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INTEGRATION OF GENERAL TECHNICAL KNOWLEDGE IN PROFESSIONAL TEACHING OF TECHNOLOGY TEACHERS

Leonid Orshanski
Drohobych Ivan Franko State Pedagogical University, Ukraine

Tetyana Pantyuk
Drohobych Ivan Franko State Pedagogical University, Ukraine

Ivan Nyshchak
Drohobych Ivan Franko State Pedagogical University, Ukraine

Valeriya Milyaeva
Borys Grinchenko Kyiv University, Ukraine

Jaroslav Matvisiv
Drohobych Ivan Franko State Pedagogical University, Ukraine

ABSTRACT

The content filling of the educational field of «Technology» provides a deeper acquaintance of students with the modern achievements of technology, mastering the practice of design and technological activities. Bearing this in mind, it is topical to develop the scientific principles of engineering training for future teachers of labor training and technology, which led to theoretical substantiation and practical implementation of structural changes in curricula in general technical disciplines. The analysis of the scientific literature and practical experience shows that the proposed structure of the content of the integrated course «Engineering Mechanics» is aimed primarily at intensifying the students' cognitive activity, as well as their broad involvement in independent work on the design and construction of technical objects. Such circumstances favor direct impact on the content of engineering training of future teachers of labor training and technology linked to the global change in scientific approaches and innovative processes in the creation of technical facilities and also indirect – caused by the development of modern production and information technologies.

The article analyzes the current system of engineering training of future teachers of labor training and technology which is characterized by the reorientation of the educational process to the project-technological activity of students. The authors substantiate the necessity of integration of knowledge from the cycle of general technical disciplines in the content of engineering training of future teachers. Based on the didactic principle of continuity and taking into account the requirements of school curricula and cross-curricular relations with different disciplines of vocational training of teachers of labor training and technology, the authors propose the structure and content of the integrated course «Engineering Mechanics», which consists of the following sections: 1) «Statics, kinematics and dynamics»; 2) «Material resistance and machine parts calculation».

Keywords: *engineering training, general technical disciplines, engineering mechanics, design and technological activity, pedagogical institution of higher education, teacher of labor training and technology.*

INTRODUCTION

In the system of engineering training of teachers of labor training and technology the knowledge of mechanics plays an important role not only for acquiring knowledge of the fundamentals of statics, dynamics, types of deformations and calculation of machine parts but also for creating the basis for the study of other professional disciplines. It is the scientific basis of engineering training of teachers that constitutes a fundamental and systemic link in the formation of their professional knowledge and skills, which leads to the introduction of appropriate changes and adjustments in the content of educational disciplines of engineering-technical and practical-technological cycles.

At present, the development of content training for future technology teachers is based upon the ontological-didactic transformation of scientific knowledge into educational material, in the process of which the innovative knowledge is accumulated, modern achievements of some applied sciences, innovations in the field of science and technology while the changes in the content of labor training and priorities in the development of modern types of production are also taken into account. The integration of the content of separate subjects on the basis of applied use of educational material in practical activities ought to serve as the basis for the formation of the system of knowledge and skills in the process of engineering training of future technology teachers.

An analysis of the system of vocational training of this category of teachers in pedagogical universities shows that their level of engineering training is insufficient for the qualitative fulfillment of functional duties in the current environment, which are marked by reorientation of the educational process in the school towards design-technological activities. Thus, engineering training of future technology teachers at the educational and qualification levels of «Bachelor» and «Master» will improve significantly if the content of individual academic disciplines of the technical cycle integrates into the holistic content of engineering training of students and qualitative new educational and methodological complexes of similar courses where the principle of continuity and unity of the substantive and procedural sides of educational and cognitive activity of future teachers are created.

An important constituent of the vocational training of a teacher of labor training and technology is the engineering-technical component. Many researchers have focused their attention on this problem: O. Avramenko, A. Bilan, S. Honcharenko, V. Husev, Y. Hushulei, R. Hurevych, M. Korets, V. Kurok, O. Lavrentieva, V. Madzigon, V. Sydorenko, V. Steshenko, G. Tereshchuk, D. Tkhorzhevskyi, P. Yakovyshyn, S. Yashchuk and others. In

particular, S. Yashchuk revealed theoretical foundations for studying general technical disciplines in the process of master's training of future technology teachers (Yashchuk, 2015); O. Lavrentieva carried out a broad review of the content and thoroughly analyzed the key trends in the development of general technical training of students of technological and pedagogical specialties (Lavrentieva, 2017); A. Bilan considered theoretical and practical approaches to integrating the subjects of computer science and the cycle of general technical training, revealing their common content and methodological aspects (Bilan, 2018). However, despite their interest in the problem of creating an integrative course in engineering mechanics, many of its aspects did not find adequate coverage.

