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Educational Studios: Theory and Practice

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3.7.TRAINING THE STUDENTS OF NATURAL-MATHEMATICAL SPECIALTIES IN ENGINEERING DESIGN AT HIGHER INSTITUTIONS OF PEDAGOGICAL EDUCATION

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Abstract.*The article is devoted to the actual issues of preparing students of natural and mathematical specialties for technical design in the process of their professional training in higher pedagogical educational institutions. The relevance of the problem of preparing a future teacher for technical design is related to a competent approach that provides the formation of technical and design competency, which allows the means technical construction to solve creatively the didactic and methodical tasks. The work for the first time considered scientific and technical creativity as a component of the future teacher's training in the natural-mathematical profile; developed, theoretically substantiated and experimentally tested the integrated technology of preparing the future teacher for technical design, which involves reproductive activity, elements of contextual learning with the development of a training design project, intragroup differentiation in different programs and at the request of students, enriching the teaching of additional organization of creative activity in extra-curricular time; conditions are found that ensure the effectiveness of integrated technology; criteria and indicators of readiness of students for technical designing are specified; the definitions are described "technical design", "readiness for technical design".*

Key words*: natural-mathematical specialties, engineering design, preparedness of students for engineering design, engineering design skills, technique of training, development of an educational-design project.*

The National Doctrine of the Development of Education in Ukraine in the 21century, the Concept of the Development of Teacher Education in Ukraine and the Law of Ukraine "On Education" (2017) stipulate that the state should provide training for skilled personnel capable of enriching intellectual, economic, creative and cultural potential the Ukrainian people. This directs educational institutions of higher education to review content, methods, and forms of education and requires the development of effective technologies to ensure the professional competence of the future teacher. An important place in this process is the issue of preparing students of higher education institutions for technical design as a component of their vocational training.

The identified problem is not new for pedagogical science. Scientists of G. Altshuller, O. Verbitsky, T. Kudryavtsev, O. Motkov, V. Molyako, K. Platonov, B. Simenach, Y. Stolyarov, L. Khomenko, P. Yakobson and others studied the question of formation of design knowledge, abilities and skills, creative application of them in practice; ensuring the unity of conscious learning of educational material with the education of the individual in design activities, etc. At the same time, the study of the existing practice of teacher training in pedagogical institutions of higher education testifies that insufficient attention is paid to the formation of the scientific and technical creativity of the future teacher in the real educational process.

The urgency of the article is determined by the need to overcome existing contradictions between the needs of society in individuals capable of introducing new in science, culture, and the degree of study of these issues in the theory of pedagogy; acquired experience in the training of future teachers of natural and mathematical disciplines and the level of technological development of the process of their preparation for technical design.

The purpose of the article is to identify the impact of the implementation of scientifically sound technology for the preparation of students of higher education institutions for technical design at the level of their readiness for vocational and pedagogical activities.

Methods of research: a) theoretical methods: analytical, retrospective for the purpose of studying the theoretical aspects of the problem, the definition of the conceptual-categorical apparatus, the genesis of the phenomena under study; b) empirical methods: diagnostic (questionnaires, interviews, conversations, control works, testing of the level of development of technical thinking by Bennet's method), observational (direct, indirect, observation included, retrospective analysis of own pedagogical practice), prognostic (expert evaluations, generalization of independent characteristics), praximetric (analysis of the products of educational and cognitive activities of students, analysis of advanced pedagogical experience) to determine the levels of formation of the readiness of the future teacher to technically about designing; pedagogical experiment to find out the effectiveness of the implementation of the technology of preparation for technical design; mathematical (statistical processing of empirical data).

Presenting basic material. Solving the problem of preparing students for technical design requires a clear view of its essence. On the basis of the analysis of psychological and pedagogical literature, different interpretations of the notion of "technical design" are defined, which is defined as the type of professional technical creativity (V. Molyako), the construction of the design according to the project (S. Goncharenko), the process of simulation of future objects (M Nechaev), the definition of the mechanical structure of the object (G. Fielden), the process of creating the image of the product (V. Kachnev) and drawings of the products that are not yet in existence (I. Bolshannin), part of the process of creating the product, which ends with the compilation of the work drawings (V. Kolotilov) [1; 2].

