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# THE COMBINATORIAL APPROACH IN THE PROJECT-BASED TECHNOLOGICAL ACTIVITY OF SPECIALIZED SECONDARY SCHOOL STUDENTS

*Abstract*

The article addresses current issues and prospects for the development of project-based technological activity in the system of technological education of general secondary education institutions in Ukraine under contemporary socio-economic challenges. The significance of students' technological training is substantiated as an important factor in shaping a creative, initiative-driven, and socially active personality capable of self-realization, professional self-determination, and adaptation to the dynamic changes of the 21st century. Special attention is paid to regulatory and legal documents that define the strategic directions of educational development and emphasize the necessity of forming key competencies, including critical thinking, entrepreneurship, creativity, and the ability to engage in lifelong learning.

Project-based technological activity is characterized as an effective pedagogical approach that integrates learning with practical activity, research, and creativity. Its main functions and pedagogical advantages for students and teachers are identified, including the development of independence, responsibility, communication skills, teamwork abilities, and the integration of interdisciplinary knowledge. The role of the teacher as a facilitator and mentor in project-based learning is highlighted.

Particular emphasis is placed on the use of the method of combination (combinatorics) in the design of interior objects within the educational module «Interior Design Objects». The essence of decorative-combinatorial form creation, its connection with the laws of composition, geometric forms, and modular design is analyzed. The expediency of applying the combinatorial-modular approach as a means of developing creative thinking, solution variability, and optimizing the structural and aesthetic characteristics of products is substantiated. The article concludes by emphasizing the important role of project-based technological activity in the formation of modern technological education and in preparing students for life and professional activity in an innovative society.

*Keywords:* project-based technological activity, combinatorics, design, decorative and applied arts, profile secondary school, learners.

*Problem statement*

In the current challenging conditions of social life in Ukraine, particularly in the context of the struggle to preserve statehood and the awareness of the challenges of the twenty-first century, the issue of increasing the effectiveness of technological training for learners has become especially relevant. The social environment and technology play a leading role in shaping a creative and proactive personality capable of mastering modern labor skills and abilities, elements of professional competence, and prepared for successful self-realization in the conditions of a market economy. A central place in this process is occupied by project-based technological activity in technology lessons at the profile secondary school level.

Such regulatory documents as the Laws of Ukraine «On Education», «On Complete General Secondary Education», the National Doctrine for the Development of Education of Ukraine in the 21st Century, the State Standard of Basic Secondary Education, and the New Ukrainian School Concept emphasize

the importance of developing students' ability for lifelong learning, critical and systemic thinking, goal setting and achievement, effective teamwork, as well as the demonstration of entrepreneurship, financial literacy, and creativity.

Project-based technological activity is valuable in that it teaches learners practical, systematic, independent, and purposeful work; develops interest in creating new products or improving existing ones; fosters diligence; promotes awareness of the possibilities for using the created product; and cultivates moral and work-related qualities, contributing to professional self-determination.

Project-based technological activity performs a number of functions: creative, research, transformative, technological, and economic. Its outcome includes not only a specific item, product, or service, but also the personal development of the learner.

*Analysis of recent research and publications*

In the scientific works of such researchers as V. Berbets, N. Borysenko, N. Dovmantovych, V. Yevtushevskyi, H. Ihnatenko, O. Kobernyk, V. Kurok, O. Lytvyn, A. Tereshchuk, T. Khoruzhenko, S. Yashchuk, O. Topuzova, N. Filipchuk, and others, the significance, essence, content, and technologies of applying project-based technological activity in the educational process of technology education in general secondary education institutions are substantiated.

The problem of teaching technology to upper secondary school students under modern socio-economic changes has constantly remained within the focus of attention of scholars and practicing educators, who propose various ways to address it. Today, this issue is being studied by researchers such as V. Burdun, V. Kurok, N. Kalinichenko, V. Makarchuk, A. Pashynskyi, V. Steshenko, S. Tkachuk, and others. Issues related to improving the forms of organization of technology education for senior students have been explored by N. Alik, S. Borysova, S. Mazurenko, I. Tsidylo, A. Tsyna, L. Shpak, S. Yashchuk, and others.

*Purpose of the article*

The purpose of the article is to theoretically substantiate the significance and pedagogical potential of project-based technological activity in the system of technological education of general secondary education institutions in Ukraine, as well as to analyze the feasibility of using the method of combination (combinatorics) in interior design as a means of preparing learners for professional activity under contemporary socio-economic challenges.

*Presentation of the main material of the study*

Technology education is aimed at deep mastery of knowledge and skills in the field of project-based, technical-technological, and everyday activities, as well as at developing the ability to realize one's own creative potential in various types of activity.

