Innovations in Pedagogy and Technology
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Digitalization of the Educational Process as an Effective Tool for Improving Its Quality

Nataliya Mutovkina

Department of Management and Social Communications, Tver State Technical University, Tver 170012, Russia

ABSTRACT

The article discusses the results of electronic information and the educational environment at Tver State Technical University over the past few years in connection with the general trend of digital transformation of the educational process in Russian universities. The electronic information and educational environment is a system that permeates all structural divisions of the University and provides significant support for their interaction. The article shows her structure and the specifics of its use, and defines the tasks and capabilities of all user categories. The research novelty is a systematic approach to assessing the quality of an educational system based on digital technologies. The digitalization of the educational process, namely the development of an electronic information and educational environment, has a positive effect on the performance of all its participants. The electronic information and educational environment contribute to the evolution of students' analytical and communicative competencies and early adaptation to the educational process. The advantages of conducting training sessions in computer classrooms and the difficulties associated with their organization are the other. Access to electronic training courses from computer-equipped classrooms permits students to receive up-to-date information on their subjects, better understand the essence of academic assignments, and interact with teachers and fellow students. The article contains recommendations on the use of computers and information and communication technologies in education. We discuss the possibilities of further development of the electronic information and educational environment to improve the effectiveness of education.

Keywords: Educational Process; Digitalization; Information and Communication Technologies; Electronic Information and Educational Environment; Higher Education; Student Satisfaction

*CORRESPONDING AUTHOR:
Nataliya Mutovkina, Department of Management and Social Communications, Tver State Technical University, Tver 170012, Russia;
Email: letter-boxNM@yandex.ru

ARTICLE INFO
Received: 20 August 2025 | Revised: 2 October 2025 | Accepted: 5 October 2025 | Published Online: 13 October 2025
DOI: https://doi.org/10.63385/ipt.v1i3.170

CITATION
Mutovkina, N., 2025. Digitalization of the Educational Process as an Effective Tool for Improving Its Quality. Innovations in Pedagogy and Technology. 1(3): 110–124. DOI: https://doi.org/10.63385/ipt.v1i3.170

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1. Introduction

In the modern world, several significant trends of digitalization have emerged, permeating almost all areas of science, technology, and people's lives. The main trends of digitalization are the integration of artificial intelligence (AI) into everyday life, the development of the Internet of Things, quantum computing and big data analysis, the advancement of smart cities, and the emergence of remote and hybrid work formats. To become competitive in the labor market, students must be well-versed in modern digital technologies and apply them both in professional and daily activities. The study of modern digital technologies is an integral part of the digitalization of the educational process. However, this requires creating conditions for effective learning, which means digitalizing the educational process itself. The digitalization of education refers to the introduction of digital technologies into the educational and management processes of educational organizations [1]. In the article, the author examines the main trends in the digitalization of the educational process in Russian universities and shares the results of research on the implementation of digitalization elements at Tver State Technical University. The study used sociological methods (surveys, testing) and statistical methods of processing the results. A paper aims to examine whether the digitalization of the educational process increases its effectiveness, which is manifested not only in raising student academic performance and teacher interest, but also in developing professional competencies. The practical significance of the study lies in demonstrating the achieved effects in the educational process of TvSTU, as well as in stimulating the leadership and staff of other educational organizations to introduce a similar digital environment.

1.1. Modern Trends in the Digitalization of the Educational Process

In the traditional understanding, at universities, the educational process is the transfer of structured information intended for solving professional problems from teachers to students, and its development, comprehension, and application by students in professional activities. However, at present, simply broadcasting educational information and monitoring the level of its development is not enough. The main thing is not to "read" the whole course or its fragments with the help of a computer and verify learning, but to have a higher level of representation in the educational process of the learned object itself, the transition from a descriptive or analytical representation of this object to modeling its essential properties [2]. For higher education, using computer capabilities in modeling research and professional activities is of paramount importance. We consider digitalization in the context of such pedagogical technologies that would ensure the transition from a formal disciplinary to a problem-based type of education. In this regard, several global trends in the digitalization of higher professional education can be identified (**Table 1**).

Table 1. Trends in the digitalization of the educational process at universities in world [3–7].

Trend	Description of the Trend
Creation of educational resources and digital platforms supporting interactive and multimedia content for shared access by higher education institutions and students, particularly tools to automate the key processes of university operations.	The basis of this trend is online learning platforms, which provide remote access to educational materials, resources, and educational modules. These include, for example, Google Classroom, Moodle, and Canvas. Such platforms create conditions for effective communication between students and teachers, and promote the dissemination of educational and practice-oriented information.
Development and implementation of innovative computer, multimedia, and computer-oriented learning tools and equipment to create digital learning environments (multimedia classrooms, STEM research centers and laboratories, inclusive classrooms, blended learning classrooms).	The use of digital learning environments requires a material base, competent, qualified personnel, digital educational resources, and a high level of ICT competence among students. That enables them to apply a computer as a learning tool. Multimedia technologies provide a representation of information that a person perceives with all senses at once in parallel, rather than sequentially, as is done with traditional learning. Multimedia educational programs are for front-end, group, and individual classroom instruction, as well as for independent work at home.

