QUBAHAN ACADEMIC JOURNAL
VOL. 4, NO. 3, September 2024
https://doi.org/10.48161/qaj.v4n3a1050

Continuity in Teaching the Course Algebra and the Beginning of Analysis: Adaptation of Students to New Conditions

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ABSTRACT: Without continuity in education, it is impossible to ensure a high level of academic achievement of students and prepare students for learning at the next stage of education. The continuity of school and higher education is one of the most difficult and still unresolved problems of general education. The urgency of this research lies in addressing the critical gap in continuity between school and higher education, as the lack of a seamless transition in teaching algebra and the beginning of analysis significantly hampers students' academic success and adaptability to university-level education. Recent studies show that the low level of training of school graduates in mathematics causes difficulties in adapting them to subjects in pedagogical universities. The purpose of this work is to develop the concept of continuity in the teaching of algebra and the beginning of analysis in secondary and higher educational institutions and to verify the conditions for its implementation. In the course of the study, a systematic analysis of scientific papers based on the PRISMA method was carried out and a questionnaire method was obtained among students. The results of the impact value analysis of 10 studies ($N = 105$) published from 2010 to 2024 showed that continuity in learning contributed to the average overall impact value ($Es = 2.27$, 95% CI [2.015–2.35], $p < 0.001$) compared to other learning methods. Also, an assessment of the effectiveness of continuity-based learning on the algebra and the beginning of analysis course was carried out based on the results of knowledge surveys. This experiment was conducted in accordance with the academic calendar of the 2022-2023 academic year on the basis of 2 universities and 2 secondary schools in Almaty, Kazakhstan. A total of 86 students who participated in the experiment were divided into control and experimental groups. The conditions for the effective implementation of continuity in higher and secondary education have shown that in experimental groups, students have a high rate of adaptation ($T_{emp} = 2.315 > 1.96$). The scientific novelty of the research is that it solves the problem of continuity in teaching algebra on a fundamentally new basis - in the context of the "school - pedagogical university" system. The results of the study can be used by teachers of mathematical disciplines at a pedagogical university and teachers of mathematics in secondary schools, which will improve both the quality of knowledge of students in grades 10 and 11 of secondary schools and students of a pedagogical university.

Keywords: continuity, teaching, algebra, analysis, school.

I. INTRODUCTION

1. PROBLEM STATEMENT

In the context of education, continuity means that new knowledge and skills are built on an existing knowledge base and experience. In the school curriculum, the continuity of learning implies that educational materials and methods should correspond to and complement the previous stages of learning, ensuring the consistent development of students [1]. To ensure continuity, it is important to develop high-quality curricula adapted to the needs and capabilities of students at different stages of their educational path. It is also important to ensure cooperation and exchange of experience between teachers of different levels of education and create conditions for constant updating and improvement of educational materials and techniques.

Especially the continuity of learning in the algebra and the beginning of analysis course plays an important role in the development of mathematical skills and adaptation of students to the next stage of education [2]. The education system in the world has been undergoing serious reforms for quite a long time. As a result of the implementation of the updated content and various educational models, signs of inconsistency in curricula and a violation of continuity in teaching algebra and the beginning of analysis began to increase.

Despite extensive research in the field of continuity in mathematics education, the current situation is alarming. Extensive reforms in global education and research in mathematics continuity, as inconsistencies in curricula and a lack of continuity in teaching algebra and the beginning of analysis have led to students requiring additional, often financially burdensome, support to meet mandatory educational standards. In addition to studying at educational institutions, students are forced to seek additional help, which often requires additional financial costs. This fact may be justified if such additional classes were a welcome addition. However, in this case we are talking about the need to master the material at a mandatory level for successful continuation of education, which is a serious problem. It seems that the reason for this problem lies not so much in the ongoing reforms as in an unsatisfactory understanding of the essence of the educational process.

Within the framework of algebra and the beginning of analysis, students begin to get acquainted with the simplest methods of functional analysis, such as finding the domain of definition and the domain of values of functions, as well as studying their behavior and properties. One of the important topics in the algebra and the beginning of analysis of the school course is the solution of systems of equations. Students learn to find the values of variables that satisfy several equations at once using various methods such as the substitution method, the exclusion method and the graphical representation method. Algebra and the beginning of analysis also tries to show students the practical application of mathematics in real life, for example, in solving problems on the topics of finance, science or engineering [3]. The consistent approach to teaching algebra in the final years of secondary school and early stages of teacher training universities is evident in the thoughtful selection of teaching techniques and approaches, as well as the identification of the most efficient pedagogical methods within the learning environment. Ensuring this continuity entails maintaining and enhancing methods that have demonstrated success and efficacy across educational tiers, including academic strategies, while also integrating novel methodologies that align with contemporary standards and cater to the psychological nuances of students.

