BD CENTER 2013

World Journal on Educational Technology: Current Issues

e-ISSN 1309-0348

Volume 17, Issue 3, (2025) 129-145

https://un-pub.eu/ojs/index.php/wjet/index

The methodology of designing educational processes in blended learning

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Suggested Citation:

Kadirbayeva, R. I., Suleimenova, L. A., Amirbekuly, A., Alimkulova, B. T. & Jamankarayeva, M. A. (2025). The methodology of designing educational processes in blended learning. *World Journal on Educational Technology: Current Issues*, *17*(3), 129-145. https://doi.org/10.18844/wjet.v17i3.7747

Received on December 2, 2024; revised on March 22, 2025; accepted on June 26, 2025.

Selection and peer review under the responsibility of *Prof. Dr. Huseyin Uzunboylu*, University of Kyrenia, Cyprus

Abstract

This study develops a methodology for designing the educational process using the inverted class model within blended learning. While blended learning is widely discussed in educational research, its adoption is often hindered by the absence of a unified design framework. This study addresses this gap by integrating in-person instruction with an information and communication environment to create a cohesive learning experience. The methodology was informed by an analysis of global literature on blended learning and a survey of 119 teaching staff to assess competencies required for implementation. A case study of the course "Algebra and Number Theory" illustrates the design stages, highlighting strategies for transferring various forms of in-person instruction to an electronic format. The approach optimizes teacher–student interaction and enhances the quality of the learning process. A quasi-experiment demonstrated the effectiveness of the methodology in improving instructional outcomes. The findings provide practical recommendations for educators seeking to design and implement blended learning models in higher education.

Keywords: Blended learning; course design; educational methodology; inverted class; teaching strategies.

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1. INTRODUCTION

In the modern world, particularly in Kazakhstan, the development of education, including pedagogical, is a relevant issue. The education system requires a fundamental and drastic update, taking into account current trends in education and digitalisation. The Digital Kazakhstan programme statement: "to achieve the set purposes of the Programme in the field of personnel qualification, the education system will be completely updated by the leading international practices. The new education will meet the needs of the digital economy with an emphasis, first of all, on skills in information analysis and the development of creative thinking, rather than on memorizing facts and formulas". Resolution of the Government of the Republic of Kazakhstan No. 827 (2017) proves the necessity to advance e-learning. The studies of numerous foreign and Kazakh researchers are devoted to the disclosure of e-learning features. For instance, Morozova (2016) observed that the role of electronic learning in higher education has been steadily increasing. She explained that many educational institutions have adopted electronic learning because it addresses the needs of contemporary learners who operate within a digital environment, stimulates pedagogical innovation, facilitates the exchange of knowledge and collaboration both within and between universities, and broadens the scope of distance education while improving accessibility for diverse groups of students.

The above led to the emergence of blended learning, which, as is common today, does not have specific authorship and was mainly developed spontaneously, as a result of numerous attempts to change existing teaching methods and principles. Consequently, researchers of blended learning define it differently. For example, Bon & Graham (2006) claim that blended learning combines the technology of in-person and distance learning in a certain manner which allows the simultaneous use of two training modes, eliminating almost all their disadvantages. However, Dolgova (2017) defines blended learning as "an educational technology within which in-person and e-learning blend and co-operate with the ability for a student to independently choose the time, place, pace, and trajectory of learning" and, based on various definitions, the authors of the study have established that "with a proper and full-fledged application, blended learning aims to develop valuable personality qualities, which are also known as skills of the 21st century" (Dolgova, 2017). Unfortunately, the integration of blended learning into the educational process is quite slow. In this regard, experts outline numerous facts that complicate its implementation, in particular, the ill-preparedness of universities and teachers for e-learning, insufficient provision of educational and methodological materials, and the lack of teaching methods in an electronic environment.

As follows from the analysis of scientific and methodological studies in the field of blended learning, the above facts are the consequences of the lack of a unified, effective strategy for its development and implementation in the education system. For example, in Kazakhstan, there is no regulatory and methodological documentation concerning the issues of supporting courses in blended training programmes. A unified methodology for the introduction of blended learning into the educational process has not been developed, although some studies suggest various methods of designing the educational process, in which the relationship of designing with classroom hours was not fully considered, which is an important factor in the introduction of blended learning into the educational process.

Based on the above and the conducted survey among teachers at the South Kazakhstan State Pedagogical University (SKSPU) on their attitude to the implementation of electronic and blended learning (given in paragraph 3 of the proposed article), it was revealed that teachers also experience considerable difficulties in introducing blended learning into the educational process since they do not have the necessary competencies for designing the educational process with blended learning.

1.1. Literature review

Blended learning may be understood as an instructional approach that integrates the strengths of both face-to-face teaching and online learning, thereby compensating for the limitations inherent in each modality (Saqui and Al-amin, 2024). It represents a model that universities can adopt to restructure the educational process in more flexible and adaptive ways. Nevertheless, as Rossett and Frazee (2006) emphasized, the successful implementation of blended learning depends on the characteristics of the university system, the adequacy of software and information infrastructure supporting academic activities, and the availability of information and communication technologies for instructional purposes.

Over the past two decades, both Kazakh and international scholars have conducted extensive research within this framework. A review by Bliuc et al. (2012) indicated that a substantial proportion of studies on blended learning adopt a case study approach. This prevalence can be attributed to two main factors: the relative novelty of the field, which leaves many aspects under ongoing investigation, and the fact that much of the literature has been produced by educators studying their innovative teaching practices.

The evidence suggests that blended learning significantly enhances student engagement and the effectiveness of instruction. Comparative studies have consistently reported higher levels of student satisfaction with blended learning than with traditional teaching methods (Hassan et al., 2024; Means et al., 2013; Lin et al., 2016; Gyamfi and Gyaase, 2015). Investigations into student perceptions have also shown attitudes toward blended environments developed on the Moodle platform, which provided a flexible and accessible medium for learning (Sáiz-Manzanares et al., 2019; Mintii, 2020; Harsh and Rush, 2007; Sinha and Sahay, 2017).

