

Feature of Engineering Training for Future Technology Teachers

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Abstract- A study of the ideas of future technology teachers about technical phenomena in machines showed that their interpretations are unsuitable for organizing the educational process of studying the basics of technology by students. Accordingly, they will not be able to orient lyceum graduates to engineering education. The purpose of this study was to form the interest of future technology teachers in the adapted content of engineering training, suitable for organizing specialized training of lyceum students in studying the basics of technology. The levels of cognitive interests of students were assessed according to qualitative criteria: cognitive activity, nature of interest, independence, nature of use of free time, method of overcoming cognitive difficulties. Quantitative data were collected using questionnaire and testing methods. The null hypothesis of the absence of significant differences in the level of change in students' cognitive interest in technical phenomena was not confirmed in the experimental group, but was confirmed in the control group. The results of this study are important for developing university work programs. The practical value of the research results for the training of students of non-technical specialties lies in defining the concept of a technology user for ideological knowledge about machines. The potential international value of the research results lies in defining technical phenomena in machine drive as a basic concept for the formation of a technical worldview.

Keywords- *engineering training, ideological knowledge about the technological machine, interest in technical phenomena, technology teacher.*

I. INTRODUCTION

The content of engineering training of future teachers of technology in Ukraine is irrelevant to the tasks of their professional activity, so students are not interested in the formation of engineering competence. This fact is a reflection of the inertia of the system of technological

education of schoolchildren. To form the content of engineering training of future teachers of technology, the concept of a holistic view of the production process from the last century is used. Accordingly, in the profile education of students, there is no study of the basics of technology and they do not form the ability to self-determination regarding training in the engineering specialty.

The concept of a holistic view of the production process determined the choice of the curriculum for the training of a design engineer in the mechanical engineering industry as the basis for the formation of engineering training of a future teacher of technology. In fact, the requirement that technical knowledge be used by future teachers of technology to solve pedagogical tasks in the technological education of students is neglected. Accordingly, in Ukraine, the content of technical science is differentiated according to two types of technical training of students - general technical and machine-learning. General technical training of students is the basis for the formation of machine learning training. So, in practice, engineering training of future technology teachers is considered a synthesis of general technical and machine learning training. We studied the aspect of improving machine learning training of future technology teachers. Since there is an interrelation between these types of technical training, general technical training will also be subject to reconstruction, but in further studies of this problem.

The object of the study was the process of engineering training of future teachers of technology. The subject of the study was the cognitive interest of students in technical phenomena in the machine drive. The purpose of the study was to use the method of solving technical problems to form the cognitive interest of students. The basic component of the didactic conditions for the formation of students' cognitive interest was the innovative content of

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technical knowledge about technological machines, which corresponds to the cultural and axiological methodological approaches [1; 2; 3]. The main idea of these approaches was to study technological machines as artifacts of material culture and to form a technical worldview in students as a means of orientation in social values. Thus, engineering training of future teachers of technology should be used in their professional activities to organize the study of the basics of technology by students in order to make a decision to study engineering specialties [4; 5]. The results of scientific research by C. Mitcham on the feasibility of using information projects about technical phenomena in technical objects in student education were also taken into account [6].

In previous studies, we justified the choice of the drive of a technological machine as a source of generalized knowledge about the physical foundations of the functioning of any machines [7]. A general idea of a technological machine was expediently obtained by studying the essence of such basic technical phenomena: motion transmission in space, change in kinematic parameters of motion, change in force parameters of motion. Our further studies were aimed at analyzing the curriculum for training a mechanical engineer as a support for selecting the content of technical knowledge about a technological machine for future technology teachers [8]. A future technology teacher is a user of technological machines, not a developer, therefore the activities of a mechanical engineer were considered by us as a standard of a technology user. The effectiveness of studying the basics of technology by students of non-technical specialties according to the user concept was reported in the study by J. Kropats [9]. M. Barak et. al argued that generalized knowledge about a machine is a description of the nature of the transmission of engine power to its working body [10]. According to E. Crawley et. al knowledge about the energy patterns of the functioning of a technological machine is relevant to the content of the process of its operation [11]. S. Purzer et. al came to the conclusion that engineering knowledge about the patterns of the functioning of the drive of a technological machine is available for assimilation by schoolchildren [12]. M. Marusic et. al recommended forming students' cognitive interest in technology on the basis of worldview knowledge, the core of which will be generalized knowledge about the machine as a trigger of conscious self-determination regarding training in engineering specialties [13]. The hypothesis of the study was the assumption that cognitive interest in technology in future technology teachers will be formed under the condition of organizing practical classes in the academic discipline "Working Machines" as a process of solving a system of educational tasks about technical phenomena in the drive of a machine. Accordingly, the following research tasks were set: to develop a system of educational tasks about technical phenomena in the drive of a technological machine; to develop a program and methodology of a pedagogical experiment; to conduct a pedagogical experiment to confirm or refute the working hypothesis of the study.

