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EXPERIMENTAL STUDY OF THE EFFICIENCY OF USING THE SYSTEM OF LEARNING PROBLEMS IN MACHINE SCIENCE

Abstract. *The criterion and indicators for assessing students' cognitive interests are described, as well as the program and methodology of the pedagogical experiment conducted at the Mykhailo Kotsiubynskyi Vinnytsia State Pedagogical University. The level of understanding of the essence of technical phenomena in the mechanical drive of a technological machine is proposed as a criterion for assessing the cognitive interests of future technology teachers. A list of control questions was developed to use the criterion indicators during the pedagogical experiment. At the formative stage, the experimental group used a system of educational tasks in mechanical science to organize the workshop, developed in accordance with the model of training a mechanical engineer as a reference user of technology. The results of the pedagogical experiment confirmed the effectiveness of using the system of educational tasks in mechanical science for the formation of students' literacy for all in mechanical science.*

Keywords: *pedagogical experiment, ascertaining stage, formative stage, control stage, evaluation criterion, criterion indicators, nonparametric statistical method of the Wilcoxon Signed - Rank Test.*

“Technical knowledge is knowledge of the properties and processes used in the conditions of artificially created systems ..., as well as knowledge of the ways of materializing this knowledge” [3, p. 13]. The above characteristics of technical knowledge clearly show that its content depends on the type of artificially created system, but future technology teachers are not involved in the creation of artificial systems, therefore, the study of mechanical science based on the model of training a design engineer [1] has been confirming its low efficiency for many years. According to the requirements of the State Standard of Basic Secondary Education and the New Ukrainian School, technological education must ensure that schoolchildren understand the general laws of the structure and use of technical devices [4]. In our opinion, this can be achieved if, for the study of mechanical science by future technology teachers, an adapted model of training a mechanical engineer as a reference user of technology is used. Adaptation consists in setting a restrictive framework for the volume of educational material and activating the process of learning the basics of mechanical science by future technology teachers through the use of a system of educational tasks in mechanical science in a workshop on the educational discipline "Working Machines".

To assess the effectiveness of using a system of educational tasks in mechanical science in the process of training future technology teachers, it is necessary to determine criteria and indicators as means of assessing students' learning outcomes and conduct a pedagogical experiment. It is known that the criterion reveals what is being evaluated, and indicators reveal the qualitative and quantitative characteristics of the measuring characteristic (how the criterion is measured). The system of educational tasks in mechanical science developed by us, when used in the educational process, activates the cognitive activity of students in the direction of acquiring knowledge about technical phenomena in the mechanical drive of a machine [1]. In the process of developing educational tasks, we identified the key features of these technical phenomena.

It is known that familiarization with technical devices occurs by studying their morphological and functional descriptions [1; 5]. The basis of the descriptions of the morphology of technical devices is the essence of the technical solutions (inventions) used in their design. In the technical phenomena of the mechanical drive of machines, two basic technical solutions are used - the use of typical mechanical gears and the inventive method of combining the geometric dimensions of their driving and driven elements [2]. Accordingly, we have chosen the nature of understanding the essence of technical solutions that implement technical phenomena as the criterion for assessing students' cognitive interest. The indicators of the criterion will be: the technical content of the proportions of the dimensions of the elements of mechanical gears; the essence of the technical phenomenon of the bicycle transmission; the ability to creatively use the acquired technical knowledge. The level of initial understanding by students (before using the system of educational tasks in mechanical science in the educational process) of the essence of technical phenomena in the drive of machines, as well as their final understanding (after students complete a practical course on solving the system of educational technical tasks) was assessed using a list of control questions. It consists of two modules, namely: “Qualitative characterization of technical phenomena in machine drive” and “Quantitative characterization of technical phenomena in machine drive.” Here is the content of the checklist.

Module 1. Qualitative characteristics of technical phenomena in the drive of machines.

Technical phenomenon of the transmission of rotational motion over a distance. What mechanical gears are used in the drive of a machine if the rotational motion is transmitted between parallel shafts, and then between shafts whose axes of symmetry intersect? What is the kinematic chain of the machine drive? Where is the beginning and end of the kinematic chain of the machine drive? Why is the belt transmission placed at the beginning of the mechanical drive of the machine, and not at its end?

Technical phenomenon of the change in angular velocity. What is the relationship between the change in the diameters of the driving and driven wheels of a cylindrical gear transmission and the change in the angular velocity of the driven shaft? When does a cyclist pedal faster on a bicycle with a gearshift mechanism? When does a cyclist pedal slower on a bicycle with a gearshift mechanism? Why does a road bicycle transmission have a large diameter driving sprocket and a small diameter driven sprocket?

