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THE PRINCIPLE OF CONTINUITY AS A FACTOR IN THE DESIGN OF A METHODOLOGICAL SYSTEM FOR TEACHING PHYSICS TO STUDENTS OF TECHNICAL SPECIALTIES OF UNIVERSITIES

For successful professional adaptation in the new socio-economic conditions, it is not enough to train specialists with a so-called «formed and fixed» character and certain qualification. The globalization of the educational space and the desire to ensure the continuity and integrity of learning, determines the diversification of factors in the design of educational programs and methodological systems for studying subject areas, taking into account the needs of labor markets and education. The modern economy requires constant updating of technologies, knowledge, skills and abilities. Their continuous updating is the key to the growth of a specialist's qualifications. The problem of continuity in lifelong education has many aspects: philosophical, methodological and psychological. In our research, we deliberately limited the area of research into the issue of continuity as a factor in the design of a methodological system for ensuring the fundamental nature and practical conditioning of the needs of society. When moving to a new level of quality, there is a problem of «loss» of the classical fundamentality. The results of our research, aimed at solving this problem, show that the principles of continuity and transdisciplinarity are effective tools for implementing the concept of lifelong education and preserving the fundamentality and modern quality of training engineers of a new formation.

The aim of the study is to design a methodological system for implementing the principle of continuity in the process of training future engineers. The principle of continuity in education is considered in the *article as a condition for the implementation of the dynamics of knowledge, depending on the content and context of teaching physics in technical specialties of universities. The theoretical result of the research is the implementation of the principle of continuity as a didactic factor in the design of a methodological system for the contextual study of a course of physics in engineering and technical education. In the article, this problem is investigated by analyzing, comparing, systematizing, interpreting various aspects of the problem in the scientific literature and educational practice of universities.*

Keywords: physics, the principle of continuity, methodical system, physical education, physical cognitive thinking, engineering education, didactic system, educational technologies.

Introduction

One of the main ideas put into the methodological system of teaching physics to students of technical specialties of a higher educational institution is **the principle of continuity**. Many researchers regard the term «continuity» as a general pedagogical principle of organizing teaching and educational work in school and university education. In their opinion, it ensures the consistency and interconnection of all stages of educational work at all levels of education [1]. Ryagin N. S. [2] proposes to consider the continuity of high school and higher education as structural levels, such as systemic, institutional, pedagogical and personal. All these levels are interconnected by various constituent elements. In his opinion, the systemic level of continuity establishes the links of the development of the subject between all educational stages at the level of the education system. This particular level is the strategic nature of the continuity. The institutional level of continuity is the establishment of continuity between associations and educational institutions. This level is functional and tactical. The pedagogical level of continuity is the development of motivational-target, organizational-technological, evaluative-productive, content-activity components of various links of lifelong education. The personal level of continuity is the development of the personality when one link of the continuous education system changes.

Continuity in the educational system is considered in two forms: vertical, which is characterized by a change in levels of education, and horizontal, which is characterized by one constant level. The authors argue that both vertical and horizontal integration of curricula improves the development of competencies and promotes learning, while the lack of this continuity, on the contrary, «harms» students, weakening their ability to learn [3].

Compliance with the principle of continuity at all levels of education, and in particular at the levels of high school and higher education, is the main condition for the formation of a system of continuous education. One of the main factors that can affect the problem of the continuity of school and university education is specialized education in the senior grades of high school. Specialized training in the context of high school education has a beneficial effect on the formation of professional self-determination [4]. It is believed that a student who is unprepared for new conditions at the previous stage of education may face such a problem as a delay in the adaptation period, which negatively affects the quality of education [5]. Various ways of solving this problem are proposed: 1) Develop a model of pre-university education, which will be the fundamental core in the structure of lifelong education [6]; 2) Improve the systems of developmental education [7]; 3) Develop training programs that meet the requirements of the updated content of secondary and higher education.

Zorana E. [8] in her work considers continuity as the goal of bridging the gap in knowledge of physics in higher education and further effective education at the university. The author considers the possibility of developing information literacy through the joint work of teachers and making changes to curricula at different levels of education. This work highlights the role of teacher collaboration at different levels of education and the continuity of learning content.