II. MATERIALS AND METHODS

V. Lamanuskas considered the technological education of schoolchildren as a means of their spiritual and social development, and not only as a means of forming design and technological competence in them [22]. We consider the knowledge of the essence of modern professions as a means of social development of schoolchildren. The social development of schoolchildren will contribute to their self-determination about further education in engineering specialties. To do this, it is necessary to reconstruct the traditional content of engineering training of future technology teachers. Future technology teachers must be able to interest schoolchildren in the profession of an engineer. The trigger for professional self-determination of schoolchildren should be cognitive interest in generalized knowledge about a modern machine. Generalized knowledge about a machine characterizes any type of machine. They are the result of integrating knowledge of mechanics with the content of engineering training of future technology teachers.

We began the search for generalized knowledge about the machine by changing the traditional concept of forming a holistic idea of the production process to the concept of a user of equipment [7; 15]. The traditional concept of a holistic view of the production process for future technology teachers considers the technological operation as its smallest component. They try to achieve integrity by forming in students the ability to describe a specific technological process as a set of interconnected technological operations. The innovative concept of the user of technical devices (equipment) considers mechanical motion as the smallest content element about technical devices. A holistic view of any type of modern machine is proposed to be achieved by forming in students the ability to describe the transformation of mechanical motion parameters on the way from the engine to the working body.

We considered the mechanical engineer as a reference user of equipment, capable of competently operating, servicing and repairing it. The content of engineering education of future teachers of technology was reoriented from a holistic idea of the production process to a holistic idea of the machine as an implemented technology of using engine energy to perform useful work. To confirm or refute the assumption that the new content of the educational material for the organization of engineering training of future teachers will contribute to the formation of cognitive interest in machines in them, a program and methodology of a pedagogical experiment were developed.

The pedagogical experiment was attended by 25 third-year students of the Mykhailo Kotsiubynskyi Vinnytsia State Pedagogical University, who are studying in the speciality 014.10 "Secondary Education (Labor Training and Technologies)". Among them, 15 (60%) were female, 10 (40%) were male, the age of women and men was 19 years. Over the course of two years, two series of the pedagogical experiment were conducted, each lasting 16 weeks, and the total array of experimental data was processed using mathematical statistics methods at the beginning of 2025. The total volume of the database, two series of the pedagogical experiment, covered 95% of the

total population of third-year students of the speciality 014.10 "Secondary education (Labor training and Technologies)" of the Mykhailo Kotsiubynskiy Vinnytsia State Pedagogical University. To assess the reliability of the shift in the levels of students' cognitive interests, taking into account the small sample size, the non-parametric G-criterion of signs (McNemar's test) was used [14]. It is used to compare the results of two small samples. In doing so, the following actions are performed: calculate the arithmetic means of the two samples; formulate statistical hypotheses; record the indicators for each respondent at the beginning and end of the experiment; compare the indicators and assign the appropriate signs (+, 0, -); calculate the empirical value of the sign criterion; find the critical value of the sign criterion from the table; test the statistical hypotheses.

