Advanced educational technologies on the basis of creative approaches in teaching mathematics

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ABSTRACT

Today, a creative approach to mathematics education provides students with the skills to direct themselves to the profession, to solve problems in their professional activities. In order to become competitive in the technologically advanced labor market in the world, students need to have a thorough knowledge of mathematics. It is known that in mathematics there are more opportunities to develop creativity and creative thinking by solving problems. The use of advanced teaching technologies in mathematics lessons improves the quality of lessons. This article discusses the role of mathematics and its “Person-oriented learning” technology in teaching, mainly, traditional approach to problem solving and creative approaches to problem-solving and logical proof methods are presented.

Keywords: technology, creative approach to education based on pedagogical technology, “subject-to-subject” relations, models, pedagogical technology, advanced educational technologies, traditional approach, problem-based approach, mathematical proof method, creative approach.

I. Introduction. Today, political, social and economic changes are taking place in the life of our republic. These changes require the society to develop a deep knowledge, the application of advanced pedagogical technologies in the teaching process of teaching the younger generation. It is necessary to create a methodology for teaching subject materials in the curriculum "Mathematics" for academic lyceums on the basis of information and pedagogical technologies. Mathematical science is the basis of knowledge of the universe, revealing the specific laws of events and phenomena around it. Mathematical knowledge is important in the development of students' intelligence, attention, determination and will to achieve the desired goal, fostering discipline, broadening their thinking. Mathematics also has a special place in the development of production, science and technology. That is why mathematical culture is a key part of universal culture.

II. Literature review. B. Abdullayeva, S. Alixov, M. Barakayev, G. Zlotskiy, J. Ikromov, M. Tojiyev, N. Toyloqov, T. To'laganov, D. Yunusova, N. G'aybullayev conducted research on improving the content and teaching methods of the Department of Fundamentals of Mathematical Analysis of the Mathematics Course. A number of textbooks on teaching the basics of mathematical analysis and the organization of lessons were created by T. A. Azlarov, Sh. Alimov, N. Dilmurodov, N. Jabborov, T. J. Jo'rayev, A. Sadullayev and others. A. Abruqodirov, M. Aripov, A. Abdixamedov, O. Musirmonov, A. Nasimov, A. Normatov, A. Yunusovs' research can be noted as research on the creation of textbooks in mathematics for academic lyceums, improving the quality of mathematics education and the study of the features and problems of teaching mathematics in academic lyceums. Research work on the features and problems of teaching mathematics in academic lyceums was
carried out by B.Ziyomuhamedov, A.Bakirova, U.Ibragimov, A.Saipnazarov, A.Sultonova and O’.Tolipov.

In the CIS countries, Yu.I.Kolyagin, Ye.U.Medeuov, V.I.Mishin, V.M.Monaxov, A.G.Mordokovich, M.N.Roganovskaya, R.S.Cherkasov, P.M.Erdniev’s research studies the pedagogical and psychological problems of teaching the basics of mathematical analysis. V.P.Bespalko, M.V.Klarin, E.Lebedeva conducted research on modern pedagogical and information technologies, the design of teaching processes and the problems of person-centered education.

Of particular importance is the research conducted by foreign scholars Bill Roberts, Mal Coad and Others, Sandy Mac Kenzielar in the field of creating textbooks in mathematics for academic lyceums, improving the quality of mathematics education.

III. Methodology. A creative approach to mathematics education creates practical skills to guide students in their profession, to positively solve problems encountered in their professional activities. It requires students to have a thorough knowledge of mathematics in order to become competitive in the technologically advanced labor market in the world.

It is known that if inventions are created as a result of technologicalization in production, the invention will be reproducible. As a result of the work of mature teachers on the creation of repetitive nature of the new methodology in education and the guarantee of results, a technological approach to the teaching process and the design of teaching processes based on pedagogical technology was introduced [8].