On the other hand, the analysis of the actual state of engineering training of future technology teachers has made it possible to outline a number of contradictions between the need of society to form a person capable of active and creative activity in the field of material production and educational services, and insufficient number of professionally-trained technology teachers as well as between the requirements of scientific and technological development of production and outdated system of engineering training of pedagogical workers in this category.

THE RELEVANCE OF THE PROBLEM OF STUDYING ENGINEERING MECHANICS BY FUTURE TEACHERS

Looking back at the history of vocational education, it should be noted that initially the knowledge of the field of mechanics was acquired by future teachers within the discipline «Engineering Mechanics», which was introduced into the educational process as a symbiosis of several disciplines in a somewhat shortened version, compared to the number of classroom hours at engineering-technical higher education institutions. We should not forget that the systematic training of teachers of labor education (technology) began in the late 1950s, which was conditioned by the adoption of the reform law of that time «On Strengthening the School's Relationship with Life and on the Further Development of the National Education System in Ukrainian SSR» (1959) (Zakon pro zmitsnennia vzaiemozviazku shkoly z zhyttiam ta pro podalshyi rozvytok systemy narodnoi osvity v URSR, 1959). Since early 60s, there were attempts at teacher training (pedagogical) institutes to mechanically unify different specialties like «Teacher of physics and technical mechanics», «Teacher of labor training, physics and electrical engineering», «Teacher of physics and basics of production». The training of engineering and teaching staff for the vocational education system was also launched. Labor education, as a separate specialty, was transformed with a certain change of qualifications and finally received the title «Teacher of vocational training and general technical disciplines», which corresponded to the name of the school subject.

In recent decades, there have been numerous scientific studies aimed at optimizing integrated knowledge of engineering disciplines, in particular technical mechanics, in the content of general technical training of future technology teachers (S. Honcharenko, 1999; M. Korets, 2015; V. Kurok, 2012; D. Tkhorzhevskyi, 1992). However, throughout the changes in the names of the specialties, the structure of engineering mechanics remained unchanged with the subject being not the only autonomous discipline before. For example, in the late 1990s, following the path of integrating the content of engineering disciplines for pedagogical specialties, such autonomous courses as «Theoretical Mechanics», «Resistance of Materials», «Theory of Mechanisms and Machines», «Machine Parts» were artificially combined into the integrated «Mechanical Engineering» course. In this period, with some approximation, the same scheme was studied in engineering mechanics in secondary specialized educational institutions – technical schools and colleges. Today, scientific research is underway to improve the methodology of teaching individual sections of engineering mechanics in accordance with this course structure. Therefore, it has become necessary to organically approximate the structure and content of engineering disciplines to the content lines, which are laid down in the State standard of basic and complete general secondary education within the educational field «Technology» (Derzhavnyi standart bazovoi ta povnoi zahalnoi serednoi osvity, 2011).

The curricula of the disciplines that can be attributed to engineering mechanics were undergoing constant changes in the number of hours and were consistently introduced into the educational process of higher education pedagogical institutions in 1970, 1981, 1987, 1998 and 2001. Moreover, in the first two curricula the course «Engineering Mechanics» did not belong to the cycle of professional preparation but to natural sciences. The first attempt to develop an integrated course in engineering mechanics was made by V. Kurok, in which she distinguished the following main sections: «Statics», «Kinematics», «Dynamics» and «Fundamentals of Machine Parts Calculation» (Kurok, 2012). For the greater part, the researcher made a bias on theoretical mechanics; therefore the classic names of its separate sections were preserved. However, the practical experience of teaching this discipline necessitated its improvement by making adjustments and additions without changing the integrative approach to the content development. The role of integrated knowledge of science and technology for future educators was reflected in numerous scientific works. They stated that due to the «integration of scientific and technical knowledge fundamentalization of pedagogical education takes place, which is realized through the combination of general educational and general technical cycles of professional training of future teachers» (Kurok, 2012, p. 69). Therefore, the scientific substantiation of the new approach to the integration of the content of the course «Engineering Mechanics» for students

studying under the educational-professional program «Labor Training, Technology and Computer Science» is beyond any doubt.