The algebra and the beginning of analysis course in school serves as a prerequisite not just for mathematical studies in teacher training universities, but also equips students with knowledge and competencies applicable across various educational domains, owing to the interdisciplinary links between algebra and other fields of study. The separation of school and higher education leads to pronounced problems of students' adaptation to university, which manifests itself in increased anxiety, emotional instability, decreased academic success, etc. Therefore, the problem of continuity is now facing the Association of Teachers of Mathematics as an important component of the new standards [4].

Over the past decades, the problem of continuity in education has attracted the close attention of educators and methodologists. The review of literature indicates that the concept of continuity has arisen as an essential framework for understanding the complexities of the pedagogical process in real-world application, highlighting the seamless and integrated nature of education. As scholars investigate continuity in learning, they often prioritize two aspects of the phenomenon: substantive and procedural. However, the substantive aspect tends to garner more attention and priority in research efforts.

The study aims to enhance the understanding of continuity within algebra and the beginning of analysis education at both secondary and higher levels, while also identifying the essential conditions required for its successful application. Based on the objectives of this study, we will consider the following research questions:

- What is the relationship between the content and methods of teaching algebra and the beginning of analysis in school and pedagogical university?
- What are the didactic conditions for the effective implementation of the continuity of learning algebra and the beginning of analysis in school and pedagogical university for adaptation of students?
- How can we experimentally verify the effectiveness of the methodology for implementing the continuity of learning in the algebra and the beginning of analysis course?

The practical significance of solving the above-mentioned research issues lies in the fact that the methodology for implementing continuity can be used by teachers of mathematical disciplines at a pedagogical university and teachers of mathematics in secondary schools, which will improve both the quality of knowledge of students in grades 10 and 11 of secondary schools, as well as students, graduates of a pedagogical university.

Regarding mathematical activity in higher education, it can be argued that most of the research concerns the training of future teachers [12-14]. The focus of researchers on mathematical education within the realm of training prospective teachers is entirely warranted. Ensuring the continuity of mathematics education across all its stages necessitates competent professional s who grasp this concept and can adeptly structure the learning process accordingly. Moreover, as previously mentioned, interdisciplinary connections are forged on the foundation of mathematical activity, extending its applicability across diverse professional domains [15].

If teaching students knowledge and activities to acquire this knowledge is accepted as one of the leading attitudes, then the implementation of continuity in the chain "school-pedagogical university" on the basis of an activity-based approach becomes progressive and relevant. The aim of the collaboration between a school institution and a pedagogical university is to establish an environment conducive to the development and social integration of students within society, facilitating their smooth transition and successful adaptation from one societal context to another.

The primary objective of researchers focusing on continuity is to consolidate the efforts of educational staff across institutions in order to mitigate the indicators of student maladaptation [16, 17].

2. DATA COLLECTION

The scientific and technological advancements of recent years, alongside the emergence of novel production methodologies and the digitalization of both production and service sectors, underscore the imperative of establishing continuous education systems. Mathematical proficiency stands out as a cornerstone in driving forward these advancements [5]. The study of mathematics, in particular algebra and the beginning of analysis, makes a decisive contribution to human mental development and research activities students [6].

The school algebra and the beginning of analysis course serves as a foundational requirement not just for subsequent mathematical studies at pedagogical universities, but also imparts students with knowledge and skills applicable across various educational domains. This is owing to the interdisciplinary connections of algebra and the beginning of analysis with other fields of study. Defining the content of the algebra and the beginning of analysis curriculum taught in both schools and pedagogical universities is a crucial aspect of preparing future mathematics educators for their professional roles. The solution of the problem of continuity of education is facilitated by the availability of disciplines aimed at implementing the principle of continuity of mathematical education in pedagogical universities. Thus, students will be able to qualitatively develop their basic knowledge of school mathematics and teach students adaptability [7].

Continuity in learning encompasses the establishment of both intra subject connections, the clarification of fundamental concepts, the structured progression of educational content, the gradual increase in complexity and difficulty levels, and the organization of learning activities across various stages [8]. Many researchers have considered continuity in learning as a way to organize knowledge in programs [9, 11].

Failure to comply with the rules of continuity and individual approach in the transition of students from one stage of education to another may adversely affect the passage of the period of adaptation of students in new conditions. Therefore, it becomes necessary to determine the conditions for the effective implementation of continuity, especially in teaching algebra and the beginning of analysis, the content and methods of teaching based on continuity. Thus, at this stage of mathematics teacher training, there is a contradiction between the need for a scientifically based methodology for implementing continuity in teaching algebra and the beginning of analysis and its real state. The need to resolve it determines the relevance of the research problem, which consists in finding the main directions and forms of continuity in the process of teaching algebra and the beginning of analysis in the "school - pedagogical university" system. After analyzing the above literature, we present the following scientific hypothesis:

- **H01:** A systematic analysis of the scientific literature allows us to determine the conditions for the effective implementation of the continuity of teaching algebra and the beginning of analysis.
- **H02:** The methodology of teaching algebra and the beginning of analysis in accordance with certain didactic conditions has a positive effect on the adaptation of students to new conditions.

