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ACTIVATION OF EDUCATIONAL POTENTIAL OF INTERDISCIPLINARY INTEGRATION IN VOCATIONAL SECONDARY EDUCATION

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Abstract

The relevance of the problem of interdisciplinary integration in an engineering vocational school is determined by the need of modern education in specialists who meet modern requirements of the labor market and have multifunctional competences, personal characteristics of competitiveness and professional mobility. This indicator assesses the quality of education in an engineering vocational school; it also influences public opinion and the contents of the information that shapes public image of an educational organization. Given the high level of competition between vocational education institutions, we can state the fact that innovative processes in a vocational school increase the level of its demand with applicants. Innovation in a vocational school can be provided through integration of social, natural science and engineering knowledge, which, in turn, determines the level of readiness of graduates not only to solve the planned tasks following simple or complex algorithms but also to perform design engineering. The article describes the results of the implementation of pedagogical conditions designed to boost the educational potential of interdisciplinary integration of mathematics and computer studies in the educational process of an engineering vocational school. The article presents the author's theoretical position, revealing the essence and contents of the concept of interdisciplinary integration, as well as the theoretical substantiation of the content-procedural characteristics of the educational potential of interdisciplinary integration, which are the basis for modelling and designing educational process in an engineering vocational school. A block-logical causal model was developed in accordance with the provisions of the system and the approach.

Keywords: Computer studies, educational potential, integration, interdisciplinary, mathematics, vocational school.

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1. Introduction

The modern system of vocational secondary education is highly dynamic, which reflects the specific processes taking place in the labor market. The need to train competitive, highly professional specialists with multifunctional competencies projects the responsibility for the organization and implementation of the high-quality educational process onto the secondary education system. Such training can be provided through the competent selection of the most optimal approaches, technologies, techniques and methods of vocational training; with the creation of new, "hybrid" ways to achieve the result of the educational process. Designing and implementing interdisciplinary integration is, in our opinion, one of the effective ways to improve the quality of training, which is especially important at the present stage of modernization of education and professional development of specialists.

2. Problem Statement

At the present time, it is necessary to come up with new strategic and tactical decisions on the organization and content filling of the educational process in a vocational school. The search for effective ways to improve the quality of education and the quality of mid-level specialists training caused the introduction of new approaches and techniques into the educational process, the content and procedural basis of which is integration. The trend of interdisciplinary integration of scientific knowledge within the individual components of the educational environment is the most productive way to ensure the improvement of the level of students' professional development, systematization and optimization of educational and cognitive activity, development of creative thinking in students and their exposure to culture, and activates hidden possibilities of the educational process. This will allow a vocational school graduate to confidently and ably solve constantly emerging and changing extraordinary professional tasks.

The relevance of the problem is also determined by the current level of development of science, where the integration of social, natural science and engineering knowledge is clearly expressed, determined by the complex requirements for the level of research in the field of specialists training, their compliance with the requirements of the professional environment, defined by the specifics of the current priorities in the educational process of a vocational school and the laws of cognitive activity of students.

The attempt to discover hidden, reserve opportunities of the educational process in a technical vocational school by integrating the content and methodological aspects of general subjects, to use this potential to improve the quality of training is not only of scientific interest but can have a real pedagogical effect.

3. Research Questions

The theory of integration as a representation of the generalized knowledge system, which originally emerged as a philosophical theory, is now widely used in various industries: manufacturing, politics, science, education.

Zverev (1974), who was among the first ones in Russian pedagogy to study characteristics of integration, defined the concept of integration as the process of joining together several subjects into one in which scientific concepts are linked by common sense and teaching methods. In his later work, integration is described as the process and result of creating an inextricably intertwined unity (Maksimova, 1987; Zverev & Maksimova, 1981).

