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IMPROVING THE METHODOLOGY OF TEACHING THE SUBJECT "INFORMATION TECHNOLOGIES IN TECHNICAL SYSTEMS" IN A PROFESSIONALLY ORIENTED DIGITAL EDUCATIONAL ENVIRONMENT

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Abstract. This article examines the issue of improving the methodology of teaching the subject "Information Technologies in Technical Systems" in a professionally oriented digital educational environment. The relevance of the study is determined by the need to teach information technologies in technical higher education not merely as a separate theoretical discipline, but as a tool for solving professionally oriented engineering problems [1]. The article analyzes the digital educational environment, virtual laboratory, simulation platform, integration of professional disciplines, digital competence, and the system of practical assignments as interrelated methodological components[5]. The study employs methods such as theoretical analysis, pedagogical modelling, comparative analysis, diagnostic assessment, experimental testing, and statistical generalization. The results indicate that lessons organized on the basis of a professionally oriented digital educational environment contribute to the development of students' competencies in applying theoretical knowledge to practical engineering situations, analyzing technical objects through digital tools, presenting simulation results in graphical form, and drawing independent conclusions. The article presents a model for improving the teaching methodology, a system of problems and solutions, tasks to be implemented, effectiveness criteria, and the results of a sample pedagogical experiment.

Keywords. digital educational environment, technical systems, information technologies, professionally oriented education, virtual laboratory, digital competence, integration, engineering education, simulation, methodology.

Introduction. In the context of modern technical higher education, information technologies are considered not merely as a means of developing computer literacy, but as a scientific and practical basis for analyzing technical objects, engineering systems, production processes, and automated control mechanisms[7]. Particularly under the conditions of digital transformation, students of technical fields are required to acquire skills in modelling technological processes, processing experimental results, assembling circuits in virtual laboratories, conducting graphical analysis of measurement results, and solving professional problems through software tools.

The subject "Information Technologies in Technical Systems" is an important educational module for students in technical fields. Through this subject, students develop competencies such as collecting, storing, processing, and visualizing data in technical systems, as well as algorithmization, software modelling, and justification of engineering decisions[3]. However, in practice, this subject is sometimes limited to the study of general information technologies, office software, or theoretical concepts. As a result, the content of the subject is not sufficiently integrated with professional disciplines such as electronics, electrical engineering, automation, microprocessor systems, and technical measurements.

The development of the digital educational environment creates new methodological opportunities for addressing this problem. Virtual laboratories, interactive simulators, electronic learning resources, distance learning platforms, digital assessment tools, and data analysis software make it possible to develop students' professional knowledge and digital competencies in an integrated manner. A 2024 meta - analysis examining the impact of virtual laboratories in engineering education reported that such laboratories have a positive effect on students' learning outcomes, acquisition of professional knowledge, and cognitive activity. In addition, the DigCompEdu framework provides a scientifically grounded description of teachers' digital competence and serves as an important theoretical basis for designing digital pedagogical activities[6].

The main problem addressed in this study is that, although the possibilities of a digital educational environment exist in teaching the subject "Information Technologies in Technical Systems," their systematic application on the basis of a professionally oriented methodology has not yet been sufficiently developed. Therefore, integrating this subject with professional disciplines, applying virtual laboratories on a methodologically grounded basis, and assessing students' learning outcomes according to clearly defined criteria constitute an important scientific and practical task [4].

The purpose of the study is to develop a model for improving the methodology of teaching the subject "Information Technologies in Technical Systems" in a professionally oriented digital educational environment and to substantiate its effectiveness. The objectives of the study are to identify the existing problems in professionally oriented teaching of the subject "Information Technologies in Technical Systems"; to analyze scientific approaches related to the digital educational environment, virtual laboratories, and the integration of professional disciplines; to develop a model for improving the teaching methodology of the subject; to determine a system of problems and solutions; to develop criteria for assessing learning outcomes; and to demonstrate the effectiveness of the proposed methodology on the basis of the results of a sample pedagogical experiment.