II. MATERIALS AND METHODS

1. DATA ANALYSIS

This section of the article describes the research methods used to conduct, analyze and select the above-mentioned research papers. In this work, a method called PRISMA was used to achieve the above-mentioned research goal. This method uses a number of database resources for systematic and in-depth analysis of the literature, the stages of the review process, acceptance and exclusion criteria, as well as annotations and data analysis. It should be noted that the consideration of documents in accordance with clearly formulated questions consists in systematic reviews of the literature and the use of systematic and understandable approaches to sort and critically evaluate relevant studies in terms of quality and relevance [18]. The literature review was conducted in accordance with the requirements of the PRISMA guidelines (Figure 1). In addition to the specific citation of the PRISMA checklist, reviewers follow the protocol of a systematic review of the literature with additions to all sections: topic, abstract, introduction, methods, results, discussion and main conclusions of the articles.

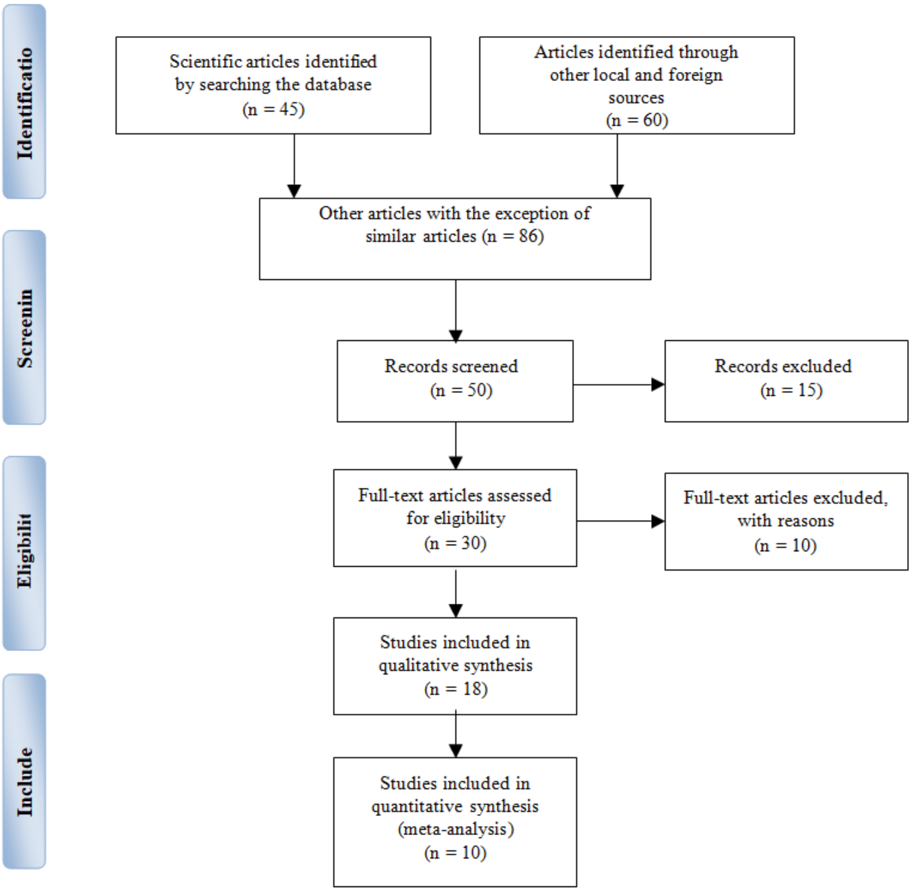


FIGURE 1. A flowchart that defines the use of PRISMA from different sides

The categorization of articles was conducted according to several criteria. Initially, a set of relevant literary works was identified. The systematic review methodology was employed during the search phase to ensure that the selected articles closely align with the research topic. Each database utilized a distinct search interface, as outlined in Table 1.

Table 1. Keywords and search stages according to the topic

Databases	Keywords used
Scopus	«continuity in teaching» and «adaptation of students*»
WOS	Title, abstract, keywords: Continuity in Teaching the Course Algebra and the Beginning of Analysis
Google Scholar	(«continuity in teaching and adaptation of students») («teachinf algebra and the beginning of analysis in school/pedagogical university*»)

Ultimately, articles focusing on the continuity of teaching the algebra and the beginning of analysis course and the introduction of analysis in secondary school and pedagogical university were chosen based on the criteria specified in Table 2.