In contemporary education, electronic content has emerged as a powerful and valuable learning resource, enabling students worldwide to study at their own pace, location, and convenience. As Dziuban et al. (2006) observed, such resources serve as an effective foundation for blended learning. The global shift to remote learning during the pandemic underscored the need for adaptive instructional strategies, one of which is the five-component blended learning framework known as Discover, Learn, Practice, Collaborate, and Assess (DLPCA) (Voogt and McKenney, 2017). This model has been proposed as a sustainable strategy to enrich blended learning in higher education during the post-pandemic period.

The technological pedagogical content knowledge (TPACK) framework provides a theoretical basis for understanding the effective integration of technology into subject-specific instruction. According to this model, successful use of educational technologies requires a nuanced understanding of the interrelationships among technology, pedagogy, and content. Within the scope of TPACK, numerous studies have examined the integration of digital tools into education, often using project-based experimental designs (Lapitan Jr et al., 2021; Mishra and Koehler, 2006; Rosenberg and Koehler, 2015; Li and Wong, 2025).

Research into the reorganization of the educational process in blended learning contexts (Legan and Astashova, 2016; Lomonosova, 2016; Veledinskaya and Dorofeeva, 2015) has shown that effective methodological design requires clear specification of learning outcomes for each discipline and thematic section, the development of methods to assess these outcomes, and the formulation of an integration plan that unites classroom-based and online components. Studies that focus on the design of online activities for blended mathematics courses have particularly emphasized the technological integration and pedagogical research specific to mathematics education (Albano, 2012; Bardelle and Ferrari, 2010).

For approximately two decades, several models of blended learning have been widely implemented in universities across the United States, Europe, and Southeast Asia. These include the Face-to-Face Driver, Rotation, Flex, Online Lab, Self-Blend, and Online Driver models. In the Russian context, since 2012, commonly applied models have included Station Rotation, Inverted Class, Flexible Model, and others. These models differ in the extent to which they incorporate electronic learning technologies and in the relative involvement of teachers and students in the learning process. For instance, the Inverted Class model enables students to engage with new content in an online learning environment prior to attending in-person sessions. Classroom time is then devoted to reinforcing and applying the material, thereby replacing traditional lecture-based instruction with more interactive forms of engagement.

However, the effective implementation of such models required that instructors coordinate student activities across both in-person and online formats within the broader information and educational environment. Teachers needed to design individualized learning trajectories that accounted for the specific features of the educational process, while also organizing diverse learning activities that made optimal use of available digital and educational resources (Li and Ye, 2025). According to the authors, misconceptions about the simplicity of blended learning and insufficient understanding of its design principles have been major factors contributing to teachers' limited competence in structuring such instruction. Consequently, enhancing the effectiveness of blended learning implementation, particularly by strengthening educators' competencies in the design and execution of the learning process, was viewed as a pressing challenge in contemporary education. Such competencies underpin essential professional qualities in future teachers, including motivation, initiative, self-regulation, and responsibility in professional practice (Han, 2024).

The need to improve the efficiency of blended learning adoption provided the rationale for developing a methodology for structuring the educational process in such environments, taking into account the distribution of classroom hours. This consideration led to the selection of the research topic: Methodology for Designing the Educational Process in Blended Learning.

1.2. Purpose of study

Overall, blended learning has been shown to increase the level and quality of interaction among participants in the educational process, while providing opportunities for active and collaborative learning. It also enables students to access instructional materials at a time, place, and pace that suits them, preparing them more effectively for discussions, laboratory activities, and other forms of interactive engagement (Price and Winchester, 2025). Despite these advantages, several challenges remain that require systematic attention. The principal aim of the study was to formulate a methodology for designing the blended learning process based on the Inverted Class model and incorporating varied instructional formats.

2. MATERIALS AND METHODS

2.1. Research design

The investigation was carried out in three phases that combined theoretical, methodological, and empirical components. In the initial phase, a comprehensive review was conducted of scientific, methodological, psychological, and pedagogical literature related to blended learning in pedagogical universities. This stage also included a survey of SKSPU instructors to identify current practices, clarify research objectives, justify the relevance of the study, and define its scope. The second phase focused on developing a methodology for designing the blended learning process, using the course Algebra and Number Theory as a case example to illustrate its application. The final phase involved implementing the proposed methodology in the SKSPU educational context and conducting quasi-experimental work to assess its effectiveness.

2.2. Participants

The study involved 119 instructors from South Kazakhstan State Pedagogical University (SKSPU). Participants represented a variety of faculties and academic disciplines and voluntarily took part in a survey on their attitudes toward electronic and blended learning. The questionnaire was made available in both Kazakh and Russian to ensure accessibility for all respondents.

2.3. Data collection tools

Data were collected through several methods. A Google Forms survey consisting of 10 multiple-choice questions was used to evaluate teachers' perceptions and readiness for integrating electronic and blended learning. The survey addressed the use of electronic educational resources, familiarity with e-learning technologies, and perceived benefits and challenges. In addition, a review of pedagogical literature and periodical publications provided theoretical grounding and insights into blended learning practices both in Kazakhstan and internationally. This literature review was complemented by an analysis and generalization of practical pedagogical experiences in using electronic environments for blended learning. Finally, data from the quasi-experiment provided empirical evidence on the outcomes of the proposed methodology.

