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PECULIARITIES OF MODELING TECHNIQUE TEACHING

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Abstract. *Based on a thorough analysis of psychological and pedagogical literature, main principles of didactics and cognitive psychology, through the prism of the works of prominent scientists of various years, modeling is considered as a powerful means of cognition which is used, as a rule, as an effective technique and teaching tool. The purpose of the article is to demonstrate the confirmation of the hypothesis that, when directive teaching the modeling method, the structure of the student's mental activity changes, directive learning leads to improving the overall success of higher learning, and this can be expected to have a significant impact on future practical activities of an engineer. The analysis is carried out and the features of usage and advantages of application of the modeling method as a method of physics teaching are determined. It was justified that the use of the modeling method in teaching students of technical specialties offers the possibility to develop professionally significant skills, including the methodological knowledge of modeling that is so important for a modern specialist. There were used the following methods to solve the desired goal: the analysis of the scientific works regarding the matters under the inquiry; generalization of the own pedagogical experience, questioning, observation and generalization, mathematical processing of the obtained statistics.*

Keywords: *modeling, modeling technique teaching, physical phenomena.*

Introduction

At present, in pedagogical literature, the task of organizing training process in such a way as to maximize the mental development of students is urgently set. The restructuring of the very nature of learning, aimed at intensifying this process, just pursues changing the structure of mental activity of students in the learning process as its main goal. The restructuring of the very nature of learning, aimed at intensifying this process, just pursues changing the structure of mental activity of students in the learning process as its main goal. Considering learning as a process of solving series cognitive tasks, gradually becoming more complex in terms of content and methods of activity, we must single out the cognitive actions

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required for their successful solution. Both tasks and actions are very diverse. They depend on the specifics of academic subjects, on the goals set in academic course unit study. It is natural that in the process of learning, modeling techniques inherent in physics are studied spontaneously. But a much greater effect is achieved when the main thing in student's activity is not just the acquisition of a certain amount of models used by physics, but their conscious targeted use in solving specific problems. Only that information that is somehow consonant with the needs of the learner undergoes mental processing. Assuming that the structure of the student's mental activity changes with the modeling technique directive training, we put forward the hypothesis to be tested that such directive training leads to an increase of the overall performance at a university, and this can be expected to affect the future practical work of an engineer. The purpose of the article is to demonstrate the confirmation of the hypothesis that, when directive teaching the modeling method, the structure of the student's mental activity changes, directive learning leads to improving the overall success of higher learning, and this can be expected to have a significant impact on future practical activities of an engineer.

There were used the following methods to solve the desired goal: the analysis of the scientific works regarding the matters under the inquiry, synthesis of ideas; generalization of the own pedagogical experience, questioning, observation and generalization, mathematical processing of the obtained statistics,

Literature review

Yu. Samarin, studying the associative nature of mental activity, suggests that the process of assimilation of knowledge is associated with the formation of increasingly complex systems of interconnected concepts (from local associations to intersystem ones) (Samarin, 1962). N. Levitov believes that mental development is characterized by such indicators as independence of thinking, resourcefulness in non-standard problems solving (Levitov, 1960). E. Kalmykova traces a change in the structure of mental activity in the emergence of an ever-increasing "economy of thinking" (the number of arguments on the basis of which a new pattern is highlighted) (Kalmykova, 1981). B. Ananyev connects mental development with independence in the formulation and solution of various problems (Ananyev, 1980). N. Leites believes that mental abilities are characterized by the possibility of theoretical learning (Leites, 1971), E. Kabanova-Miller holds the view that the main criterion for mental development is the "wide and active transfer" of the developed techniques of mental activity from one object to another (Kabanova-Miller, 1968).

