Formation of general technical training of students through the integration of computational and graphic works

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Abstract. The article deals with the role and tasks of general technical training of future engineers, justifies the choice of general technical subject “Machine parts, design basics and lifting and transport machines” as a link between general and special subjects. The article reveals the possibilities of using integrative computational and graphic works to form the general technical competence of engineering students, the technological aspect of designing integrated content of general technical subjects on the example of developing end-to-end complex individual tasks.

1. Introduction

General technical training is one of the fundamental components of engineering education. Sometimes its content is understood very narrowly and is reduced to the content of general technical subjects studied at the university. In fact, the content of general technical training is broader, since its elements are implicitly embedded in the content of mathematics, computer science, physics, and special subjects. General technical subjects occupy an important place in the training of engineering students, occupying an intermediate position between general and special subjects. At the same time, special subjects also fully “work” for general technical training, illustrating the general provisions of engineering science with concrete examples.

The core of general technical training is knowledge of the general laws of the structure and functioning of technical objects, the basics of technology, production, and the formation of a system of polytechnic knowledge and skills. Students who have mastered such a system of knowledge and skills quickly adapt to the conditions of constant updating of equipment and technology, master professional flexibility and mobility.

The importance of general technical training is not limited to the task of forming the general technical competence of the future specialist. It contains significant educational opportunities for the formation of many professionally significant personal qualities of students that determine the responsible attitude of the future specialist to their professional activities, creative approach to solving engineering problems, readiness for inventive and innovative work, etc. Also, general technical training has a great developing potential for creating prerequisites for increasing the professional mobility of future specialists,
improving their technical outlook and engineering thinking, creativity, attention, etc. General technical training allows to apply the laws studied in the cycle of subjects of the mandatory part of the curriculum and the part formed by participants in educational relations to explain the design and operation of numerous technical devices. This approach to the study of technical objects based on the scientific laws of nature makes it possible to expand the horizons of students, helps them to freely navigate the modern world of technology.

An important element of general technical training is the study of the interaction of technology with the environment, the impact of the use of machines and mechanisms on the reasonable transformation of the surrounding reality. A deeper study of the essence of the design and operation of devices allows to see their “weak” points and understand the prospects for further improvement. This contributes to the development of invention and innovation, technical creativity, as it provides greater opportunities for the production of existing educational models of the studied objects in comparison with other academic subjects.

2. Goal and tasks
The goal of the study cycle of technical subjects is to prepare technically competent professional with a high level of fundamental knowledge in the field of technical subjects and skills to carry out technical and technological calculations, capable of designing, manufacturing, developing production process, in the analysis of the “behavior” of the product in different conditions to make the right decisions based on the engineering thinking [1].

Thus, general technical training is designed to solve the following main tasks:

- provide fundamental engineering education;
- be the basis for professional mobility and the ability to navigate the changing socio-cultural and industrial environment;
- contribute to the formation of students' system engineering thinking;
- foster social responsibility of future engineers.

All this gives the reason to say that the basis for training a competent and technically competent specialist with mobility and professional flexibility is laid in the process of technical training. In other words, the general technical competence of the future modern, certified engineer is being formed.

The modern specialist is now faced with new functional and structural requirements that take into account the skills and abilities to design, construct, make decisions and take responsibility for their implementation. Under these conditions, the role and systematization of the competence approach in modern education becomes particularly relevant and theoretical significance.

Of course, the change in economic conditions in our country and prospects of development of professional education in the XXI century require changes to the blocks of courses general technical training, the most important mission which should be to integrate the content of education with the aim of laying the foundations of common cultural and professional competences of future engineer. This is a complex, large-scale task that will have to be solved permanently, because rapidly accelerating technological progress will always initiate changes in the content of training engineers. In a broad sense, our area of interest in the study of the integrative potential of general technical training is a mandatory part of the curriculum. For example, according to the Federal state educational standard in major of 35.03.06 “Agroengineering”, the mandatory part of the curriculum includes such subjects as “Descriptive geometry and engineering graphics”, “Theory of mechanisms and machines”, “Resistance of materials”, “Metrology, standardization and certification” and “Machine parts, design basics and lifting and transport machines”, which are traditionally called general technical. They are responsible for the general technical training of an engineer, which is essentially the basis, the backbone of engineering education.

At the initial stage of the study the integrative possibilities of technical subjects, it is first useful to develop a pedagogical subsystem of training engineering students of the university one technical
discipline, for example, to study all the basic patterns and to test methodological apparatus of pedagogical design, and then move on to other technical subjects and further to the whole system of technical training in general.