Table 2. Criteria for adding and removing articles according to the topic.

Criteria	Eligibility	Exclusion
Search string in	Title and abstract only	In full text
Language	English, Kazakh	Other than Kazakh, English
Literature type	Articles	Proceedings, books
Subjects	continuity of teaching the algebra and the beginning of analysis	non - continuity of teaching the algebra and the beginning of analysis

The remaining 10 articles were analyzed in detail and the final wording was given on the analyzed articles. We used the formula (1) below to calculate the effect measurements during the meta-analysis.

$$Es = t\sqrt{\frac{1}{NE} + \frac{1}{NC}} \quad (1)$$

Es - Effect size; t - Result of t-test; NE - Sum of experimtental group; NC = Sum of control group. Based on the didactic conditions determined as a result of the analysis of scientific literature, a pedagogical experiment was organized.

To achieve this goal, the available educational programs of universities and schools - Kazakh National Pedagogical University named after Abai, M.Auezov South Kazakhstan University, Gymnasium №159 named after Y.Altynsarin, Gymnasium №168 named after K. Katykbayev - served as material. Table 3 presents comprehensive details regarding the students involved in the experiment.

Table 3. Participants of the pedagogical experiment

University/school name	Educational Program/grade	Number of Students	Gender
Kazakh National Pedagogical University named after Abai	1st year on mathematics teacher	46	female (26) male (20)
M.Auezov South Kazakhstan University		40	female (25) male (15)
Gymnasium №159 named after Y.Altynsarin	10th grade	50	female (25) male (25)
Gymnasium №168 named after K. Katykbayev	11th grade	52	female (32) male (20)
Total		188	female (108) male (80)

During the pedagogical experiment, the 1st year students developed algebra curricula in accordance with the school curriculum. This allows students to adapt to the content of education in the educational process in the course of a pedagogical experiment.

The pedagogical experiment was organized in 3 stages: *At the first stage*, conversations were held with teachers and schoolchildren about emerging problems in the process of teaching algebra at school; the curricula for algebra and the beginning of analysis for grades 10-11 were analyzed; the content of the educational program "Mathematics" was also analyzed. *At the second stage*, the main methodological approaches to teaching algebra and the beginning of analysis courses in secondary schools and pedagogical universities were identified, and a methodology for organizing algebra courses using didactic conditions was developed. *Then in the next stage*, control papers aimed at identifying the pre- and post-curricular inclinations of the course were obtained. A mathematical and statistical analysis of the results was carried out. A total of 188 students took part in the interview. In the 2022-2023 academic year, 86 students of the 1st course mathematics teachers educational program took part in the educational process. The course participants were randomly divided into control (44 students) and experimental (42 students) groups. The classes lasted 15 weeks and were followed by 2 weeks of practical classes in secondary schools.

III. RESULTS AND DISCUSSIONS

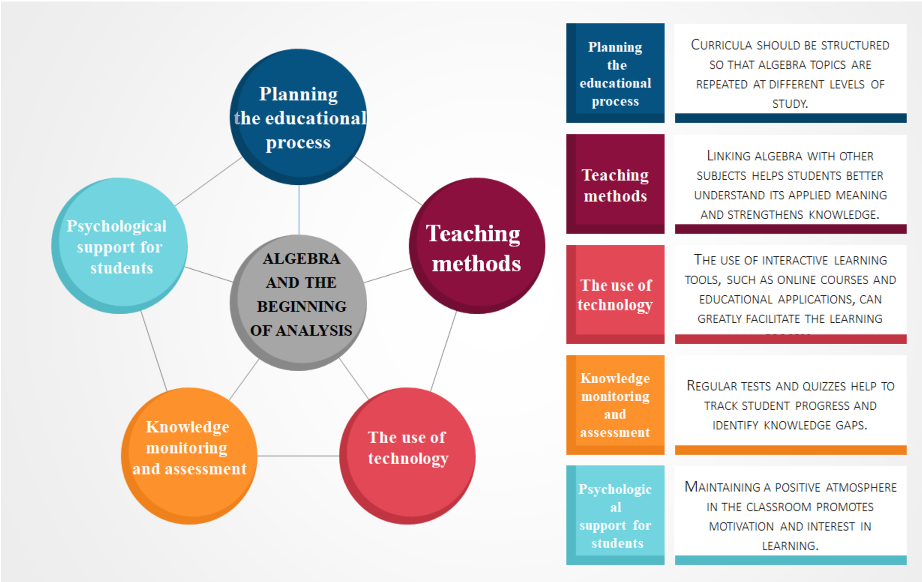
1. *CONCLUSIONS ON THE EFFECTIVE IMPLEMENTATION OF CONTINUITY IN TEACHING ALGEBRA AND THE BEGINNING OF ANALYSIS COURSE: RESULTS OF A SYSTEMATIC ANALYSIS OF THE LITERATURE*