At the ascertaining stage of the pedagogical experiment, an array of experimental data was collected using the questionnaire method (criterion of students' understanding of the purpose of transforming the parameters of mechanical motion in a machine). At the formative and control stages of the pedagogical experiment, an array of experimental data was collected using the methods of observation, conversation, testing and questionnaire. The following characteristics were assigned to the actual levels of development of students' cognitive interests: low level (-), medium level (0), high level (+). The level of formation of students' cognitive interests was assessed by the following qualitative characteristics: cognitive activity (criterion of the nature of questions and going beyond the curriculum), the nature of cognitive interests (criterion of interest stability), independence (criterion of seeking advice), the nature of the use of free time (criterion of the amount of free time spent), the way of overcoming cognitive difficulties (criterion of the nature of prompts). The transition from qualitative indicators to quantitative ones was carried out according to the following interval scale of cognitive interest levels: +3 ... +5 - high level; +2 ... 0 - medium level with a predominance of active cognitive interest; 0 ... -2 - medium level with a predominance of passive cognitive interest; -3 ... -5 - low level of cognitive interest.

To test the working hypothesis of the study, the method of solving educational technical problems was used in practical classes on the academic discipline "Working Machines". A system of types of educational technical problems was used. The following types of educational technical problems were used: to understand the essence of technical phenomena in the machine drive; to analyze technical phenomena in the machine drive; quantitative problems about the gear ratio; problems for constructing kinematic diagrams of gearboxes with missing elements in their condition; problems for constructing kinematic diagrams of gearboxes according to the spatial arrangement of the driving and driven shafts. The system of educational technical tasks directed the educational and cognitive activity of future technology teachers in a deductive direction from the essence of technical phenomena in the drive of machines to technical solutions of elements of power chains (reducers, gearboxes, feed boxes) and from

technical solutions of individual elements of power chains to technical solutions of power chains (main motion drives and drives of feed motion of metalworking machines, transmissions of cars). The sequence of using the types of educational tasks we chose allowed us to form and develop in students the components of technical thinking, in particular, technical knowledge integrated with elementary knowledge of mathematics and physics; operating with knowledge of technical phenomena in the drive of machines; operating with graphic images of elements of kinematic schemes; operating with knowledge of technical phenomena in the drives of machines in combination with images of elements of power chains of machine drives; operating with images of elements of power chains of machine drives, if the condition of the technical task does not have enough data for its solution.

III. RESULTS AND DISCUSSION

The results of assessing the actual levels of cognitive interests of third-year students of Vinnytsia State Pedagogical University named after Mykhailo Kotsiubynskiy in technical phenomena in the drive of machines at the beginning of studying the academic discipline "Working Machines" (stage of the ascertaining experiment) are given in Table 1.

TABLE 1 LEVELS OF COGNITIVE INTEREST OF STUDENTS

Years	The Number of Students According to the Level of Cognitive Interest, %			
	<i>Strong</i>	<i>Medium, with active interest prevailing</i>	<i>Medium, with passive interest prevailing</i>	<i>Low</i>
2023 - 2024	12	24	32	32
2024 - 2025	16	16	36	32

The analysis of the obtained results confirmed the fact of the presence of low and medium with a predominance of passive levels of cognitive interest of students in the study of technical phenomena in the drive of machines. We interpreted the obtained results as a lack of understanding by students of the potential opportunity to use technical knowledge in their future professional activities for the organization of student education. The homogeneity of the obtained results in two series of the ascertaining stage of the pedagogical experiment gave us grounds to divide the sample into experimental and control groups. In two series of the formative stage of the pedagogical experiment, practical classes in the academic discipline "Working Machines" in the experimental group of students were conducted using the method of solving educational technical problems developed on educational material of innovative content, and in the control group of students, a traditional methodology based on the educational material of the concept of a holistic view of the production process was used. To analyze the experimental array obtained at the formative stage, the method of calculating the G-criterion

of signs was used; the results obtained are given in Table 2 and Table 3.

TABLE 2 COGNITIVE INTEREST SHIFT

Groups	The Number of Students According to the Level of Cognitive Interest, persons											
	Strong			Medium, with active interest prevailing			Medium, with passive interest prevailing			Low		
	Shift			Shift			Shift			Shift		
	+	-	0	+	-	0	+	-	0	+	-	0
EXP			1	4		1	3	1		2		
CTR			1	1	2	2	2	2	1	1		1

TABLE 3 CALCULATION G-CRITERION

Groups	Total			G _{EXP}	Without the Zero Shift	G _{CRIT}
	+	-	0			
EXP	9	1	2	1	10	3
CTR	4	4	5	4	8	3

The inequality $G_{EXP} \leq G_{CRIT}$ served as a criterion for refuting the null hypothesis of the absence of changes in the levels of cognitive interests of students and, as evidenced by the results of the pedagogical experiment for the experimental group, it was refuted (Table 3). For the control group, the null hypothesis was confirmed (Table 3).