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Later in the works of numerous authors addressing this problem, two main directions were worked out in detail - pedagogical integration as a principle of development of pedagogical theory and practice (Arkhipenko, 2007; Manuylov, 2002; Pravdina, 2007) and pedagogical integration as a process of establishing links between objects and creating a new holistic system (Abramkov, 2010; Baturina, 2003; Efremenkova, 2010; Nikulina, 2010). An attempt to "restructure" the philosophical concept of integration is made in

> Bezrukova's (2010) work "Pedagogical integration: essence, structure, implementation", where the author distinguishes the concept of integration in pedagogy from the concept of pedagogical integration. "Integration in pedagogy... implies manifestation of general scientific integration trends in it", it "can be interpreted as a science studies concept that reflects the consistency of the development of pedagogical theory". (p. 27)

Another term – pedagogical integration – involves the explanation, prediction and management of a specific manifestation of integration within pedagogy, within the subject of its knowledge, in accordance with the aims of functioning. Pedagogical integration is the variety of scientific integration within the framework of pedagogical theory and practice (Bezrukova, 1987).

Based on the conducted analysis of philosophical, psychological, pedagogical, methodological literature, generalization of experience of vocational secondary education institutions of the Republic of Bashkortostan, we came to the conclusion that integration contributes to both continuity of interdisciplinary content and synthesis of concepts within a discipline. This, in turn, increases the theoretical level of teaching the subject, creates a scientific foundation for interdisciplinary subject generalizations, and, accordingly, increases the quality of training. We consider the concept of interdisciplinary integration as interaction and interpenetration of content and procedural aspects of academic disciplines of invariant (general) and variant(individual) components of the federal educational standard, which is especially important when stating educational results. This "coupling" of content and methodological aspects provides the development of a competent, mobile engineering specialist, and helps students develop a comprehensive, integrated, dialectically interconnected holistic system of knowledge about the professional sides and the properties of the material world (Yafizova & Amirova, 2012).

We consider the integration of engineering and general education training as interdisciplinary (involving mathematics and computer studies) and intradisciplinary (integration of concepts, methods, forms, means of education existing within a subject) within a single discipline. The process of interdisciplinary integration has a number of essential characteristics, which include: accumulation of knowledge in certain current and ever-improving forms of expression; efficiency of cognitive processes, unification of knowledge and functional activities of specialists, etc. Its implementation is facilitated by the establishment of complex interdisciplinary relations, involving the presence of certain multistage structures, which are determined by the objective factors of educational contents. The greatest complementarity is achieved with the integration of related disciplines. It has a significant educational potential that allows optimizing the contents and technologies of training and use different forms of training sessions organization. At the same time, according to our assumptions, students develop such an ability as mental perception, they gain experience in mastering various cognitive strategies, methods of professional and social interaction, acquire tactics of professional construction and professionally mobile behaviour in general.

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The study of the state of this problem in the practice of vocational secondary education allows to conclude that, on the one hand, implementation of interdisciplinary integration of mathematics and computer studies in an engineering vocational school requires special efforts, and on the other hand, the integration itself changes the quality of the educational process and for the most efficient manifestation of it, pedagogical conditions that activate its educational potential and are designed exclusively in accordance with the specifics of training are necessary. The process of activation in the unity of goals, results and pedagogical conditions of its implementation is described in the theoretical block-logical causal model (figure 1). The structure of this model is presented in the form of a set of blocks and reflects the structural and content filling, real connections and relations, which allows specifying the place and role of interdisciplinary integration in the structure of an improved educational process.

