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Dynamic Exercises in Teaching Mathematics in Higher Educational Institutions

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Abstract: In recent years, in the teaching of almost all disciplines around the world, there has been a tendency to take into account the individual characteristics of students, which also affected the subjects of the physics and mathematics cycle in higher education. At the same time, taking into account such a factor as the main channel of perception is practically not covered in modern literature. The article analyzes taking into account the modality of students' perception when teaching mathematics at a university, describes the features and methodological methods of teaching kinesthetics. The purpose of the article is to show the possibilities of individualization in the teaching of mathematics by means of assignments that take into account differences in the leading channel of information perception. Particular attention in the article is paid to the use of dynamic exercises, which require, along with the performance of mental actions, the performance of physical movements or their imitation. Performing this kind of exercise is one of the most effective forms of learning for kinesthetic learners. The article discusses specific examples of the use of dynamic exercises in the study of mathematical disciplines in higher education, describes an approach to using a cycle of practical work and experiments to confirm the truth of the provisions under consideration. An analysis is given of the use of a laboratory experiment, outdoor games and quest tasks in the context of using dynamic exercises in the methodology of teaching mathematics. Taking into account possible changes in the organization of education caused by the global pandemic, the features of the use of dynamic exercises in the course of studying mathematics during distance learning are considered. The article considers the consideration of the individual characteristics of students in the study of mathematics, the conclusion is made about the prospects of using the forms and methods of teaching, taking into account the modality of perception by students.

Keywords: mathematics; information technology; teaching; modality; kinesthetics; dynamic exercises.

The principle of individualization and differentiation of education is one of the main principles of modern didactics. The problem of an individual approach has been studied quite well in the psychological and pedagogical literature. Theoretical issues of individualization of education are widely covered in the works of V. Bespalko, A. Kirsanov, E. Klimov, V. Serikov, M. Skatkin, I. Yakimanskaya and others. In the twentieth century, the theoretical aspects of the process of individualization of learning continue to be developed by modern researchers. The basis of individualization in various pedagogical innovations was the speed of thought processes, learning ability, educational achievements, the dominant hemisphere of the brain,

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etc. Among the means of individualization, individual and group tasks are often indicated, developed taking into account certain characteristics of students.

The purpose of the article is to show the possibilities of individualization in the teaching of mathematics by means of assignments that take into account differences in the leading channel of information perception. In psychology, depending on the channel for reproducing and processing information, three types of people are traditionally distinguished - auditory, visual, and kinesthetic. Recently, a rare fourth type has been added to them - discretes that perceive information through logical comprehension. Differences between people of the above types are manifested both at the stage of perception and at the stage of memorizing information. Other cognitive mental processes also proceed differently. It is generally difficult for a kinesthetic person to concentrate his attention, it is easy to distract him with anything; the auditory is easily distracted by sounds; The noise doesn't interfere with the visual. If we talk about the features of memorizing educational material, then it is obvious that the visual remembers what he saw, remembers with pictures, the auditory remembers what he discussed, remembers, listening, and the kinesthetic remembers the general impression; remembers, moving, feeling, sniffing.

It is worth noting that there are two types of kinesthetics: external and internal. External kinesthetics are guided by sensations from external stimuli (water temperature, surface roughness, softness of a blanket), they tend to hold everything in their hands and touch everything, including people during communication. Internal kinesthetics are more focused on internal sensations, feelings and emotions.

N. Fleming conducts a conditional division of all kinesthetics into four groups: 1) those who prefer practical tasks; 2) those that involve their entire body in mastering the skill; 3) those who prefer to learn with the help of artistic abilities; 4) those who learn best when they involve emotions

Most people use different channels for perceiving and processing information, but one of them is predominant [2]. Marketers have long learned to use these features of perception and information processing, using different behavior strategies to increase sales. It is logical to take into account these features of memory and perception in building a strategy for teaching educational material, including when teaching mathematics.