Literature Review. Contemporary research on teaching technical subjects in a digital educational environment is developing in three main directions: first, virtual laboratories and simulation technologies; second, the formation of digital competencies; and third, methodological models based on the integration of technological, pedagogical, and subject - specific knowledge [9].

Virtual laboratories are regarded as an effective tool for reducing the gap between theoretical knowledge and practical experience in engineering education. In a meta - analysis published by Li and Liang in 2024, the effectiveness of virtual laboratories in engineering education was analyzed on the basis of studies obtained from the Web of Science and Scopus databases, and it was emphasized that this approach has a positive impact on students' learning outcomes. This conclusion indicates the need to use virtual laboratories in the subject "Information Technologies in Technical Systems" not merely as an auxiliary tool, but as a core methodological component. Systematic reviews of virtual laboratories highlight such advantages as safety, economic efficiency, the possibility of repeated experimentation, flexibility of the learning process, and the enhancement of students' independent learning activities. Studies published in 2025 also note that virtual laboratories contribute to the development of conceptual understanding, laboratory skills, scientific literacy, analytical thinking, and critical thinking.

In the context of digital competencies, the DigCompEdu framework serves as an important theoretical foundation. This framework provides a scientifically grounded description of educators' digital competence and systematizes competencies related to the effective use of digital technologies in the educational process, assessment, learner engagement, and the creation of digital resources. In teaching the subject "Information Technologies in Technical Systems," this approach requires the teacher not only to know the technology, but also to integrate it with professional content and pedagogical objectives.

The TPACK model is also recognized as an important theoretical source for integrating technology into the educational process. The TPACK approach implies the integration of teachers' technological knowledge, pedagogical knowledge, and subject-matter knowledge. Studies on the organization of technology - enhanced instruction based on TPACK in engineering education show the necessity for teachers to design subject content, pedagogical strategy, and digital tools in an integrated manner. At the same time, organizing laboratory classes in a digital educational environment is not limited to the use of a virtual device or platform. Studies conducted in 2025 indicate that, in a laboratory-based online learning model, interactions between student and content, student and teacher, and student and feedback are important factors. Therefore, the effectiveness of a virtual laboratory in the subject "Information Technologies in Technical Systems" depends not only on its technical capabilities, but also on task design, assessment criteria, teacher guidance, and professional context.

Based on the literature review, the following scientific conclusions can be drawn. A digital educational environment serves as an important methodological platform for developing practical competencies in technical disciplines. Virtual laboratories are an effective tool for ensuring the integration of professional disciplines and information technologies. The methodology should be developed not merely through the introduction of technology, but in conjunction with educational objectives, professional content, a system of assignments, assessment criteria, and reflective analysis. In technical education, digital competence should not be formed separately from professional competence; rather, it should be developed through activities aimed at solving technical problems by means of digital tools.

Research Methodology. The research focuses on the process of teaching the subject "Information Technologies in Technical Systems" in technical higher education institutions. The subject of the study comprises the content, model, tools, and assessment mechanisms for improving the methodology of teaching this subject in a professionally oriented digital educational environment.

