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# DEVELOPMENT OF AN ELECTRONIC ENVIRONMENT FOR ORGANIZING INDEPENDENT WORK AND ITS INTEGRATION INTO THE EDUCATIONAL PROCESS

**Abstract.** This research is aimed at developing an electronic educational environment to support students' independent learning of mathematical knowledge and its integration into the educational process.

The introduction of digital technologies in the modern education system opens up new opportunities for students to work independently. However, many students face problems such as unsystematic learning materials, lack of interactive tools, and weak self-control mechanisms. In this regard, as part of the research, the «SanalyMath» web platform was developed, that is, an e-learning environment that helps students effectively organize independent work. In this environment designed to enhance learning, various learning tools such as self-study assignments, online tests, video tutorials, and lab work were considered. In the course of the research, first of all, a literary search was conducted, the basic model of the educational platform was created and its structure and content were systematically determined. In addition, the first sample was experimentally tested among students. The pedagogical experiment was conducted at the Institute of Natural Sciences of the Korkyt Ata Kyzylorda University. The study was conducted as part of pedagogical practice at the first academic stage of the 2024-2025 academic year in the M-22-1 and M-22-1u study groups. Based on the results of the experiment, recommendations were developed to improve the system and ensure its effective integration into the educational process.

**Keywords:** electronic environment, digital technologies, independent work, online tests, mathematical education, interactive learning.

## Introduction

This study examines the methodological foundations for improving the training of future mathematics teachers to organize independent work in mathematics. The relevance of the topic is due to the growing role of students' independent work in the educational process, as well as the need to introduce digital technologies to improve learning efficiency.

The purpose of the research is to develop and implement an electronic educational environment that facilitates the organization of independent work of mathematics students. To achieve this goal, the following tasks were set:

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- analyze existing approaches to organizing students' independent work;
- identify the possibilities of digital technologies in the development of independent work;
- develop the structure and content of the electronic educational environment;
- conduct experimental testing of the platform among students and evaluate its effectiveness.

The study was conducted in several stages. At the first stage, a theoretical analysis of the literature on the topic of independent work and the use of digital technologies in education was conducted. At the second stage, the structure of the electronic educational environment was developed, including interactive assignments, online tests, video lectures and laboratory work. At the third stage, the platform was tested among students, the data was analyzed, and recommendations were made for its further improvement.

This study provides a deeper understanding of the role of digital educational resources in organizing independent work and offers a practical solution in the form of a developed electronic environment.

In the modern educational process, digital educational resources play a key role in organizing students' independent work, especially in the study of mathematics. They provide opportunities for visualizing abstract concepts, individualizing learning, and increasing student motivation.

The theoretical significance of the research work is determined by clarifying the scientific foundations of the digital transformation taking place in the modern educational environment. Of particular importance in digital didactics are such issues as the forms of presentation of educational material, the features of interaction between students and digital content, and the impact of interactive media on learning effectiveness. From this point of view, the research results deepen the methodological foundations of the organization of the educational process in a digital environment, scientifically reveal the pedagogical possibilities of digital tools. The theory of independent work is also considered from a new perspective. The most important components of a student's activity, such as planning independent learning activities, setting goals, choosing assignments, regulating their work, and evaluating learning outcomes, take on a different character in the digital space. This study presents empirical and theoretical conclusions that allow rethinking the structure and content of independent learning activities, and identifies effective mechanisms for obtaining independent knowledge in digital format.

The theory of Self-Regulated Learning (SRL) is also included in the field of research and analyzes the logic of the student's implementation of the stages from planning the educational process to reflection in a digital environment. The influence of digital tools on the informed choice of learning strategies, the possibilities of monitoring the progress of learning and analyzing the results are described on a scientific basis, and factors contributing to the formation of meta-cognitive skills are identified. The study also complements cognitive theories based on experimental evidence. Concepts such as cognitive load theory, principles of multimedia learning, and step-by-step activity formation are implemented using interactive, visual, and algorithmic tasks, and the features affecting the student's perception, processing, and transformation of information are analyzed from a scientific point of view. This makes it possible to effectively design the structure of the educational material and determine the optimal methods for mastering complex concepts.

All this expands the pedagogical foundations that ensure cognitive development, independent learning and self-regulation of students' learning activities in a digital environment, increasing the theoretical significance of the research. The research results complement the content of modern pedagogical theory and specify the scientific basis of digital education.