Articles by A. Tsybulya, O. Smirnova, N. Yakovleva, and others are devoted to taking into account the modality of perception in teaching mathematics. auditory), teaching has been built in innovative schools and experimental sites. Thus, this thesis is the basis of the “Prevention of school failure” methodology, the author of which is Tatiana Aristova, a specialist in the speech-thinking activity of the Academy of Postgraduate Pedagogical Education, the methodology of the New Zealand scientist Neil Fleming, and many other experimenters in the field of education. On the basis of scientifically substantiated postulates about the need to take into account all channels of information perception, we have developed a series of differentiated tasks, in the performance of which different channels are involved. In this article, we describe those of them that are used in teaching students various mathematical disciplines. We pay special attention to dynamic exercises, which are not so often used in the traditional teaching of mathematics. By dynamic exercises we mean tasks and exercises of mathematical content, for the performance of which, in addition to traditional mental operations, it is necessary to

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perform physical movements or their imitation in a virtual environment. Such exercises are most in demand for teaching students with a predominant kinesthetic channel of information perception. It should be noted, and this is confirmed by the conducted studies, that kinesthetics prevail in groups of students of preschool age, in middle and senior school age they remain in the minority, even fewer in student groups. This explains why the traditional teaching methodology is visual and auditory oriented. When teaching mathematics, the peculiarities of kinesthetic students are practically not taken into account, who, in order to understand, need to literally feel mathematics, because they perceive information through sensations. Students with a dominant kinesthetic type of perception are usually no more than 3–5%, but the fact that the kinesthetic channel is not the leading one does not mean that it does not work at all when mastering mathematical knowledge. Therefore, we will focus on the description of techniques focused on the kinesthetic type of perception and memorization of information.

Taking into account the peculiarities of kinesthetics is described in relation to the teaching of music by N. Gorbacheva [3], a foreign language by E. Chibisova [4]. The practical disregard for the interests of kinesthetics in educational institutions is justified, among other things, by their extremely small number among teachers in schools, and their almost complete absence among teachers of higher educational institutions [4, 8]. M. Markova notes that the educational process in educational institutions is focused primarily on visual perception, secondly on auditory, almost no attention is paid to the specifics of kinesthetics, moreover, such students often become the subject of nit-picking by teachers [5–6]. The huge gap between the presence of a significant number of kinesthetics among students and the lack of real steps to take into account their characteristics in the traditional education system indicates the need to solve this problem by the scientific community.

Often, teachers, speaking about how to use sensations in the perception of mathematical objects, are limited mainly to the proposal to feel the models of stereometric figures. But this is not the only step. Our selection of tasks and exercises is aimed specifically at using the kinesthetic channel of perception and transformation of mathematical information. The main idea that unites all the presented tasks is the maximum of movements, emotions, sensations. Dynamic assignments make extensive use of objective activities traditionally characteristic of elementary school. One of the conditions for the qualitative assimilation of the material is the integrated use of all channels of perception and transformation of information. For this purpose, attention should be switched from one type of activity to another. The same information is presented visually, voiced and objectified. For example, when getting acquainted with the properties of relations, a series of traditional tasks is performed: name the properties of relations on the specified sets (the task is written in a textbook or on the board), a mathematical dictation, where, according to the images of graphs of relations, you need to put plus signs opposite those properties that these relations possess - for visuals , give examples of relations that have the property of symmetry or transitivity, name the property with which there is an analogy in the presented proverb or poem - for auditory, etc. There are "live" dynamic tasks for kinesthetics. For example, a group of students is selected and a ribbon is given to them. They are invited to give this ribbon into the hands of someone who lives in the same city as the student himself. Further, it is proposed to divide into subgroups, each of which contains those who live in the

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same city. So students participate in the construction of the graph of the equivalence relation "to live in the same city" and visualize what the division of sets into classes of equivalent elements is. Mathematics is not an experimental science; it uses experiments and practical work much less than in physics or chemistry. Nevertheless, it is possible to offer a whole series of practical works and full-scale experiments, the results of which either put forward a mathematical hypothesis, or clearly demonstrate the truth of scientific provisions.

The idea of organizing laboratory experiments is not new in the methodology of teaching mathematics. For example, its description can be found in one of the textbooks of the early twentieth century. (textbook by D. D. Galanin “Methods of Arithmetic”, 1910). The expediency of using experiments has always been a subject of discussion in the methodology of teaching mathematics. Nevertheless, this idea, improving and acquiring new content, is periodically proposed for implementation in the educational process, being even the basis of some school reforms. We consider a laboratory experiment as one of the types of dynamic tasks.