2.4. Procedure

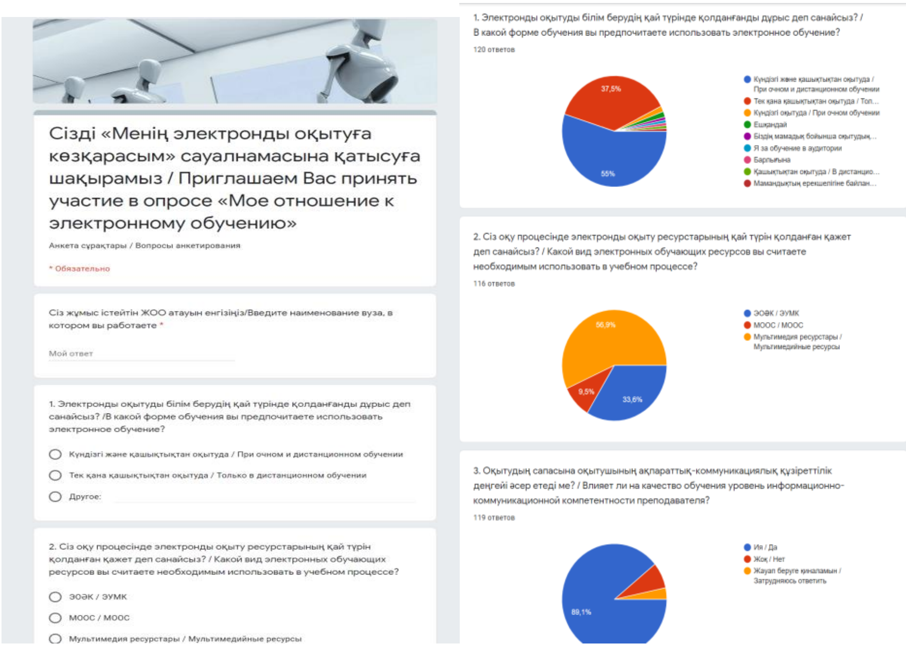
The research began with an in-depth literature review and content analysis to establish the conceptual and methodological basis for the study. The survey was then distributed to 119 instructors to gather quantitative data on their perspectives regarding blended learning. Based on these insights, a blended learning model tailored to SKSPU's educational environment was developed and integrated into the Algebra and Number Theory course. The model was applied in practice and evaluated through quasi-experimental methods to determine its impact on teaching and learning outcomes.

2.5. Data analysis techniques

Survey responses were examined using quantitative methods, with frequencies and percentages calculated to summarize the results. Data from the quasi-experiment were analyzed through comparative techniques to assess the differences in performance and engagement following the implementation of the blended learning model. Findings from the literature and pedagogical practice reviews were synthesized qualitatively to contextualize and support the empirical results. The survey was conducted through Google Forms, fragments of the results of which are presented below (Figure 1).

Figure 1

Fragments of the survey and its results in the Google form



3. RESULTS

3.1. Analysis of the survey results

The results of the survey are presented in the table (Table 1) and are reflected in the form of a histogram (Figure 2), which shows the percentage of respondents' answers to 10 questions:

Table 1

Questions and results of the survey among SKSPU teachers

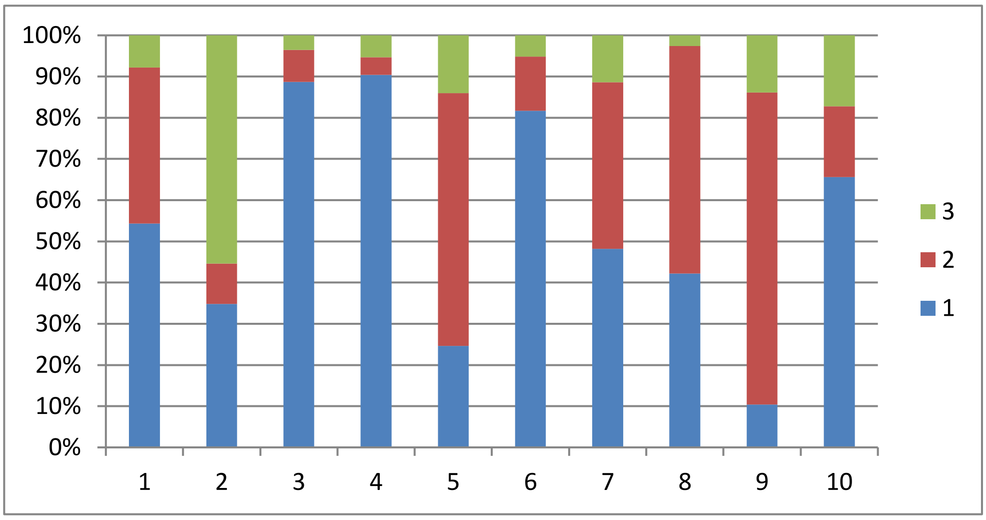
Questions	Survey results, %
1. In what form of training do you prefer to use e-learning?	During in-person and distance learning – 54.3 Only in distance learning – 37.9 Other – 7.8
2. What kind of e-learning resources do you consider necessary to use in the educational process?	EEMC – 34.8 MOOC – 9.8 Multimedia resources – 55.4

3. Does the level of information and communication competence of the teacher affect the quality of training?	Yes – 88.7 No – 7.8 I find it difficult to answer – 3.5
4. Does the level of information and communication competence of the student affect the quality of training?	Yes – 90.4 No – 4.3 I find it difficult to answer – 3.5
5. Do you have an electronic training resource, the author of which you are personally?	Yes – 24.6 No – 61.4 Co-authored – 14
6. Do you have any video lectures prepared due to the need that has arisen in the context of the pandemic?	Yes – 81.7 No – 13.1 There was no need – 5.2
7. Are you ready to develop your open online course?	Yes – 48.2 No – 40.4 Other – 11.4
8. Were you interested in information about blended learning technology before the pandemic?	Yes – 42.2 No – 5.2 Other – 2.6
9. Are you ready to design the educational process in your subject in a blended learning environment?	Yes – 0.4 No – 75.7 I find it difficult to answer – 13.9
10. Do you think people will return to conventional education after the pandemic?	Yes – 65.5 No – 17.2 I find it difficult to answer – 17.2

The abbreviations presented in Table 1 are defined as follows: EEMC refers to an Electronic Educational and Methodical Complex for the discipline, while MOOC denotes a Massive Open Online Course, which is an interactive, large-scale course delivered through electronic learning technologies and made freely accessible via the Internet.