Insufficient attention to the principles of continuity in teaching and upbringing negatively affects both the quality of knowledge and the development of skills, as well as the communicative and socially significant aspects of the student's personality. Thus, without observing continuity in education, it is impossible to ensure a high level of educational achievements of students and prepare students for learning at the next stage of education, as well as maximize the development and realization of the abilities and inclinations of each student. In our study, the results of the literature analysis, which allowed us to draw conclusions on the effective implementation of continuity in teaching algebra and the beginning of analysis, are presented in table 4 below.

Table 4. A summary to help you understand research on which research issues are based.

No.	Authors (Year)	Description of the result obtained	Effect Size	Standard error
1	Kieran, 2011	The question of solving equations is central to the school algebra course [19].	2,20	0.085
2	Botuzova, 2020	The study allowed us to identify four factors influencing the process of ensuring the continuity of mathematics education [20].	2,35	1.105
3	Fonseca& Henriques, 2020	The study provides information to propose innovative methodologies for teaching and learning mathematics [21].	2,15	0,068
4	Bikmaz et al., 2010	The effectiveness of the active activities of students and teachers is evaluated [22].	2,17	0,012
5	Wang et al., 2024	New patterns have been identified that emphasize the importance of developing inclusive learning methods and specific support mechanisms [23].	2,15	0,080
6	Villa-Ochoa et al., 2023	This study examines the impact of technology on the succession system [24].	2,015	1.005
7	Suhendra, 2022	Teachers used their reflections on the lessons to help them improve the standards of lesson continuity [25].	2,25	0.905
8	Lau, 2021	The increase in knowledge of pedagogical content in algebra has led to an increase in teachers' confidence in the continuity of knowledge [26].	2,15	0.301
9	Ormond, 2016	It is better to prepare some novice teachers by modeling a more consistent approach to teaching mathematics [27].	2,20	0.085
10	Gholami, 2022	Teaching the maximum and minimum values of the trigonometric function through various solutions and possible misconceptions among students [28].	2,015	1.005

Research has shown that one of the main tasks facing secondary schools is the formation of an able personality that maximizes student mobility and invests all opportunities in the development of society at the next stage of education. Each student has a great contribution of mathematical knowledge to the formation and development of personality. The results of the analysis of scientific and methodological literature [29] showed that in Kazakh pedagogical universities, in the educational programs of the specialty "Mathematics", the disciplines "Algebra-1" and "Algebra-2" are components of choice from the cycle of basic disciplines. In the curricula of pedagogical universities, mathematical disciplines are poorly correlated with the content of the school course of mathematical education, whereas they should be aimed at implementing the principle of continuity. The main elements and strategies that help to implement continuity in teaching algebra and the beginning of analysis are shown in Figure 2.



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IGURE 2. Didactic conditions for the implementation of teaching continuity

Having analyzed the curricula of the school algebra course, having considered the coverage and development of individual school sections in the university course, we come to the conclusion that the substantive aspect of continuity in the "school-pedagogical university" system is insufficiently formed because there is a gap between school knowledge and abstract knowledge of algebra at the university. We consider it necessary to pay special attention to the independent work of high school students so that when they enter the university, they are sufficiently prepared for the new form of the educational process at the university.

Although there are many methodological and psychological-pedagogical studies devoted to the educational process and ensuring continuity in the transition from school to university, the problem is still not solved due to continuous changes in the education system, especially in mathematics education.

Continuity should be maintained not only in the content of algebra and the beginning of analysis courses at school and university, but also in the organization of the educational process. At school, students work under the guidance of teachers who monitor the assimilation of material in each subject, emphasize the need to study the theoretical part, and in case of omissions or insufficient understanding, provide additional tasks to fill in the gaps. At the university, almost the entire process is aimed at self-education and independent study. Of course, due to the age characteristics of schoolchildren, school education cannot be completely left to their independent learning, but it is necessary to prepare them for the process of acquiring knowledge at the university, developing their responsibility for their academic performance.

2. *THE CONTENT AND EXAMPLES OF ALGEBRA AND THE BEGINNING OF ANALYSIS EDUCATION IN A PEDAGOGICAL UNIVERSITIES AND SCHOOLS*

In Kazakh schools, high school students study not only algebra, they get acquainted with the basic concepts of mathematical analysis. Regarding algebra, students have questions when solving systems of trigonometric equations and trigonometric inequalities.