Table 1. *Cont.*

Trend	Description of the Trend
Free access to the Internet for students in classrooms.	The importance of students' free access to Internet resources during classroom activities lies in the fact that it allows: to activate the learning process, to make the learning process more vivid and exciting, to diversify the forms of students' work, to stimulate the need to find the necessary resources to solve the task, and to foster team spirit and partnerships between students.
Development of distance education using cognitive and multimedia technologies.	Cognitive technologies include machine learning technologies and an agent-based approach. They enable the application of generalized knowledge in intelligent systems, which form new solutions for purposeful behavior. Cognitive technologies are used in learning systems to acquire new knowledge and in simulators to create skills. Multimedia technologies include the use of presentations, audio, and video materials. They increase visibility and emotional engagement. The main types of multimedia technologies include interactive platforms and simulators, virtual classrooms and digital laboratories, design and game technologies with digital support, and remote communication tools. The use of multimedia technologies takes into account the individual characteristics of information perception, which is significant in the computer-mediated transmission of educational information from a teacher to a student.
Personalized learning.	Neural networks analyze a student's preferences, learning progress, and create a lesson plan tailored to everyone's needs, capabilities, pace, and schedule.
The use of immersive technologies.	Universities are actively implementing virtual reality (VR) and augmented reality (AR). With such technologies, we must create unique learning environments where students can master even the most complex concepts in professional fields.
Increased attention to cybersecurity.	The digitalization of the learning environment requires new approaches to protecting the data of students, teachers, and other representatives of educational organizations. Universities are implementing programs and activities that aim at improving digital security.
Assessment using augmented reality technologies.	In augmented reality, students can demonstrate professional competencies in practice and make decisions in as natural an environment as possible.

The effects of these trends are expanding the possibilities of cognition, enhancing self-control over your learning process, promoting lifelong learning, and others. The importance of digitalization of education is emphasized in many modern studies, for example, in B. Kebir[8], M.D. Omojemite[9], V. Potocan, Z. Nedelko, M. Rosi[10], K. Bibi, M. Sultana, M. Baig[11], E.O. Grantseva[12]. Indeed, there is no doubt about it, since digital technologies make the learning process more convenient, exciting, and productive.

1.2. The Role of a System Approach in the Digitalization of the Educational Process

In the digitalization of the educational process, we must approach it with a systems approach. A system approach in the educational process is the coordinated use of modern systems and technologies, including digital ones, that ensure the most effective learning of educational materials by students and, consequently, the development of professional competencies[13].

A system approach to the use of digital technologies in the educational process should ensure the integrity of the learning material; contribute to improving the objectivity of evaluating the performance of educational tasks, and, consequently, the formation of a set of productive measures to improve students' academic performance and enhance their interest in learning. At the same time, digitalization concerns not only the educational process, but also managerial, organizational, and methodological processes. One of the directions of the system approach is to engage all university participants in the digital environment[14].

The trends of digitalization listed in **Table 1** largely overlap and complement each other. For example, the use of educational digital platforms is impossible without free access to the Internet. Therefore, the main backbone element of the digitalization of the educational process is EIEE, which includes a variety of digital tools. The digitalization of the educational process is to ensure its high quality. That is the goal of digitalization. Accounting for the existing diversity

of digital tools, we must select tools that meet the set goal. For a sufficient choice at each university, we must answer four questions.

1. What is the content of each digital instrument?
2. What are the features and conditions of using a digital instrument?
3. How can a specific digital tool be used in the educational process?
4. What effects are planned to be achieved using a specific digital instrument?

The issue of choosing software and hardware for a digital tool in the educational process is also significant. Therefore, in accordance with the system approach, it is necessary to perform a system analysis of the existing educational environment, considering the use of digital tools, and then summarize the results with a list of potential effects. Based on this, each university will have its own set of digital tools, which we join into the system. Next, the author presents an example of a digital educational system developed at Tver State Technical University and shows an assessment of its application in the educational process. The grades we group into two categories of users: students and teachers.

2. Materials and Methods

The research materials include the facts on the use of EIEE at TvSTU and the results of a survey of EIEE users regarding their satisfaction with digital services. This section discusses the EIEE structure, its design environment, and the software and hardware requirements for seamless access to the system. The author also describes some statistical methods for analyzing the ratings of EIEE users. The main users of EIEE are teachers and students. Every year, TvSTU monitors the assessment of the quality of education by the organization's standard "Internal Educational Quality Assessment System of Tver State Technical University" STO QMS 02.020–2024 [15]. The second document regulating the assessment of the quality of education, including the use of digital technologies, is the Standard of the organization "Quality Management System. Satisfaction Monitoring" STO QMS 02.010–2024 [16]. The research methods are questionnaires and statistical processing of their results. The survey is online through the official website of TvSTU. The purpose of the questioning is to gather information about satisfaction with the quality of education. But many questions are related to the use of digital elements.

2.1. The Main Directions of Digitalization of the Educational Process in TvSTU

The key directions of digitalization of the educational process in TvSTU are the use of online courses, electronic libraries, learning management systems, virtual reality, and other modern tools (**Figure 1**) [17, 18].