Figure 2

Histogram of the survey results on blended learning among teachers



Analysis of the survey data revealed considerable variation in teachers' responses to the first question. Approximately 54.3 percent of the respondents indicated a preference for integrating electronic learning in both in-person and distance instruction, whereas 37.9 percent favored its use exclusively in distance education. The remaining participants expressed various other perspectives. These findings suggest that most teachers acknowledged the necessity of employing electronic learning in both instructional formats. Furthermore, 55.4 percent expressed a preference for utilizing multimedia resources over Electronic

Educational and Methodical Complexes (EEMC) or Massive Open Online Courses (MOOC).

Responses to questions three and four highlighted that the digital competence of teachers constituted a significant determinant of instructional quality. Nevertheless, the majority (61.4 percent) had not participated in the development of electronic resources, although 81.7 percent had prepared video lectures, and 48.2 percent reported being prepared to develop open online courses as a result of needs that emerged during the pandemic period.

The findings from questions eight and nine demonstrated that prior to the pandemic, most teachers (55.2 percent) had shown little interest in blended learning and, consequently, 75.7 percent were not prepared to design the instructional process for their subject within a blended learning environment. The response to the final question indicated that 65.5 percent of participants expressed a desire to return to traditional classroom instruction after the pandemic. This suggests that, despite generally positive attitudes toward electronic learning, many educators remained attached to conventional teaching formats, even though, in the view of the authors, such a transition to blended approaches appeared inevitable.

Overall, the low level of awareness regarding blended learning and the reluctance to engage in instructional design within this framework underscored the need to develop a structured methodology for designing educational processes in blended learning contexts.

3.2. Methodology for designing the educational process in blended learning

The determination of an appropriate methodology for designing the educational process in a blended learning format was grounded in the fundamental principles of information and pedagogical technology, including pedagogical principles, enabling conditions, emerging areas of knowledge development, and approaches to lectures, organization of practical activities, and assessment (Kadirbayeva and Jamankarayeva, 2019). The following section presents a step-by-step illustration of the design process, using the course Algebra and Number Theory for students at a pedagogical university as a case example.

3.2.1. Step 1: Designing learning outcomes by discipline and thematic sections

At this stage, the target audience for the discipline was analyzed in detail. The process was guided by the principles of didactics and the process-oriented approach to teaching. Based on the graduate competence model, the objectives of the academic discipline and the requirements for learning outcomes were identified. Subsequently, the format and criteria for achieving these learning outcomes were specified in alignment with the intended educational goals.

For the course Algebra and Number Theory, the primary instructional aim was to equip students with theoretical knowledge of the key concepts, theorems, and methods within selected areas of higher mathematics, namely linear algebra, number theory, polynomials, and the comparison theorem. In addition, the course aimed to develop students' problem-solving skills and their ability to apply mathematical concepts to practical and applied contexts.

The discipline covered fundamental concepts, theorems, and problem-solving methods in classical algebra, including matrices and determinants, vector algebra, systems of linear equations, complex numbers, linear operators, and polynomials. It also addressed the preparation of problem sets, the justification of the discipline's role in scientific inquiry, and the integration of mathematical knowledge across subject areas.

The expected learning outcomes for the discipline were defined as follows:

- Students demonstrated knowledge of the fundamental concepts and methods relevant to algebra and number theory.
- Students applied operations on matrices and determinants to the solution of systems of linear equations.
- Students explained the properties of divisibility and modular arithmetic.
- Students used these properties in solving algebraic problems.

- Students analyzed the application of algebra and number theory concepts to problem-solving in high school mathematics.
- Students designed problems based on general algebraic principles and theorems.
- Students integrated mathematical knowledge to enhance mathematical reasoning.

For the thematic section Matrices and Determinants, the expected learning outcomes were specified as:

- Demonstrating knowledge of matrices and determinants.
- Computing minors and algebraic complements and applying determinant properties.
- Determining the rank of a matrix and finding the inverse matrix using multiple methods.
- Formulating and solving problems based on the properties of matrices and determinants.

3.2.2. Step 2: Developing methods for assessing learning outcomes

The second stage involved the creation of an assessment framework to measure the attainment of the planned learning outcomes. The assessment system incorporated a set of actions explicitly aligned with the stated outcomes and adapted to the characteristics of the information and communication subject environment (ICSE).

In the in-person component of the course, lecturers facilitated lessons that included the review of test results and online assignments. During class, students engaged in peer evaluation of individual tasks, responded to problem-based questions, and received clarifications from the instructor. Additional exercises and supplementary materials were occasionally provided to reinforce learning.

Below is an assessment plan, coordinated with the learning outcomes in the discipline “Algebra and Number Theory” (section “Matrices and determinants”) (Table 2).