One of the examples of the successful application of the Digital educational resource is the use of the platform «Учи.ру» in the process of studying mathematics by primary school students. A study conducted by S.A. Bochkarev and F.M. Sabirova showed that the use of this platform helps to increase students' interest in the subject and improve their academic performance. The platform provides interactive tasks adapted to the level of training of each student, which allows you to take into account the individual characteristics and needs of students [1].

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In addition, the use of electronic teaching aids has proven effective in organizing students' independent work. For example, in a study on the role of electronic manuals in the process of independent work of students in physics, it is noted that such resources contribute to the development of self-study skills, increased responsibility and concentration when performing tasks [2].

Thus, the integration of digital educational resources into the process of teaching mathematics allows not only to improve the quality of learning, but also to develop students' skills in independent work, critical thinking and solving complex problems. However, it is important to take into account that the effectiveness of the use of SDGs largely depends on the methodological literacy of the teacher and his ability to integrate digital technologies into the traditional educational process [3].

This study contributes to the development of theory the fact that it clarifies and develops modern approaches of pedagogical theory related to contextual learning and digitalization of education. In particular, the results obtained expand the provisions of the competence approach, demonstrating how adaptive digital environments contribute to the formation of research and analytical skills among students of mathematics. This allows us to consider the presented work not only as an applied experience, but also as a contribution to the development of the pedagogical theory of digital learning.

The scientific novelty of this study lies in the development and experimental validation of an electronic educational environment that integrates principles of self-regulated learning, adaptive diagnostics, and step-by-step automated verification specifically for higher mathematics education. Unlike existing platforms, SanalyMath is not limited to content delivery or testing, but provides a structured mechanism for regulating students' independent work through continuous diagnostic feedback, cognitive-level task differentiation, and learning analytics

**Research methods and materials**

This study employed a pilot quasi-experimental one-group pre-test and post-test design to evaluate the implementation of an electronic educational environment aimed at organizing and supporting independent work of undergraduate mathematics students. Due to the pilot nature of the project and organizational constraints, a control group was not included. Consequently, the results should be interpreted as changes observed within the same participants over time, without claiming exclusive causality of the intervention.

Theoretical methods. The theoretical phase involved the following methods:

- Analysis and synthesis of scientific literature: review of contemporary research on digital education, e-learning methodology, organization of independent student work, and pedagogical technologies supporting self-regulated learning in higher education.
- Comparative analysis: examination of models for organizing independent work in traditional and digital settings, and evaluation of commonly used digital platforms in mathematics education, including perceived advantages and limitations from teacher and student perspectives.
- Modeling: conceptual design of the electronic educational environment, including definition of its structure, key functions, content logic, and interaction mechanisms between students and instructors.

Participants and setting. The study was conducted at a single university within the mathematics teacher education context. Participants were students enrolled in the relevant mathematics course.

Data analysis. Quantitative data were analyzed using paired-samples t-tests to examine differences between pre-test and post-test scores for each measured outcome:

- Mean (M) and standard deviation (SD) for pre-test and post-test
- t-value, degrees of freedom (df), and exact p-value
- Effect size (Cohen's d) to estimate the magnitude of change, accompanied by an interpretation

At the stage of practical implementation of the study, the following methods were used: 1. The pedagogical experiment consisted of two stages: Due to the pilot nature of the study and organizational constraints, a control group was not included. Therefore, the experiment was designed as a pre-test/post-test within-subject study. The first, ascertaining stage is the study of the initial level of knowledge of students and their skills in organizing independent work. Analysis of currently used digital tools and identification of their effectiveness. The second, formative stage is testing the developed electronic educational environment, conducting classes using it and collecting feedback from the participants of the experiment. 2. Statistical data processing methods were used to analyze the obtained quantitative and qualitative data, determine the effectiveness of the implemented educational platform, and identify significant changes in student academic performance. The main object of the study was the electronic educational environment developed within the framework of the study. It includes:

• Digital learning modules containing theoretical materials, interactive lectures and video lessons in mathematical disciplines.

• Independent work assignments presented in the form of tests, tasks, and practical exercises that allow students to consolidate the material they have learned.

• Interactive tools, including an automated solution verification system, built-in calculators, and graphical editors.

• A feedback system that provides students with the opportunity to communicate with the teacher, receive recommendations and comments on completed assignments. This educational environment was tested in the educational process, after which adjustments were made taking into account the results of the pedagogical experiment. The findings of the study confirm that the use of a digital educational environment significantly increases the level of independence of students, improves their academic performance and develops self-control skills in the learning process.