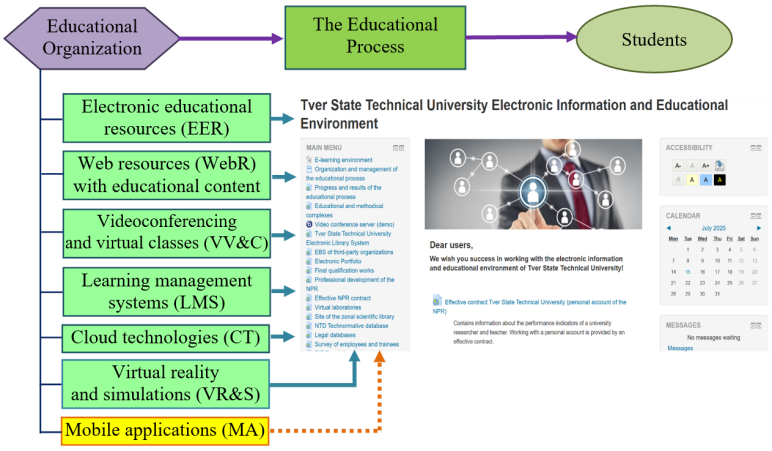


Figure 1. The main elements of the digitalization of the educational process.

Figure 1 shows seven elements of digitalization, the first six of which are in the TvSTU EIEE. The start page of the digital educational environment is also in this figure. Electronic educational resources include any educational resources available in digital format (teaching and methodological manuals, workshops, collections of assignments,

tests, videos, etc.)[19]. They can use it at any time and from anywhere in the world, which is especially important for students who are away from an educational organization. Web resources with educational content serve teachers in organizing the students' cognitive activity. There are websites and portals containing thematic information. Students independently master this content, analyze it, learn to think critically, and formulate conclusions about the studied information. Web resources also include resources with creative contests, Olympiads, and quizzes, in which students receive additional points for their academic performance rating[20]. Learning management systems are programs and services that help organize learning by providing students with access to materials and assignments, and teachers with the ability to track academic performance. Videoconferencing and virtual classrooms are platforms that allow teachers and students to communicate online. They are often used to organize remote lectures and seminars. Cloud technologies have become an indispensable tool for storing, sharing, and collaborating on educational materials. Cloud storage helps students and teachers to access their data from any device, ensuring mobility and accessibility of learning[21, 22].

With the help of virtual reality and simulations, students and teachers can immerse themselves in real situations and environments. That is especially useful for gaining practical experience and skills in electrical engineering, construction, and other fields. Mobile applications help in studying various training courses and fields of knowledge by providing access to additional materials and tasks via a smartphone or tablet. The last element of digitalization has not yet been in the TvSTU EIEE, but work on this is already underway. In the future, the development of a mobile version of EIEE will be. The advantage of mobile devices is that they are almost always in human possession, are small in size, and are connected to the Internet almost anywhere. The mobile information and educational environment can be considered a specialized system that uses smartphone technology and micro-education. It enables users to access the information contained in it from anywhere and at any time. The mobile version of EIEE gives a new quality to the educational process: It is more autonomous, fully reflects the trends in modern human education, and provides constant access to learning information. It is these characteristics that contribute to the development of students' interest in self-learning, which is a key task of mobile learning[23].

The time required to create a mobile version of the e-learning environment depends on the project's complexity.

The basic level. It takes from 2 to 6 months to collect requirements, design UI/UX, develop basic functions, QA, and deployment rounds[24].

The average level. The estimated duration is from 6 to 12 months. During this period, they include basic functions, gamification, integration with social platforms, advanced analytics, and more[25].

The highest level. The expected duration is 12 months or more. During this period, we will add self-learning algorithms, chatbots, adaptive learning mechanisms, and AR/VR integration.

Therefore, we expect the mobile version of EIEE no earlier than the following year.

2.2. The Structure of the Electronic Information Educational Environment of TvSTU

EIEE at TvSTU emerged in 2017 as a response to the current Russian legislation's requirement for the informatization of the educational process in educational organizations[26].

The purpose of creating and using EIEE is to ensure the required level of quality in learning conditions at the university. The state educational standards for higher education regulate the quality of education.

The first work devoted to EIEE for open learning at TvSTU was published in 2002 by V.K. Ivanov, the founder of EIEE, and his colleagues[27]. In this and other authors' works, one of the key features of the open education system is the flexibility of learning. The open education system ensures that learning is accessible while maintaining its quality. Adaptability accounts for the users' preferences for the system when forming the content of educational materials. All these principles are at the development of the TvSTU EIEE.

We constructed the EIEE on the Moodle platform, a well-known system for organizing the educational process that uses intensive e-learning technologies. It has been used in Russia for a long time and is the most popular e-learning system in the world. Moodle technologies are full-fledged, independent work, in-depth study of the material, and effective control of knowledge. The e-learning system includes

a website, a database, and a repository of educational materials and student papers. A large community of qualified developers and users ensures the dynamic development of Moodle. The Moodle system has been in operation at TvSTU since 2010. The e-Science and Learning Center supports its operation. Details: http://elearning.tstu.tver.ru[28].

Most standard internet browsers support Moodle, including Chrome, Firefox, Safari, and Edge. Databases for working with Moodle are, for example, PostgreSQL 9.6, MySQL 5.7, MariaDB 10.2.29, Microsoft SQL Server 2012, Oracle Database 11.2, as well as their latest versions. Windows 7 and higher, macOS 10.10 and higher, and any x64 build of Linux are suitable operating systems. Standard hardware is sufficient to work with Moodle-based EIEE. For example, 200 MB of disk space is adequate, but we recommend at least 5 GB. The minimum processor frequency is 1 GHz; we recommend a dual-core processor with a frequency of 2 GHz or faster. RAM minimum is 512 MB; we recommend 1 GB or more on a computer and 8 GB or more on a large production server. The minimum Internet connection speed should be 56 Kb/sec, and the recommended speed is 528 Kb/sec[29, 30].