Aimicheva G. and other researchers [9] propose a spiral model for the implementation of the principles of continuity between high school and higher education, which eliminates the possibility of gaps in student knowledge and improves learning outcomes. This model proposed by the authors covers all levels of education from high school to higher education and assumes the development of knowledge. The name of this model is associated with the concept of founding (from German fundierung – foundation, basis), the developers of which are Smirnov E. I. and Shchadrikov V. D. The spiral of founding is a holistic integrating mechanism for the implementation of the continuity of the content of school and university education. The basic principle of the concept of founding is the transition from the processes of founding knowledge to founding the experience of the individual [10, 11].

The implementation of this principle provides an inextricable link between physical and technical knowledge. Coordination of high school and university programs is the main requirement for the implementation of the principle of continuity of high school and university education. For this, if any sections or topics necessary for mastering university disciplines are removed from the high school course of physics, then the university programs should be supplemented with the corresponding sections and topics. Conversely, as a solution to this problem in the system of lifelong education, we can recommend the following: the organization of special academic structures that ensure interaction between high school and university education; development of high school educational programs and didactic materials focused on the requirements of a higher educational institution.

In connection with these data, we decided to compare the content of a standard program in physics [12] for grade 11, with the content of university courses «Physics» and «Fundamentals of Information and Measurement Technologies» of the educational program «Instrument Engineering» [13].

As a result of this analysis, we see that the continuity of the course of physics in high school and university education is traditionally preserved within the paradigm of the knowledge approach in terms of content. The unit of instruction here is a portion of knowledge, in which students must understand the definition and physical meaning. Within the knowledge-based approach, the main attention is paid to the selection of subject material. In the new paradigm of lifelong education, the unit of learning should be a system of hard and soft skills, that is, not only subject knowledge, skills and abilities, but also physical cognitive thinking, a cognitive way of thinking, as the goal of learning. This will allow the student to acquire new general professional and specialized knowledge, skills and competencies related to workplace. However, in order to achieve modern learning goals, the content of the didactic system must satisfy the didactic principles of continuity, transdisciplinarity and integrity. Therefore, it is necessary to develop a didactic system as a whole, as well as didactic material in such a way as not to lose the basic qualities of modern education: such as fundamentality and practical orientation, which will ensure the development and growth of the student's professional potential throughout his life in the future. The implementation of the principle of continuity of the content of high school and higher education gives a chance to preserve the core of the content of general education. In order for future specialists to be able to quickly master new knowledge and new types of professional opportunities, they must have a sufficiently powerful fundamental theoretical knowledge base. Therefore, the tendency to preserve and develop the fundamentalization of vocational education requires strengthening the general educational and theoretical professional foundation.

The purpose of this study is to design the methodological system based on the continuity for students of technical specialties of universities, which would form a stable system of cognitive physical thinking and competencies of future jobs. The research objectives are the following:

1) Development of a methodological system for the implementation of the principle of continuity, ensuring the fundamental nature, consistency and practical effectiveness of the implementation of the didactic system of the subject content of physical and technical disciplines;

2) Implementation of technologies for studying physics in the technical specialties of the university on the basis of the principle of continuity;

3) To give a new interpretation of the principle of continuity as a factor in building a methodological system for studying fundamental and applied disciplines in engineering and technical education.

The grounds for building the content and structure of fundamental and professionally oriented disciplines of a high school subject and a university course in physics, as well as major disciplines, may be promising directions for the development of innovative production technologies, the emergence of new specialties that require specialists of a new formation. In order to improve the quality of training in physics for students of technical specialties, we propose to create didactic materials for the high school course, which would ensure the implementation of the development of fundamental knowledge in physics and the professional orientation of future students in choosing a specialty. Additionally, to implement the principle of continuity, create an educational and methodological complex of the discipline «Fundamentals of Information and Measurement Technologies», where professionally oriented material is compiled on the basis of the integration of physical and technical knowledge.

The main goal of the implementation of the principle of continuity is the formation of fundamental knowledge in modern physics and to teach students to apply basic physical phenomena and laws to various objects of professional activity using information technologies. To achieve this goal, it is necessary to determine the knowledge and skills that are being formed, which are the main content of the learning process, as well as methods, forms and means. The content of these courses must comply with didactic principles.

The model we have compiled for the implementation of the principle of continuity in teaching physics to students of technical specialties consists of the learning goal, course content and learning technology (Fig. 1). To achieve this goal, didactic materials of an invariant, variable and research nature are used. Mixing of these components is also possible. It depends on the content of the courses.