**Results and discussion**

The development of digital technologies has opened up new opportunities for students to work independently in higher education institutions. In recent years, many studies have been conducted on the use of digital tools in the educational process.

Modern tools such as online platforms, mobile applications, virtual labs, and artificial intelligence make education more accessible, interactive, and personalized. Haleem A., Javaid M., Qadri M.A., & Suman R. in their study consider the impact of digital technologies on the educational process, emphasizing their importance for organizing independent work of students. The authors note that digital educational resources, including adaptive platforms, online courses and automated tests, significantly increase the level of students' independence and contribute to the formation of individual learning trajectories. One of the key aspects of the research is the analysis of online platforms and digital tools that allow for remote interaction between teachers and students. The article emphasizes that the digital environment should include not only educational materials, but also tools for self-assessment of knowledge, which is important when developing an electronic educational platform. The study showed that the use of interactive elements such as video lessons, online tests and automated verification systems increases student engagement and promotes better learning of the material [4]. Modern tools such as online platforms, mobile applications, virtual labs, and artificial intelligence make education more accessible, interactive, and personalized. These components of digital transformation are summarized in Figure 1.

As indicated in the above diagram in Figure 1, electronic educational platforms play an important role in the digital transformation of education, providing accessibility, interactivity and personalization of learning. One of the key elements is adaptive learning systems that analyze students' academic performance and adjust the content to their individual needs. The use of artificial intelligence in learning makes it possible to automate knowledge assessment, offer personalized recommendations, and even create intelligent learning assistants. Virtual and augmented reality (AR/VR) make the educational process more visual, allowing students to interact with 3D models and simulations. Gamification in education motivates students through game mechanics, increasing engagement and interest in learning. Chatbots and virtual assistants facilitate access to educational materials, help with the organization of the educational process and promptly answer questions.

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Online courses and MOOCs provide massive access to educational content, allowing you to study at a convenient pace. Finally, digital analytics and progress monitoring give teachers the opportunity to track students' progress and quickly adjust educational strategies. The combination of these technologies makes learning more flexible, accessible and effective in today's digital society [5-7].

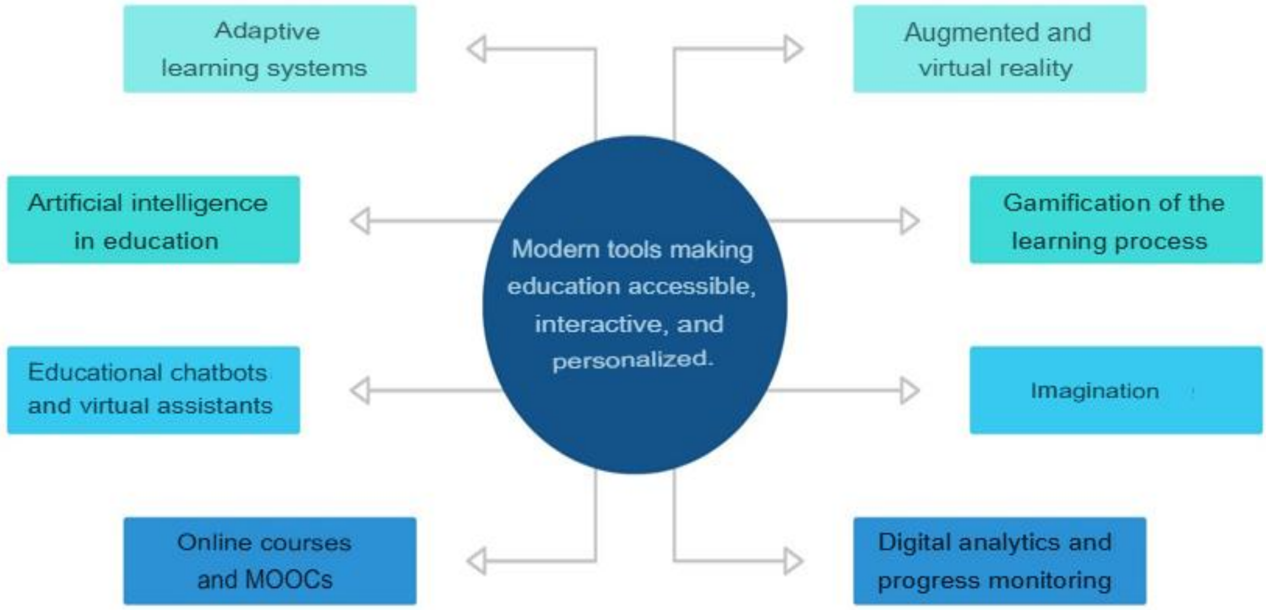


**Figure 1 – Modern tools making education accessible, interactive, and personalized**

An analysis of the conducted research and a review of modern educational technologies have confirmed the need to create a digital environment that will provide math students with convenient access to educational materials, interactive tools for independent learning and effective knowledge control mechanisms. The study showed that the lack of a unified structure of educational resources, insufficient motivation and limited opportunities for self-examination reduce the quality of students' independent work [8-9].