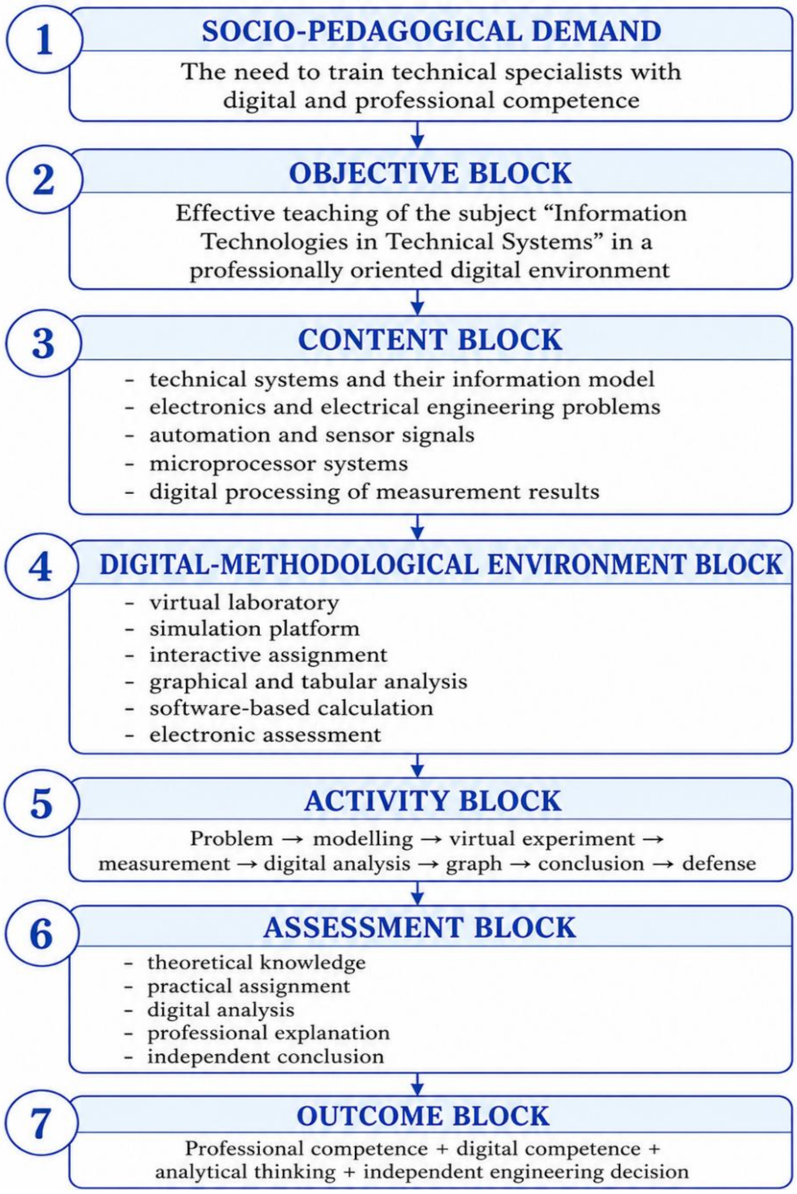
If the subject "Information Technologies in Technical Systems" is taught on the basis of a professionally oriented digital educational environment - that is, through virtual laboratories, simulation, interactive assignments, digital analysis, graphical visualization, and integration with professional disciplines - then students' theoretical knowledge, practical skills, digital competence, and ability to solve professional problems will develop at a higher level compared with traditional teaching.

The following methods were used in the study: analysis of scientific and pedagogical literature, comparative analysis, pedagogical modelling, diagnostic testing, assessment of practical assignment outcomes, questionnaire survey, experimental testing, statistical generalization, and graphical analysis.

The proposed methodology is based on the following components: the professional content component, which includes topics related to electronics, electrical engineering, automation, microprocessor systems, and technical measurements; the digital-technological component, which includes virtual laboratories, simulators, electronic platforms, graphical analysis software, Python, MATLAB, or Excel; the pedagogical component, which includes problem-based learning, project-based instruction, practical assignments, reflection, and individually parameterized tasks; and the assessment component, which includes tests, virtual experiment reports, graphs, software - based analysis, conclusions, and presentation or defense.

The outcome component is an important structural element that reflects the final effectiveness of the improved methodology. This component is manifested through the level of formation of students' professional competence, digital competence, analytical thinking, independent learning skills, and ability to justify engineering decisions. In particular, professional competence is reflected in the student's understanding of problems related to technical systems, electronics, electrical engineering, automation, and microprocessor devices, as well as in their ability to apply this knowledge in practical situations. Digital competence includes the skills of effectively using virtual laboratories, simulation platforms, software-based calculation tools, electronic spreadsheets, and graphical analysis environments, as well as processing data and presenting results in digital form.