One of the compulsory-elective educational modules of the curriculum «Technologies. Grades 10–11» (standard level) is «Interior Design Objects». Among secondary education learners, this area traditionally enjoys considerable popularity in the process of designing and implementing their own ideas. Most objects used by people in everyday life have been known for a long time; however, their form and functionality are constantly changing and improving. This is due to technological progress, the introduction of innovative technologies, the use of modern materials, and changes in requirements for the products themselves.

In technology lessons, various design methods are used to create new versions of familiar objects, one of which is the method of combining (combinatorics). The word «combining» originates from Latin and means «to unite» or «to merge». The essence of the combining method lies in creating a new object by integrating individual features, properties, or parts of other objects. This method is widely used in the development of new products – such as furniture, automobiles, household appliances, and interior design items in particular. In the professional activity of designers and fashion artists, the method of combining plays an important, and often a key, role.

Project-based technological activity is currently regarded as one of the most promising, relevant, and in-demand approaches to teaching technology in upper secondary (specialized) school. The results of numerous pedagogical studies indicate that this form of learning organization has a positive impact on learners' intrinsic motivation, increases their level of academic achievement, and contributes to the effective implementation of elements of early career guidance. This, in turn, helps senior students make a more informed choice of their future profession and educational institution.

Scholars, including Barron, Darling-Hammond, and Thomas [3], identify a number of characteristic features of learning based on project-based technological activity:

– students apply the knowledge and skills they have acquired to solving real-life problems;

– the level of responsibility for completing assigned tasks increases, both individually and in teamwork;

– the teacher performs the roles of coach, mentor, and facilitator, and also organizes the reflection process;

– work is often carried out in pairs or groups, which fosters collaboration skills.

This approach to learning involves the active engagement of students in generalizing previously acquired knowledge and gaining new knowledge, as well as in creating their own products – project outcomes. In the course of their work, students develop critical thinking, analytical abilities, communication skills, creativity, and teamwork skills under conditions of limited time and clearly defined goals.

Education in general secondary education institutions is a socially oriented process. It takes place in conditions of collective interaction among students, taking into account the cultural context and the personal experience of learners. In

such an environment, project-based technological activity makes it possible to integrate knowledge from different subjects while simultaneously developing students' abilities to negotiate, make decisions, distribute responsibility for their roles within a project team, as well as present and justify the results of joint activities.

Project-based technological activity opens up new opportunities for students' self-expression and contributes to the identification of their talents and inclinations, which do not always emerge in the context of a traditional lesson. In addition, it often involves interdisciplinary connections, allowing students to go beyond the boundaries of a single academic subject. This expands both the opportunities for technology teachers' creative realization and the formation of practical skills in students that are difficult to develop through exclusively theoretical instruction.

As noted by J. Krajcik, «project-based learning in science is an engaging way to explore the world. By focusing on core ideas in combination with hands-on activities and crosscutting concepts, classrooms become learning environments where students, together with teachers, model phenomena, conduct investigations, develop and justify hypotheses, and support them with evidence and logical reasoning» [2].

Modern education in Ukraine in the twenty-first century is actively developing, which necessitates the introduction of innovative approaches, concepts, programs, methods, and technologies into the process of teaching technology subjects in general secondary education institutions. One of the main tasks of technological education at the specialized level is the formation of a personality capable of making conscious choices in various life situations. It is important to develop students' ability to adapt quickly to change, effectively solve practical problems, navigate the information environment, and build individual life trajectories.

An advantage of project-based technological activity in technology lessons is its focus on the development of students' key competencies. This method combines the gradual involvement of learners in creative work, which includes selecting an object of labor, planning the stages of implementation, analyzing analogues, working with information sources, and implementing optimal solutions. The foundation of such learning is a learner-centered approach that takes into account the interests and needs of students. The role of the teacher is to organize students' independent activity, provide methodological support, and guide their actions [1].

According to O. Kobernyk, the application of the project method in technology lessons ensures the development of the following in students: the formation of skills for independent information search in various sources; the development of technological thinking through practical interaction with materials and tools; increased independence that stimulates creativity and originality; strengthening of emotional and volitional qualities that help overcome difficulties during task performance; development of logical and abstract thinking; acquisition of self-education and self-development skills; increased learning motivation through task individualization; formation of purposeful activity as a basis for professional self-determination; development of business communication culture and the ability to express one's own opinion in a reasoned manner and present activity results; stimulation of creative thinking, the search for non-standard solutions, and the formation of an innovative approach; integration of knowledge through interdisciplinary connections; mastery of project documentation skills; and the formation of essential life competencies for professional and social realization [4].

Let us analyze the advantages of project-based technological activity in the educational process. Project-based technological activity opens up new

opportunities for all participants in education, contributing not only to the acquisition of knowledge but also to the development of key competencies.