Therefore, it is necessary to abandon the theoretical approach to teaching mathematics in the educational process, and to focus on the application of mathematical knowledge in everyday life and the activation of students’ independent thinking skills in the design of lessons based on advanced educational technologies.

For this purpose, we consider it expedient to perform the following tasks in teaching mathematics:

- creative approach to the educational process, i.e. ensuring the teacher’s readiness for innovative activities;
- enrichment of teaching materials with new content based on advanced educational technologies;
- to create educational teaching aids that serve to ensure that students acquire knowledge consciously by increasing their activity in the educational process;
- when the teacher communicates a subject of mathematics or the content of educational material to students in an interactive way:
  - introduction of modern pedagogical technology in the teaching process (interactive methods);
  - demonstration of material through information and communication technologies;
  - performing the task of developing training projects [9].

Bilateral (teacher and student) and person-centered actions are required in the organization of education. Problems of implementation of “subject-to-subject” relations in education, the relevance of teaching materials to the motivational interests of students, the effectiveness of the lesson is achieved as a result of the teacher’s individual approach to students. The problem of transferring the teacher to the role of the subject of the educational process in the implementation of lessons and independent learning. Problems of interaction dialogue in the educational process. Models of organization of educational process. Forms of dialogical organization of teaching. Problems such as the application of advanced educational technologies based on pedagogical
Explaining the practical importance of the issue in the teaching of mathematics increases students’ interest in mathematics. In order to form the basic concepts and mathematical competencies in the field of mathematics, it is advisable to use in the teaching process of teaching practical and non-standard issues on the basis of technology “Person-centered education”. Person-centered learning technology places the learner’s personality at the center of an entire education system and creates a comprehensively comfortable, safe, free environment for him or her to realize his or her innate abilities. The learner’s personality in this technology is not only a subject but also a subject given a wide range of possibilities, it is not a means to achieve non-core goals in the education system, but its primary goal. Person-centered educational technology demonstrates the harmony of human philosophy, psychology, and pedagogy. The focus of the educator should be on the personality of a whole unique student who strives to acquire knowledge to the best of his ability, who can accept new experiences and make independent, conscious and responsible decisions in different situations of life. In contrast to traditional pedagogical technologies, which provide education to students on the basis of social norms, in the technology of person-centered education, the main goal of education is to achieve the above-mentioned directions (qualities).

Person-centered education cultivates such qualities in the student’s personality as independence, initiative, sense of responsibility, critical thinking. This allows the student to develop not only in accordance with the education system, but also taking into account the individual characteristics of the student, his self-development, independent reading, self-expression, activation, comprehension, observation, experimentation, expression of new ideas and thoughts, giving freedom to search for effective ways to solve existing problems, creating conditions for the development of creative, critical thinking of the student. Every student strives to activate and demonstrate his unique nature, character traits.

The teacher should use methods that help to develop students’ thinking (problem-solving, research, dialogue, heuristic conversation, discussion, group work) in such a way that the object, which was initially neutral for the student, suddenly acquires a subjective character. To do this, the content of teaching materials is processed by the teacher in a creative way that interests the student, corresponds to his personal experience, encourages thinking.

Solving problems from such learning materials develops students’ logical observation activities such as analysis, synthesis, analogy, generalization, deduction, and induction. Sometimes solving problems of a practical and non-standard nature takes a long time and is solved as a result of several attempts of the student. As a result, the student develops quality qualities such as diligence and determination in achieving a personal goal. In short, the resolution of such issues by students creates a sense of excitement in students.

IV. Theory and discussion. We provide students with schemes for solving such mathematical problems through creative approaches to different approaches to solving them. The scheme of solving mathematical problems in the traditional approach:

In the traditional approach, the learner is portrayed as a performer of problem-solving tasks. This is because the previously mastered mathematical concepts required for application in the traditional approach can only be identified when analyzing the condition of the problem. The scheme of solving mathematical problems in a problem-based approach:
The skills and competencies that students acquire through solving standard problems are of practical importance and have a positive impact on non-standard problem solving activities. Therefore, practical issues should be approached as a problematic issue. Taking into account the advanced national and foreign experience, the concept (idea) of teaching STEM (science, technology, engineering and mathematics) widely used in developed countries in the teaching of science, as well as the basic concepts and methods of programming (logical operations, algorithms, block diagrams, etc.) it is expedient to rely on the methodology of formation [6].