The generalization of the definitions of the concept of "technical design" in the psychological and pedagogical literature, taking into account the specifics of the design activity and the purpose of the study give grounds to consider technical design as a kind of technical creativity, aimed at the creation of technical products in a graphical way (through the development of design documentation: schemes, drawings, etc.).

On the basis of the analysis of psychological and pedagogical literature it is established that the purpose of preparing students for technical design is to form a teacher who is positively directed to the implementation of design activities within the limits of professional competence. The specified purpose specifies the following tasks:

1) provision of content and operational training of future teachers on the basics of technical design through the organization within the educational environment of the University of theoretical and practical training of students, aimed at the formation of design knowledge, skills and abilities;

2) introduction into the educational process of various forms of organization of educational and cognitive activities of students in order to increase the level of theoretical knowledge and practical skills from the foundations of technical design;

3) the formation of students focusing on the technical design and accumulation of pedagogical experience of leadership technical amateur students [1; 3].

Taking into account the modern researches of pedagogical theory and practice (E. Bogdanov, P. Galperin, M. Dyachenko, L. Kandybovich, N. Kuzmina, V. Slastonin) the preparation of students of natural and mathematical specialties for technical designing should be considered as a learning process that provides readiness of future teachers for design activities within their professional competence. Readiness is defined as an essential characteristic of the result of the preparation of future teachers, which involves the formation of a significant positive for a technical design in the future professional activity of a positively conscious set of motivational-value orientations, goals (motivational-value component); systems of knowledge, skills, skills (content component) and personal qualities, potential opportunities (professional-personal component) [1, 4].

The motivational-value component of readiness reflects the needs, interests, motives, beliefs, ideals, which ensure the students' activity in the training of technical design and future technical and design activities. Formation of the student's motivational and value orientation on the design activity is conditioned primarily by such socio-pedagogical factors as the lack of the basic mass of students of practical experience, their lack of orientation in pedagogical activity, underdevelopment of installations and needs in engineering activities; low level of preparation for technical design in higher education institutions, etc. The nature of motivation depends to a large extent on both the educational activity of the individual and on his success in the implementation of technical and design activities [1; 5; 6].

The content component of readiness for technical design is determined by the theoretical (knowledge of the basic concepts and categories, principles, patterns, basic stages and content of technical and design activities) and practical (the formation of technical and design skills and skills) components.

The analysis of psychological and pedagogical literature (I. Bolshannin, A. Verkhola, Yu. Stolyarov, J. Talens) allows to establish that the theoretical readiness for technical designation involves knowledge of the basic conditional notations applied in the schemes; rules for drawing drawings in accordance with the requirements of the Unified system of design documentation; structural materials (properties, thermal treatment, marking); manufacturing technology (processing, assembly); most common parts and mechanisms, design techniques,

etc. Among the most important skills and abilities were determined drawing skills (the ability to use the design documentation to convey their thoughts, read and execute drawings and schemes of both manufactured and not yet existing products) and engineering and analytical skills (the ability to mentally divide the design into separate nodes and parts, the process – to separate operations and movements, determine their purpose, the principle of the product and find the causes of problems with its use).

The professional-personal component of readiness for technical design is associated with the development of the student's ability to mobilize personal qualities of professional, reflexive and creative orientation, relevant for technical design.

Ensuring the preparation of students of natural and mathematical specialties for technical design requires the development of a certain technology, which involves the phased, logically constructed use of forms and methods of training that contribute to the formation of positive motives, goals, personal qualities, system of engineering and design knowledge, skills and abilities for application in future professional activity.

Taking into account the modern studies of pedagogical theory and practice (V. Bespalko, V. Yevdokimov, M. Kukharev, A. Pekhota, I. Prokopenko, L. Spirin, N. Talyzina) and taking into account the structure of readiness of students of natural and mathematical specialties for technical design (motivational-value, content, professional-personal components), it is substantiated that the person-oriented technology of teaching technical design involves the following stages: 1) mastering the necessary knowledge; 2) formation of abilities at the reproductive level; 3) consolidation of knowledge and skills; 4) independent practice in terms of educational design; 5) organization of search and creative activity in the conditions of real design. The content, methods and forms of implementation of stages are determined by the existing level of ownership of technical design [3].