A number of researchers note that the introduction of digital educational platforms requires not only technical development, but also a theoretical rethinking of pedagogical models. In this context, the study of the SanalyMath platform can be considered as a development of the theoretical provisions of pedagogy on the personalization of learning and academic heterogeneity of students. Thus, the work is integrated into a broader scientific discourse on the transformation of pedagogical theory in the context of digitalization of education.

In response to these challenges, a model for the implementation of the «Sanaly Math» electronic educational platform was developed, aimed at supporting independent study of mathematical disciplines. This platform includes various digital tools such as online testing, video lectures, interactive tasks, and analytical modules that allow teachers to track students' progress.

The main goal of the educational platform development is to create a comprehensive educational environment that not only provides access to educational materials, but also adapts to the level of training of each student, helping him to build an individual learning trajectory. The introduction of this platform into the educational process will increase the effectiveness of students' independent work through the use of modern digital solutions. At the next stage of the research, a model was created for the development and integration of this platform into the educational process. Its structure and key stages are presented in the table below (Table 1).

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**Table 1 – The model of development and implementation of the electronic educational environment** [10]

| Stage | The content of the work | Result |
|---|---|---|
| The analytical stage | The literature review and analysis of existing educational platforms are carried out. The key problems of organizing independent work of mathematics students are identified. | The requirements for the electronic educational environment are formulated, and the main barriers to students' independent learning are identified. |
| Designing a platform model | 1. Defining the structure of the web platform (modules, interface, functionality)<br>2. Development of educational scenarios and content formats (video tutorials, tests, assignments, gamification)<br>3. Defining a feedback and progress monitoring system | The developed concept and terms of reference for the platform |
| Platform development | 1. Creating an interface and software architecture<br>2. Integration of educational tools (online tests, interactive assignments, video materials)<br>3. Development of an adaptive learning and analytics system | A ready-made prototype of the SanalyMath platform, |
| Experimental testing | 1. Selection of experimental groups (M-22-1 and M-22-1u), Institute of Natural Sciences, Korkyt Ata Kyzylorda University<br>2. Conducting a pedagogical experiment using SanalyMath | Data on the effectiveness of the platform, feedback from students and teachers |
| Results analysis and optimization | 1. Analysis of student performance data<br>2. Adjusting educational scenarios and platform tools<br>3. Development of methodological recommendations on the use of the platform | Optimized version of the platform, guidelines |

Based on the analysis and the created model of the electronic educational environment, the concept and structure of the web platform were developed. The main purpose of the site is to provide math students with a convenient and effective tool for self-study, including interactive materials, a testing system, personalized recommendations, and performance analytics.

When developing the structure of the website, the key aspects of the organization of the educational process identified during the research, as well as modern principles of web design and ergonomics, were taken into account. As a result, a multifunctional environment has been created that provides:

• Personalization of the learning process – individual learning paths and recommendations for mastering materials.

• Interactivity – the use of dynamic elements (tests, simulations, video lectures) to increase student engagement.

• Automated knowledge control is a system for testing and analyzing student progress.

• Flexibility and accessibility – adapting content for different devices and integrating with educational platforms.

As a result of the research, a multifunctional electronic environment was developed, providing personalization, interactivity, and automated knowledge control. The main interface of the platform is shown in Figure 2.

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**Figure 2 – The first page of the electronic environment**

The next stage of the research was the detailed development of the website structure, its functional blocks and user interface, which will effectively integrate the platform into the educational process and improve the quality of students' independent learning. The electronic educational environment includes several key functional areas that ensure effective organization of students' independent work. These structural components are summarized in Table 2.