In the transition from the classical model to the four-stage training of technology teachers, the amount of hours spent on studying engineering mechanics decreased significantly and that tendency led to a decrease in the attention to engineering training of teachers. With the introduction of the two-staged teacher training after the national higher pedagogical education entered the Bologna process, engineering mechanics has been taught at second and third years of university because its knowledge is mandatory for graduates of educational and qualification level «Bachelor». In the previous curriculum, a dramatic reduction in the amount of hours for studying engineering mechanics led to the compaction of the content of this course on a rational principle, namely: not by eliminating separate issues and topics but in the form of concentration of educational information and based on expediency, which is determined by typical programs of school subjects «Labor Training» for students of grades 5 – 9 (Prohrama dlia zahalnoosvitnikh navchalnykh zakladiv: Trudove navchannia. 5-9 klasy, 2017) and «Technology» for students of grades 10 – 11 (Zahalnoosvitnia prohrama: Tekhnolohii 10 – 11 klasy (riven standartu)).

The analysis of the established fundamental definitions of engineering and mechanics shows the emergence of a single harmonious categorical field and definitions of modern innovative technologies. Without new technologies, it is impossible to create new technical appliances and their corresponding mechanics, and therefore the name of the integrated course «Engineering Mechanics», in our opinion, completely corresponds to its content. Engineering mechanics as a discipline has traditionally functioned in the system of general technical training of engineers and technicians and it existed in the period from 1991 to 1998 for the teachers of labor training, which was carried out in pedagogical schools, colleges, institutes and universities.

STRUCTURE OPTIMIZATION AND CONTENT INTEGRATION COURSE «ENGINEERING MECHANICS»

Today, machines and mechanical devices perform the major part of production processes. Their rational use is possible in case of steady awareness and understanding of the processes that take place in them. Therefore, it can be assumed that understanding of the structure and nature of a machine or mechanism is a social need of a modern technology society. It is the technology teacher who is called upon to form this knowledge in the students, which requires first and foremost a very high level of general technical competence from him.

The work of machines and mechanisms is studied by a large number of scientific, natural and general technical disciplines, so it is virtually impossible to cover the whole spectrum of knowledge about the machine. In the first stages

of integration, the course «Engineering Mechanics» used materials of the previous program in mechanical engineering and this was carried out according to the model, as shown in Fig. 1.