To theoretically substantiate the obtained quantitative results, we conducted an in-depth analysis of literary sources, and also studied the current state of engineering training of students of non-technical specialties, during which it was found out that for a long time in Ukraine the task of changing the content of engineering training of future teachers of technology was not set. Researchers did not pay attention to the fact that when training future engineers, the method of solving technical problems is used in the context of designing, constructing, manufacturing, and operating technical systems, and when training future technology teachers, this method is used in the context of forming technical literacy in schoolchildren as a trigger for conscious self-determination regarding further education in the engineering specialty.

Mechanical transfer to higher pedagogical education institutions of Ukraine of the content of engineering education based on the curriculum for training an engineer-designer in the mechanical engineering industry has not found practical use. The production process as a complex object of study for students cannot be used by future technology teachers to form the technical literacy of students. The first step to solving this problem was the division of engineering training of students into two categories - classical engineering training and engineering training in non-technical specialties (for example, future technology teachers) [16; 17]. That is, the focus is changed from the production process to the means of production. Then the means of production are narrowed down to the machine as its main component. However, the machine is

also a complex object for students to study, so the generalized functional scheme of the machine was studied, namely: engine - transmission - working body [7]. It was taken into account that the generalized functional scheme of the machine is an attribute of any technological machine, regardless of the technical solutions used to transfer energy from the engine to the working body.

The correct orientation for students in the world of technology is one of the main didactic conditions for the formation of cognitive interest in machines [18; 20]. The generalized functional scheme of the machine was chosen as a reference point. An analysis of studies on the generalized functional scheme was carried out. In particular, the conclusions of D. Broo et. al that in engineering education there is a convergence of various academic disciplines [1], the reason for this is that C. Hampton et. al characterized technical science as the border between natural sciences and humanities [17]. Van den Beem et. al argued that the nature of modern engineering education is clearly interdisciplinary [2]. The recommendations of researchers on the essence of the formation of technical knowledge in students were also taken into account. For example, the statement of S. Lottero-Perdue & Lachapelle et. al that technical knowledge is a means of solving the pedagogical task of diagnosing and forming students' abilities for engineering activities, as well as for the formation of students' technical thinking [15]. J. Pleasants et. al considered the concept of the user of technology as the basis for the formation of students' technical literacy [19], and J. Kropach used it for engineering training of students studying non-technical specialties [9]. S. Tzeng et. al recommended the content of educational material about technology for students with a low level of difficulty [18]. There are alternative recommendations that students' ideas about technology are formed in the process of obtaining technological education [8; 21], as well as V. Lamanuskas, that the basis of the organization of the educational process of studying technology is a competency-based approach [22].

Students' answers to the questions of the open questionnaire showed that for the first question there is a connection between understanding the content of the question and interest. The second question of the open questionnaire assessed students' interest in changing the power parameters of the chain transmission by a cyclist when moving uphill. The results showed a predominant influence on students' interest of life experience at the beginning of the pedagogical experiment. The third question of the open questionnaire assessed students' interest in the cyclist changing the kinematic parameters of the chain transmission when going downhill. Here, the predominant influence on students' interest was also recorded by life experience at the beginning of the pedagogical experiment. In the fourth question of the open questionnaire, students determined the correct placement of the principle of engagement and the principle of friction in the power chain of the mechanical transmission drive. At the beginning of the pedagogical experiment, this question was irrelevant, but at the end of the pedagogical experiment it changed its status. In the fifth question of the open questionnaire, students analyzed the kinematic diagram of

a worm gear and the kinematic diagram of a passenger elevator drive for the presence of the fractal property. The question turned out to be irrelevant and changed its status only at the end of the pedagogical experiment. In the sixth question of the open questionnaire, students had to explain why a cyclist increases the pedal rotation frequency when going uphill. The results of the answers showed the predominant influence on the interest of students of life experience at the beginning of the pedagogical experiment. In the seventh question of the open questionnaire, students were asked to determine the rate of fatigue of cyclists riding bicycles with wheels of large and small diameters. The results of the answers showed the partial irrelevance and influence on the interest of students of life experience at the beginning of the pedagogical experiment. In the eighth question of the open questionnaire, there were images of devices with which a bicycle is used for a new purpose, and students chose the correct combination of a bicycle and a device. At the beginning of the pedagogical experiment, the question was irrelevant, but at the end of the pedagogical experiment it changed its status. During the pedagogical experiment, tests were also used to continuously monitor the level of students' knowledge about technical phenomena in the drive of a technological machine as a means of assessing knowledge.