A high school subject and a university course in physics are aimed at the consideration and study of fundamental knowledge. That is, the experimental content of the course is invariant. The course «Fundamentals of Information and Measuring Technologies», aimed at considering the physical foundations of measuring technologies, is implemented in terms of the variation component. The transition to innovative production activities requires from a specialist not only the knowledge of the basics of physics, but also the ability to carry out research work (modeling, design, and development work).

The implementation of the principle of continuity, in turn, provides for the solution of an urgent problem as a fundamentalization of education. Modern approaches to the training of a highly qualified specialist provide for the formation of an educated creative personality of a specialist who is able to master new knowledge and competencies, and this presupposes fundamental knowledge and a creative cognitive professional way of thinking. Since the spectrum of higher technical specialties is diverse and their arsenal will grow, the most likely is the emergence of new physical and technical disciplines.

The more diverse the object of a specialist's professional activity, the more diverse the arsenal of disciplines.

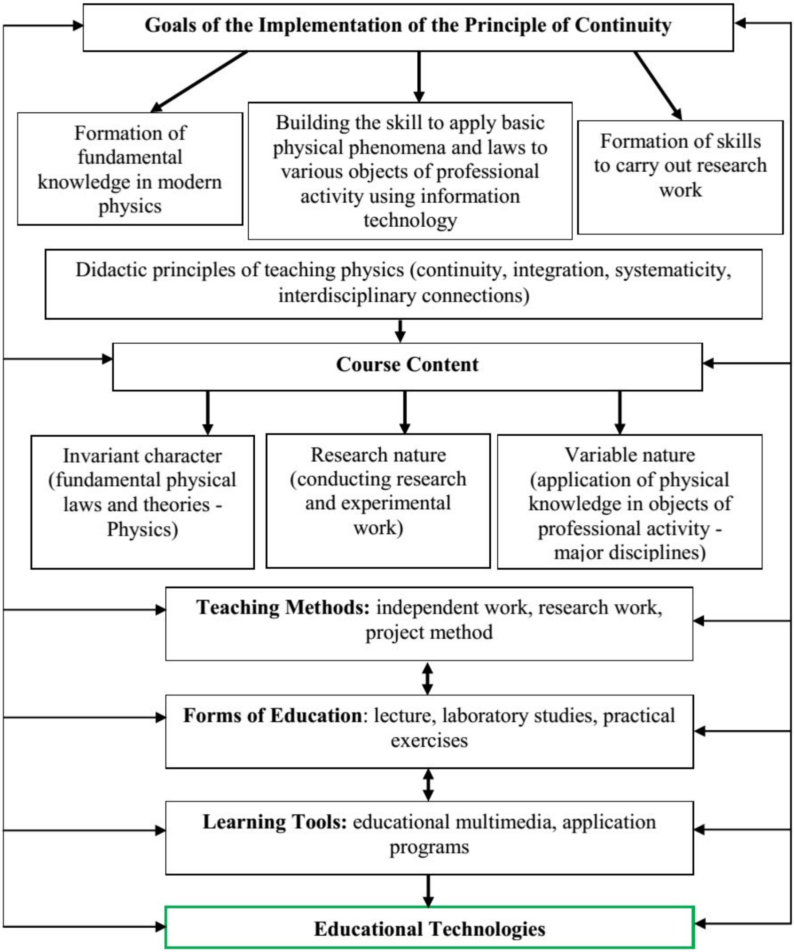

Figure 1 – Model of the implementation of the principle of continuity in teaching physics to students of technical specialties

Still, in terms of structure and fundamental principles, they have a lot in common. The structure of a special discipline includes: a fundamental core, a sphere of general professional knowledge, a sphere of special knowledge. The study of major disciplines requires a deep integration of all these components from university programs. In addition, in order to study major disciplines, deep knowledge of natural science, general professional, as well as humanitarian and economic disciplines is required. This is due to the fact that the study of the object of professional activity in a higher educational institution is aimed not only at the descriptive part, but also at the study of scientifically grounded optimal structures, methods of application and creation, as well as practical operation.