A systematic approach to the teaching methodology of individual technical subjects, on the one hand, contributes to the quality of technical training of the future engineer, and the unifying factor in such systems is the formation of general technical competence, but on the other hand, due to its integrating nature allows to model professionally significant situations and functional units of future professional activity for formation of technical competence through an independent educational activity of students [2].

Each of the general technical subjects performs its functions in the system of general technical training of future engineers, making a significant contribution to the formation of their professional competence. However, from the list of general technical subjects, one can choose one that plays the role of a link between the subjects of the mandatory part of the curriculum and the part formed by participants in educational relations. We believe that such a link is the subject “Machine parts, design basics and lifting and transport machines”, since its study requires knowledge of theoretical mechanics (statics, kinematics, dynamics, rotating and bending moments, geometric characteristics of sections, etc.); theory of mechanisms and machines (classification of mechanisms, balancing of rotating parts of machines, etc.); material resistance (determination of reactions of supports, theoretical prerequisites for calculations for various types of deformations, etc.); technologies of construction materials (properties of various materials, their mechanical characteristics, plasticity, brittleness, strength, endurance in various conditions, etc.); technical drawing (knowledge of standards, ability to perform working and assembly drawings, etc.) [3]. A separate link is the subject “Metrology, standardization and certification”, which was established in 1993. It is formed from the subject “Fundamentals of interchangeability”, so the first block of the discipline deals with the issues of ensuring the accuracy of parts and connections, studying tolerances [4], methods for calculating landings with a gap [5] and tension [6], special attention is paid to the landings of standard connections – threaded, spline, keyway [7], as well as methods of incomplete interchangeability [8]. When considering dimensional chains and various connections from the position of accuracy [9], there is a complete integration and the need for knowledge of the subject “Machine parts, design basics and lifting and transport machines”. In the second block of the subject “Metrology, standardization and certification” various issues of metrology and metrological support of production are studied [10, 11].

In fact, the subject “Machine parts, design basics and lifting and transport machines” is the “hub” of all general technical training and the basis for studying other general professional and special subjects provided for in the curriculum of engineer training. Having mastered the content of the subject “Machine parts, design basics and lifting and transport machines”, the student almost completes the first half of engineering training and proceeds to the second half-to special subjects of industry training.

Integration of technical subjects, global goal is the formation of technical competence as a set of general and generic skills of future engineers, is designed to solve a number of specific tasks:

- coordination of the sequence of study of academic subjects in strict accordance with the logic of formation of professional competencies of future engineers;
- ensuring continuity in the formation of general concepts, the study of laws and theories;
- ensuring unity in the interpretation of concepts, laws and theories, unity of requirements for their assimilation;
- providing common approaches to the formation of students' common skills in general technical subjects, continuity in their development;
- creating conditions for the active application and deepening of knowledge obtained by students in the study of related subjects;
- revealing the relationship of phenomena of different nature studied by different sciences;
- students' awareness of the commonality of research methods used in different sciences;
formation of engineering thinking by strengthening the focus of training on the development of professional functions.

3. Principles, methods and results
The content of professional training is prescribed in training programs, plans, manuals and textbooks for training specialists in various fields. All this educational and program documentation should be carried out in accordance with the didactic principles that determine the selection of all educational information, its structure, content and the necessary links between its elements.

The following are accepted as the leading principles of integration of general technical subjects:

- the principle of professional orientation of training;
- the principle of structural unity of educational content;
- the principle of continuity of training;
- the principle of synergy.

Analysis of working programs on subjects of the obligatory part of the curriculum and a part formed by participants of educational relations for the students of agricultural engineering specialties showed the predominant autonomy without logico-meaningful relationships, not only between cycles of subjects but also between subjects of one cycle. Knowledge of general technical subjects is not quickly applied in the educational process and begins to be used only in the study of special subjects in the last courses.

A review of research papers on the subject of the study allowed to establish that integration is a means of forming, preserving and developing an integral pedagogical system, and in the process of learning, while integrating general technical subjects, will contribute to achieving the following results:

- eliminate parallelism, duplication, and information overload of students;
- develop students' ability to transfer knowledge from one subject to another;
- form the basis for high-level generalization actions;
- develop the ability to think in broad information categories;
- form alternative democratic thinking of students, free to evaluate facts and events;
- ensure the implementation of a value-based approach to teaching, increase the level of personal motivation of students.