To work in EIEE, each user needs to register. Registration is standard. The user is assigned a unique username and password. The general part of the EIEE consists of menus with an extensive list of digital tools (**Figure 2**).

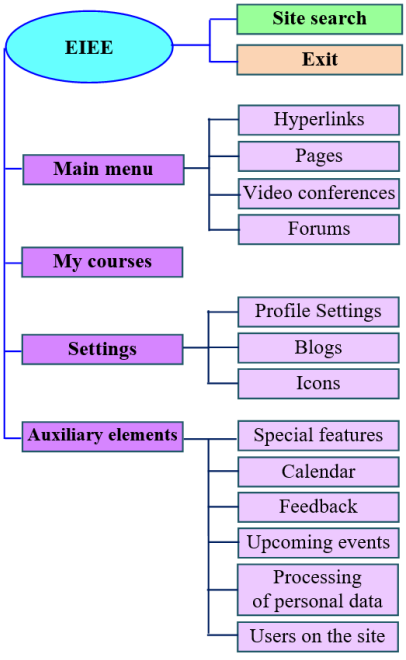


Figure 2. EIEE structure.

The menus provide easy navigation through the elements of the educational environment. The main menu contains the types of elements: hyperlinks, pages, video conferences, and forums. Clicking on the hyperlink opens the corresponding resource, for example, virtual laboratories, educational and methodological complexes, a Customer Service and Support Center, and others. The pages are class schedules, study plans, and educational programs. Each user can initiate a video conference using the BigBlueButton cloud platform. This platform is an open-source web conferencing software that is primarily for distance learning. This service is often used by teachers when organizing classes with correspondence students[31]. A significant element of the main menu is forums, where participants can discuss general issues, the organization of training sessions, extracurricular activities, and other topics. The first item in the main menu is the "e-Learning Environment" (**Figure 1**). Clicking on it opens a page with electronic training courses, organized by thematic sections and structural divisions of the university (**Figure 3**).

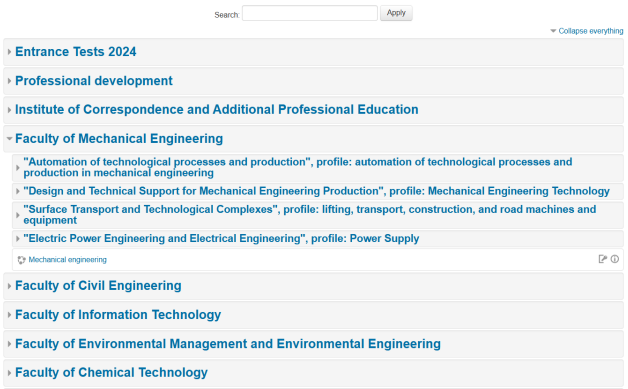


Figure 3. A fragment of the grouping of electronic courses in the TvSTU EIEE.

On this page, students can easily find the course they are interested in, enroll in it, and use the available materials. The teacher can order a course template from the EIEE administrator, develop the course according to the current work program of the discipline, and apply it in the educational process. The courses created by the teacher appear in the "My Courses" menu of the main EIEE window. This way, you can quickly open the desired course without a search. The menu "Settings" is for users to change their profiles. The remaining EIEE elements are considered auxiliary.

Auxiliary elements of EIEE are:

- "Special features" for interface design and working with text;
- A "Calendar" in which key dates for the user in color;
- "Feedback" is used to view and share messages;
- "Upcoming events" is information for the user about events planned by him or for him;
- "Processing of personal data" contains an Order "On approval of the Policy regarding the processing of personal data in TvSTU";
- "Users on the site" shows active users in the system for the last five minutes.

The administrator can add menu items or remove unnecessary sections from the EIEE menu. The flexibility of EIEE settings is one of the advantages of this system, with a systematic approach to information system design [14, 21].

2.3. Description of the Statistical Samples and Methods of Their Formation

The effectiveness of digital technologies in the educational process is evaluated by the following methodology:

1. Selection of evaluation objects;
2. Formation of criteria for evaluation and evaluation scale;
3. Determination of assessment subjects and their number;
4. Preparation of assessment questionnaires;
5. Conducting a survey;
6. Analysis of the survey results;
7. Summarizing the results.

The estimation of the usefulness of digital elements in the educational process is part of an analysis of the university's environmental quality. The key objects of evaluation are the electronic library and its educational resources, the official website, EIEE, computer resources, and the ability to access the Internet [18, 21]. Respondents' satisfaction with these facilities acts as a factor (x_i) that affects their satisfaction with the quality of education (y). The questionnaires contain various types of questions. Some questions need to be answered on a scale from 0 to 10, where a score of "10" indicates the highest degree of satisfaction. There are possible answers to other questions, and each respondent can choose only one option. For example, in the questionnaire for research and teaching staff, almost all the questions had four possible answers: "Completely dissatisfied", "Partially satisfied", "Mostly satisfied", "Completely satisfied". We use the following evaluation scale for the transition from scores to qualitative assessments (**Table 2**).

Table 2. Evaluation scale.