A model for improving the methodology of teaching the subject "Information Technologies in Technical Systems" in a professionally oriented digital educational environment is presented. Figure 1. Model for Improving the Teaching Methodology in a Professionally Oriented Digital Educational Environment.



In this model, the educational process is organized not in the form of a linear lecture, but as an activity directed toward solving a professional problem. The student is no longer merely a recipient of theoretical information, but becomes an active subject who analyzes a technical problem using digital tools. Table 1. Existing Problems in Teaching the Subject and Methodological Solutions

No.	Identified problem	Pedagogical essence of the problem	Proposed solution	Expected result

1	Teaching the subject content separately from professional disciplines	The student is unable to apply information technology to technical problems	Linking each topic with electronics, electrical engineering, automation, or microprocessor systems	Professionally oriented knowledge is formed
2	Insufficient connection of practical classes with real technical situations	Exercises are abstract and general in nature	Developing problem-based assignments based on technical objects	The student learns to solve professional problems
3	Episodic use of virtual laboratories	Digital tools do not become part of a methodological system	Transforming the virtual laboratory into a compulsory activity component of the lesson	Experimental, measurement, and analytical skills are developed
4	Relying only on test results in assessment	Practical and analytical competencies are not sufficiently identified	Assessment based on test + virtual experiment + graph + report + defense	Comprehensive assessment is implemented
5	Low level of students' independent learning activity	The likelihood of copying ready-made answers increases	Assigning tasks with individual parameters	Independent decision-making is developed
6	Insufficient digital-methodological preparedness of the teacher	Technology is not applied in accordance with pedagogical objectives	Organizing digital-methodological manuals and training sessions for teachers	Methodological stability is ensured
7	Insufficient attention to the analysis of obtained results	The student records the result mechanically without explaining its cause	Introducing an algorithm for writing graphs, tables, and conclusions	Analytical thinking is strengthened

To implement the proposed methodology in practice, the following tasks should be carried out. Each topic of the subject "Information Technologies in Technical Systems" should be linked with a real technical problem from professional disciplines. For example, the topic "processing data in a table" may be taught not through a simple statistical table, but through the processing of voltage, current, frequency, and phase shift results in an RLC circuit [9].

It is advisable to develop virtual laboratory assignments for the subject at least in the following areas: calculation of electrical circuit parameters; analysis of the current-voltage characteristic of a diode; study of bipolar transistor characteristics; observation of the resonance phenomenon in an RLC circuit; digital processing of sensor signals; modelling a control algorithm using a microcontroller; graphical analysis of technical measurement results; and development of a system of practical assignments with individual parameters. Each student should be given separate parameters.

Student	R, Ohm	L, mH	C, μF	U, V	f, Hz
Student 1	100	50	10	220	50
Student 2	120	60	15	220	50
Student 3	150	70	20	220	50

This approach ensures students' independent work and reduces the likelihood of copying results. Assessment should be carried out on the basis of the following criteria:

Assessment criterion	Content	Score
Theoretical preparation	Knowledge of basic concepts	15
Performing a virtual experiment	Correct organization of the simulation	20
Data processing	Correct completion of tables and calculations	20
Graphical analysis	Visual interpretation of results	15
Professional explanation	Relating the result to a technical discipline	15
Conclusion and defense	Independent reasoning and well-grounded conclusion	15
Total		100

A methodological manual should be prepared for teachers. The manual should include the following: a map of professional links by topic, virtual laboratory links or instructions for use, assignment templates, assessment criteria, a sample report form, examples of graphs and tables, and criteria for analyzing students' errors.