For learners, the advantages include the following:

– the traditional perception of the classroom changes: it becomes an open, dynamic space in which students can develop at an individual pace and along a personal learning trajectory;

– by performing practice-oriented tasks, students feel the need for continuous self-development and improvement of their knowledge and skills, and learn to process information independently;

– instead of mechanical memorization and reproduction of material, the learning process becomes integrated and inquiry-based, focused on discovering new knowledge and presenting results;

– students go through all the key stages of product creation, similar to real production processes: from the emergence of an idea, its modeling and design, to implementation, evaluation, and improvement of the final product;

– social skills are formed, including the ability to work in a team, distribute responsibilities, make joint decisions, and justify one's own viewpoint.

For teachers, the advantages include the following:

– teachers gain new opportunities for high-quality interaction with students: instead of the traditional role of a source of knowledge, they act as mentors, facilitators, and coordinators of the project process;

– there is an opportunity to better reveal students' individual abilities by selecting tasks in accordance with their interests, aptitudes, and level of preparedness;

– motivation for continuous professional development increases, along with the need to implement innovative approaches and to reflect on and update methodological tools.

An educational environment formed on the basis of the project-based technological approach creates prerequisites for:

– students' self-identification as individuals;

– the formation of stable intrinsic motivation;

– increased ability to integrate knowledge;

– self-affirmation and self-expression through productive activity.

In the design process, an important stage is substantiating the relevance of the chosen topic, applying specialized research methods, conducting experimental verification of possible ways to solve the problem, and searching for new approaches to implementing the defined tasks. Project activity is capable of producing not only material objects but also intellectual products – drawings, textual documents, calculations, charts, software, three-dimensional computer models, and other outcomes of intellectual work.

At the same time, for example, in the field of engineering design, the final result of project work must necessarily be embodied in a real, physically existing object. It is precisely this object that makes it possible to adjust calculations, as well as to verify the structural and technical parameters embedded in the project [4].

The term «project» is often used in a broad, interdisciplinary sense. In this understanding, it denotes the scientifically grounded formation of a system of parameters of a future object, phenomenon, or process, combined with the means of achieving a defined goal. Such a multifaceted approach to interpreting a project opens wide prospects for its application in production, scientific activity, and everyday human life.

For design goals to be implemented in a timely and effective manner, it is necessary to create a set of conditions that ensure the achievement of interrelated objectives: social integration, socio-economic effectiveness, civic engagement, and organizational manageability of the process.

The main purpose of design lies in determining a set of means capable of solving the identified problems and ensuring the achievement of the planned results. These means are fixed in two complementary forms:

1. as a list of specific measures that guarantee the implementation of the planned characteristics and indicators;

2. as a system of parameters of the future object and their quantitative measurements [5].

Thus, project-based technological activity is not only an effective means of instruction but also an important factor in education, contributing to the formation of a modern, creative, and socially active personality prepared for life in a dynamic world. Project-based technological activity is a key component of the contemporary educational field «Technology». It involves a holistic and staged process of creating an object of labor—from conception to implementation – taking into account environmental, economic, and entrepreneurial aspects. Its introduction into specialized education promotes the acquisition of technological knowledge, the development of practical skills, and the education of conscious, creative, and competent individuals.

In order to understand decorative-combinatorial form-making, it is necessary to possess knowledge of the fundamentals of composition in art studies. Every object created by humans, depending on its form and structure, acquires certain compositional characteristics.

Composition (from Latin *composition* – «putting together», «combination») is the organization of a holistic product in which all elements are harmoniously coordinated. The main means of form-making in composition include:

– the volumetric-spatial structure and tectonics of the product;

– scale, proportions, rhythm, and meter inherent in the object;

– contrast or nuance in the process of form creation;

– symmetry or asymmetry in construction, organization, or decoration;

– the coloristic solution of the object and its individual parts;

– the surface quality and texture of the material from which the product is made.

The volumetric-spatial structure of a composition is the aesthetically considered interdependence between the form of an object, its internal structure, and its environment. It is based on the combination of internal and external harmony, which should be inherent in any artificially created object.

In addition to the plastic properties of form, the physical characteristics of an object's surface – such as the surface finish and texture of the material – play an important role in the process of form creation.

The artistic and aesthetic means of composition include color scheme, as well as contrast and nuance in the combination of various elements.

Combinatorics is a branch of mathematics that studies discrete sets, their elements, and various ways of combining them, including permutations, arrangements, and combinations. It is closely related to algebra, geometry, and probability theory and is used in many fields, such as genetics, computer science, and statistical physics. The term was introduced by G. Leibniz in his work Dissertatio de Arte Combinatoria.