The descriptive part of this course is based on the study of the elements of modern measuring technologies and their practical application in instrument engineering. The descriptive part on this issue is well presented in reference materials, tutorials. That is, the student can independently study this part in order to simply state the actual data of the object. This is only the first side of the methodology for studying major disciplines. There is also the second side of the methodology, which is aimed at the formation of such competencies as skills and abilities to conduct experiments, process measurement results and analyze them, as well as knowledge of the physical foundations of the operation of measuring instruments and methods of their research. To form such competencies, students need the skill of practical application of physics and a range of other disciplines. Thus, the majoring discipline is an integrated discipline, since its structure includes a certain share of fundamental knowledge. The effectiveness of the role of major disciplines in the training of a highly qualified specialist in a technical direction is determined by the inextricable link between the individual components of this discipline. The lack of solid knowledge of the fundamental foundations of major disciplines will not allow to fully implement the requirements of the State Compulsory Standard of Higher Education. Of course, you can master the descriptive part of the discipline, but the part that is aimed at the formation of professional competencies is difficult to comprehend qualitatively without knowledge of the fundamental foundations.

To achieve the goal of implementing the principle of continuity in teaching physics:

– First, an educational multimedia on the course of physics was developed for the 11th grade in the area of natural sciences [14] (Fig. 2);

– Second, the authors developed distance courses in «Physics» and «Fundamentals of Information and Measuring Technologies» for students of the specialty «Instrument Engineering», which are uploaded in the distance educational portal «Toraigyrov University» (Fig. 3, 4).

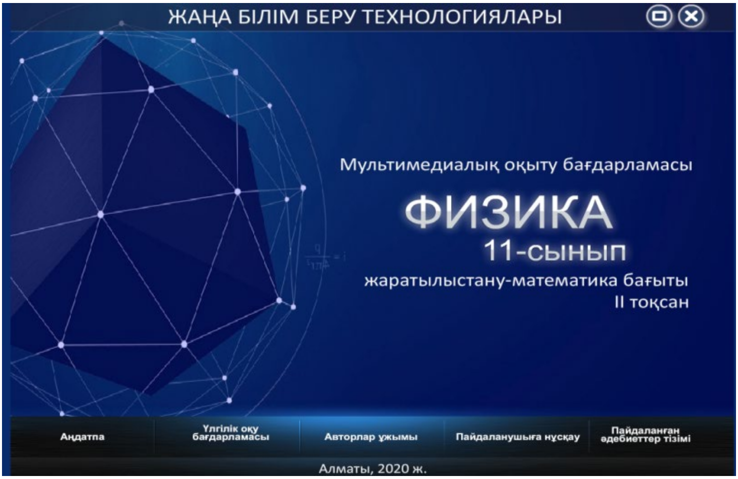

Figure 2 – Educational multimedia

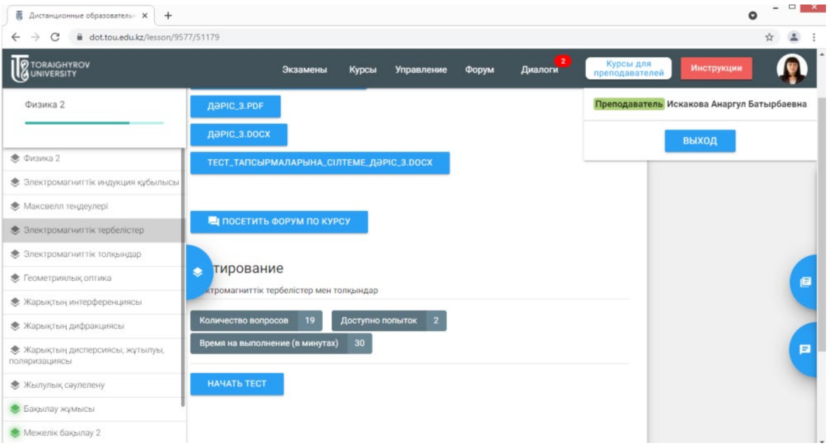

Figure 3 – Course in «Physics 2»