Results. In order to assess the effectiveness of the proposed methodology, a sample pedagogical experiment model was developed [11]. The experiment was organized on the basis of two groups: the control group was taught using the traditional methodology, while the experimental group was taught on the basis of a professionally oriented digital educational environment, virtual laboratories, simulation, graphical analysis, and individual assignments. Table 2. Learning Outcomes of the Control and Experimental Groups

Indicators	Control group, initial	Control group, final	Experimental group, initial	Experimental group, final
Theoretical knowledge	58	71	57	84
Performance of practical assignments	54	68	55	86
Digital analysis	50	64	51	82
Working with graphs and tables	52	66	53	85
Professional interpretation	49	62	50	81
Drawing independent conclusions	51	65	52	83
Average indicator	52.3	66.0	53.0	83.5

As can be seen from the table, the average indicator in the control group increased from 52.3 points to 66.0 points. In the experimental group, however, the average indicator increased from 53.0 points to 83.5 points. This indicates that the proposed methodology has a positive impact on the development of theoretical knowledge, practical skills, digital analysis, and professional interpretation competencies [4]. Figure 2. Growth Graph of Learning Outcomes in the Control and Experimental Groups

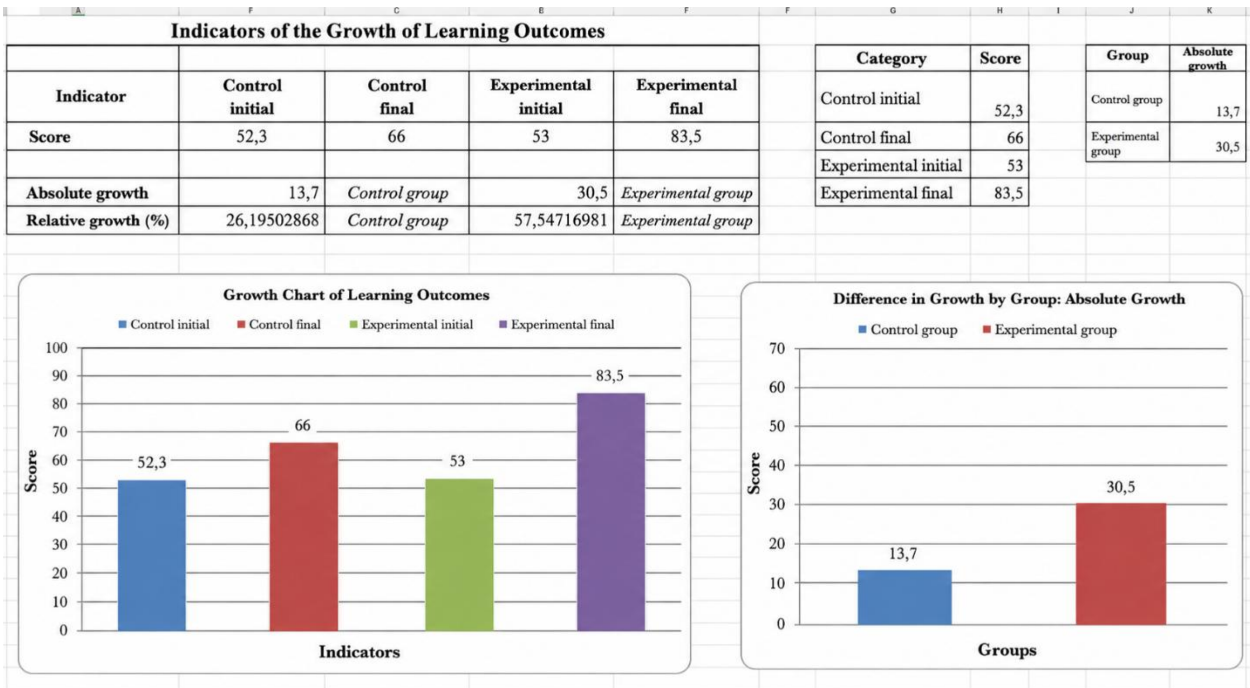


Table 3. Growth Indicators

Group	Initial average score	Final average score	Absolute growth	Relative growth

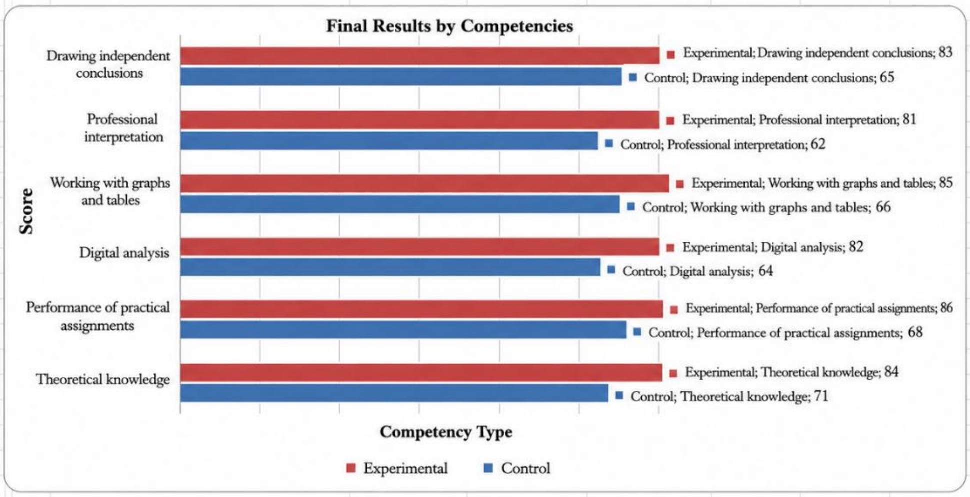
Control group	52.3	66.0	13.7	26.2%
Experimental group	53.0	83.5	30.5	57.5%

According to the results, the experimental group demonstrated an absolute growth of 30.5 points, while the relative growth reached 57.5%. In the control group, these indicators were 13.7 points and 26.2%, respectively. This finding indicates that the methodology organized on the basis of a professionally oriented digital educational environment had a significant positive effect on students' learning activity. In particular, virtual laboratories, simulation-based tasks, graphical analysis, practical exercises performed on the basis of individual parameters, and digital assessment tools contributed to linking students' theoretical knowledge with practical activity [8].