Table 2

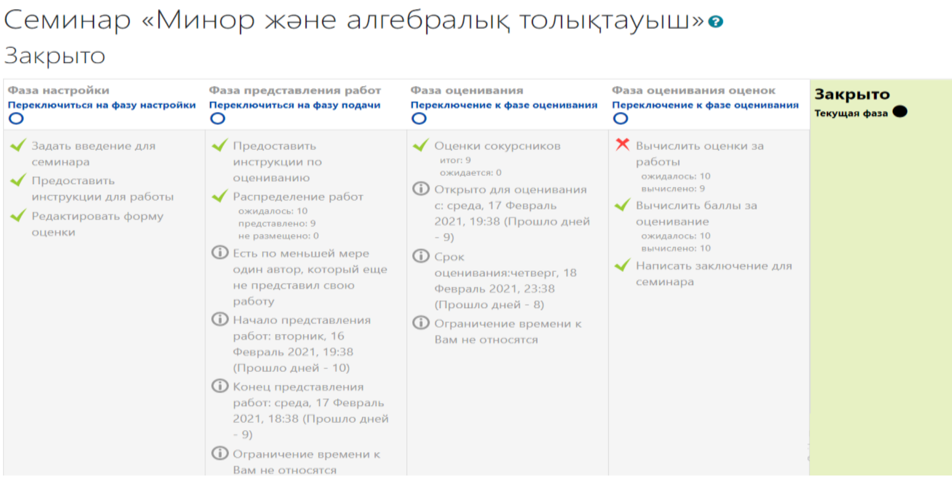
Assessment plan

Learning outcomes in the section	Description of the assessment	The environment of the lesson (C-classroom, ICSE)
1. Demonstrating knowledge of matrix and determinant;	Theoretical questions and completing tasks	ICSE
	Passing a survey on terms, completing tasks (theoretical exercises)	C
	Completing homework	ICSE
2. Finding minor and algebraic complements, using the properties of determinants	Performing practical work	C
	Passing the test	ICSE
	Writing an essay	ICSE
	Mutual commenting on the essay	
	Performing individual works. Mutual checking	ICSE
3. Finding the rank of the matrix and the inverse matrix in various ways	Passing a survey on terms, completing tasks (theoretical exercises)	C
	Passing the test	ICSE
	Completing homework. Mutual review	ICSE
	Self-checking of completed tasks using a computer	C
4. Compiling and solving problems based on the properties of the matrix and the determinant	Compiling tasks for applying the properties of the matrix and the determinant. Mutual review	ICSE
	Performing practical work	C
	Performing individual works	ICSE
	Final testing on the section	ICSE

Examples of the application of didactic assessment elements within the ICSE included the Seminar and the Test. Within the LMS Moodle environment, the Seminar activity was characterized by its interactive and collaborative nature. Each student was required to submit the results of their completed work for collective public discussion. The platform automatically distributed the submitted assignments among participants for peer review and discussion (Figure 3).

Figure 3

Seminar settings window "Minor and algebraic complements"



The seminar discussed essays written by students and their comments for mutual assessment (Figure 4).

Figure 4

Examples of students' essays and comments

Essay	Comment
"Minors and algebraic complement " To describe the properties of a determinant, it is essential to know what minor and algebraic complements are. **The minor** *Mij* to the element *aij* of the nth order determinant is the (n-1)th order determinant obtained from the initial one by deleting the ith row and the jth column. In other words, minor is a determinant that remains after deleting the row and column at the intersection of which the element *aij* is located. This remaining determinant is written out will be considered as the minor of this element. Now, it is worth including the definition of algebraic complement. **The algebraic complement** of *Aij* to the element *aij* of the nth order determinant is the number $\mathbf{A}_{ij} = (-1)^{i+j}\mathbf{M}_{ij}$ Thus, to find the algebraic complement of an element *aij*, one must first determine the minor of this element, and then take this minor with the sign "+" (there will be + if the sum (i + j) is an even number) or "-" (there will be - if the sum (i + j) is an odd number). Minor and algebraic complement will be further applied to find the rank of a matrix.	**Commentary # 1 on the essay on "Minor and Algebraic Complement "** The essay on "Minor and Algebraic Complement " fully covers the considered subjects.It explains very clearly how the minors of an element are indicated, how to find the minor of an element. Moreover, it includes the definition of the algebraic complement and the corresponding formula for the calculation. Thus, these two new subjects are explained well in this essay.
	Comment # 2 on the essay on "Minor and Algebraic Complement " The essay is devoted to the explanation of "algebraic complement " and "minor". It provides their exact definitions, indicated cases where they are further applied, what they are needed for. It also describes in detail how to find the minor of an element, how the algebraic complement of an element is determined and found. In my opinion, it seems necessary to supplement the essay with examples of considered subjects. In general, the essay explains minor and algebraic complement well

After the completion of all interactions, mutual assessment of the submitted works, the seminar is closed, and its results are issued (Figure 5).

Figure 5

Results of participants in the online seminar, incorporating peer assessment conducted through the LMS Moodle platform

Отчет об оценках семинара

Имя / Фамилия	Работа / Последнее изменение	Полученные оценки	Оценка за работу (из 80)	Данные оценки	Баллы за оценивание (из 20)
Бекзат Асан	Эссе изменено: среда, 17 Февраль 2021, 11:58	48 (20)< Лаура Сулейменова 48 (20)< Аяжан Тағай	48	64 (20)> Асылмұрат Асаубай	20
Асылмұрат Асаубай	Эссе изменено: среда, 17 Февраль 2021, 14:51	64 (20)< Бекзат Асан 56 (20)< Лаура Сулейменова	60	48 (20)> Аяжан Тағай	20
Назым Байбосын	Эссе изменено: среда, 17 Февраль 2021, 14:53	48 (20)< Лаура Сулейменова	48	48 (18)> Ақнұр Тәліпбек	18
Бердібек Қадырбек	Эссе изменено: среда, 17 Февраль 2021, 15:00	40 (20)< Лаура Сулейменова 56 (20)< Аяжан Тағай	48	56 (20)> Ақнұр Тәліпбек	20
Болат Сапархан	Эссе изменено: среда, 17 Февраль 2021, 12:04	64 (20)< Лаура Сулейменова 56 (20)< Абдуллабек Турдибеков	60	48 (20)> Аяжан Тағай	20
Аяжан Тағай	Эссе изменено: среда, 17 Февраль 2021, 14:54	48 (20)< Асылмұрат Асаубай 48 (20)< Болат Сапархан 64 (16)< Лаура Сулейменова	53	48 (20)> Бекзат Асан 56 (20)> Бердібек Қадырбек	20
Ақнұр Тәліпбек	Эссе изменено: среда, 17 Февраль 2021, 14:56	48 (18)< Назым Байбосын 56 (20)< Бердібек Қадырбек 56 (20)< Лаура Сулейменова	53	48 (20)> Ерзат Тузелбай	20
Ерзат Тузелбай	Эссе изменено: среда, 17 Февраль 2021, 14:59	40 (20)< Лаура Сулейменова 48 (20)< Ақнұр Тәліпбек	44	56 (20)> Абдуллабек Турдибеков	20
Абдуллабек Турдибеков	Эссе изменено: среда, 17 Февраль 2021, 15:00	64 (20)< Лаура Сулейменова 56 (20)< Ерзат Тузелбай	60	56 (20)> Болат Сапархан	20
Нұрбол Тұрғанбай	Не найдено работ этого пользователя	-	-	-	-