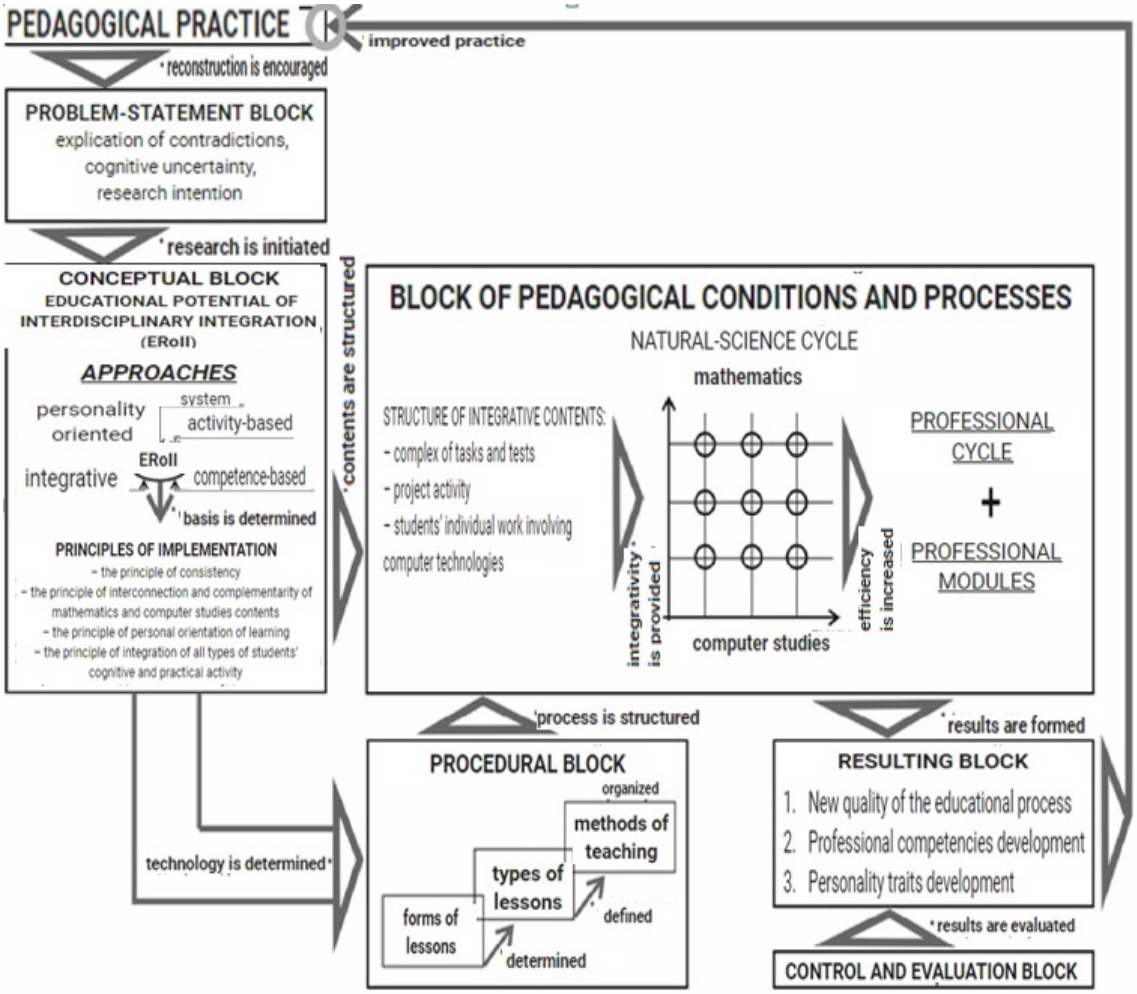

Figure 01. A block-logical causal model of activation of educational potential of mathematics and computer studies interdisciplinary integration in an engineering vocational school

The model development process allowed us to update the classical approaches to training and to fill them with new knowledge about the structure, contents and causality of the changed learning technology which embeds interdisciplinary integration. The improved of quality of the training process is expressed through its following content-procedural characteristics:

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1. Optimization of the contents and technology of training.
2. Visualization of processes, properties, states of objects.
3. Extension of the abilities to demonstrate processes in dynamics.
4. Possibility to reflect the contents of one discipline in another.
5. Broad character of training sessions organization.
6. Interactivity of the educational process.
7. Increased level of practice orientation in the educational process.
8. Clarification of the subject contents and professional activities of students.
9. Increased level of professional motivation.
10. Development of theoretical and logical thinking.
11. Increased level of creativity in students.
12. Increased competence in professional design engineering in students.
13. Efficiency of knowledge acquisition.

The summative experiment has shown that teachers working in vocational schools highly appreciate the usefulness of different types of integration and consider it necessary to use it in the classroom, but rarely implement this resource, as they experience certain difficulties. However, many students do not realize the interdependence of the contents of the natural sciences, are not aware of their relations with the disciplines of the professional cycle and have no idea about the possibilities and significance of professional design engineering.