Figure 3 presented below illustrates a comparison of the final results by competencies. It compares the final performance indicators of the control and experimental groups across the main competencies, including theoretical knowledge, performance of practical assignments, digital analysis, working with graphs and tables, professional interpretation, and drawing independent conclusions.

No.	Competency Type	Control	Experimental	Difference
1	Theoretical knowledge	71	84	13
2	Performance of practical assignments	68	86	18
3	Digital analysis	64	82	18
4	Working with graphs and tables	66	85	19
5	Professional interpretation	62	81	19
6	Drawing independent conclusions	65	83	18

Competency Type	Control	Experimental
Theoretical knowledge	71	84
Performance of practical assignments	68	86
Digital analysis	64	82
Working with graphs and tables	66	85
Professional interpretation	62	81
Drawing independent conclusions	65	83



The effectiveness of the proposed methodology was assessed on the basis of several criteria. In traditional instruction, students often know a technical concept at a theoretical level, but experience difficulties in applying it in real or virtual situations. In a professionally oriented digital educational environment, however, theory is directly linked with simulation, experimentation, and graphical analysis. For example, a student not only studies the impedance formula in an RLC circuit, but also observes how current and voltage change by modifying the R, L, and C parameters in a virtual laboratory. The student enters measurement results into an electronic spreadsheet, constructs a graph, processes the results using software tools, and draws conclusions. In this process, digital competence is formed in close connection with professional activity.

The DigCompEdu approach also emphasizes that digital technologies enrich the educational process, support assessment, and contribute to developing learners as active participants. The student understands a technical object as an information model. For instance, sensor signals, voltage, current, resistance, frequency, or temperature values are considered as information. This information is processed, analyzed, and used in making technical decisions. As a result, the student recognizes information technology as an integral part of professional activity.