Kinesthetic learners are much more interested in seeing and touching (which happens when doing practical work) than reading and hearing (which happens in the traditional teaching system). Using an ordinary cup of tea, you can simulate a paraboloid of rotation by stirring the tea quickly enough, and a cardioid by observing the rays from a point light source reflected in a cup of tea in the evening. One of the experimental tasks may be the repetition of the experiments of ancient mathematicians, for example, Thales, using his methods of measuring inaccessible distances. When getting acquainted with the rows, the following task may be offered: to walk from one object to another, the distance between which is 3 m, making each next step half as long as the previous one. Numerical experiments, tasks to search for patterns are considered as one of the ways to discover new formulas. Such an experiment, for example, can be organized to derive Euler's formula about the relationship between the number of vertices, edges, and faces of a polyhedron. Widespread computerization of education allows modern students to conduct virtual experiments. For example, in the GONExT virtual geometric environment, it is possible to create dynamic drawings. Consider, for example, a drawing of a triangle inscribed in a circle, one side of which is the diameter of the circle. By changing the position of the vertex lying on the circle and observing the resulting change in the values of the angles, students can “discover” a theorem stating that an inscribed angle based on a diameter is a right one [2]. The MathCAD program, three-dimensional modeling systems can be a convenient tool in geometry lessons, which will make the assimilation of material for kinesthetics more memorable, implementing the didactic principles of clarity and the connection between theory and practice.

A computer experiment that allows you to see the behavior of a function for different values of the argument, visualizes well the concepts of the limit of a function, its breakpoints, and asymptotes. At the moment, a sufficient number of virtual mathematical laboratories have been developed that allow performing computer research in various sections of mathematics - planimetry, solid geometry, probability theory, etc. In them, for example, tossing a real die can be replaced by a virtual how the concepts of frequency and probability are related. In the dynamic environment "mathematical designer" you can clearly see how rectangular and polar (elliptical, hyperbolic) coordinates are related, how graphs look in each of these coordinate

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systems, how their appearance changes depending on the parameters, etc. Augmented and virtual technologies realities for kinesthetic learners can be a great solution if used in middle and high school. In our opinion, printed books that use augmented reality technology will allow not only to visualize the process of deriving mathematical proofs, but also to increase the efficiency of its assimilation by kinesthetics.

The widespread use of computer experiments also has its risks, which researchers warn about. Thus, they note that computer dynamic visualizations not only make statements easily perceived, but also convince students of their truth. The mass nature of the experimental data obtained in this way and the degree of their consistency is so high that the illusion of the prevalence of these criteria over deductive proof is created. Frequent use of computer scripts reduces the need and skills of deductive proofs. There is also a negative impact of dynamic visualization tools on the development of students' own visual thinking, on the skills of building with classical constructive tools [2]. In connection with these warnings, we do not focus on the frequent use of dynamic visualization, but consider its involvement in setting up experiments as one of the exercises of the developed series.

Connecting to the memorization of material not only visual and audio channels, but also tactile sensations, occurs when performing dynamic exercises from the arsenal of eidetics. Let's consider such exercises when getting acquainted with curves of the second order. One of the typical mistakes made by students in this topic is to confuse the equations of an ellipse and a hyperbola, because their equations are similar and differ only in signs. In order to prevent this error, we propose to cut out an ellipse and a hyperbola from paper (the hyperbola must have some width), and draw the ellipse with pluses, and the two branches of the hyperbola with minuses. The second option - these two models of curves are covered with material that feels different in sensations, for example, silk and sandpaper, and it is proposed to write on them with a finger several times either the equation itself or the sign by which they differ. In the future, when recalling this equation, it is enough to recall the material on which the inscription was made, and the sensations will prompt the desired sign.

The Lego constructor helps to attract tactile sensations to the formation of ideas about some mathematical objects. It will help you see and feel the number series and its sum with your own eyes, it can be used to build a histogram when studying the elements of statistics, etc.

In addition to traditional tasks, in which the process and result of the solution are presented on paper, we use tasks using various actions with objects. For example, a task of this type is traditionally performed - write down (or name) among the given elements those that belong to some set A. We modify this task in such a way as to attract the kinesthetic channel. For example, we write numbers on cards, and on plastic plates - the designation of numerical sets. It is required to place the number in the correct plate. At the same time, the essence of the task does not change, only the way it is performed changes. When studying correct and incorrect statements in a course of mathematical logic, parts of these statements are written on separate cards and students are invited to build an argument according to the proposed scheme, stacking the necessary cards in a certain way. The reverse task is offered in pairs: one student makes a reasoning, the second one says whether this statement is correct, choosing the necessary scheme for it.