The empirical study revealed a number of problems and contradictions that forced us to reconstruct the contents of the problem-statement block of the model. The conceptual basis (the conceptual block) of the activation of the educational potential of interdisciplinary integration is the approaches and principles that meet the purposes of the research. The methodological analysis of this problem showed the impossibility of studying the activation process by means one or two approaches. To solve complex problems, the necessity of a set of approaches is obvious. In accordance with this fact, we have used several scientific and pedagogical approaches, namely:

– the system approach, promoting identification of integrative system properties and qualitative characteristics which are obviously not observed at the elements of the system;
– the integrative approach, considering the evolving educational system as a totality, organically incorporating procedural and resulting components, thereby making it possible to manage them;
– the competence-based approach, that contributes to the efficiency and quality of training by updating all types of competencies in the process of integration of theory and practice;
– the activity-based approach, determining different forms of activities in the process of personality development in mid-level specialists who master solid professional knowledge;
– the personality-oriented approach, that provides development and acquisition of individual style of activity formed on the basis of individual characteristics.

Considering these approaches we have identified the following principles of integrative and innovative educational process as leading:

– the principle of consistency manifested in considering mathematics and computer studies as an integral system in the structure of professional training. This principle allows to introduce studying the disciplines in the unity and diversity of their components; principle of interaction and complementarity of the contents of

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mathematics and computer studies, professional knowledge in which involves a specific focus on the study of certain subject matters, strengthened interest, motivation and value-based attitude to these subjects due to understanding of the importance of these disciplines in professional activity of an engineering specialists to solve professionally important problems;

– the principle of integration of all types of cognitive and practical activities of students – the principle that we followed in the selection and structuring of the contents of training sessions and independent work of students, in the implementation of organizational and managerial functions of a teacher and educational and cognitive activity of students;

– the principle of personal orientation of training – the principle that allows executing individual tasks and assignments design in accordance with the expected professional situation, to improve both the quality of the educational process and the quality of graduate's training.

These approaches and principles have allowed us to structure the contents of disciplines, classes and independent work of students in accordance with the objectives of the study, as well as to implement the learning process within the framework of interdisciplinary integration.

The procedural block allows structuring the process and demonstrates the teaching strategy, where on the first place one can see the form of the lesson, which, in turn, determines the type of lesson and training methods are determined by the type of lesson. It should be noted that in the process of teaching students at an engineering vocational school, well-known methods of teaching mathematics and computer studies are used, here adapted to the purposes of the research in the context of the leading idea of interdisciplinary integration. We consider four groups of methods: methods for creating positive motivation to learn (building a system of professional perspectives, regard for personal educational achievements, provision of psychologically comfortable learning environment); methods of organization of cognitive and practical activities of students (group discussions, problem solving based on case studies, educational projects, educational and professional studies, etc.); reflexive-evaluative methods (analysis of the results of monitoring and self-assessment, diagnosis of learning difficulties, assessment of the significance of the acquired knowledge, skills, etc.); methods of development of personal educational learning environments (involving personal experience of a student, practical orientation, working with additional sources of information, etc.).

In the study we have identified, theoretically grounded and tested pedagogical conditions for activation of the educational potential of interdisciplinary integration of mathematics and computer studies in institutions of secondary vocational education, implementation of which promotes and boosts the activity of students in acquiring knowledge, ways of their obtaining and processing, development of skills and competences, their application for solving professionally-oriented tasks (organization of the educational process at a vocational school on the basis of a set of tasks and tests sharing the same integrating framework, application of the project method of learning; application of computer technologies in the organization of students' independent work of an interdisciplinary nature). Implementation of these pedagogical conditions, as shown by further experimental research work, ensures the integrity of the content component of the pedagogical processes block which is based on the information component of natural sciences, represented in the model as the intersection of the key elements of the contents of mathematics and computer studies. Implementation of interdisciplinary integration of these disciplines increases the effectiveness of studying the contents of the professional cycle and professional modules.

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Control and evaluation block contributes to the establishment of immediate feedback between a teacher and students, timely access to information and elimination of deficiencies. In the process of pedagogical assessment, qualitative and quantitative methods are used. The result of the implemented model is a new feature of students' training that manifests itself in optimization of the contents and technology of training, visualization of processes, properties and objects, increased level of practice orientation of the educational process, integration of content components of natural sciences and professional disciplines, etc., as well as formation of professional competencies and personal qualities of students.

Thus, the proposed block-logical causal model of activation of the educational potential of mathematics and computer studies interdisciplinary integration demonstrates the interrelation of all components of the educational process, is a standard of requirements for the process of interdisciplinary integration implementation and allows to design and implement the necessary set of pedagogical conditions and options for pedagogical activity in an engineering vocational school.