In an artistic context, combinatorics is understood as: a theoretical approach that explores form creation through various combinations of elements; and a method of form generation based on variation and combination of geometric shapes.

Thus, combinatorics is a system of techniques that allows for finding diverse variants of combinations, arrangements, and permutations of given elements.

The main objectives of combinatorial form creation include ensuring the uniqueness of compositional solutions, decorative value, and aesthetic expressiveness.

A decorative combinatorial element should organically integrate into any structure and function as a component of the overall composition. The most productive approach is the search for such elements based on geometric shapes with rectilinear contours. In nature, a great variety of geometric forms can be observed. Nature often unifies these structures, for example in flower petals, tree leaves, cereal grains, fish scales, or animal shells. Decorative combinatorial elements created by analogy with natural forms that have curvilinear contours possess more limited form-generating potential. These possibilities depend on the structural type of the element (its geometric parameters), the degree of regularity of its structure, and the level of its inherent symmetry. The least form-generating elements are the circle or curvilinear contour, whereas elements in the form of a square, an equilateral triangle, or a rectangle have significantly greater form-generating capacity.

Thus, in interior product design, combinatorial–modular design is considered one of the most promising methods. The systematic variation of modular, unified structural elements in different combinations, arrangements, and permutations makes it possible to modify product constructions. Modular design ensures structural, technological, and functional completeness. The interchangeability of combinatorial–modular elements and the universality of constructions increase the economic efficiency of models, while the use of such modules contributes to rhythmic coherence of parts and harmony of the overall form.

One of the effective means of improving project-based activity is the use of combinatorics. This method is widely applied in the fields of design, architecture, mathematics, biology, programming, and others. The combinatorial approach makes it possible to create a variety of functional and aesthetic solutions based on a limited number of elements. For example, DNA is formed from a limited set of

nucleotides, music from a certain number of notes, and language from letters and sounds.

In the project-based technological activity of specialized secondary schools, combinatorics contributes to the creation of new forms and structures through the variable combination of already known elements. This optimizes the creative search and makes it possible to achieve the desired aesthetic or functional result with fewer resources. In particular, when developing products or ornaments, students experiment with combining basic parts and elements, forming complex compositions [4].

Thus, the application of combinatorics in design promotes the development of students' creative thinking, encourages experimentation, and enables the creation of new solutions without the need to constantly invent fundamentally new elements. This approach is relevant in both technical and artistic creativity.

More often, during the design of interior objects, students apply combinatorial techniques. A technique is understood as a method of execution or achievement of something, or a set of actions aimed at attaining a specific goal.

Combinatorial techniques in project-based technological activity help to find optimal solutions and variants for creating new objects or improving existing ones. They make it possible to systematize and explore various combinations of elements, properties, and characteristics, which leads to more effective and innovative solutions.

Combinatorial techniques in project-based technological activity can be applied for different purposes.

1. Development of new products and services. They help identify optimal combinations of functions, forms, materials, and technologies for creating new products with improved characteristics. For example, in website development, different blocks, design elements, and functional features can be combined to create a user-friendly and visually appealing interface.

2. Optimization of production processes. Combinatorial techniques can be used to determine the optimal sequence of operations, the placement of equipment in the workplace, and the distribution of resources. For example, in production planning, various technological processes can be combined to minimize production time and costs.

3. Search for creative solutions. Combinatorial techniques promote the development of creative thinking and the generation of new ideas. For example, when creating products in technology lessons, different shapes, colors, textures, and materials can be combined to produce unique and expressive works.

The application of combinatorial techniques in practical activities during technology lessons is often limited by certain conditions, in particular the number of available elements, the rules governing their combination, functional characteristics, the type of material being processed, and the level of complexity of the product appropriate for a specific grade. The most common way of generating new variants is permutation, which is frequently used in the creation of compositions, models, construction, design, and programming.

*Conclusions*

Thus, modern technological education in Ukraine is aimed at developing twenty-first-century competencies that ensure students' ability to adapt to rapid changes, think creatively, and act effectively in various life situations. An important component of this process is project-based technological activity, which combines independent information search, practical work with materials, the development of logical and abstract thinking, the capacity for self-education, and professional self-determination. This approach not only enhances learning motivation but also fosters a culture of business communication and the ability to present the results of one's own activities.

The use of combinatorial techniques in design significantly expands opportunities for creative exploration and optimization of solutions.

Combinatorics makes it possible to vary forms, elements, and their combinations, and to create new structures and compositions in both technical and artistic tasks. The application of such techniques develops students' ability to recognize patterns, generate unconventional ideas, work effectively with limited resources, and select optimal options from a wide range of possibilities. As a result, combinatorial methods become an essential component of modern project-based technological activity, supporting the development of creativity and innovative thinking among students.

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