Implementation of the first three stages of technology enables to reach the level of reproductive activity, four – reproductive-search, all (five) – the search level of students in the field of technical design.

In order to verify the effectiveness of the technology of preparing students for technical designing, a pedagogical experiment was conducted in the conditions of the natural educational process at the Kharkiv National Pedagogical University named after G.S. Skovoroda. The experiment was attended by students of the training groups of the third year of the Faculty of Physics and Mathematics, who studied the educational subject on the basis of technical design (future teachers of physics with an additional specialty "Mathematics" and "Informatics", future teachers of mathematics with an additional specialty "Physics").

At the formative stage of the variational pedagogical experiment, different approaches were introduced for the technology of preparing future teachers for technical design. Each of the following options was an improvement to the previous one and contained innovations that had to eliminate the disadvantages found during the study on the previous version of technology. The presence of

essential differences in the variants of the technology of preparation for technical design gave grounds for the organization on their basis of a variational pedagogical experiment with time-diluted studies of their effectiveness.

Initially, with the aim of eliminating the disadvantages of the existing practice of preparing students of natural and mathematical specialties in technical engineering at the Faculty of Physics and Mathematics, a special course "Fundamentals of Technical Design" was introduced [3]. The first option of the special course program was to study the students of the experimental group E_1 (57 persons), which included three training groups of students of the Faculty of Physics and Mathematics on the specialties "Physics-Mathematics", "Physics-Informatics", "Mathematics-Physics". The learning technology contained such an algorithm: 1) mastering the necessary knowledge; 2) formation of skills at the reproductive level; 3) consolidation of knowledge and skills.

This version of technology, which received the conventional name "traditional technology", provided the following content of work with students: the formation of a stable interest in technical design; eliminating the gaps in knowledge, skills and abilities of the drawing; assimilation of special technical and design knowledge, formation of technical and design skills and abilities; acquisition of initial experience of design activity; development of professionally necessary personal qualities; taking into account typical difficulties in learning.

"Traditional technology" of technical design training was supplemented with elements of contextual learning (frontal development of a training project in the context of the designer's activities). This version of the technology was implemented in the E_2 group (140 people), which included nine training groups of students of the Faculty of Physics and Mathematics. "Traditional technology with elements of contextual learning" was intended to focus on learning how to work, because the disadvantage of previous technology was the excessive attention to special knowledge that was not fully used in laboratory and practical classes.

The structure of laboratory and practical classes of the subject on the basis of technical design was changed: half of them were allocated for the development of a training project in the context of the designer's activities. The design object was proposed by the teacher as one variant of the design for the entire training group. The design was planned collectively in the audience, but the drawings were made individually at home. The teaching material, which was taught at lectures, also undergone changes, since theoretical knowledge of laboratory and practical classes was partially transferred to them.

"Traditional technology with elements of contextual learning" contained an additional stage of training - an independent practice in terms of educational design. This allowed raising the level of students' performance from reproductive to reproductive search.

In the group E_3 (72 persons), which included six school groups of students, a level-differentiated training with group development of a training design project was carried out in the context of the designer's activity, which received

the conditional name "Differentiated technology with elements of contextual learning". It provided for in-group differentiation of training at certain levels, and therefore developed three types of multilevel curricula: A, B, C.

Program A was defined as a training program for the minimum necessary for the technical design of knowledge, skills and abilities. It didn't contain a training project. Program A should have been mastered by every student, even the one who didn't study in the school drawing.

Additional information was added to program B, which deepened the curriculum material for program A. Program B recommended to students who had high propaedeutic graphic training and showed interest in engineering activities. Program B training was not final, but envisaged the transition to program C with the same part of the group that assimilated program A. Program C provided for the development of a differentiated training project. The specifics of the organization of work on it consisted in the fact that students who studied under the program B had the opportunity, individually or as part of the training microgroup, to develop projects on the chosen topic or to prepare a draft of their design variant of the product, which the remaining students at the end of program A developed collectively.