Interval	0.0–2.5	2.6–5.0	5.1–7.5	7.6–10.0
Level Interpretation	"Completely dissatisfied"	"Partially satisfied"	"Mostly satisfied"	"Completely satisfied"

The subjects of the estimation were students and teachers. The university annually enrolls an average of 6780 students and employs 358 teachers. We calculate required representative sample sizes using formula (1). That is, the following conditions. The sample is random, selection of units is repeated, and the marginal error of the share of EIEE users among teachers and students should not exceed 7.0 % with a probability of 0.954 [32].

$$n = \frac{t^2 \cdot w(1-w)}{\Delta_w^2} \quad (1)$$

In formula (1), t is the confidence coefficient, which is 2.0 at P = 0.954. At the same time, the share of digital technology users is unknown, so the maximum value of the share variance is in the calculations. It is equal to 0.25.

Therefore, it is necessary to interview at least 102 teachers and students. The actual number of respondents was 114 teachers and 446 students. That indicates the representativeness of the samples.

We calculated in the last column of **Table 3** and **Table 4** the average annual estimates of the respondents in the samples using the formula:

$$\overline{x} = \frac{\sum (x_i \cdot f_i)}{\sum f_i} \quad (2)$$

In formula (2), x_i is the average estimate in the "Student training area" group, and f_i is the size of this group.

Table 3. Student graded on a ten-point scale.

Indicator	Chemistry (Medical and Pharmaceutical Chemistry)	Management	Construction (Industrial and Civil Engineering)	Software Engineering	Biotechnology	Computer Science and Engineering	Land Management and Cadastres	Economic Security	Sociology	Average Score
Number of respondents, people	42	34	50	78	26	151	33	13	19	—
Satisfaction with the quality of computer classes (x_1)	8.70	7.68	7.10	8.10	6.81	7.90	7.18	6.85	6.74	7.71
Satisfaction with the work of the library, including electronic educational resources (x_2)	8.80	8.97	8.80	8.30	7.81	8.50	8.97	7.38	7.74	8.49
Satisfaction with the information content and user-friendliness of the university's official website (x_3)	8.80	8.41	8.00	7.70	6.96	8.30	8.88	6.08	7.47	8.08
Ease of use of EIEE (x_4)	8.80	8.21	8.00	7.70	6.85	8.10	9.06	7.38	7.26	8.03
The state of computer resources, the ability to access the Internet (x_5)	8.70	7.79	7.30	8.20	6.38	8.40	7.36	6.00	6.21	7.87
Satisfaction with the quality of education in general (y)	8.90	8.82	7.90	8.10	7.04	8.70	8.82	7.00	7.68	8.35

Table 4. Scientific and pedagogical staff grades on a ten-point scale.

Indicator	Chemistry (Medical and Pharmaceutical Chemistry)	Management	Construction (Industrial and Civil Engineering)	Software Engineering	Biotechnology	Computer Science and Engineering	Land Management and Cadastres	Economic Security	Sociology	Average Score
Number of respondents, people	14	10	15	14	10	15	10	10	16	—
Satisfaction with the quality of computer classes (x_1)	5.23	5.30	4.45	5.58	4.54	4.46	4.54	6.55	5.20	5.07
Satisfaction with the work of the library, including electronic educational resources (x_2)	6.84	7.05	6.96	6.12	7.30	7.80	6.05	7.55	6.61	6.91
Satisfaction with the information content and user-friendliness of the university's official website (x_3)	7.37	7.30	6.80	6.84	7.80	7.80	6.05	7.30	7.24	7.18
Ease of use of EIEE (x_4)	6.13	7.30	6.97	6.48	7.05	7.47	5.80	7.80	7.24	6.92
The state of computer resources, the ability to access the Internet (x_5)	7.02	7.30	6.63	7.02	7.05	7.97	5.80	7.55	6.93	7.05
Satisfaction with the working conditions at TvSTU (y)	7.50	8.40	7.90	7.90	7.60	7.70	7.80	8.20	7.50	7.80

We use the correlation analysis method to identify the relationship between the quality of education and factor characteristics (**Table 3**). The paired correlation coefficient (Pearson correlation coefficient) is a statistical tool that allows you to assess the degree of relationship between two variables. It takes values from −1 to +1. To estimate the closeness of the relationship between the two traits, we use the Robert Emmet Chaddock scale [33]. We determine the paired correlation coefficient using the formula:

$$r_{xy} = \frac{\overline{xy} - \overline{x} \cdot \overline{y}}{\sigma_x \cdot \sigma_y} \tag{3}$$

In formula (3), where σ_x and σ_y are the average square deviations in x and y, respectively.

The matrix of paired correlation coefficients is in Section 3 of this article.

We checked whether there were significant differences between the respondents' grades (students and teachers) using the t-test (Student's criterion). Since we tested representatives from two general populations, we applied a two-sample t-test with different variances. Such a tool is available in the MS Excel Data Analysis add-on. We used a one-way analysis of variance (One-Way ANOVA) to compare the average values for samples from different fields of knowledge. That is a statistical method that evaluates the effect of one factor on a dependent variable. The aim is to identify whether there are statistically significant differences between the average values of the dependent variable in different groups formed by factor levels. Here, the dependent variable is satisfaction with the digitalization of the educational process, and the group factor is the direction of education (vocational training). These methods are classic statistical tools and do not need detailed explanations. In both cases, we calculate the actual values of the criteria and compare them with the

critical values. If the fact values exceed the crit values, the discrepancies in the estimates are considered statistically significant[34].