4. Purpose of the Study

The aim of the present work was to find a pedagogical solution to the problem of activating the educational potential of interdisciplinary integration of related disciplines in an engineering vocational school. Content and methodical aspects of mathematics and computer studies in an integrative variant have not been defined, therefore the scientific basis for the development of teaching materials for classroom-based and independent forms of learning activities of students was not presented.

5. Research Methods

The study implied using a set of complementary methods: theoretical (analysis of scientific literature, theoretical generalization, theoretical modelling); diagnostic (survey, questionnaire, interviewing, conversation, expert evaluation); empirical (generalization of pedagogical experience, qualitative and quantitative analysis of experimental data, pedagogical experiment); method of mathematical statistics (statistical processing of research results).

6. Findings

The basis of the formative experiment was the model of interdisciplinary integration, developed by the authors of the given research. The techniques, methods and means, that stimulate the purposeful implementation of the interrelation between general education disciplines and engineering disciplines, emphasised and developed in the course of the study; contribute to the professional orientation of mathematics and computer studies courses. Activation of the educational potential of interdisciplinary integration is determined by pedagogical conditions. The first condition is the organization of the educational process in an engineering vocational school on the basis of a set of tasks and tests, sharing the same integrating content basis. There are special requirements for the contents of the tasks, namely: practical contents of the tasks, that communicate the importance of mathematical skills obtained for solving applied tasks; integrative nature of the tasks: interrelation with other disciplines, as well as with practice, tasks with the workplace contents are offered; availability and clearness of the tasks: a

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statement, known and unknown data; organizing classes using a set of tasks and tests reflecting the approaches stated in the model.

To fulfill the second condition, it is necessary to implement the project method of teaching, involving execution of creative projects by students based on the use of integrative knowledge. The very fact of the organization of project work of interdisciplinary nature in the study of mathematics and computer studies brings some novelty to the educational and cognitive activity of students, creates their idea of integrity, affinity of these disciplines. Execution of project work allows students to apply their knowledge and personal experience, solve educational and professional problems, provides them with the opportunity for self-expression and reflection; emotional experiences, new forms of behaviour and communication. It should be noted that the implementation of the project method is the basis for the formation of competence in professional design engineering.

The next important condition is the use of computer technologies and various Internet services in the organization of independent work of students in accordance with a future speciality. Organizing independent work that has an interdisciplinary nature, allows to optimize the forms and methods of teaching, introduce new learning technologies into the educational process, actively use informational and computer resources, allowing a student to master new educational material at a convenient time. A student's role in material selection, search for ways to solve problems increases. The use of electronic computers contributes to the widespread introduction of computer testing, increasing the role of electronic textbooks and multimedia teaching aids.

We evaluated the effectiveness of the experiment using several criteria. The first criterion is satisfaction with teaching. The survey showed that students of the experimental group consciously and confidently identify positive aspects of integrated study of mathematics and computer studies, such as the integrity of the knowledge system, ease of knowledge acquisition, specificity, continuity with practice, etc. In the control group, this issue caused considerable difficulties. The second criterion is the improvement of quantitative and qualitative learning outcomes. We carried out testing in experimental and control groups. In total, 128 students of each group passed a test. The following types of tasks were proposed: questions from the course of computer studies, mathematical problems, problems of interdisciplinary and engineering content. Analysis of the results of the first test (computer studies) showed that the overall performance in the experimental group was 93.75%, in control group – 56.28%. The quality of training was 53.13% in the experimental group, and was 9.3% in the control group. The work that followed included mathematical examples and problems. The overall performance of the experimental group was 100%, and the quality of education was 68.75%. The overall performance in the control group was 84.37%, the quality of teaching was 28.13%. The third testing included tasks of interdisciplinary nature. To execute the testing students needed knowledge in the field of mathematics, computer studies and disciplines of the professional cycle. The overall performance in the control group was 43.75%, in the experimental group it was much higher: 100%, the quality of education in the control group was 9.4%, and 62.5% in the experiment group.