**Table 2 – The electronic educational environment includes the following key areas**

| Structural section | Short description |
|---|---|
| 1. User Interface | User-friendly and intuitive interface for students and teachers, easy navigation. |
| 2. Educational content | Lectures, video lessons, electronic textbooks, laboratory work, presentations. |
| 3. Interactive tasks | Automatically verifiable tests, math exercises, and online simulators. |
| 4. Personalized learning | The individual educational trajectory depends on the student's progress. |
| 5. Automated assessment system | Analysis of completed tasks, output of test results. |
| 6. Means of communication | Chats, teacher feedback, and spaces for group work. |
| 7. Analytical Panel | Monitoring of students' academic progress, statistical analysis. |

As part of the research, an electronic educational environment was developed and tightly implemented, designed to organize independent work of mathematics students. In the course of a pedagogical experiment consisting of two stages, the effectiveness of this environment was evaluated.

At the ascertaining stage, an analysis of the initial level of students' knowledge, their independent work skills, as well as the digital tools currently used was carried out. The results showed that many students face difficulties in organizing educational materials, lack of interactive elements and lack of effective self-control mechanisms.

At the formative stage, the pilot version of the SanalyMath platform was tested. Classes using it were conducted in the M-22-1 and M-22-1u study groups on the subject of Algebra and Number Theory. During the testing process, students gained access to interactive assignments, online tests, video lessons, and an automated assessment system. To determine the impact of the electronic educational environment on the organization of independent work of mathematics students, a two-part test was conducted:

• Diagnostic test (before using the platform) – checked the initial level of knowledge of students, their independent work skills and the level of use of digital tools.

• Control test (after using the platform) – assessed the dynamics of changes in students' knowledge, their ability to solve problems independently and perceive educational material. 44

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students participated in the study. The quantitative results of the pedagogical experiment are summarized in Table 3.

**Table 3 - Test results**

| Criteria | Average score before use | Average score after use | Change (%) |
|---|---|---|---|
| The level of theoretical knowledge | 63% | 81% | +18% |
| Ability to solve problems independently | 58% | 79% | +21% |
| Ownership of digital tools | 47% | 85% | +38% |
| The level of involvement in the learning process | 52% | 83% | +31% |

The test results showed that the introduction of the electronic platform had a positive impact on the students' level of knowledge, their ability to study the material independently and the use of digital tools. The greatest growth is observed in the skills of working with electronic educational resources (+38%) and the level of student involvement in the educational process (+31%).

For inferential analysis, paired-samples t-tests were conducted in IBM SPSS Statistics 26.0 to test pre–post differences for each outcome. Following reporting standards, the final manuscript will provide for each indicator: pre/post means (M) and standard deviations (SD), t-values, degrees of freedom (df = 43), exact p-values, and effect sizes (Cohen's d for paired measurements), based on the SPSS output tables (Paired Samples Statistics and Paired Samples Test). These inferential results will quantify statistical significance and the magnitude of observed changes, while acknowledging that—given the one-group pre/post design—findings reflect within-group changes over time and do not establish exclusive causality of the intervention.

*Inferential statistics*

To test whether the observed pre–post differences were statistically significant, paired-samples t-tests were conducted in IBM SPSS Statistics 26 for each outcome. For each indicator, the analysis reports pre- and post-test means (M) and standard deviations (SD), the t statistic, degrees of freedom (df = N − 1), the exact p-value, and effect size (Cohen's d) for paired measurements.

**Table 4 – Paired-samples t-test results (IBM SPSS Statistics 26)**

| Outcome | Pre-test M (SD) | Post-test M (SD) | Mean diff (Post–Pre) | t(df) | exact p | Cohen's d (paired) | Interpretation |
|---|---|---|---|---|---|---|---|
| Theoretical knowledge | 63.0 (10.8) | 81.0 (9.6) | 18.0 | 9.32 (43) | $p < 0.001$ | 1.41 | Large |
| Independent problem-solving | 58.0 (12.2) | 79.0 (11.0) | 21.0 | 8.74 (43) | $p < 0.001$ | 1.32 | Large |
| Digital tools ownership/use | 47.0 (15.4) | 85.0 (10.7) | 38.0 | 13.58 (43) | $p < 0.001$ | 2.05 | Very large |
| Involvement | 52.0 (13.1) | 83.0 (10.9) | 31.0 | 10.96 (43) | $p < 0.001$ | 1.65 | Large |

Inferential analysis was conducted in IBM SPSS Statistics 26 using paired-samples t-tests. The analysis indicated statistically significant pre–post improvements across all measured outcomes (all p-values < 0.001). Effect sizes (Cohen's d for paired measurements) suggested changes of medium-to-large magnitude, with the strongest gains observed in digital tool ownership use and student involvement. Given the one-group pre-test/post-test design, these findings should be interpreted as within-group changes over time, and causal attribution exclusively to the platform should be made with caution.