The Test element was employed to evaluate students' readiness for the assimilation of new material, their proficiency in solving standard problems, their mastery of the conceptual framework, their understanding of key topics, and their ability to apply problem-solving skills. Furthermore, each module required students to complete a test. As an illustration, Figure 6 presents sample test items in various formats used to monitor the extent to which the material had been mastered.

Figure 6

Fragments of test tasks

№1. Matrices are given: $A=\begin{pmatrix}5 & 2 & -1\\ 7 & 4 & -2\\ 1 & 0 & 0\end{pmatrix}$, $B=\begin{pmatrix}2 & -4\\ 4 & -2\end{pmatrix}$, $C=\begin{pmatrix}10 & -1 & 0\\ 7 & -5 & 3\end{pmatrix}$.

Which of the products exist?

1) AB и AC;
2) AC и CB;
3) BC и CA;
4) BA, AB и AC;
5) CA, AC и BC

№2. Calculate the determinant: $\begin{vmatrix}3 & 1 & 0\\ 0 & 5 & -4\\ 0 & 0 & -2\end{vmatrix}$?

№3. Match between left and right table columns.

A) Find the element c_{43} in the matrix $C=B^T$, if $B=\begin{pmatrix}1 & 2 & 3 & 5 & -2\\ 0 & 4 & 7 & 8 & -1\\ 2 & 5 & 3 & 9 & -3\end{pmatrix}$	1) 9
B) Find the element c_{12} in the matrix $C=A\cdot B$, if $A=\begin{pmatrix}-2 & 5 & 1\\ 3 & 0 & -1\end{pmatrix}$, $B=\begin{pmatrix}-1 & 0\\ 2 & 3\\ 4 & 1\end{pmatrix}$	2) 16
C) Find the element b_{22} in the matrix $B=A^2$, if $A=\begin{pmatrix}2 & 1\\ 1 & 3\end{pmatrix}$	3) 10
D) Find the element c_{21} in the matrix $C=AA^T$, if $A=\begin{pmatrix}1 & -7 & 0\\ 2 & -3 & 4\end{pmatrix}$	4) 23

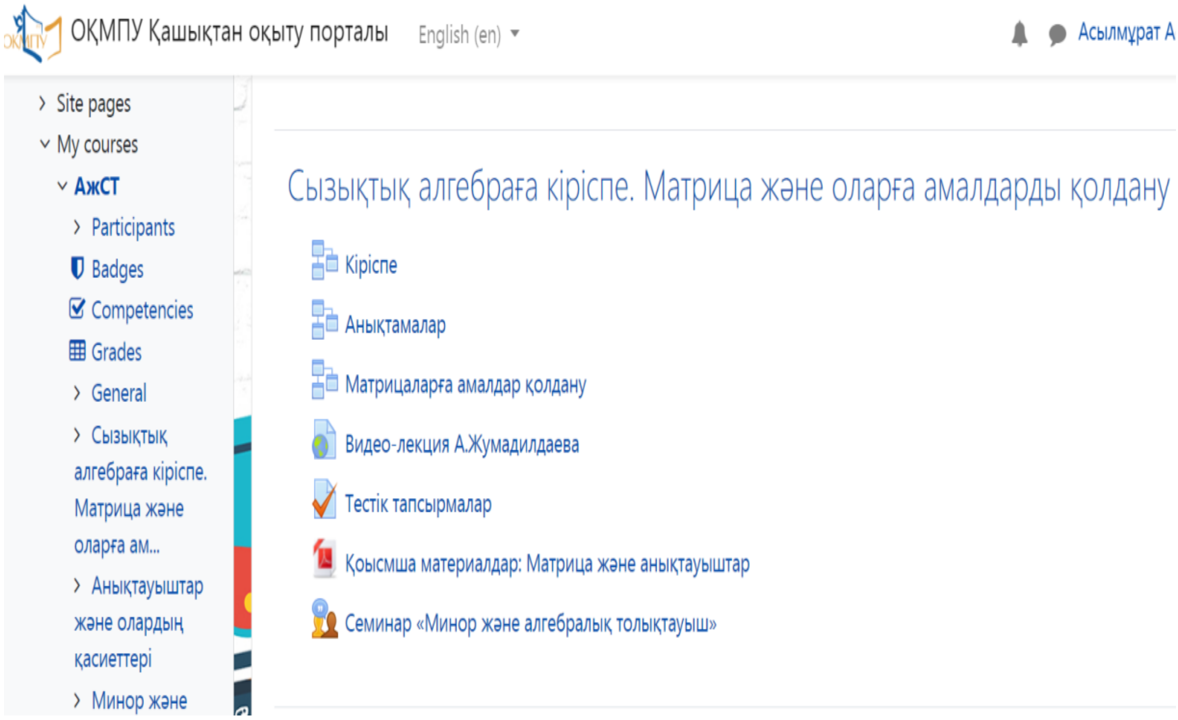
Testing was conducted at the end of each unit of training material assigned for independent study, as well as upon completion of the module in the form of a final assessment.