The third criterion is the efficiency of knowledge acquisition. To determine the effectiveness on this indicator, more tests were carried out. As a result, the average score in the experimental group was 3.42, in the control group – 2.43. These data indicate that the knowledge gained by students during the experiment has a high acquisition rate, which, in turn, indicates the effectiveness of the implementation of interdisciplinary integration of mathematics and computer studies.

To assess the competence in professional design engineering students were asked to perform a number of tasks and tests that were getting more and more complicated from course to course. The final task was to pass

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a test where it was necessary to prove the efficacy of the heating pipeline plan each of them developed. Indicators of the quality of performance were higher in the experimental group (average score – 4.25) than in the control group (average score – 3.45).

When assessing the level of creativity, we checked the technique of alternative use of objects, used testing and diagnosis of nonverbal creativity. We stuck to eight indicators: fluency, flexibility, originality, ease of association, the ability to bring together distant associated ideas, human evaluative abilities, ease of generating ideas, the level of imagination or fantasy. Students of the experimental groups showed higher results than during the summative experiment.

When assessing the level of professional motivation, students were offered a questionnaire. The number of positive responses to the following questions: "will you continue your education after graduating from the vocational school in this specialization?", "do you consider your choice of profession the right choice?" in the experimental group was much higher than in the control group.

According to the results of the survey, it can be noted that the students of the experimental group are more confident about the correctness of their professional choice, demonstrate a desire to engage in professional activity and continue professional development in the chosen direction.

7. Conclusion

The article reveals and theoretically substantiates the essential characteristics of interdisciplinary integration, which include: accumulation of knowledge in certain current and ever-improving forms of expression; efficiency of cognitive processes, unification of knowledge and functional activities of specialists. The very process of interdisciplinary integration is performed in several stages, which can result in a level system including the level of intradisciplinary connections, the level of interdisciplinary connections, the level of integration of two or more disciplines of one cycle (in our example – natural sciences cycle), the level of integration between diverse disciplines (in our example between scientific and professional cycles).

The implementation of interdisciplinary integration of mathematics and computer studies allows to optimize the contents and technology of training, use different forms of training sessions organization, while there is a development of such an ability as mental perception, processing of external information, students receive theoretical and practical knowledge, skills, providing the acquisition of various cognitive strategies, methods of professional and social interaction, the experience of professionally mobile behaviour grows.

The process of integration of mathematics and computer studies is the basis for identifying and substantiating the content-procedural characteristics of the educational potential of interdisciplinary integration of these disciplines, as the following conditions of its course are provided: a) the objects of research coincide in professionally oriented content and procedural aspects; b) related methods of study are used; c) the disciplines are based on general laws, general theoretical concepts.

The content-procedural characteristics of the educational potential of interdisciplinary integration of mathematics and computer studies ensure the effectiveness of students' training in the disciplines of the natural science cycle through the optimization of the contents and technology of training; visualization of processes, properties, of objects; expanding opportunities to demonstrate processes in their dynamics and reflection of the contents of one discipline in another; broad character of training sessions organization, increasing interactivity and practice orientation of educational process; clarification of the subject contents and professional activities of

students; increased level of professional motivation, theoretical and logical thinking, creativity; developing the ability to perform professional design engineering in students.

The article also presents a block-logical causal model of activation of the educational potential of interdisciplinary integration of mathematics and computer studies for engineering vocational schools, contributing to the enhancement of the process of interdisciplinary integration in the context of goals, results and procedural actions of teachers and students and allowing students to master the system of professional knowledge, competency in professional design engineering, modelling and increasing their own professional mobility.

The complex of pedagogical conditions for activation of educational potential of interdisciplinary integration of mathematics and computer studies is proved and tested: the organization of the educational process at an engineering vocational school on the basis of a set of tasks and tests sharing the same integrating content basis; the implementation of the project method of teaching, involving students' designing of creative projects based on the focus on implementation of interdisciplinary integration of mathematics and computer studies; as well as updating and active subject use of computer technologies and Internet services in the organization of students' independent work of an interdisciplinary nature and connected with a future specialization of students.

The study conducted does not claim to be an exhaustive solution to the problem, it reveals only a part of the issues related to the study of the possibility and efficiency of using the process of interdisciplinary integration in engineering education. It seems relevant to study the problem of formation of general cultural competences of students of engineering vocational schools in the integrative process of disciplines of technological and liberal arts cycles.

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