The results confirmed the feasibility of studying technical phenomena in machine drives by future technology teachers as generalized knowledge about machines. When organizing practical classes in the academic discipline "Working Machines" for future technology teachers based on the method of solving educational technical problems, the disadvantages included the presence of mosaic knowledge about technical phenomena in machine drives among some students. The feasibility of using the concept of a technology user to form engineering training for future technology teachers based on the curriculum for training a mechanical engineer as a reference user of technology was confirmed. The shift in the indicators of students' cognitive interest in the innovative content of engineering knowledge indicates the possibility of forming readiness for organizing the educational process of studying the basics of technology by students as a trigger for their conscious choice of future education in an engineering specialty.

The use of the concept of the user of technical devices in the process of solving educational tasks helped to interest a significantly larger number of students in the essence of modern machines. Therefore, we can talk about the effectiveness of the author's developments. At the same time, the main drawback, in our opinion, is the increase in the level of complexity of students' mental actions. Not all educational tasks in the pedagogical experiment performed the heuristic function of revealing the essence of the educational material. Accordingly, students made additional mental efforts to understand the conditions of educational tasks and find ways to solve them.

To interest schoolchildren in the profession of an engineer, in our opinion, teachers need to focus on the profession of a mechanical engineer. The basis of the performance of functional duties by a mechanical engineer

is generalized knowledge about any type of modern machine. To reduce the level of complexity of schoolchildren's mental actions, teachers need to integrate project methods and solving educational problems. Educational project activities of schoolchildren will perform the function of heuristics in the approach we propose.

IV. CONCLUSIONS

This study fills the existing gap in the literature on the use of cultural and axiological approaches to selecting the content of engineering knowledge in teaching students of non-technical specialties. Demonstrates their implementation to interest future technology teachers in knowledge about machines in the educational process organized using the method of solving educational technical problems. Students not only gain a deep understanding of technical phenomena in the machine drive, but also develop the ability to use educational technical problems to organize the process of studying the basics of technology by senior students.

The results of the study show that students whose engineering training was formed on the basis of the innovative content of the educational material demonstrated a higher level of cognitive interest in knowledge about machines, compared to those who were trained according to the traditional content of training according to the curriculum for the training of a design engineer in the mechanical engineering industry. The innovative content of knowledge about machines in the process of engineering training of students of non-technical specialties is a component of didactic conditions for the formation of cognitive interest in basic engineering in them. For future technology teachers, the process of forming an interest in the basics of technology should be integrated with their preparation for organizing specialized education of senior school students. The importance of such content of engineering training of future technology teachers is emphasized so that its results are relevant to their professional tasks. It is established that the new content of engineering training of future technology teachers is determined by the curriculum of training a mechanical engineer as a reference user of technology. To implement the concept of a user of technology, it is advisable to use a description of a generalized functional scheme of a machine with the basic concept of "technical phenomena of machine drive". In addition, this study encourages the formulation of a new task to determine the effectiveness of using innovative content of knowledge about machines for the development of technical thinking of future technology teachers. It is appropriate to recognize that a small sample size does not sufficiently represent the entire general population of future technology teachers in Ukraine. Future studies will need to use a blended learning or STEM education approach, a longer study period, and a larger sample size to fully assess the impact of the innovative content of educational material about machines on the development of cognitive interest in students of non-technical specialties. It is important that the content of engineering training of future technology teachers helps them solve professional tasks. The results of the study

provide grounds for their use in developing an improved work program for the academic discipline "Working Machines". The practical value of the concept of the user of technology for the formation of worldview knowledge about machines in students of non-technical specialties is established. The potential international value of the fact of choosing technical phenomena in the drive of a machine as a basic concept for the formation of students' technical worldview is revealed.

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