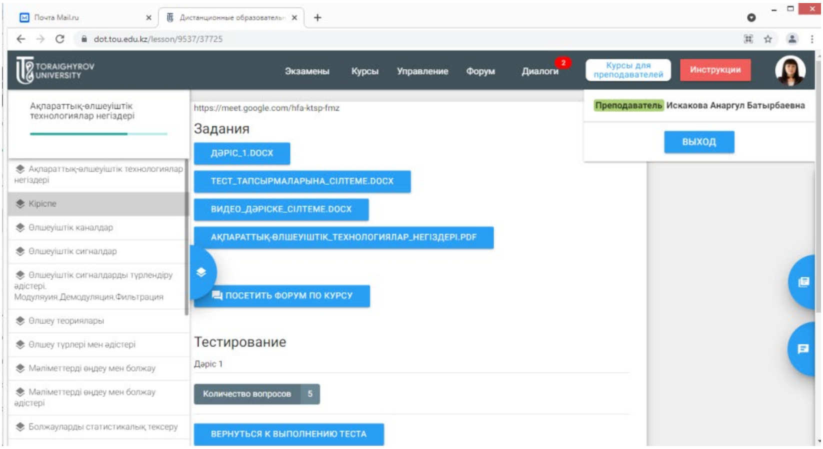

Figure 4 – Course in «Fundamentals of Information and Measuring Technologies»

The developed laboratory works on the specialized course «Fundamentals of Information and Measurement Technologies», which is studied on the 3rd grade, is also presented in the tutorial entitled «Fundamentals of Information and Measurement Technologies» [15].

Materials and methods

To implement the tasks, the following research methods were used: theoretical (comparison, analysis and systematization of the problem in pedagogical literature), empirical (pedagogical experiment for the implementation of the didactic principle of continuity as providing an inextricable link between physical and technical knowledge and a statistical method for evaluating the results of the experiment). To conduct a quantitative assessment of the effectiveness of the implementation of the didactic principle of continuity, a method was used based on the express control of a student's certain knowledge, which makes it possible to assess the level of cognitive thinking formation among students in the subject under study [16].

The pedagogical experiment was carried out at Toraighyrov University. The experiment involved students of the specialty «Instrumentation». Students were offered a questionnaire that contained 28 integrated questions in physics and the discipline «Fundamentals of Information and Measurement Technologies». In the questionnaire, the students had to mark with «+» signs their opinion about their ability to answer the questions posed. Next, it was required to briefly outline the essence of the answers to the questions marked with a «+». Thus, the students could either confirm the knowledge of the question, which they marked with a

«+», or set it aside without confirmation. When answering some questions, it was necessary to show the ability to integrate the knowledge gained at the previous stages of training.

When answering some questions, it was necessary to demonstrate the ability to integrate the knowledge gained at the previous stages of training.

Results and Discussion

Let us denote the number of questions asked to students by N_F. The number of answers of *i-th* students at the stage of self-assessment N_{Fi}^{+}. The number of questions recognized by teachers as correct are denoted by N_{Fi}^{++}. Next, we enter the relative share of correct answers for self-assessment of *i-th* student $a_{Fi}^{+} = \frac{N_{Fi}^{+}}{N_F}$ and according to the teacher's assessment $a_{Fi}^{++} = \frac{N_{Fi}^{++}}{N_F}$ and the corresponding indicators are found for all surveyed students:

$$a_F^{+} = \frac{\sum_{i=1}^{k} N_{Fi}^{+}}{kN_F}, \quad (1)$$

$$a_F^{++} = \frac{\sum_{i=1}^{k} N_{Fi}^{++}}{kN_F} \quad (2)$$

where k is the number of surveyed students.

Computer processing of the results obtained was carried out according to Formulas (1) and (2), which is shown in Figure 5.

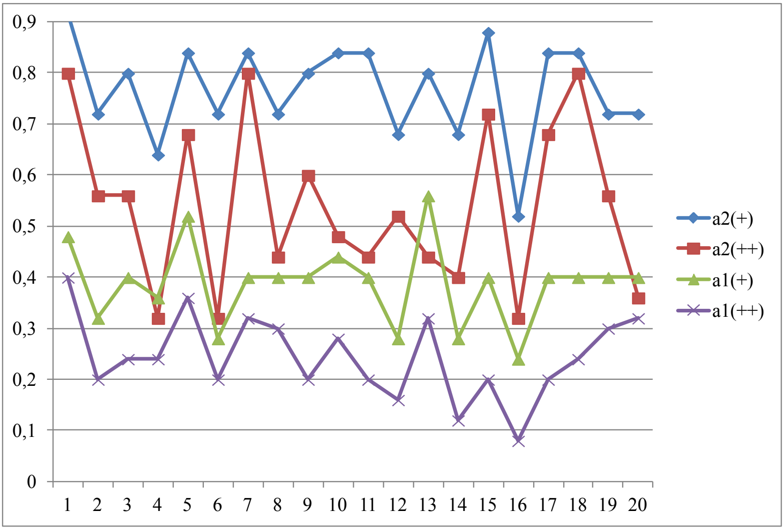

Figure 5 – General averaged indicators of relative knowledge during input (1) and output (2) control according to student self-assessment (+) and teacher assessment (++)