We have conducted the survey every year since 2020. The survey period is April 15th - May 26th. During this period, respondents visit the website and, depending on the group to which they belong, select a questionnaire (**Figure 4**).

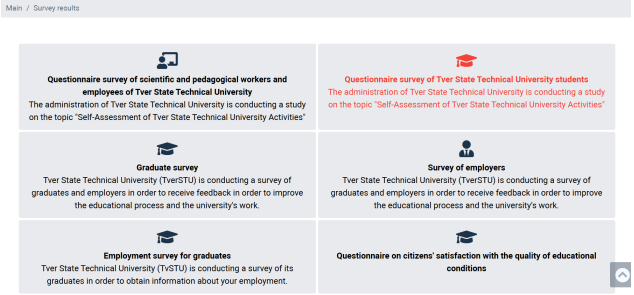


Figure 4. Types of questionnaires on the TvSTU website.

The TvSTU Quality Management Center develops all the questions and answers.

Each questionnaire contains six questions related to satisfaction with the level of development of digital components. We use the Alpha-Kronbach test to determine the internal consistency of the questionnaire questions. We calculate this coefficient using the formula[35]:

$$\alpha = \frac{N}{N-1} \cdot \left(1 - \frac{\sum_{j=1}^{m} \sigma_j^2}{\sigma_x^2}\right) \qquad (4)$$

In formula (4), N is the number of questions in the questionnaire, σ_j^2 is the variance for the j question of the questionnaire, and σ_x^2 is the variance of the total points for the entire questionnaire.

3. Results

We present the results in the following order. Firstly, we consider the results of a 2024 survey of students and teachers on their satisfaction with digital technologies. The dependence of the quality of the educational process on factors of satisfaction with the main digital elements is determined using a student sample in the leading areas of training. Finally, we reveal the dynamics of satisfaction with digital technologies among students and teachers from 2020 to 2024.

3.1. Survey Results in 2024

3.1.1. The Results of the Student Survey

Table 3 presents some of the survey results for students in individual areas of study conducted in 2024. There are differences in the estimates. We tested the null hypothesis (differences in grades do not depend on the direction of students' education and are random) using the ANOVA method. The calculated value of the F-criterion is 10.79, which is greater than its critical value (F_{cr} = 2.21), p = 0.00. Therefore, we reject the null hypothesis and accept the alternative hypothesis - the differences in estimates are statistically significant and depend on the direction of professional training. We explain this dependence by the varying degree of students' involvement in the use of digital technologies in graduate departments. In many ways, the teaching staff has an impact. If teachers make little use of digitalization's elements and show little interest in them, students take it for granted. However, the estimates are statistically homogeneous. The coefficient of variation is 10.5%. The test questions demonstrate internal consistency (α = 0.82). We calculated the values in the last column using the formula (2). Based on the assessment scale (**Table 2**), it argues that student satisfaction, as measured by all criteria, corresponds to the qualitative assessment of "Completely satisfied".

Students use digital technologies in the educational process, noting the annual improvement in their quality. For example, 76.9 % of the respondents confirmed the possibility of connecting to the TvSTU electronic library system from anywhere with Internet access. Almost 36.0 % of the respondents link teachers outside of the educational process via email, and 27.6 % via the Internet (EIEE, messengers). More than 65.0 % of the respondents believe that information on the educational process is always available. On average, 89.0 % of the respondents answered that they liked the University.

3.1.2. The Results of the Survey of Scientific and Pedagogical Staff

Table 4 presents some of the survey results for scientific and pedagogical staff in individual areas of study conducted in 2024. There are also differences here. We apply the same methods to assess the consistency of the questionnaire questions for teachers and check for significant differences in the grades of teachers working in different departments,

as in paragraph 3.1.1. The value of the F-criterion is 3.86, the p-level is 0.002 (less than 0.05), the coefficient of variation in grades in this group is 14.8%, and the Cronbach's Alpha coefficient is 1.16. The latter value indicates a strong correlation between the questions in the teacher questionnaire. Thus, the differences in teachers' grades are also not accidental. However, in general, the sample is adequately homogeneous (the coefficient of variation is less than 30%).

We calculated the values in the last column using the formula (2). Based on the assessment scale (**Table 2**), it is evident that the scientific and pedagogical satisfaction, as measured by all criteria, corresponds to the qualitative assessment of "Partially satisfied".

Teachers' assessments of the same factorial features are more modest than those of students. That is understandable based on the teachers' experience, their understanding of the need for specific elements of digitalization, and their meaningful content. For example, the x_1 factor received a low rating. That indicates to the university management the need to update the software and hardware in computer classrooms as soon as possible.

3.2. Correlation Analysis Results

We tested the hypothesis about the dependence of the quality of the educational process on the factors of satisfaction with the main digital elements using a student sample in the leading areas of training. For this, we used MS Excel and its Data Analysis and Correlation tool. **Table 5** shows the matrix of paired correlation coefficients.

Table 5. The matrix of paired correlation coefficients.