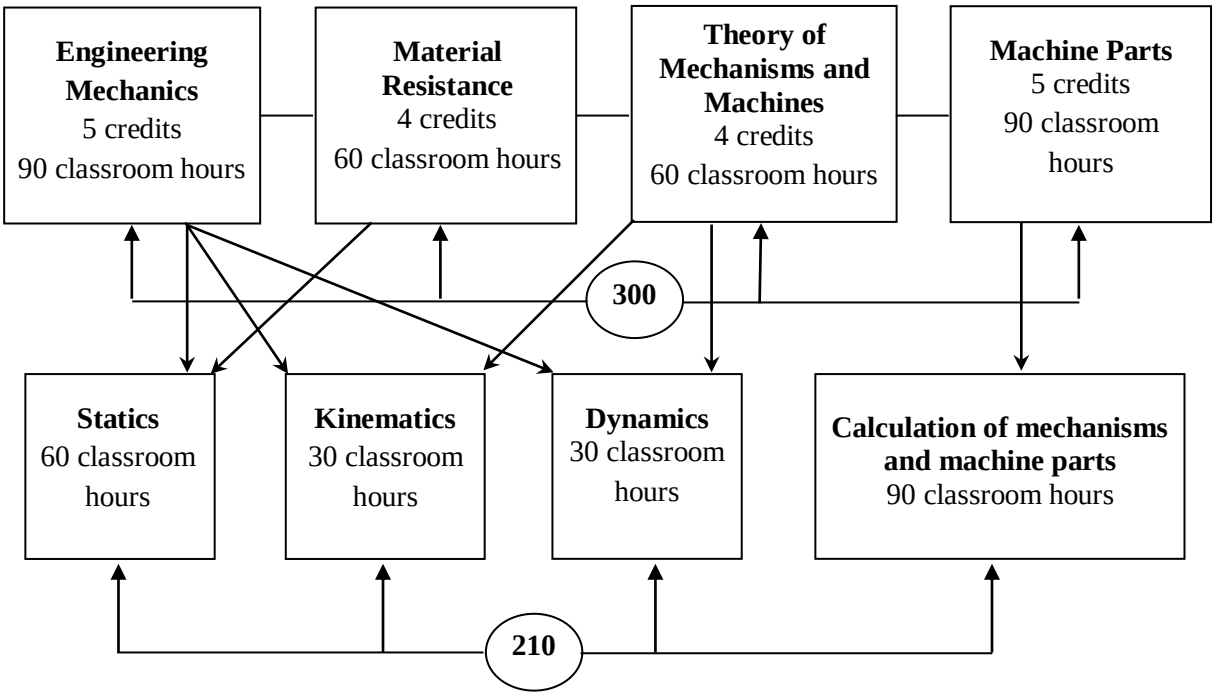

Fig. 1. ***Structural integration scheme of the discipline «Engineering Mechanics»***

This scheme eliminates the duplication of content in general engineering disciplines, so the integrated course «Engineering Mechanics» contains a set of general technical knowledge that is needed for the future teacher of labor training and technology to organize the educational process in the school.

The intermediate stage in the improvement of the program in engineering mechanics involved structural changes with the introduction of such sections as: statics of absolutely solid body; statics of complex systems; kinematics and dynamics; basics of machine parts calculation, etc. If we analyze the dynamics of the amount of hours envisaged for the study of engineering mechanics, then we see a tendency for their significant decrease (by 30%), which may indicate that the content of this discipline dropped out of attention or worse – it did not find its place in the system of professional training of teachers for the educational field «Technology». Reducing the amount of hours led to a superficial study of widely used mechanical transmissions and auxiliary elements and some of the knowledge was taken outside the curriculum and became a part of students' independent work. Therefore, a systematic analysis was carried out, which resulted in the obligatory list of topics to be studied and for research-calculation works, which allowed to deepen the knowledge, to form and consolidate the skills of development of technical objects.

The analysis of the school programs «Labor training» for students of grades 5 – 9 (Prohrama dlia zahalnoosvitnikh navchalnykh zakladiv: Trudove

navchannia. 5-9 klasy, 2017) and «Technology» for students of grades 10 – 11 (Zahalnoosvitnia prohrama: Tekhnolohii 10 – 11 klasy (riven standartu)) testifies in favor of the fact that the topics in this section are studied in depth in school teaching and production work-shops. Among them are the following issues: 1) general description of the parts of the mechanisms and machines used in technology; concept of parts and mechanisms; types of mechanisms; crank mechanism; 2) kinematic circuits, symbols on the circuits; 3) types of connections of machine parts; threaded connections; elements of thread; connecting parts with rivets; types of riveted connections the forces acting on the rivets and the condition of their strength; 4) mechanical gears (belt, screw and rail).

Engineering training requires the development of methods and didactic tools, the development of the creative potential of future technology teachers in the process of studying general technical disciplines. Modern pedagogical science has created a variety of teaching methods; however, in our view, we consider systematic the classification of teaching methods from the standpoint of the information approach to the educational process with the method of self-education and self-knowledge with the advisory assistance of the teacher being the most effective. Unfortunately, the educational process of mastering the content of technical disciplines does not always stimulate students' creative cognitive work. In addition, the course project, as one of the few forms of independent work of a practical nature, requires a creative approach to the application of the whole range of general technical knowledge. Performing design work encourages the student to systematize previously obtained scientific, natural, general and technical knowledge, which intensify educational-cognitive and creative activities aimed at developing a new technical object. On the other hand, creative approach to one's job is the main characteristic of a competent specialist. After all, living in a time of rapid development of new information technologies, it is inappropriate to use exclusively teaching methods. Therefore, the use of specialized computer programs should be the main method of accelerated study of the integrated course «Engineering Mechanics».

To this day, the main components of the integration of engineering mechanics were: statics of absolutely rigid body; statics of complex systems (resistance of materials); kinematics and dynamics; basics of machine parts calculations. They were studied from the 3rd till the 7th semester with applied mechanics completing the course in the 8th semester. After analyzing the state of teaching of general technical disciplines and taking into account many years of experience in this integrated program, we came to the following conclusions:

1) rename the section «Statics of absolutely rigid body» into natural «Statics» without changing its content and study in the amount of 2 ECTS credits;

2) continue to study the section «Kinematics and Dynamics» (2 ECTS credits);

3) combine the section «Statics of Complex Systems» («Material Resistance») with the section «Fundamentals of calculating machine parts» while maintaining the total amount of hours (4 ECTS credits) and call it «Resistance of materials with machine parts calculations»;

4) at the end of the course, incorporate some issues of applied mechanics as part of preparation for the course project (2 ECTS credits).