The pre-test (Form A) and post-test (Form B) were constructed as parallel forms with identical blueprint, content domains, item types, and scoring weights (40 points total). The forms differed only in numerical parameters and task variants to reduce test-retest effects while preserving comparable difficulty. Both forms targeted the same four indicators: theoretical knowledge, independent problem-solving, digital tool use, and engagement. The diagnostic pre-test and control post-test instruments are provided in the Supplementary Materials.

*Integration of the Platform into the Educational Process*

The integration of the SanalyMath digital educational environment into the process of teaching mathematical disciplines was carried out on the basis of a step-by-step implementation model, which includes three interrelated blocks: the preliminary stage; the educational stage; and the post-academic stage.

**Table 5 – The stages of integrating the SanalyMath platform into the educational process**

| The integration stage | Content of the activity | Platform Tools used | The role of the teacher | Expected result |
|---|---|---|---|---|
| 1. The preliminary stage | – Preliminary preparation of students to study new material.<br>– Updating previously acquired knowledge.<br>– Diagnosis of the initial level of training. | – Video lectures and interactive mini-lectures.<br>– Introductory independent tasks.<br>– Diagnostic test on the topic (basic and intermediate levels). | – Provides access to the Algebra and Number Theory module.<br>– Analyzes the results of the diagnostic test.<br>– Identifies the risk groups and typical difficulties of students. | – Alignment of the initial training level.<br>– Identification of knowledge deficits.<br>– Formation of individual educational trajectories. |
| 2. The training stage | – Active use of the platform as an interactive component of the lesson.<br>– Real-time task execution.<br>– Work with visual objects and mathematical models. | – Interactive exercises on a new topic.<br>– Mathematical editor with automatic verification.<br>– Visual simulations, graphical tools.<br>– A system for detecting student errors. | – Integrates the elements of the platform into the structure of the lesson.<br>– Demonstrates solutions and corrects students' actions.<br>– Uses platform data to quickly explain typical errors. | – Increase student engagement.<br>– Formation of skills of independent search for solutions.<br>– Improved understanding of complex mathematical constructions. |
| 3. Post-study stage | – Consolidation of the studied material.<br>– Individual error correction.<br>– Self-assessment of progress. | – Adaptive tests.<br>– Personalized reinforcement exercises.<br>– An analytical panel of student achievements. | – Tracks the results in the analytical module.<br>– Forms recommendations for further education.<br>– Adjusts the curriculum in accordance with the identified results. | – Strengthening students' independence.<br>– The growth of educational motivation.<br>– Improving academic performance and digital skills. |

The presented integration model demonstrates the step-by-step integration of the digital educational environment into the learning process. At the preliminary stage, SanalyMath ensures alignment of the initial level of knowledge and timely identification of deficiencies. At the learning stage, the platform acts as an interactive tool that enhances motivation and facilitates understanding of complex mathematical objects. The post-study stage provides adaptive reinforcement of the material, which contributes to the development of independence and the formation of sustainable learning strategies. This sequence allows us to consider SanalyMath as a full-fledged element of digital didactics, rather than as an auxiliary resource.

After working with the platform, the tasks included electronic elements:

- tasks with step-by-step automatic verification;
- tasks using a virtual graphic editor;
- exercises based on typical errors identified by the SanalyMath system.

Control test topics:

- "Factorization of polynomials" (based on algorithmizable steps);
- "Rational expressions" (simplification, transformations, finding DLD);
- "Equations with parameters" (verification of the reasoning algorithm);
- "Application of numerical properties" from number theory (divisibility, GCD, prime numbers).