Considering learning as a process of solving series cognitive tasks, gradually becoming more complex in terms of content and methods of activity, we must single out the cognitive actions required for their successful solution. Both tasks and actions are very diverse. They depend on the specifics of academic subjects, on the goals set in academic course unit study. Unfortunately, as noted by G. Shchukina, there are no studies that "would reveal the mechanism of dependence and correspondence of the task itself and the actions of students caused by it. So far, these processes are given separately by researchers" (Schukina, 1979). This problem is the subject of many didactic studies. There are works of I. Lerner which provide a classification of cognitive tasks in the study of history. The classification is based on the subject content of cognitive tasks. The work of N. Menchinskaya, E. Kabanova-Miller and other famous didacticians are devoted to the study of methods for solving cognitive problems. M. Danilov in his work "The Learning Process in the Soviet School" formulated the most important rules for tasks advancement. First of all, the cognitive task must flow from the subject matter, so that the knowledge system and the logic of science are preserved (Danilov, 1960). When setting the task, it is necessary to take into account the level of development of students in order to create real conditions for their fulfillment. However, the task must contain elements of novelty, otherwise the teaching will not advance students in their development.

It is natural that in the process of learning, modeling techniques inherent in physics are studied spontaneously. But a much greater effect is achieved when the main thing in student's activity is not just the acquisition of a certain amount of models used by physics, but their conscious targeted use in solving specific problems. Only that information that is somehow consonant with the needs of the learner undergoes mental processing. Therefore, when developing a strategy for studying the course of physics, we this circumstance was taken into the consideration.

The course of general physics has great potential for the formation of the ability to build models, since the study of any physical phenomenon begins with the construction of its model.

The analysis of combining the study of a course in general physics with the study of methods for constructing models of physical phenomena and working with them was carried out using the case of the following specialties: "Power Engineering", "Industrial Engineering", and "Technologies in Catering Business". It turned out that this could be done without prejudice to the physics course itself, and even made it possible to make the course treatment more consistent and logical. In addition, the use of the modeling method in the study of physics allows to solve the main problems facing the course itself:

1) enables students to discover that the whole variety of natural phenomena and laws that describe them are permeated by general principles that are somehow contained in every phenomenon, law and which form the foundation of modern physics;

2) prepares students for the constant independent gaining new knowledge;
3) leads to an increase in the overall success of studies at a university. There are three ways to study a physics course: lectures, seminars, and laboratory precticals. Each of these types of classes performs its specific functions. At the lecture, students get acquainted with the basic concepts that form the foundation of their future physical worldview and are structural units in the construction of models; get acquainted with the methods of building models. If the lecture lays the foundation for scientific knowledge in a generalized form, practical exercises are designed to deepen, expand and detail this knowledge, they should form the most important skills that help to build models of physical phenomena. Laboratory practicals are designed to show how the model and the experimentally observed physical phenomenon are related (Nikandrov, 1971).

Such an approach to the construction of the course made it possible to organically combine the study of physics with the study of the method of modeling physical phenomena, move away from practice when it states "acquired knowledge, but does not mention who got it and how."

Assuming that the structure of the student's mental activity changes with the modeling technique directive training, we put forward the hypothesis to be tested that such directive training leads to an increase of the overall performance at a university, and this can be expected to affect the future practical work of an engineer.

Our hypothesis was experimentally tested at the Academic and Scientific Institute of Restaurant and Hotel Business and Tourism of Donetsk National University of Economics and Trade named after Mykhailo Tugan-Baranovsky (DonNUET). The specifics of this institute is that students, starting from the second year, are involved in the direct industrial activities of the DonNUET laboratories (from two days a week during the second year of Studying, to four in the fourth one). All students carry out term papers and graduation thesis related to the subject of the institute's laboratories, i.e. training is very closely intersected with their activities in the laboratory. Special courses for students are taught by engineers and researchers. All this allows us to judge the success of students' practical activities in laboratories by the performance of senior students. And this, as it seems to us, allows us to judge the success of their future independent activity as an engineer. To test this hypothesis, we analyzed the results of examinations of special physics courses by students of the institute. Among these special courses are theoretical physics, semiconductor physics, thin-film physics, nuclear physics, etc. The students of the experimental group got acquainted with the modeling method when studying a course in general physics, while students of the control group (60 people) were not trained in this method targetedly. It turned out that the overall progress in special physics courses of students studying the modeling method, all other things being equal (the same initial level – entrance exams, the same progress in mathematics, the same performance level in mechanics and engineering graphics), is higher than that of the students not studying the simulation method. Significant difference by Student's criterion at the level of a = 0.01.