The figure shows that when studying a specialized course, fundamental knowledge in physics increases significantly, that is, students' knowledge increases with the integration of natural science and specialized disciplines of higher technical education. It is also seen that self-assessment (curves a1 (+) and a2 (+)) significantly exceeds actual knowledge (curves a1 (++) and a2 (++)). Let us represent the relative «overestimation» of our own knowledge (b) by the ratios:

$$<b_1>=\frac{<a_1^+>-<a_1^{++}>}{<a_1^{++}>}=0{,}59;$$

$$<b_2>=\frac{<a_2^+>-<a_2^{++}>}{<a_2^{++}>}=0{,}42.$$

Correlation $<b_1>$ and $<b_2>$ shows that $<b_2>$ is less than $<b_1>$ and $\frac{<b_2>}{<b_1>}=0{,}71<1$.

In other words, the students begin to critically assess their fundamental knowledge in natural sciences. The higher the level of knowledge among the students of a given group, the higher the level of knowledge of the same students turns out to be after studying a specialized course. The corresponding relationship is shown in Figure 6 with a correlation coefficient of 0.645.

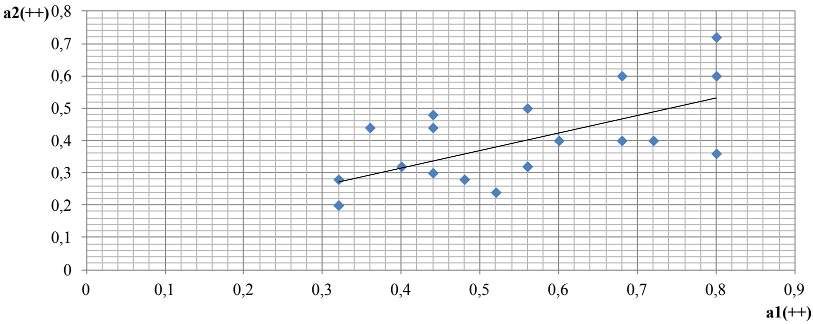

Figure 6 – Correlation between the initial level of residual knowledge of students $< a_1^{++} >$ and the level of their knowledge after the study of a specialized course $< a_2^{++} >$

Conclusions

The conducted research allowed us to draw the following conclusions: 1) The goal of creating a methodological system based on the principle of continuity to form a stable system of cognitive physical and technical thinking, knowledge and competencies, within the elective course for students of technical specialties of universities; 2) The developed methodological system for the implementation of the principle of continuity ensures the fundamental and practical effectiveness of knowledge and competencies of students in the experimental course. It is confirmed by the level of correlation between the initial level of residual knowledge of students $< a_1^{++} >$ and the level of their knowledge after studying a specialized course $< a_2^{++} >$; 3) The research hypothesis of the effectiveness of applying the didactic principle of continuity to ensure the fundamentality and practical orientation of training technical specialists based on the development of cognitive professional physical and technical thinking is confirmed.

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САБАҚТАСТЫҚ ПРИНЦИПІ ЖОҒАРЫ ОҚУ ОРНЫ ТЕХНИКАЛЫҚ МАМАНДЫҚТАРЫНЫҢ СТУДЕНТТЕРІНЕ ФИЗИКАНЫ ОҚЫТУДЫҢ ӘДІСТЕМЕЛІК ЖҮЙЕСІН ЖОБАЛАУДЫҢ ФАКТОРЫ РЕТІНДЕ