In the group E_4 (27 people), which consisted of three training groups of students, preparation for technical design was carried out for the "enriched technology", which implemented profile-differentiated training with a group development of a training project, enriched with an additional organization of creative activity in extra-curricular time.

For the "enriched technology" of technical design training, students had the opportunity to choose for the development of the subject of a training project with an attractive field of technology for them, from which they had in-depth knowledge (domestic experience, self-education, classes in circles). Such a variant of technology combines the profile differentiation of the study, which was carried out on the student's choice within the educational process, with the deepening of the study of the chosen profile in extra-curricular time and subsequent creative engineering and design activities, which was facilitated by the organization of search and creative activity in real-life design.

Within the educational process, the "enriched technology" was implemented as compulsory teaching of students first in program A ("program-minimum"), then, in addition to the "equalization group", – according to program B, which provided for the deepening of technical design training on the chosen profile (mechanics, electrical engineering, radio engineering) by developing an appropriate training project. Outside of the educational process, training was continued in the technical circle, scientific and technical society, student design bureau.

In general, during the conducted variational experimental and research work, it has been proved [3] that the technology of preparing students of natural and mathematical specialties for technical design, which was implemented in the variants "traditional technology", "traditional technology with elements of

context learning", "differentiated technology with elements of context learning", "Enriched technology", significantly influenced the results of students' preparation for technical design.

Conclusions and results of the research. Based on the analysis of the results of the experiment, it has been proved that "traditional technology" provides the best way to increase the levels of technical knowledge of "weak" students, due to the emphasis in learning on learning knowledge and the orientation towards achieving a sufficient level of readiness. "Traditional technology with elements of contextual education" provides a higher level of quality levels of knowledge on technical design and drawing skills of "average" students through the application of knowledge and skills in practice under the conditions of frontal educational design. "Differentiated technology with the elements of contextual learning" significantly affects the improvement of the level of quality of engineering and analytical and drawing skills, knowledge of technical design, the activity of "weak" and "strong" students through the differentiation of training in accordance with the propaedeutic preparation of the drawing and independent practice in the conditions group training design. "Enriched technology" essentially provides an increase in the readiness level of "middle" and "strong" students through the organization of search and creative activities in the conditions of real design.

Perspective directions. The study doesn't exhaust the problem. Future study of the issues of differentiation of students' preparation for technical design may be promising.

Література

1. Дейниченко, Г.В. (2011). Підготовка майбутнього вчителя до технічного конструювання: теоретичний аспект. Харків: ХНПУ імені Г.С. Сковороди [in Ukrainian].

2. Дейниченко, В.Г. (2013). Поняття «проектування» в наукових дослідженнях. Педагогіка та психологія. (Вип. 43), (С. 109-115). Харків: ХНПУ імені Г.С. Сковороди [in Ukrainian].

3. Дейниченко, Г.В. (2011). Науково-технологічне забезпечення підготовки майбутнього вчителя до технічного конструювання. Харків: ХНПУ імені Г.С. Сковороди [in Ukrainian].

4. Мотков, А.А. (1981). Обучение техническому творчеству в педвузе. Киев: Вища школа [in Russian].

5. Дейниченко, Г.В., Дейніченко, Т.І. (2010). Формування у майбутніх учителів позитивної мотивації до технічного конструювання методами імітаційної технології навчання. В.І. Сипченко (заг. ред.), Гуманізація навчально-виховного процесу (Вип. LIII, Ч. I), (С. 60-67). Слов'янськ: СДПУ [in Ukrainian].

6. Моляко, В.А. (1983). Психология конструкторской деятельности. Москва: Машиностроение [in Russian].

Bibliography

1. Deynychenko, G.V. (2011). *Preparation of the future teacher for technical design: theoretical aspect*. Kharkiv, Ukraine: KHNPU imeni H.S. Skovorody.