When teaching a relevant topic in mathematics, the basic concepts related to the topic should be given in a sufficiently clear and simple way. To do this, the teacher uses person-centered teaching to convey the basic ideas and results to a certain degree of freedom, the teacher acts as a coordinator of the dialogue and creates the necessary conditions for maximum activity of students. Instead of the teacher’s “repeat definition”, “work on the problem”, “work according to the given conditions” and other command functions, “let’s think together”, “can you tell us how you worked on the problem”, “what suggestions do you have for such a conclusion”? It would be expedient if the following suggestions were made. The person-centered technological process includes the organization of the lesson process, teacher activities, student activities, methods of managing the learning process, diagnostics of the learning process.

In order to increase the quality and effectiveness of the student’s independent work in person-centered teaching, it is expedient to use a logical scheme of proof of the theorem on the basis of previously learned basic concepts, in short, without giving full proof of all theorems and logical problems. Focusing more on the practical application of the topic and doing the topic-related exercises and exercises will yield good results. In proving the theorem:

- first the condition and conclusion of the theorem are distinguished;
- the basic concepts in terms of the theorem are defined;
- conclusions of basic concepts in terms of the theorem are given;
- the system of basic concepts leading to the conclusion of the theorem is defined.

The conclusion of the theorem follows from the application of the defined system of basic concepts.
Based on these considerations, we recommend a scheme of logical proof of theorems and logical problems based on the criterion of the relevance of mathematical basic concepts to the logical and cognitive thinking of students in proving theorems and logical problems.

**Example.** If \( n \geq 2 \), then check the \( x_n = \left( 1 + \frac{1}{n} \right)^{n+1} \) sequence for monotony.

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**Theorem**

Teacher's activity (coordinator, referral, cooperation, consulting)

Determining the condition and conclusion of the theorem

Determining and identifying the condition and the basic concepts in the theorem.

Draw a diagram corresponding to the condition of the theorem and interpret it.

The system of basic concepts used.

Independent activity of the teacher in the teaching process

Application of basic expressions in the proof of the theorem.

Making conclusion for the theorem.

Conclusion of the theorem.

The theorem is proved.

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**Scheme of logical proof of the problem**

If \( n \geq 2 \), then check \( x_n = \left( 1 + \frac{1}{n} \right)^{n+1} \) sequence for monotony.

Given \( x_n = \left( 1 + \frac{1}{n} \right)^{n+1} \) sequence, where \( n \geq 2 \). The monotony of this sequence should be checked.

**Example condition.** The terms of a given sequence have the same sign.

**Basic concept:** positive term sequence.

**Summary of basic concepts:** since the terms of the given sequence have the same sign \( x_n = \left( 1 + \frac{1}{n} \right)^{n+1} \), the ratio of the \( n \) – term and \( x_{n-1} = \left( 1 + \frac{1}{n-1} \right)^n (n - 1) \) terms are estimated.

**System of basic concepts.**
1. Properties of the natural degree of a number:
   1. \( a^n a^m = a^{n+m} \).
   2. \( \frac{a^n}{a^m} = a^{n-m} \).
   3. \((a + b)^n = a^n + n a^{n-1} b + \cdots + na b^{n-1} + b^n \).
   4. Simplification of fractional expression.
   5. If inequality \( x_n < x_{n-1} \) arises for number \( \forall n \in N, \{x_n\} \) sequence is called a decreasing monotonous sequence.
   6. 
   \[
   1 + \frac{1}{n} < 1 + n \cdot \frac{1}{1 + \frac{1}{n^2}} + \frac{n(n-1)(n-2)}{1 \cdot 2 \cdot 3} \left( 1 - \frac{1}{n^4} \right)^3 + \cdots + \frac{n(n-1)(n-2) \cdots [n-(n-1)]}{1 \cdot 2 \cdot 3 \cdot \cdots n} \left( \frac{1}{n^4} \right)^n = \left( 1 + \frac{1}{n^2} \right)^n.
   \]