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When using an algorithm for solving a problem of mathematical analysis (for example, finding the extrema of a function), its steps are not simply called, but the task is modified so that these steps need to be connected with arrows or put on the table the correct sequence of actions that are written on the cards. Many math problems can be formulated in such a way that materials that feel different will be used to complete them. For example, when studying graph theory, in addition to the traditional “draw a graph according to certain data”, you can use “construct a graph”, the starting material for which can be plasticine and sushi sticks or a children's designer. Motor activity increases even more when students have the opportunity to move around the classroom, performing some didactic task. Thus, work can be built while consolidating and generalizing knowledge. Of particular interest to students are tasks in the form of mini-quests, in which in order to find the next task, it is necessary to complete the previous one. Its result will somehow indicate the location of the next task. For example, when consolidating knowledge of analytical geometry, the task begins at the bookcase. Three coordinates are given, one of which is the shelf number, the second is the book number, and the third is the page number. The hint is written on the right page, for example, the name of Descartes. This means that the next task is reinforced by the portrait with the French mathematician. A note is fixed on the portrait, where it is proposed to determine the figure according to its equation, and next to it there are models of figures, the next task is written on the desired figure, etc.

A variety of games that involve body parts help kinesthetic learners establish associations to memorize certain mathematical properties, for example, a simple warm-up game will help to learn the values of sine and cosine for angles of 0, 90, 180, 270 degrees. Let's agree that the hand is the radius of the unit circle. The host calls the function and the angle, and the rest of the players must show the location of the point on the unit circle by hand, for example, sine 90 - hands up, cosine 180 - left hand to the side, sine 270 - hands down. If the value is zero, then hands on the belt.

A nice bonus for kinesthetic students is the information that fingers can be used not only for direct counting up to 10, but also to make it easier to remember tabular sine values, to understand the translation of numbers from binary to decimal and vice versa.

The widespread use of outdoor games for didactic purposes also involves kinesthetic memory. For example, when studying the connectivity property of a graph, we play traditional games, followed by a discussion of whether the connectivity property was violated in each of them, how many connected components were obtained at one or another step of the game. In these games, the role of the vertices of the graph is played by the students themselves, the role of the edges is played by their hands connected to each other. For example, in the game "cat and mouse" we have two isolated vertices, the connectivity does not change during the game. In the game "Boyars" (another name is "Little Red Riding Hood White Feather"), initially there are two groups of players holding hands, i.e. a non-connected graph with two connected components. A player from the opposite team scatters and tries to break the enemy line. If he succeeded, the connection of the graph is broken.

Quest tasks and movement exercises help to increase the overall positive emotional background in the classroom, and therefore leave positive memories. It is these sensations that internal kinesthetics keep in memory for a longer time, they help them to make a bunch: emotions -

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knowledge.

Emotions can be involved in learning by staging mathematical miniatures, viewing and creating thematic memes, using analogies from literature and various types of art, and performing creative tasks. A strong emotional response among students is caused by specially selected interesting facts from the biographies of mathematicians whose activities are somehow related to the material being studied. Every person has favorite colors. It is the favorite color of the text highlighter that we suggest using to highlight the main formulas to be memorized in the abstract.

Dynamic tasks for kinesthetic students can also be provided when working remotely. To consolidate the educational material, great opportunities are available on the Quizlet platform. Here, students are first asked to create so-called flashcards for memorizing terminology: the name of the term is written on one side, its definition (or the left and right parts of the formulas) on the other. For self-control, the resource offers different game modes. In one of them, the definition of the term appears on the screen, and the player needs to type the name of this term on the keyboard or select it from those offered below while the meteorite is falling. In the other, all parts of the cards are present on the screen and it is necessary to choose the right pairs; if one part of the definition is correctly aligned with the other, this pair disappears. According to our observations, the second mode is most often chosen by kinesthetics.

There are various ways to determine the leading perception channel. They differ depending on the age of the student. For adolescents and students, in our opinion, it is advisable to use the method of diagnosing the dominant perceptual modality of S. Efremtseva (Audial. Visual. Kinesthetic test), Leakey Ricky Linksman's questionnaire, and the VARK method. The work [7] substantiates the choice of these methods for diagnosing the leading perception channel in students and notes the most objective and broad assessment of the VARK method. Accounting for the individual characteristics of kinesthetics is currently practically not carried out either in higher or in secondary school. At the same time, the classical teaching model, in which the main emphasis is placed on the visual and auditory presentation of information, shows low efficiency in mastering the material for them.

A special role belongs to taking into account individual modalities of perception in teaching the disciplines of the physical and mathematical cycle. In our opinion, for kinesthetics it would be appropriate to use dynamic exercises. At the same time, it should be noted that the effectiveness of using dynamic exercises in the strategy of differentiating mathematics teaching, taking into account the dominant channel of information perception, is still awaiting its experimental confirmation.

In our opinion, the optimal model of teaching mathematics should take into account the polymodality of perception. We believe that this approach will be effective not only for mathematics, but also for all disciplines that are taught in higher and secondary schools.

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