The analysis of experimental data indicates that training in the method of modeling contributes to the success of training at a university and, apparently, will positively affect future activities of an engineer.

The ability to build models and work with them at the university is not specifically taught. This may be evidenced by a study carried out by Russian scientist N. Tretyakova. She conducted a survey of 120 graduates of technical universities of the country. While being asked the question "Do you know how to create models of physical phenomena?" only 20% of the graduates who participated in the survey answered positively, 80% of the graduates generally ignored the question. Of the 24 respondents, only 5 graduates noted the maximum skill (2 points), 8 rated their skill with a score of 1, and 11 graduates with a score of 0 (Tretyakova, 2019).

The results of our survey of researchers and engineers also indicate that the third-year students who come to internship have poor knowledge of modeling methods.

This skill can be taught during special courses in the process of performing professionally-oriented self-directed work of students, which provides interdisciplinary relationships and allows the effective use of simulation methods on computers of various design and technological processes.

An engineer has to apply his ability to build models in a wide variety of settings (starting with the ability to imagine the future behavior of an undeveloped machine and ending with the ability to imagine the behavior of an unformed team).

While analyzing the literature on the use of the modeling method in the educational process in higher education, it should be noted that there are practically no works that would consider the structure of the teacher's activities, ensuring the development of one of the students' basic general engineering skills – the ability to model various processes and phenomena.

The ability to model the behavior of a system is associated with a certain ratio of figurative and verbal components of thinking. In the psychology of thinking, there is a lot of data testifying the active role of figurative components in mental activity (I. Akimova, B. Ananyev, Z. Dedovets, V. Fedoseev, O. Malykhin, M. Rodionov, G. Shabanov and others). Studying their specific relationship for engineers of different specialties is an independent research task, but for all engineers it is necessary to have a universal set of spatial images (vectors, graphs, potential reliefs, etc.), which are the language of engineering problem analysis. Therefore, in a technical department of university in the process of selecting and constructing educational information, it is necessary to pay special attention to the development of figurative patterns among students (Rodionov, Fedoseev, Dedovets, Shabanov, & Akimova, 2018).

To form professionally significant skills among students, the teacher needs to develop a long-term exposure program. Modeling of the expected results and the development of a teacher's activity strategy involves, first of all, determining the appropriate pedagogical influences. The requirements for the teacher are specified as requirements for his ability to select, systematize and state educational information, which is the material of the mental activity of students in the process of cognition. We adhere to a point of view that considers thinking as a reversible translation of information from the language of images of different levels of generalization into the language of sign systems (B. Ananyev, A. Dorrer, T. Ivanilova, B. Sovetov, S. Yakovlev etc.). The most optimal way of presenting educational information is to correlate figurative and verbal units of the model in accordance with the process of converting information received by a person. Therefore, ***the teaching methodology should be based on the development of figurative patterns, methods of coordination of figurative and verbal structures***. It is known that imperfect methods of activity of a teacher form imperfect ways of activity of students. In addition, the progress in mastering the methods of cognitive activity is determined by the type of training in which these methods are learned. Therefore, first of all, it was necessary to study the lecture activity of the teacher on the formation of students' ability to model physical phenomena. T. Kuchina developed a map for monitoring the activities of the teacher. The following was recorded in the map during the lecture:

1) the form of the problem statement, which will be discussed in lectures;
2) the preferred form of the lecture deliverying;
3) types of visual aids used by the lecturer;
4) types and number of images used in the class;
5) operations performed on images (rotation, overlay, shift, etc.);
6) the use of techniques for working with the model related to the figurative part;
7) a form for discussing the results of lectures, etc. (Kuchina, 1984).

It turned out that in the sample of 57 physics teachers from different universities of the country (90% of them are professors and associate professors, 83% of teachers had more than 10 years of teaching experience, 92% - with more than 10 years of research experience), two groups of teachers stood out. Group A (40% of the teachers in our sample) uses a combination of figurative and verbal forms of information and Group B (60% of teachers) – the presentation is mainly in verbal form.