1. Development of a plan for integrating the classroom and electronic components.

At the final, third stage, the training strategy was determined: a system of transitions and connections between the classroom and electronic components was developed, the necessary training materials and supplementary resources were recommended, and mechanisms for interaction were designed. As a means of integrating in-person and electronic elements of blended learning, the authors selected the ICSE developed within the LMS Moodle platform. Based on the capabilities of the ICSE, interactions between the subjects of the educational process were considered, such as student–student, student–content, and student–teacher (Kadirbayeva et al., 2019). Figure 7 presents an example of the ICSE user page for the course Algebra and Number Theory in LMS Moodle.

Figure 7

ICSE user page "Algebra and Number Theory" in LMS Moodle



Designing the course with consideration of the capabilities of the ICSE at this stage ensured a reduction in classroom hours and the transformation of the remaining in-person activities to maintain the coherence of the educational process. To achieve a balanced approach to blended learning, the Inverted Class model was applied, structured as a sequence of extracurricular and classroom stages within the educational process. Extracurricular activities were implemented through the ICSE, where students engaged in independent learning tasks that were subsequently continued and consolidated in classroom sessions.

Extracurricular work encompassed the following educational activities: studying learning materials (including reading texts, viewing video lectures, and selecting relevant resources), completing standard exercises, providing mutual feedback, engaging in self-assessment, undertaking tests, reflecting on learning, participating in collaborative activities, finalizing assignments, submitting completed work (and, where applicable, defending it), completing homework, conducting peer reviews, and performing evaluations. Classroom work focused primarily on providing feedback regarding extracurricular and practical tasks. Table 3 presents the distribution of educational activities between instructional formats in the section Matrices and Determinants of the course Algebra and Number Theory, as applied in the educational process.

Table 3

Distribution of educational activities between the classroom and extracurricular activities

Extracurricular work (work in ICSE)	**Classroom work**
Before the lecture, classroom work: – study of notes, presentation of the *Lecture 1 – Introduction. Matrices and operations on them;* – getting acquainted with the examples;	– generalization of independently studied material (survey on terms, answers to students' questions); – *Lecture 2– Determinants and their properties;*
Before practical classroom work: – preparation for practical work (study of the theoretical material of the lecture); – passing the test; – *completing homework;* – writing an essay "Minors and algebraic complements"; – mutual commenting on the essay	– discussion of independently studied material, analysis of test results, and answers to students' questions; – *performing practical work* (discussion of solutions to typical problems on matrices and determinants);
Before the lecture, classroom work: – completing homework; – study of notes, presentation of Lecture 3 – *Elementary transformations of matrices and their properties. Matrix rank;* – passing the test;	– generalization of independently studied material (a survey on terms, analysis of test results, and answers to students' questions); – Lecture 4 – The inverse matrix and ways to find it;
Before practical classroom work: – *execution of individual works;* – mutual checking of completed works; – compiling tasks for applying the properties of the matrix and the determinant; – passing the final test on the theoretical material.	– discussion of the results of mutual checking, analysis of the test results, and answers to students' questions; – *performing practical work* (solving and discussing the compiled tasks for applying the properties of the matrix and the determinant).

As a result of transferring selected educational activities to the ICSE, classroom instruction was reduced by a total of four hours, comprising two hours of lectures and two hours of practical sessions. Consequently, the teacher's task was to ensure the optimal distribution of the activities relocated to the ICSE between the in-person and extracurricular components of the educational process. The developed methodology for designing the educational process in a blended learning format thereby not only enhanced interaction among students and between students and the instructor but also improved academic performance by increasing the overall intensity of the learning process.

3.2.3. Quasi-experimental verification of the efficiency of the developed design methodology in blended learning

The efficiency of the proposed design methodology was examined during the "Algebra and Number Theory" course with 49 first-year students from the Faculty of Physics and Mathematics at SKSPU, representing three groups (one experimental and two control) enrolled in the programmes 6B01501 – Mathematics, 6B01508 – Mathematics-Physics, and 6B01509 – Mathematics-Computer Science.

The quasi-experiment aimed to demonstrate that the effectiveness and efficiency of training future mathematics teachers depend on the instructional methodology, specifically, the organization of blended learning. In this context, effectiveness referred to the extent to which the developed methodology for the course achieved the intended learning objectives, while efficiency related to identifying the factors that prompted the methodology's development. Effectiveness was considered a result of the technological structuring of the learning process, serving as a prerequisite for efficiency.

Each module commenced with an online session in the ICSE, where instructional materials, videos, readings, exercises, and tasks were made available one week before the corresponding offline class. This arrangement allowed students to engage with the materials independently in advance. Students were required to submit completed tasks before the in-person session, enabling the lecturer to adopt student-centered teaching strategies during class.

Offline sessions, led by the lecturer, involved analyzing and discussing the results of online tests and assignments. These lessons also incorporated peer-to-peer interactions, mutual review of task performance, and opportunities for students to pose challenging questions to each other and to the teacher, who was also expected to respond. When necessary, additional exercises, quizzes, and supplementary resources were provided.

Examples of online activities included student essays accompanied by peer comments for mutual assessment, as well as test items designed to monitor content mastery, as described. To objectively measure learning outcomes, the authors developed a set of final test tasks, with assimilation coefficients automatically calculated in LMS Moodle. The results of the final tests for both experimental and control groups are presented in Table 4.