Technical phenomenon of the change in torque. Using a technical solution, the amount of torque on the driven shaft increases? Using which technical solution, the amount of torque on the driven shaft decreases? How does the amount of torque on the driving wheel of a bicycle change if, after switching gears, the cyclist began to pedal faster? How does the amount of torque on the driving wheel of a bicycle change if, after switching gears, the cyclist began to pedal slower?

Module 2. Quantitative characteristics of technical phenomena in the drive of machines.

Technical phenomenon of transmitting rotational motion over a distance. Describe the options for the kinematic chain of the machine drive if, with a gear ratio of 35, it is necessary to use a worm gear or a combination of cylindrical gears. What number of connected cylindrical gears ensures that the direction of rotational motion of the driven shaft is the same as the direction of rotational motion of the engine? How many bevel gears are there in the kinematic chain of a machine drive, in which the rotational motion first moves away from the engine position and then returns back to the engine position? In the condition of the problem, the “black box” has one drive shaft at the bottom and two parallel driven shafts at the top. What mechanical gears are in the “black box”?

The technical phenomenon of changing angular velocity. In a cylindrical gear, the diameter of the drive wheel is twice as small as the diameter of the driven wheel, how does this technical solution affect the angular velocity of the driven shaft? In a cylindrical gear, the diameter of the drive gear is 5 times larger than the diameter of the driven gear, how does this technical solution affect the angular velocity of the driven shaft? In a road bicycle, the diameter of the drive sprocket is 2.5 times larger than the diameter of the driven sprocket, how does this technical solution affect the angular velocity of the bicycle wheel? In a mechanical drive of a machine, it is necessary to reduce the angular velocity by a factor of 15. What combination of mechanical gears can achieve this?

Technical phenomenon of torque change. In a cylindrical gear transmission, the diameter of the driving wheel is twice smaller than the diameter of the driven wheel, how will the value of the torque of the driven shaft change? In a cylindrical gear transmission, the diameter of the driving gear is 5 times larger than the diameter of the driven gear, how will the value of the torque of the driven shaft change? In a road bicycle, the diameter of the driving star is 2.5 times larger than the diameter of the driven star, how will the value of the torque on its driving wheel change? In a mechanical drive of a machine, it is necessary to increase the value of the torque by 15 times. What combination of mechanical gears can achieve this?

It is known that the basic indicators of the formation of students' cognitive interest are performance, activity, independence, emotional response [4]. However, there is a cause-and-effect relationship between the degree of understanding of the educational material by students and their activity, independence and positive modality of emotions in the learning process. This explains why, at the formative stage of the pedagogical experiment, we chose the indicators of the criterion of students' understanding of technical phenomena in the mechanical drive of a machine as a means of assessing the formation of their cognitive interest. The criterion we chose belongs to the cognitive type. We did not consider such types of criteria for the development of students' cognitive interest as motivational, activity, and reflexive due to the noticeable impact on the psycho-emotional state of students and the learning process in general of martial law in Ukraine and the mass terror of the invaders against Ukrainians throughout the territory of the state. Also, due to the decrease in the prestige of the work of a teacher of labor training and technologies in the public consciousness, the number of students studying in this specialty has sharply decreased. Therefore, we decided to limit ourselves to a small sample size using the non-parametric statistical method of the Wilcoxon signed-rank T-test to process the data set collected during the pedagogical experiment.

Thus, at the ascertaining stage, using a list of control questions, we determined the actual state of understanding by students of basic technical phenomena in the mechanical drive of a machine and based on the results selected the experimental and control groups. At the formative stage, the practical training in the academic discipline “Working Machines” in the experimental group was organized using a problem-based approach according to the model of training a mechanical engineer, and in the control group without a problem-based approach according to the traditional model of training a design engineer [1]. At the control stage, the list of control questions was again used and the array of data collected in the experimental and control groups before and after the formative stage of the pedagogical experiment was processed. As a result, the ranks between the pairs of data “before and after” were determined, the positive and negative ranks were summed up and the T_{emp}-criterion (the smaller sum) was compared with the tabular value of the T_{crit}-criterion. Since the inequality $T_{emp} \leq T_{crit}$ was fulfilled in our case, the differences in the results of the experimental and control groups are statistically significant.

Thus, the change in the concept of training future technology teachers from the design engineer model to the mechanical engineer model has confirmed its effectiveness in forming literacy for all in mechanical science. Further research should be directed at developing a methodology for using a system of educational tasks in mechanical science to organize design and technological activities of secondary school students in the process of specialized training.

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