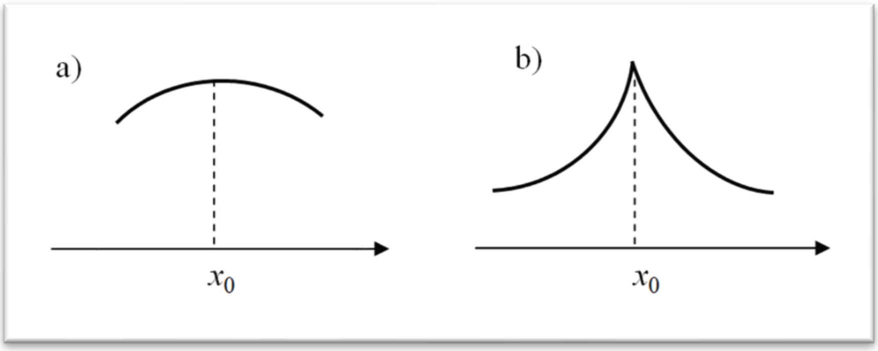
Higher algebra, the course of which is studied at the university by students, is a generalization of the main content of the school course of elementary algebra. The question of solving equations is central to the school algebra course. The content of the subject is structured in such a way that the study of equations begins with a simple case when an equation of the first degree with one unknown is given, and then develops in two directions.

When studying the sections "Derivative" and "Application of derivative", the concept of derivative is introduced, the ability to find derivatives using differentiation formulas is developed. Students are introduced to the methods of differential calculus and they develop the ability to apply them in the simplest cases. Next, high school students get acquainted with exponential, logarithmic and power functions, learn how to solve exponential and logarithmic equations and inequalities.

The derivative is the velocity. More specifically: if a certain process – mechanical, electrical, chemical, thermal, etc. –is given by a function (of one variable), $y = f(x)$, $x \in D$ then the rate of flow of this process is the derivative $y' = f'(x)$.

The derivative is also a function (of the same variable) that is calculated – for a given function $f(x)$ – according to some uniquely defined rules. At the same time, at each fixed point $x \in D$, the value of the derivative expresses the so-called instantaneous rate of the specified process or, what is the same, the instantaneous (point) rate at which $f(x)$ changes at this point.

Obviously, if the function increases at a given point, the process accelerates, then the derivative is non-negative, if it decreases, then the derivative is not positive. In the case when neither one nor the other takes place, the derivative is either zero – the process is in a stationary (equilibrium) state, or the derivative does not exist, which corresponds to a critical (non-stationary, non-smooth) state. The simplest drawings explaining these statements are shown in Figure 3.



FIGUARE 3. Example of transformation of functions

In Fig. 3 a) to the left of the point x0, the function grows, i.e. it changes at a positive rate. To the right of this point, the velocity (derivative) is negative. The transition from ascending to descending at point x_0 is performed in a smooth manner, $f'(x_0) = 0$. In Figure 3 b), the change in the nature of monotony does not occur smoothly (as with sudden braking, the speed changes with a push). There is no derivative here, $f'(x_0)$ does not exist. The mechanical meaning of the derivative. Thus, the problem of determining the derivative is at the same time the problem of determining the velocity. It was this approach that allowed Newton to create differential calculus, which formed the basis of his mechanics explaining the structure of the world.

Now we will show a demo version of the control work on pedagogical experiments in an experimental group.

Task 1. Calculate the partial derivatives of the following function: a) $z = arcsin^2(\sqrt{x}y)$; b) $z = lny \cdot e^{x^2y}$.

a) When calculating the partial derivative ∂z/∂x, we assume that the variable y is a constant. Using the table of derivatives and applying the rules of differentiation, we obtain:

$$\frac{\partial z}{\partial x} = 2\text{arcsin}\,(\sqrt{x}y) \cdot \frac{1}{\sqrt{1-xy^2}} \cdot \frac{y}{2\sqrt{x}} \quad (2)$$

When calculating the partial derivative ∂z/∂y, we assume that the variable x is a constant. Similarly, we get:

$$\frac{\partial z}{\partial y} = 2\text{arcsin}\,(\sqrt{x}y) \cdot \frac{1}{\sqrt{1-xy^2}} \cdot \sqrt{x} \quad (3)$$

b) When calculating the partial derivative ∂z/∂x it must be remembered that if y is a constant value, then lny is also a constant value. Then:

$$\frac{\partial z}{\partial x} = lny \cdot e^{x^2y} \cdot 2xy \quad (4)$$

When calculating the partial derivative ∂z/∂y you need to use the formula to find the derivative of the product of functions. We will get:

$$\frac{\partial z}{\partial y} = (lny)'e^{x^2y} + lny(e^{x^2y})' = \frac{1}{y}e^{x^2y} + lny \cdot e^{x^2y} \cdot x^2 \qquad (5)$$

When solving problems of this type, it is important to establish continuity with other tasks in the algebra course of the pedagogical university.

