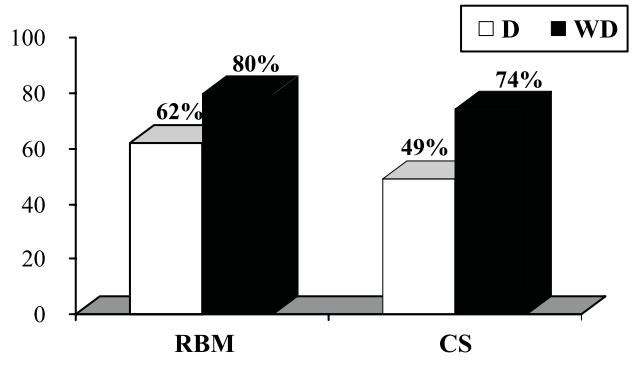

Figure 4. Percentage of correct answers by the dyslexic (D) and without dyslexy pupils (WD) in the group using rod-ball models RBM and that using computer simulations CS.

Using both models the dyslexic pupils obtained worse results compared to those without dysfunction. The data in the above figure show that using rod-ball models gives better results for both groups of pupils. The dyslexic pupils' results were by 13% better than those obtained while using computer animation which proves their greater efficiency. However, for the pupils without dysfunction this difference was 6%. Thus application of rod-ball models supports significantly learning by dyslexic pupils who then achieve the results similar to those by pupils without dysfunction contrary to using computer simulations where the differences between both groups are larger. Application of rod-ball models for training–problem tasks enabled better visualization of chemical problems owing to the possibility of manual and individual construction of models of chemical compound molecules. That promoted "chemical thinking" manifesting itself in more competent solution of training–problem tasks while using rod-ball models compared with those using computer simulations. Consequently, proper intellectual models are built and used in reasoning. This allows more effective exploitation of pupils' knowledge (Kamińska-Ostęp, 2005).

Discussion and Conclusions

The studies showed that particularly good results are obtained by the dyslexic pupils using:

- proportion methods to solve chemical calculation tasks,
- instruction in the film form for performing chemical experiments,
- educational computer games for consolidation of formulae, nomenclature of inorganic chemical compounds and chemical reaction equation,
- rod-ball models for learning formulae, names of organic chemical compounds and chemical reaction equations.

The obtained results confirm the fact that there are methods supporting the dyslexic in the chemistry teaching and learning process.

This diminishes school achievement differences of dyslexic pupils compared with those of dysfunction-free pupils taking specificity of intellectual processes into account for whom non-verbal methods are of more importance. Most methods used promoted creation of a proper representation of a given process or concept and then association with its verbal counterpart. They enabled numerous revision of acquired knowledge and skills exploiting all senses to get familiar with new knowledge and preserve concentration of attention while learning. Owing to their attractive and interesting way of presentation, they grew interest and motivation for learning (Davis, Braun, 1994).

The methods and means employed in the research are only the examples of possibilities for support of pupils having specific difficulties in learning. Based on these methods and their characteristics, teachers can search for their own educational means to enable effective participation in chemical education by the dyslexic pupils.

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