	$\mathbf{x_1}$	$\mathbf{x_2}$	$\mathbf{x_3}$	$\mathbf{x_4}$	$\mathbf{x_5}$	**y**
x_1	1					
x_2	0.55	1				
x_3	0.61	0.93	1			
x_4	0.57	0.84	0.86	1		
x_5	0.94	0.74	0.77	0.67	1	
y	0.71	0.88	0.94	0.88	0.84	1

The matrix of paired correlation coefficients is symmetric and positive definite. To calculate the paired correlation coefficients, one may use the formula (3). The closer the value of the correlation coefficient is to unity, the closer the relationship. For example, the correlation coefficient between the factors "Satisfaction with the quality of computer classes" and "The state of computer resources, the ability to access the Internet" is 0.94. That indicates a strong positive relationship. However, this means that these factors are mutually correlated; that is, one of them should be selected for inclusion in the questionnaire (the one that is more strongly associated with the dependent variable). Approaching the coefficient to zero means weakening the linear relationship between the variables. Correlation indicates only the presence of a statistical relationship, but not a causal relationship. The correlation of two variables may be strong, but this does not necessarily mean that a change in one causes a change in the other. Therefore, to assess the statistical significance of the paired correlation coefficients, we also applied the t-test. Calculations in MS Excel have not shown statistical significance for all correlation coefficients. So, for $r_{x_1x_5}$ = 0.94, t = 0.56 with its critical value of 2.36, the p-level is 0.59 (significantly more than 0.05). These calculations also confirm the need to revise the questionnaire's structure.

We have identified a strong statistically significant correlation between the level of satisfaction with the quality of education in general and factors such as the use of the TvSTU website, electronic library resources, and EIEE.

3.3. Dynamics of Satisfaction with Digital Technologies at TvSTU

3.3.1. Dynamics of Satisfaction with Digital Technologies among Students

Figure 5 shows the dynamics of students' satisfaction with digital technologies from 2020 to 2024.

We are witnessing a slight but steady increase in student satisfaction with the computer classroom facilities and the ease of working in the EIEE. Other factors do not have a stable trend, but the recorded decreases are insignificant,

within an acceptable range of not more than one point. In general, there is high satisfaction among students with the digitalization of the educational process at TvSTU.

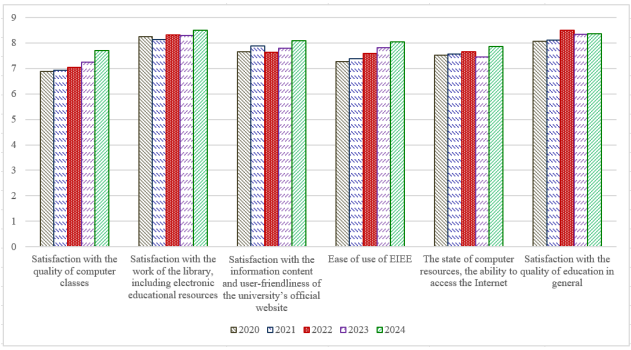


Figure 5. Dynamics of satisfaction with digital technologies among students.

3.3.2. Dynamics of Satisfaction with Digital Technologies among Research and Teaching Staff

Figure 6 shows the dynamics of teachers' satisfaction with digital technologies from 2020 to 2024.

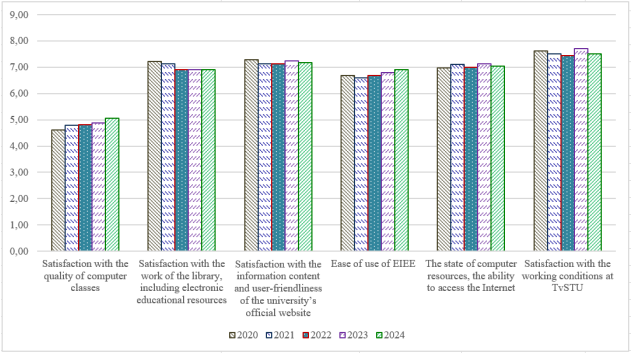


Figure 6. Dynamics of satisfaction with digital technologies among teachers.

We note a slight increase in satisfaction with the condition of computer classes, but a low assessment of this factor. Its maximum value was 5.07 in 2024. There is also a positive trend in the estimation of the convenience of EIEE, but the maximum value is less than seven points (6.92 points in 2024). The dynamics of other indicators are ambiguous.

4. Discussion

An analysis of the questionnaires completed by students and teachers shows a positive attitude towards the digitalization of the educational process. Digital technologies, supported by modern hardware and software, can significantly improve the quality of the educational process and enhance its effectiveness. The basis of digitalization at TvSTU is EIEE, which has developed nearly all the learn and organizational components that make EIEE a full-fledged digital system. The issue of the EIEE mobile application for comfortable work from a mobile device is relevant. The digital environment of TvSTU is constantly improved. To identify specific improvements, the so-called "weaknesses", the Quality Management Center conducts annual surveys of students and research and teaching staff about their satisfaction with the use of digitalization elements. When filling out the questionnaire on the TvSTU website, the system checks the IP address of each respondent. That excludes the appearance of answers to questions more than once from one IP address. That is data quality control.

We have received student grades that are higher than the teachers' grades. That is due to the following reasons:

1) Students' grades are more individualized and take into account their learning progress. Many students from rural areas arrive at the university. They had not heard much about digitalization before going to university. University opportunities seem significant to such students;
2) For research and teaching staff who are well acquainted with advanced technologies, digitalization is a natural development of the university environment;
3) Many scientific and pedagogical workers, on the contrary, are accustomed to traditional methods of teaching and evaluating knowledge. They are aware that digital technologies are not always applicable, for example, when evaluating creative work. Remote digital technologies cannot replace live communication between a student and a teacher.