The implementation of the internal communication of the discipline will allow to achieve an effective result in the process of compiling a report with students. When choosing such exercises, one should proceed from the creative content of each of them, the students' understanding of the basics of the necessary theoretical knowledge and the definition of the main mathematical idea of the problem under consideration.

For example task 2: Find the derivative of the function $u(x, y, z) = y^2 + \sqrt{x^2 + z^2}$ at point, A(1;2;0) towards point B(3;0;1). Decision. First, let's find the partial derivatives of the function u(x,y,z) using the rules of differentiation:

$$u'_x(x, y, z) = \frac{x}{\sqrt{x^2+z^2}};\ u'_y(x, y, z) = 2y;\ u'_z(x, y, z) = \frac{z}{\sqrt{x^2+z^2}}. \qquad (6)$$

Now let's substitute the coordinates of point A here, namely x=1,y=2,z=0:

$$u'_x(A) = 1;\ u'_y(x, y, z) = 4;\ u'_z(x, y, z) = 0. \qquad (7)$$

Thus, we find the gradient of the function at point A: $\overrightarrow{grad}\ u(A) = (1; 4; 0)$. Now let's find the coordinates of the vector (AB) ⃗ by subtracting the coordinates of the points of the end and beginning of the vector:

$$\overrightarrow{AB} = (3 - 1; 0 - 2; 1 - 0) = (2; -2; 1), \qquad (8)$$

and the length of this vector is:

$$AB = \sqrt{2^2 + (-2)^2 + 1^2} = 3. \qquad (9)$$

Finally, we calculate the desired directional derivative as the scalar product of the gradient of the function at point A and the unit vector of the direction to point B:

$$u'_{\overrightarrow{AB}}(A) = \frac{\overrightarrow{AB} \cdot \overrightarrow{grad}\ u(A)}{AB} = \frac{2 \cdot 1 + (-2) \cdot 4 + 1 \cdot 0}{3} = -2. \qquad (10)$$

Continuity between school and university in solving algebra problems is an important aspect that contributes to the smooth transition of students to a higher level of education and the development of the necessary skills for successful study of mathematics in higher education. It is important that the school curriculum prepares students for the types of tasks they will face at university, and the university program continues and deepens these skills.

3. *THE RESULT OF AN ORGANIZED LEARNING EXPERIMENT*

In order to test the hypothesis of the study and the effectiveness of our methodological recommendations and didactic conditions, control work was carried out in the control and experimental groups. The Kramer-Welch criterion was used to confirm the effectiveness of the proposed methodological recommendations based on research methods.

The empirical value of a given criterion is calculated based on information about the *N* and *M* volumes of samples *x* and *y*. The selective mean values of $\bar{x}$ and $\bar{y}$, and the Dx and Dy selective variances of the compared samples. These values were calculated by formulas using the descriptive statistics tool in the Excel computer program. *x* and *y* - student test results. *x = (x1, x2, …, xN)* – experiment group; *y = (y1, y2, …, yM)* – control group.

$$\bar{x} = \frac{1}{N}(x_1 + x_2 + x_3 + \ldots + x_{n-1} + x_n) = \frac{1}{N}\sum_{i=1}^{N} x_i \qquad (11)$$

The sample averages $\bar{x}$ and $\bar{y}$ and the sample variances *Dx* and *Dy* of the compared samples can be calculated manually using the formulas (11) and (12).

$$D_x = \frac{1}{N-1}\sum_{i=1}^{N}(x_i - \overline{x})^2 \qquad (12)$$

Table 5 presents the results of the experiment in the Excel computer program, calculated by the Cramer-Welch criterion before the experiment on the basis of research methods.

Table 5. The results of a pre-experimental assessment of the degree of students' adaptation

Groups	Total number of students	Average values of students ' test results	Dx and Dy selective variances
Experiment group	42	2.75	12.71
Control group	44	2.12	12.15

Table 6 presents the results of the experiment in the Excel computer program, calculated by the Cramer-Welch criterion after the experiment on the basis of research methods.

Table 6. The results of a post-experimental assessment of the degree of students' adaptation

Groups	Total number of students	Average values of students ' test results	Dx and Dy selective variances
Experiment group	42	3.45	14.65
Control group	44	2.72	12.43

The Kramer-Welch criterion is used to test the average equality hypothesis of two samples. For The compared samples, to evaluate this criterion, the Formula (13) is used, which allows you to calculate its empirical value.

$$T_{emp} = \frac{\sqrt{M \cdot N}|\overline{x} - \overline{y}|}{\sqrt{M \cdot D_x + N \cdot D_y}} \qquad (13)$$

The solutions were calculated using the descriptive statistics tool in the Excel computer program according to the formula (table 7).