Table 4

Results of the final testing

Groups	The number of students who received the appropriate assessment (people)				Academic performance (%)	Average rating	Mean square deviation б
	Less than 70	70-80	80-90	Above 90			
experimental	1	2	9	4	93.7	84.1	0.58
control	5	14	8	6	84.8	79.4	0.71

The standard deviation (б) reflected the degree of variation in academic performance within the group. A lower value indicated that students' scores were closer to the group mean, suggesting more consistent learning outcomes and, by implication, more effective instruction. In this context, the ideal value was considered to be б = 0.25.

As shown in Table 4, the experimental group's б was closer to the ideal than that of the control group, indicating greater consistency and higher overall academic performance. Although the investigated issues were not exhaustively explored, and the implemented inverted classroom model may not yet have reached its full potential, the quasi-experimental results demonstrated that the proposed methodology for organizing the learning process enhanced students' academic achievement and fostered the development of 21st-century skills, as outlined in the introduction.

The authors concluded that the efficiency of blended learning, when based on the developed methodology for designing the educational process, was underpinned by the factors discussed above.

4. DISCUSSION

The findings of this study affirm the consensus in the literature that blended learning, when deliberately designed and strategically integrated, can enhance both academic performance and learner engagement in higher education. Consistent with the principles outlined in the Digital Kazakhstan programme and supported by Morozova (2016), the results demonstrate that technology integration in the educational process can stimulate pedagogical innovation, broaden access to resources, and foster new modes of interaction between learners and instructors. In our quasi-experimental implementation, the Inverted Class model within a blended framework yielded measurable gains in academic performance, with the experimental group achieving higher mean scores and greater score consistency than the control groups. This corroborates earlier work by Hassan et al. (2024), Means et al. (2013), and Gyamfi and Gyaase (2015), who found that blended learning often results in higher student satisfaction and improved learning outcomes compared to traditional methods.

A key finding of this study, the positive relationship between teacher digital competence and instructional quality, aligns with Rossett and Frazee's (2006) emphasis on the role of institutional readiness and instructor capacity in the success of blended programmes. Our survey revealed that while a majority of teachers recognized the value of blended approaches, most were unprepared to design courses for this modality, reflecting the "ill-preparedness" and lack of methodological resources identified by Dolgova (2017) and observed in earlier Kazakhstani contexts. These challenges suggest that technology adoption without a parallel investment in teacher training and methodological support is unlikely to yield optimal results.

The methodology developed in this study extends the practical guidance available in the literature by providing a step-by-step design framework tailored to a specific pedagogical context. While prior research (Legan & Astashova, 2016; Lomonosova, 2016) has underscored the importance of aligning learning outcomes with both online and face-to-face components, few studies have illustrated the distribution of activities with the level of granularity provided here. This contribution responds to Li and Ye's (2025) call for models that enable teachers to design individualized learning trajectories and coordinate classroom and online activities effectively.

Our results also support Dziuban et al. (2006) and Voogt & McKenney (2017) in demonstrating that structured blended models, particularly those that incorporate asynchronous preparation before synchronous interaction, can increase the intensity and focus of classroom activities. The ICSE-based implementation allowed students to engage with materials independently in advance, thus freeing classroom time for collaborative problem-solving, peer feedback, and targeted clarification. This aligns with the principles of the Inverted Class model described in Bon & Graham (2006) and resonates with global best practices reported in the U.S., European, and Asian contexts (Bliuc et al., 2012).

However, our study revealed a stronger-than-expected preference among surveyed instructors for a return to traditional classroom teaching post-pandemic (65.5%), diverging from the optimism reflected in some international studies where blended learning adoption accelerated after COVID-19 disruptions. This may reflect a combination of cultural factors, infrastructure variability, and lingering gaps in digital pedagogy skills, issues also noted in Han (2024) in the context of developing teacher professional competencies.

Overall, the findings corroborate the widely acknowledged benefits of blended learning for flexibility, engagement, and skill development while also exposing persistent barriers in teacher readiness and methodological integration. By demonstrating the effectiveness of a context-specific, outcome-aligned design framework, this study contributes both empirical evidence and practical solutions to ongoing challenges in blended learning adoption, particularly within Kazakhstani higher education.

5. CONCLUSIONS

The 21st century demanded motivated, active, self-regulated, and responsible teachers; consequently, they needed to determine effective approaches to developing such qualities through self-education and collaboration with colleagues. The findings of the present research indicated that the implementation of the proposed methodology for designing blended learning classes in the form of an "inverted class" required future mathematics teachers to acquire a range of essential skills. These included complex problem solving, critical thinking, creative interpretation of available information, collaboration in pairs and teams, continuous self-education, and sound decision-making. The introduction of this methodology not only facilitated and streamlined the educational process but also enhanced the social prestige of teachers and contributed to improving the reputation of secondary, specialized, and higher education institutions.

The application of the "inverted class" model had a demonstrably positive impact on the teaching of the Algebra and Number Theory course. The integration of online classes allowed students to engage with procedural content in advance, which, in turn, provided additional time for in-depth discussions of conceptual materials during offline sessions. This approach strengthened the connection between independent study and in-person engagement, leading to more effective knowledge acquisition.

The experience gained in transferring specific in-person teaching activities to an electronic environment, demonstrated through the example of the Algebra and Number Theory course, offered valuable insights for the design of blended learning in other subject areas. The developed recommendations may serve as a practical guide for adapting traditional courses to blended formats in order to improve the efficiency, accessibility, and overall quality of higher education.

Acknowledgments: The research was conducted with the financial support of the grant of the Ministry of Education and Science of the Republic of Kazakhstan (grant **AP08956523**).

Conflict of interest: No potential conflict of interest was reported by the authors.

Ethical Approval: The study adheres to the ethical guidelines for conducting research.

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