According to the curriculum for the preparation of teachers of vocational training and technology at the educational-professional (bachelor) level, 10 ECTS credits (300 hours) are allocated for engineering mechanics, which include 120 hours of classwork (30 hours of lectures and 90 hours of laboratory work). The course of engineering mechanics begins in the 3rd semester (2 hours a week) and ends in the 7th semester (1 hour a week). It is advisable to study separate sections according to the following scheme:

1) 3rd semester – 2 hours per week, of which: 2 hours – statics of solid objects (one hour of lectures and one hour of laboratory work); type of control – credit;

2) 4th semester – 3.5 hours, of which: 2 hours – kinematics and dynamics (2 hours of lectures and 1.5 hours of laboratory work); type of control – examination;

3) 5th semester – 1 hour, of which: 1 hour of lectures on material resistance and machine parts calculation; type of control – none;

4) 6th semester – 3 hours to continue studying the resistance of materials and machine parts calculations, of which: 1 hour of lectures and 2 hours – laboratory work; type of control – examination;

5) 7th semester – 2 hours to study selected issues of applied mechanics, of which: 1 hour – lectures and 1 hour – laboratory work; type of control – credit; design of technical objects (machines and mechanisms) – course project.

As we can see, due to the integration of the content, the total number of classroom hours for the study of the subject «Engineering Mechanics» has decreased from 160 to 120 hours.

Taking into account the requirements of school curricula and cross-curricular links with other disciplines of vocational training of teachers of labor education and technology, we propose to fill the content of the integrated course «Engineering Mechanics» as follows:

1. The section «Statics, Kinematics and Dynamics» should covers the question of the statics of the material point and the solid as a whole. In this context, one should consider the basic concepts and tasks of statics, bracings and their reactions, composition of forces, the system of convergent forces, the moment of forces relative to the center and the axis, the pair of forces, the conditions of equilibrium, bringing the system of forces to the center, the plane system of forces. It is quite important that one should consider statically defined

and unidentified tasks and a spatial system of forces. Friction and its laws is also one of the essential issues of mechanics. Methods for determining the center of gravity coordinates, general questions for solving static problems are included as applied problems.

After that the students get acquainted with the basic concepts of kinematics, types of motions and methods of their task (translational and rotational motions of a point and a solid, complex body motion), plane-parallel motion, kinematic pairs and chains, structure of flat and spatial mechanisms, kinematic study of lever mechanisms, kinematic study of cam gears, dynamic study of planar mechanisms, types of friction in mechanisms and its consideration in calculations, D'Alembert's principle for flat linkages, uneven movement of mechanisms and machines, the basics of the theory of regulation of motion of mechanisms and machines – this is a list of key issues that should be studied after the completion of the course and mastering the basics of dynamics.

2. The section «Materials resistance and machine parts calculation» is proposed to be integrated into one since all theoretical issues of material resistance are implemented in the process of practical calculation of machine parts. Such integration of sections will eliminate the duplication of individual issues of material resistance when calculating machine parts. The theoretical part includes: basic hypotheses and assumptions, types of loads and major deformations; deformation by stretching and compression, deformation energy; concept of hypotheses of strength, theory of strength; statically indeterminate problems, geometric characteristics of flat sections; deformation by shear, torsion, bending and combined stress; dynamic loading; requirements to machines, their parts, types of gears in machines and mechanisms, axles, shafts, bearings; couplings, coupling machine parts, exploring wave, planetary gears and gearboxes.

CONCLUSION

The content filling of the educational field of «Technology» provides a deeper acquaintance of students with the modern achievements of technology, mastering the practice of design and technological activities. Bearing this in mind, it is topical to develop the scientific principles of engineering training for future teachers of labor training and technology, which led to theoretical substantiation and practical implementation of structural changes in curricula in general technical disciplines. The analysis of the scientific literature and practical experience shows that the proposed structure of the content of the integrated course «Engineering Mechanics» is aimed primarily at intensifying the students' cognitive activity, as well as their broad involvement in independent work on the design and construction of technical objects. Such circumstances favor direct impact on the content of engineering training of future teachers of labor training and technology linked to the global change in

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