Қазіргі әлеуметтік-экономикалық шарттармен берілген жағдайда тиімді кәсіби бағдарлауды жүзеге асыру үшін белгілі бір біліктілікке ие болатын мамандарды даярлау жеткіліксіз. Білім беру кеңістігін жаһандандыру, үздіксіздік пен сабақтастықты қамтамасыз етуге ұмтылу білім беру мен еңбек нарығының сұраныстарына сәйкес келетін пәндік салаларды игерудің әдістемелік жүйесі мен білім беру бағдарламаларын жобалау факторларын диверсификациялаудың негізгі шарттары болып табылады. Заманиу экономика технологияларды, білімдер мен дағдыларды тұрақты түрде жаңартып отыруды талап етеді. Оларды үздіксіз белсенді ету – маманның біліктілігін арттырудың кепілі. Үзіксіз білім берудегі үздіксіздік мәселесі философиялық, әдіснамалық және психологиялық аспектілерінен тұрады. Авторлар сабақтастықты зерттеу мәселесін әлеуметтік талаптарға тәжірибелік тұрғыда негізделген және іргелілікті қамтамасыз ететін әдістемелік жүйені жобалаудың факторы ретінде қарастырады. Білім беру сапасының жаңа деңгейіне көшуде классикалық іргеліліктің «жоғалу» мәселесін байқауға болады. Осы мәселені шешуге арналған авторлардың зерттеу нәтижелері сабақтастық және транспәндік принциптері үздіксіз білім беру концепциясын және жаңа форматтағы инженерлерді сапалы даярлауды жүзеге асыруға, іргелілікті сақтауға мүмкіндік беретін тиімді құралдар болып табылады. Зерттеу мақсаты: инженер мамандарды даярлау процесінде үздіксіздік принципін жүзеге асырудың әдістемелік жүйесін жобалау. Мақалада білім берудегі сабақтастық принципі жоғары оқу орындарының техникалық мамандықтарында физиканы оқытудың мазмұны мен контекстіне байланысты білімдердің динамикасын жүзеге асыру шарты ретінде қарастырылады. Зерттеудің теориялық нәтижесі: сабақтастық принципін инженерлік-техникалық білім *беруде физиканы контекстілік тұрғыда игерудің әдістемелік жүйесін жобалаудың дидактикалық факторы ретінде жүзеге асыру. Мақалада аталған мәселе талдау, салыстыру, жүйеге келтіру, ғылыми әдебиеттерде келтірілген және жоғары оқу орындарының білім беру тәжірибелеріндегі мәселелердің түрлі аспектілерінде қарастыру арқылы зерттеледі.*

Кілтті сөздер: физика, сабақтастық принципі, әдістемелік жүйе, физикалық білім беру, физикалық когнитивтік ойлау, инженерлік-техникалық білім беру, дидактикалық жүйе, білім беру технологиялары.

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ПРИНЦИП ПРЕЕМСТВЕННОСТИ КАК ФАКТОР ПРОЕКТИРОВАНИЯ МЕТОДИЧЕСКОЙ СИСТЕМЫ ОБУЧЕНИЯ ФИЗИКЕ СТУДЕНТОВ ТЕХНИЧЕСКИХ СПЕЦИАЛЬНОСТЕЙ ВУЗОВ

В новых социально-экономических условиях для успешной профессиональной адаптации недостаточно подготовить специалистов, имеющих «конечный» характер, определенной квалификации. Глобализация образовательного пространства и стремление к обеспечению непрерывности и преемственности обучения обуславливает диверсификацию факторов проектирования образовательных программ и методических систем изучения предметных областей с учетом потребностей рынков труда и образования. Современная экономика требует постоянного обновления технологий, знаний, умений и навыков. Их непрерывная актуализация – это залог роста квалификации специалиста. Проблема преемственности в непрерывном образовании имеет множество аспектов: философских, методологических и психологических. В своем исследовании мы сознательно ограничили область исследования проблемы преемственности, как фактора проектирования методической системы обеспечения фундаментальности и практической обусловленности потребностям социума. При переходе на новый уровень качества существует проблема *«утери» классической фундаментальности. Результаты нашего исследования с целью решения этой проблемы показывают, что принципы преемственности и трансдисциплинарности являются эффективными инструментами реализации концепции непрерывного образования и сохранения фундаментальности и современного качества подготовки инженерных кадров новой формации.*

Целью исследования является проектирование методической системы реализации принципа непрерывности в процессе подготовки инженерных кадров. В статье принцип преемственности в образовании рассматривается, как условие реализации динамики знаний в зависимости от содержания и контекста обучения физике на технических специальностях вузов. Теоретическим результатом исследования является реализация принципа преемственности в качестве дидактического фактора проектирования методической системы контекстного изучения курса физики в инженерно-техническом образовании. В статье данная проблема исследуется путем анализа, сравнения, систематизации, интерпретации разных аспектов проблемы в научной литературе и образовательной практике вузов.

Ключевые слова: физика, принцип преемственности, методическая система, физическое образование, физическое когнитивное мышление, инженерно-техническое образование, дидактическая система, образовательные технологии.

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