Application of basic concepts in the proof of the theorem:
Taking into account that \( \forall n \in N, x_n > 0 \), the following inequality arises

\[
\frac{x_n}{x_{n-1}} = \left( 1 + \frac{1}{n} \right)^n \cdot \left( 1 + \frac{1}{n} \right) = \left( 1 + \frac{1}{n} \right)^n \cdot \left( 1 + \frac{1}{n} \right) < 1.
\]

The conclusion of the theorem arises as a result of the application of basic concepts: For a natural number \( \forall n \in N, \frac{x_n}{x_{n-1}} < 1 \). From this \( \forall n \in N, x_n < x_{n-1} \) inequality arises. Hence, the given sequence \( \{x_n\} \) is a decreasing monotonous sequence.

The \( \{x_n\} \) sequence was checked for monotony.

Here is an example of the algorithm of the logical structure of the model of the lesson process project by the teacher on the topic “Limit of sequence”.

**Algorithm for the logical structure of the model of the project of the middle module lecture course on the topic “Limit of sequence”**

I. Phase of preparatory activity.

1. Defining the general purpose of the secondary module (topic)

2. Defining sub-modules and objectives of the middle module (topic).
3. Identify basic concepts in small modules and create a system of control questions based on them.

4. A text script for the middle module (topic) is prepared.

5. Type and type of training of small modules. It defines the pedagogical methods and techniques used.

6. The role of ICT and didactic materials used in the pedagogical process are indicated.

II. Control phase (repetition of the previous topic before the start of the new topic lesson).

III. The teacher-student collaboration phase.

7. A text script that expresses the content of the middle module

The first small module

The second small module

The third small module

8. Checking the mastery of the middle module

8.1. Theoretical handouts

Answers

8.2. Practical handouts

Solutions

9. Announcement of correct answers

IV. Stage of diagnosis and correction (determination of the effectiveness of the lesson).

It is advisable to have a discussion before the text scenario that expresses the content of the middle module. Handouts for discussion questions will be distributed to small groups (each desk).

To check the mastery of the secondary module, practical handouts are distributed to the groups as follows. Each of the five students in the group discusses one example. To work with the 5x5 method of interactive methods, we use the sequence number in the student’s class journal.

Group 1:

Example 1. Prove that the sequence $x_n = \frac{3n+1}{n^2-4}$ is an infinitesimally small sequence.
Example 2. Describe the sequence $x_n = \frac{2n+3}{4n-3}$ in terms of the sum of an infinitely small sequence with a constant number.

Example 3. Describe the sequence $x_n = \frac{3n^2-4}{n^2-1}$ as the sum of an infinitely small sequence with a constant number and find the limit.

Example 4. Prove that $\lim_{n \to \infty} \frac{2n}{n+1} = 2$.

Example 5. Prove that the sequence given in the recurrent method has a limit and find the limit $a_1 = \frac{1}{2}, a_{n+1} = \frac{1}{2-a_n}$.

Students work on solving the example together for 7-8 minutes each. After that, new groups are formed. The students explain the solution of each example one by one based on the sequence number.

For the new group 1:

For the new group 2:
Improving the mechanisms of development of spiritual culture in students on the basis of educating physically healthy, mentally and intellectually developed, independent-minded, loyal to the Fatherland, deepening democratic reforms and increasing their social activity in the development of civil society plays an important role in the Strategy of Actions for further development of the Republic of Uzbekistan [4]. Therefore, teaching students based on the above creative approaches in teaching mathematics is a guarantee that students will grow into a harmoniously developed generation.