Nevertheless, the role of digital technologies in improving the effectiveness of the educational process is undeniable. The main effects include:

1. Digital technologies allow us to take into account the individual needs of students. For example, if there are video lectures, students can view any part of the video lecture as needed;
2. Digital technologies provide real-time communication with teachers;

3. With the help of digital technologies, we can better understand and analyze the successes and difficulties of each student and take concrete action. For example, we can provide students with additional resources, study materials, individual assignments, and recommendations to improve their academic performance.

The introduction of digital elements into the educational process contributes to the formation of general professional and special competencies among students. Learning arouses interest, which means that students' perception of training courses is activated. Students learn more and better, which helps to increase their competitiveness in the labor market [36].

However, distance learning technologies have their drawbacks. These include: the lack of direct communication between students and the teacher, which makes it hard to create a creative atmosphere in a group of students; the lack of a well-established system of legal regulation of the implementation of distance technologies, in particular, the preservation and protection of copyrights to electronic courses; the high cost and complexity of building a distance learning system; the problem of user authentication when verifying knowledge [37, 38].

In addition to these problems, there are technical, psychological, and pedagogical toughs of using digital technologies in the educational process [12, 39]. These are the reasons why it is necessary to continue research on the introduction of digital technologies into the educational process.

We recommend the computerization of all classrooms as the key event for further digitalization of the educational process at TvSTU. The organization of the educational process in computer classrooms allows students not only to gain access to EIEE and all the materials available in it, including methodological and teaching aids, workshops, but also to understand the teacher's explanations due to the use of information technologies for transmitting and displaying information through a computer and a projector. Until recently, lessons in computer classrooms were the prerogative of courses related to computer science and information technology. However, with the introduction of digital technologies and the need to process large amounts of information, classes in computer classrooms should also be organized in the humanities (history, philosophy, sociology, and others), especially in those subjects for which electronic courses have been developed and uploaded to the EIEE. Such simplifies the transfer of educational material to students and partially removes the psychological and auditory burden associated with the need to repeat what has been said, especially to international students. Thus, the teacher gets less tired, and international students experience less discomfort due to a misunderstanding of what the teacher said in the classroom.

A significant advantage of organizing classes in a computer classroom rather than in an auditorium not equipped with modern computer technology is the availability of an operational search for thematic information, the acquisition of skills in its arrangement, and logical interpretation of the results. That is important when studying all academic disciplines, not only those related to calculations and solving computational problems [40, 41].

When working with international students, it is advisable to conduct not only practical and laboratory classes in computer classrooms, but also lectures accompanied by presentation material shown through a projector. This form of study is beneficial not only for international students but also for Russian speakers. Unfortunately, there are a few difficulties in providing it. First of all, this is a limited number of computer audiences. In most classrooms in Russian universities, there is a traditional blackboard, and they lack computer equipment. The second difficulty is related to the unwillingness of most teaching staff to move from the traditional teaching style to the advanced digital one. To solve the psychological problem of teachers' transition to the digital format of teaching in Russian universities, and to increase interest in it, we can suggest:

1. The development of models of digital competencies of the teacher, which will become guidelines for teachers in the direction of improving professional skills. The use of such models by teachers should be financially encouraged by the university management;
2. Organization of advanced training courses where teachers will be able to compare different teaching styles and forms of classes, and gain an interest in the use of digital technologies in the educational process. For example, we have had such work at TvSTU for several years now;
3. Providing teachers with the technical means to implement the digital format of the educational process

(laptops, tablets, and other devices connected to the Internet).

At the same time, management of the TvSTU must improve the material and technical base, increase the number of automated workplaces for both teachers and students, and ensure their networking.

5. Conclusions

Digital educational technologies make the learning process open, technological, and focused on the students' professional competence. The creation and application of such technologies have greatly simplified the educational process, making it more accessible to people with disabilities or living in remote places far from the university.

The advantages of digital educational technologies are:

1) Providing more comfortable conditions for students' self-expression;
2) Providing educational opportunities for people with health problems, living in remote areas, etc.
3) Organizing remote communication with specific professionals, high-level experts, teachers, and fellow students who are at a great distance (group projects, online discussions, chats, forums);
4) Economic benefits.

Indeed, the experience of using digital technologies at TvSTU has proved that they contribute to improving the quality of the educational process.

However, to increase the objectivity of students' and teachers' assessment of the levels of development of the elements of digitalization, it is recommended to review some of the questionnaire questions and add new questions. The presented research will be continued next year, taking into account new achievements in the field of digitalization of the educational process and improving the methods of collecting and processing statistical information.

Funding

This work received no external funding.

Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

The key source of data on the attitude of students and faculty towards the digitalization of the educational process at Tver State Technical University was the results of a survey, which you can find at the link: https://elearning.tstu.tver.ru/course/view.php?id=1461. You can also read about the electronic information educational system of the university itself here: https://elearning.tstu.tver.ru/course/view.php?id=365.

Acknowledgments

I want to thank my colleague Andrey Gusarov, Head of the user support group for the electronic information educational environment of the Office of Information Resources and Technologies at Tver State Technical University, for his methodological assistance in preparing the author's training courses and their support in the educational process.

Conflicts of Interest

The author declares no conflict of interest.

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