Assignments based on individual parameters strengthen students' independent learning activity. Within the same laboratory topic, each student performs calculations and analysis based on separate values. This leads to independent inquiry and well-grounded conclusions rather than copying ready-made answers. The proposed methodology requires the teacher to act not merely as a transmitter of information, but as a methodologist who designs the digital environment, selects professional problems, manages virtual experiments, and evaluates outcomes. In the TPACK approach, the integration of technology, pedagogy, and subject content is also regarded as the basis of effective digital education.

Discussion. The results of the study demonstrate the need to improve the methodology of teaching the subject "Information Technologies in Technical Systems" in a professionally oriented digital educational environment. For students in technical fields, information technology is not merely a general computer skill, but a tool for analyzing, modelling, and managing professional problems. The main advantage of the proposed methodology is that it places the content of the subject within a professional context [4]. The student does not study software, spreadsheets, graphs, or virtual laboratories separately. Instead, these tools are applied in the process of solving a specific technical problem. For example, studying the current-voltage characteristics of a transistor in electronics, analyzing the parameters of an RLC circuit in electrical engineering, or processing sensor signals in automation is closely integrated with the subject of information technologies.

The experimental results show that classes based on virtual laboratories, simulation, and graphical analysis activate students' learning activity. The student changes parameters, observes the results, identifies errors, enters the results into a table, and analyzes them through graphs. This process requires a higher level of cognitive activity than simple knowledge transmission. At the same time, virtual laboratories should not completely replace real laboratory classes [3]. They are highly effective at the stages of preparation before working with real equipment, creating a safe experimental environment, consolidating theoretical knowledge, and analyzing results. However, skills such as connecting wires, using measuring instruments, identifying faults in real devices, and eliminating contact errors should also be developed through real laboratory work. Therefore, the most appropriate approach is a blended methodology that integrates virtual and real laboratories.

The scientific novelty of this study is reflected in the following aspects. A structural - methodological model for teaching the subject "Information Technologies in Technical Systems" in a professionally oriented digital educational environment was developed. The algorithm for integrating the subject content with professional disciplines was substantiated on the basis of the sequence "problem → modelling → virtual experiment → measurement → digital analysis → graph → conclusion." A methodological system based on virtual laboratories, simulation, graphical analysis, and assignments with individual parameters was proposed.

Criteria for assessing students' theoretical, practical, digital, and professional competencies were developed. The effectiveness of the proposed methodology was demonstrated on the basis of the results of a sample pedagogical experiment. The results of the study may be used in the following practical areas: improving the curriculum of the subject "Information Technologies in Technical Systems"; developing a set of virtual laboratory assignments for technical fields; integrating the subjects of electronics, electrical engineering, automation, and microprocessor systems with the digital educational environment; organizing students' independent work; and preparing methodological manuals for teachers.

Conclusion. Improving the methodology of teaching the subject "Information Technologies in Technical Systems" in a professionally oriented digital educational environment is an important scientific and practical task in technical higher education. The results of the study show that, in order to teach this subject effectively, it should be organized not within the framework of general information technologies, but in integration with professional disciplines.

Virtual laboratories, simulation platforms, graphical analysis, digital data processing, and individual assignments make it possible to link students' theoretical knowledge with practical engineering activity. The proposed methodology develops students' professional competence, digital competence, analytical thinking, ability to perform independent experiments, and skills in drawing well-grounded conclusions.

According to the results of the sample experiment, the average learning outcomes in the experimental group increased from 53.0 points to 83.5 points. In the control group, this indicator increased from 52.3 points to 66.0 points. This demonstrates the higher effectiveness of the methodology organized on the basis of a professionally oriented digital educational environment compared with the traditional approach [5].

Thus, improving the methodology of teaching the subject "Information Technologies in Technical Systems" on the basis of a professionally oriented digital educational environment contributes to enhancing the quality of training technical specialists, strengthening interdisciplinary integration, and preparing competitive personnel under the conditions of digital transformation.

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