The set of theoretical knowledge and practical skills obtained by students during the development of general technical subjects is the methodological and methodological basis of professional activity of an engineer. Therefore, when studying these subjects, a large amount of educational work falls on course design as one of the main types of educational and professional activities, the core form of student's educational work in all courses in engineering universities. Moreover, among the educational technologies used in the system of engineering education, project-based training is becoming more widespread. In fact, the basics of course design are implicit in the content of the general technical subjects listed above. Course design finds its explicit, tangible (in other words, apical) manifestation in computational and graphic works in these subjects [12].

Thus, we can conditionally distinguish three levels of learning the content of general technical subjects: theoretical (at lectures), laboratory research (at practical and laboratory-practical classes) and computational and graphic (in course design and writing the final qualification work).

Analysis of research on pedagogical integration and experience in system of preparation of specialists of engineering profile allows to put forward as a strategic factor in the integration of technical subjects for students of agricultural engineering specialties the production and technological type tasks of professional activity, which is understood as multi-tiered system operations in the design, calculation and drawing of projections, mechanisms and their elements, structures, their components, parts, products, etc., based on a set of knowledge about the methods of searching for optimal design and technical solutions.
Integration methods of universalization and concentration [13] in relation to course design allow to reveal the technological aspect of designing the integrated content of general technical subjects on the example of creating end-to-end complex individual tasks [14] that have the similarity of the object, teaching goals, and conceptual and terminological apparatus.

Students' implementation of integrative calculation and graphic works, including end-to-end complex individual tasks, allows them to implement the idea of integrating the content of general technical subjects in practice and contributes to the formation of future engineers' foundations of general technical competence.

The development of end-to-end complex individual tasks is a rather complex methodological task of selecting the necessary connections from the entire set of their types and methods of establishing. At the same time, a balance must be maintained between ensuring the logic of continuous formation of general technical competence of future engineers when they master their main professional functions and maintaining a certain independence, autonomy of the content of specific general technical subjects.

As a result, end-to-end complex individual tasks represent the form that objects take when they interact with each other. This is not an integrated course in which the components lose their independence. These are blocks that combine several subjects, but in such a way that the constituent elements do not "mix" in them, but clearly retain their independence, enriching the new educational structure.

The transition from simple information transmission in the study of facts, phenomena, and laws of each individual of the discipline to generalize and systematize the material in the integrative calculation and graphic works means a qualitative change in learning content and associated with the use of new educational technologies, allowing to optimize the educational process as in the classroom and during independent work of students, with the latter becoming increasingly important, gradually moving the functions of the teacher from information transfer to facilitation.

The mandatory part of the curriculum for training an engineer reflects the scientific foundations of engineering and technology for intersectoral purposes, typical for a group of industries (sub-sectors, industries). And if the content of such subjects still to some extent must be profiled according to the content of activities in a specific industry to which the profession, what concerns the general technical competence (within the framework of the general technical training of an engineer), its essential features, based on the activities and structure of personality, we assume the set of integral criteria, defined by the combination of the following structural components [2]:

- technical and technological knowledge at the predictive stage of abstraction, successful motivation, perception and assimilation by students of basic scientific concepts, laws, formulas, calculation methods, physical essence of processes, phenomena of general technical profile;
- a wide range and depth of knowledge, students' ability to apply knowledge in computational and graphical activities, confidence in their potential for independence in the field of engineering, the ability to make responsible decisions, mobility for orientation in changing conditions, the ability to rationally organize and plan their work;
- constant desire to learn and update their knowledge, interest in scientific research, flexibility of thinking, communication skills, culture, dialectical worldview, knowledge of methods of analysis, synthesis, comparison;
- abstract, systematic and creative thinking, spatial imagination, creative attitude to professional activity, ability to make decisions in non-standard situations, readiness and desire for professional self-improvement, readiness to quickly adapt to changes in equipment, technology, organization and working conditions.

After such a systematic approach, it is possible in the future to conduct a comprehensive exam on the materials of all studied general technical subjects in order to analyze the quality of material assimilation before and after innovations.
4. Conclusion
We live in the age of information technology and each of us needs the ability to quickly and effectively master new knowledge that will allow us to quickly adapt to new conditions of existence. The method of course design based on the integration of general technical subjects will transform educational activities into a programmable and purposeful process that will realize its goal in the training of technically competent specialists with a broad outlook, clearly representing the prospects and tasks of their future activities, with a high level of knowledge and creative ability, able to specialize in any field.

Thus, to improve the quality of training in technical subjects, which are essential in the professional outlook, clearly representing the prospects and tasks of students' performance of end-to-end complex individual tasks as a means of integrating calculation and graphic works in general technical subjects allows them to more effectively model professionally significant situations and functional units of professional activity of future bachelors in the field of training "Agroengineering".

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