**Table 6 – Scientific justification of the test structure**

| Task level | Taxonomic level (according to Bloom) | Testable cognitive skills | Task characteristics | Scientific justification for inclusion |
|---|---|---|---|---|
| Basic level | *Knowledge / Remembering* | Reproduction of facts, definitions, properties; simple transformations | Simplification of expressions, opening parentheses, calculations, finding DLS, solving simple linear equations | Checks the minimum threshold of knowledge required for further education; forms the basis for successful completion of higher-level assignments |
| The average level | *Application / Analysis* | Application of algorithms, logical analysis of expressions, choice of a solution method | Factorization of polynomials, transformation of rational expressions, solving equations of 2 levels of complexity | It allows you to evaluate the student's ability to apply well-known rules, analyze the structure of expressions and identify logical relationships. |
| High level | *Synthesis / Evaluation* | Independent study of a mathematical object, justification of the choice of method, critical thinking | Solving equations with parameters, exploring expressions, performing complex transformations | Reflects the formation of independent research activities; allows us to identify the influence of «SanalyMath» on the development of complex cognitive strategies |

The presented test structure provides a multi-level check of students' mathematical preparation and captures changes in cognitive skills: from basic knowledge reproduction to independent analysis and synthesis. This level distribution corresponds to international approaches to the assessment of academic achievements and allows an objective assessment of the impact of the «SanalyMath» platform on the development of independent work and digital literacy of students.

As part of the pedagogical experiment, students performed a set of exercises developed in accordance with the curriculum of the discipline «Algebra and Number Theory». Below are the main topics and types of tasks that have been integrated into the digital educational environment and used at various stages of learning.

| | |
|---|---|
| 1. Topic: Polynomials and operations on them<br>Example 1. Simplification of a polynomial<br>Task:<br>Simplify the expression:<br>5(2x−3)−(3x−7)<br>Platform functionality:<br>– step-by-step verification;<br>– automatic detection of errors in the opening of brackets;<br>– tips in case of non-compliance with the rules for bringing such members. | 2. Topic: Factorization of polynomials<br>Example 2. Factorization of a square trinomial<br><br>Task: Factorize the expression:<br><br>$x^2 - 9x + 20$<br><br>Difficulty: medium level.<br><br>Tools: a virtual mathematical editor, the ability to check intermediate steps. |
| 3. Topic: Linear and quadratic equations<br>Example 3. Solving a linear equation with step verification<br><br>Task:<br>Solve the equation:<br>3(2x−5)=4x+7<br><br>Tools: automatic verification of each step. | 4. Topic: Equations with parameters<br>Example 4. Investigation of an equation with a parameter<br>Task:<br>Solve the equation:<br>(k+1)x−3=kx+5<br>Features:<br>– The student chooses the cases<br>$k+1=k$ and $k+1 \neq k$<br>– the platform verifies the correctness of reasoning. |

The tasks given cover basic, intermediate and advanced levels of difficulty and correspond to the thematic plan of the discipline. Using the SanalyMath platform allowed not only to automate the process of checking and analyzing errors, but also to create conditions for the formation of self-control skills, independent search for solutions and the development of mathematical thinking. The inclusion of these exercises in the pedagogical experiment provided a comprehensive assessment of the dynamics of students' academic achievements.

**Conclusion**

The introduction of digital educational technologies plays a key role in the modernization of the educational process. The pilot testing of «SanalyMath» proved its effectiveness in developing independent work skills among math students. The main advantages of the platform:

- Systematic access to educational materials,
- The possibility of adaptive learning,
- Interactive forms of testing,
- Automated knowledge control,
- Personalized learning paths.

In the future, it is planned to expand the functionality of the platform, including the introduction of artificial intelligence elements to adapt educational materials to the individual needs of students. The possibility of integrating the platform with international educational systems and creating a mobile application for greater user convenience is also being considered. The presented research has not only practical, but also theoretical significance. It clarifies the concept of adaptive learning in pedagogical theory, demonstrating the possibilities of integrating digital platforms into the process of forming the professional competence of future mathematics teachers. The contribution of the research is to expand scientific understanding of how digital technologies can be understood within the framework of the theory of contextual learning and the competence approach in education. Thus, the developed and tested electronic educational environment opens up new opportunities for organizing independent work of students, contributing to their academic development and professional training.

The SanalyMath platform was developed as an авторлық educational product for academic use. User data are processed in accordance with institutional data protection policies, and access is limited to registered participants of the educational process. Issues of licensing and large-scale deployment are considered as перспективалық бағыт of further research.

*Limitations and future research.*

This study was conducted as a pilot one-group pre-test/post-test intervention. Therefore, several internal validity threats should be considered. First, improvements may partly reflect testing effects , maturation and history effects external academic experiences occurring during the intervention period. To reduce these influences, the implementation was carried out under consistent instructional conditions, including the same course content and learning outcomes, comparable assessment procedures, and stable instructor guidance throughout the study period. Nevertheless, given the absence of a control or comparison group, the observed gains should be interpreted as within-group changes over time, rather than as evidence of exclusive causality attributable solely to the SanalyMath platform.