Research results

Consideration of the grouping the teachers by length of lecture work revealed the following.

In group A there are no teachers with a lecture experience of 5-10 years. The beginning of a new activity, entry into it is associated with the predominance of the figurative component of thinking, as the stereotype of the activity is developed, the presentation of educational information is increasingly verbalized. According to our observations, teachers with more than 5 years of lecturer experience often use verbally expressed images that do not detail figurative information. We can assume that as you master the course, the images do not disappear from the mental activity of the teacher, but acquire a convoluted, generalized character. The consideration of figurative thinking as one of the levels of mental processing and transformation of information is characteristic of modern concepts of thinking. Moreover, at each subsequent level there is a gradual compaction of information, an increase in the degree of its abstraction, generalization. With regard to the educational process, the lack of detailing of figurative information, the jump from a simple image to a generalized one without showing the dynamics of the image development should be attributed to the disadvantages of the lecture method, since this makes it difficult for students to understand the material presented.

Experience (long work experience) itself does not lead to structural changes in the activities of the teacher, characteristic of a productive type of activity (Kuchina, 1984). There are teachers with experience of over 10 years in both groups: in group A – 26%, in group B – 39%. The teachers of group A are characterized by a focus on the pedagogical activity along with the scientific one (46% of teachers), or on pedagogical (44%), while 67% of the teachers of group B are focused only on scientific activity. The interest in pedagogical work, the desire to do it, to achieve certain progress lead to the analysis of possible difficulties for students, the desire to generalize, systematize educational information, convey it to students using all available means. The existence of correlation between the orientation, the predominant form of presentation (1 = 0.71), the form of discussion of the results (1 = 0.71) can confirm this, and lecture experience also affects (1 = 0.76).

The results of the correlation analysis showed that the teachers of group B (half of them have university degrees) are characterized by the desire to theorize the presentation of the course of physics, which is manifested in the use of a significant number of formulas, images of imagination and mainly the verbal form of presentation. They are dominated by the didactic principle of science to the detriment of the principles of visibility and accessibility.

To find the optimal structure of the teacher's activities, providing students with the ability to model physical phenomena, T. Kuchina developed a scale of skill levels in this type of activity. This allowed to analyze and compare the structure of the activities of teachers of various skill levels (Kuchina, 1984).

The main differences were revealed in the constructive, design and gnostic components of the activity.

The greatest differences are revealed in the constructive skills of teachers of different skill levels. Master teachers take into account the peculiarities of perception and assimilation of educational information by students and, in accordance with this, design their presentation, are able to compose various task systems for students in order to form their basic general engineering skills, when presenting educational information, they widely use a combination of figurative and verbal forms of presentation, They know how to coordinate various forms of presenting this information well.

In the revealed structure of the skills of teachers of different skill levels, the main differences are associated with constructive skills, which are largely determined by the degree of development of figurative patterns. Therefore, in educational systems engaged in the training of teachers (universities, pedagogical universities), it is necessary to pay special attention to the development of constructive abilities, constructive skills of future teachers. An analysis of problem solving by graduates of the Academic and Scientific Institute of Restaurant and Hotel Business and Tourism of Donetsk National University of Economics and Trade named after Mykhailo Tugan-Baranovsky (50 people) showed that tasks that require passing from one image using conceptual processing to another caused the greatest difficulties (the progress rate was 18%), while the problems solved at the verbal level (formula level) did not cause difficulties (the progress rate was 79%).

Conclusions

Our observations over the methodology of lectures and practical classes delivering by teachers who successfully form the basic general engineering ability of students to model physical phenomena showed that the distinctive features of their information design activities are: the use of review lectures using educational television to show a system of models with an emphasis on the development of images; problematic lectures organization (moreover, the creating of a problematic situation at the lecture is applied both in the figurative and verbal part of the model).

Thus, at present, modeling has become a general scientific tool of cognition, so future engineers, and especially research engineers, must be knowledgeable about modeling techniques.

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