Table 7. Results of the experiment in the Excel computer program, calculated by The Kramer-Welch criterion after and before the experiment based on research methods

Criterion	Before the experiment	After the experiment
Temp	0,2105	2,315

We compare this value with the critical value T0.05 = 1.96. If the Temp is≤1.96, then "the characteristics of the compared samples coincide at the value level of 0.05". If the Temp is > 1.96, then "the reliability of the differences between the characteristics of the compared samples is 95%".

To do this, we first compared the number of calculations in the control and experimental group before the start of the experiment. According to the results of the calculation, we obtained the value Temp = 0.210≤1.96. Therefore, before the start of the experiment, the hypothesis about the coincidence of the characteristics of the control and experimental groups is accepted at the level of 0.05.

Now, after the end of the experiment, let's compare the characteristics of the control and experimental groups. According to the results of the calculation, we obtained the value Temp = 2.315 > 1.96. Therefore, after the end of the experiment, the reliability of the differences between the characteristics of the control and experimental groups is 95%. Thus, the initial (before the start of the experiment) States of the experimental and control groups coincide, and the latter (after the end of the experiment) are different. Therefore, we can conclude that the effect of the changes is related to the use of experimental learning techniques and that our H01 and H02 hypotheses are correct.

IV. HYPOTHESIS TESTING

Experimental verification of the effectiveness of such a methodology would require a systematic approach, combining qualitative and quantitative methods to evaluate student performance and adaptability. This would include controlled experiments to assess whether the proposed continuity in teaching algebra and analysis improves learning outcomes across school and university settings.

Researchers attach different importance to the structure of the concept of mathematical continuity, its status and place between pedagogical categories. Some see this meaning in the way knowledge is organized [30], others relate it to intra-subject relationships [31]. In the context of modern requirements for the quality of mathematics teacher training at a pedagogical university, certain aspects of continuity have been reflected in the context of other problems: teaching mathematical disciplines at school and pedagogical university [32]. The results of the work of these authors are of great importance for improving the methodology of implementing the continuity of teaching mathematics in secondary schools and pedagogical universities. However, despite the large number of works in this field, the issue of continuity in teaching mathematics in the "school - pedagogical university" system requires special research. This is due to the fact that the study of the problem of succession was carried out in the context of the "school - pedagogical university" or "pedagogical university - school" system and covers twos autonomous groups, one of which is related to the substantive and the other to the procedural aspects of the phenomenon under study.

According to our research methods, the research results show that technological teaching of mathematics and geometry in accordance with the traditional teaching method is more effective in terms of academic performance [33]. The researchers find that the degree of influence on academic performance in algebra and geometry does not change depending on the time of entry, the level of knowledge and the field of study.

The validity and reliability of our research, its effectiveness and conclusions are due to the reliance on theoretical developments in the field of pedagogy, theory and methodology of teaching algebra, a combination of various research methods, as well as the results of the experiment.

V. CONCLUSION

The scientific novelty of the research lies in addressing the problem of continuity in teaching algebra and the beginning of analysis through the "school - pedagogical university" system, which has not been fully explored in previous studies. By developing and testing strategies for effective continuity, this research provides new insights into improving student adaptation and academic performance during the transition from secondary to higher education. The adaptive ability of students to teach an algebra course depends on a number of factors, including previous educational experience, teaching methods, level of training, motivation and individual characteristics of students. The development of these abilities can be supported and enhanced through various strategies. These strategies (Gradual complication of the material; Spiral learning; Division into modules; Diagnostics of the initial level of knowledge; Adaptive tasks; Interactive teaching methods; Support and support of students; Development of self-education skills; Motivation and involvement; Consideration of individual characteristics; Assessment and self-control; Psychological support; Work with motivation and stress) will help students adapt to studying algebra at the university will improve their academic results and ensure a smooth transition from school to university level of education.

The continuity of school and higher education is one of the most difficult and still unresolved problems of general education. In this work, we have developed the concepts of continuity in the teaching of algebra and the beginning of analysis in secondary and higher educational institutions and tested the conditions for its implementation. A study of the conditions for the effective implementation of continuity in higher and secondary education has shown that students in experimental groups have a high level of adaptation. The scientific novelty of the research lies in the fact that it solves the problem of continuity in teaching algebra on a fundamentally new basis

- in the context of the "school - pedagogical university" system. The results of the study can be used by teachers of mathematical disciplines at a pedagogical university and mathematics teachers in secondary schools.

Funding statement

The authors wish to acknowledge that no specific funding or support was provided for this study.

Author contribution

All authors made an equal contribution to the development and planning of the study.

Conflict of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data are available from the authors upon request.

Acknowledgements

The authors would like to acknowledge assistance of the Editor and Reviewers in the preparation of the article for publication.

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