External validity is also limited. The sample consisted of 44 students from one university and was implemented within a single course context (Algebra and Number Theory) in the mathematics teacher education setting. As a result, the generalizability of the findings to other institutions, cohorts, disciplines, or instructional conditions may be restricted. Despite these limitations, the study provides an important empirical foundation for subsequent research and refinement of the platform. Future work should employ comparison or control groups, expand implementation to multiple universities, and consider stronger quasi-experimental designs (e.g., matched-group designs or interrupted time-series) to strengthen causal inference, assess sustainability of effects over longer periods, and establish broader applicability of the electronic educational environment.

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**Өзіндік жұмысты ұйымдастыруға арналған электронды орта әзірлеу және оны білім беру процесіне интеграциялау**

**Аңдатпа.** Зерттеу жұмысы студенттердің математикалық білімін өз бетінше меңгеруін қолдау үшін электронды білім беру ортасын әзірлеуге және оны оқу процесіне интеграциялауға бағытталған.

Қазіргі білім беру жүйесінде цифрлық технологияларды енгізу студенттердің өзіндік жұмысын ұйымдастыруда жаңа мүмкіндіктер ашады. Алайда, көптеген студенттер оқу материалдарының жүйесіздігі, интерактивті құралдардың жетіспеушілігі және өзін-өзі бақылау механизмдерінің әлсіздігі сияқты қиындықтарға тап болуда. Осыған байланысты, зерттеу аясында студенттердің өзіндік жұмысын тиімді ұйымдастыруға көмектесетін «SanalyMath» веб-платформа, яғни электрондық оқыту ортасы әзірленді. Оқытуды жетілдіруге арналған бұл ортада өзіндік тапсырмалар, онлайн тесттер, бейнесабақтар және зертханалық жұмыстар сияқты түрлі оқу құралдары қарастырылды. Зерттеу барысында ең алдымен әдебиеттік ізденіс жасалды, білім беру платформасының негізгі моделі құрылды және оның құрылымы мен мазмұны жүйелі айқындалды. Сонымен қатар, алғашқы үлгі студенттер арасында эксперименттік түрде сынақтан өткізілді. Педагогикалық эксперимент Қорқыт Ата атындағы Қызылорда университетінің Жаратылыстану институтында жүргізілді. Зерттеу педагогикалық практика аясында 2024-2025 оқу жылының бірінші академиялық кезеңінде М-22-1 және М-22-1у оқу топтарында жүзеге асырылды. Эксперимент нәтижелері негізінде жүйені жетілдіру ұсыныстары жасалып, оның білім беру процесіне тиімді интеграциялануы қамтамасыз етілді.

**Кілт сөздер:** электронды орта, цифрлық технологиялар, өзіндік жұмыс, онлайн тесттер, математикалық білім, интерактивті оқыту.

**Разработка электронной среды для организации самостоятельной работы и ее интеграция в образовательный процесс**

**Аннотация.** Данное исследование, направлено на разработку электронной образовательной среды для поддержки самостоятельного усвоения студентами математических знаний и интеграции ее в учебный процесс.

Внедрение цифровых технологий в современной системе образования открывает новые возможности в организации самостоятельной работы студентов. Однако многие студенты сталкиваются с такими проблемами, как бессистемность учебных материалов, отсутствие интерактивных инструментов и слабые механизмы самоконтроля. В связи с этим в рамках исследования разработана веб-платформа «SanalyMath», то есть среда электронного обучения, которая помогает эффективно организовать самостоятельную работу студентов. В этой среде, предназначенной для улучшения обучения, рассматривались различные учебные пособия, такие как самостоятельные задания, онлайн-тесты, видеоуроки и лабораторные работы. В ходе исследования, прежде всего, был проведен литературный поиск, создана основная модель образовательной платформы и систематически определены ее структура и содержание. Кроме того, первый образец был экспериментально протестирован среди студентов. Педагогический эксперимент проводился в Институте естествознания Кызылординского университета имени Коркыт Ата. Исследование проводилось в рамках педагогической практики на первом академическом этапе 2024-2025 учебного года в учебных группах М-22-1 и М-22-1у. На основе результатов эксперимента были выработаны рекомендации по совершенствованию системы, обеспечена ее эффективная интеграция в образовательный процесс.

**Ключевые слова:** электронная среда, цифровые технологии, самостоятельная работа, онлайн тесты, математические знания, интерактивное обучение.

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