V. Experimental results. The basis of mathematical analysis in academic lyceums is a practical approach aimed at the effective development of the organizational and pedagogical system with a systematic approach to the design of the teaching process, the results of practical research conducted on the basis of previously developed experimental program.

Academic lyceum “Nuriston” under KEEI, academic lyceum named after “Muhammad al-Khwarizmi” under the Samarkand branch of TUIT, academic lyceums under the Polytechnic University of Turin were identified as experimental sites at the stage of organizational preparation of experimental work. third-year students were selected, from whom experimental and control groups were formed.

The purpose of the first stage of the experimental work was to study the state of the selected...
problem in the academic lyceum, to find criteria for determining the level of formation of independent learning skills in students in the teaching process.

In the second stage of the experiment, the initial state of the level of mastery of the teaching material in the department of the basics of mathematical analysis in the design and teaching of academic lyceum students (based on person-centered educational technology) was determined. Learning outcomes based on traditional teaching technologies were compared with project-based teaching on the basis of an improved methodological system (advanced learning technologies), experiments were studied, generalized, theoretical and practical knowledge on the basics of mathematical analysis was summarized.

In the third stage of the experimental process, the problems of testing interactive methods were solved, based on the design and teaching of an improved methodological system (advanced learning technologies) developed for teaching the basics of mathematical analysis. The main goal was to make changes in the methods of learning, to organize independent learning of students in the learning process based on project-based teaching on the basis of an improved methodological system (advanced learning technologies), to determine the effectiveness of teaching through various methods of control.

The results of the intermediate control and test conducted in the first and final stages of the pedagogical experiment were analyzed. At the beginning of the pedagogical experiment, on the basis of the criterion of closeness of levels of knowledge, 422 students from academic lyceums studied in experimental groups and 420 students were selected for the control groups and the results of the test and written control work taken from them were analyzed. The results obtained can be seen in the tables.

The results of the pedagogical experiment obtained from the experimental and control groups were statistically processed.

The effectiveness of teaching based on the improved methodology based on the design of the sections “Fundamentals of Mathematical Analysis” is confirmed by the indicators in Table 1 (see Table 1).

### Table 1

<table>
<thead>
<tr>
<th>Lyceum name</th>
<th>Involved groups</th>
<th>Total students</th>
<th>Grade</th>
<th>The average grade</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>«Muhammad al-Khwarizmi»</td>
<td>Experiment</td>
<td>130</td>
<td>50</td>
<td>38</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>130</td>
<td>38</td>
<td>32</td>
<td>19</td>
</tr>
<tr>
<td>«Nuriston»</td>
<td>Experiment</td>
<td>172</td>
<td>42</td>
<td>34</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>170</td>
<td>34</td>
<td>80</td>
<td>23</td>
</tr>
<tr>
<td>Turin polytechnics university</td>
<td>Experiment</td>
<td>120</td>
<td>40</td>
<td>30</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>120</td>
<td>34</td>
<td>29</td>
<td>17</td>
</tr>
</tbody>
</table>

These statistics are defined as follows (see Table 2).
Table 2
The general result of the analysis of experimental work carried out in selected academic lyceums

<table>
<thead>
<tr>
<th>Grading value</th>
<th>Experimental group N₁ = 422</th>
<th>Control group N₂ = 420</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of eligible grades</td>
<td>5 4 3 2</td>
<td>5 4 3 2</td>
</tr>
<tr>
<td>The arithmetic mean of the values</td>
<td>X₁ = 3.79</td>
<td>X₂ = 3.38</td>
</tr>
<tr>
<td>Efficiency coefficient</td>
<td>η = X₁ / X₂ = 1.12</td>
<td></td>
</tr>
</tbody>
</table>

The diagram of the level of mastery in the experiment and control group is as follows (see Figure 5).

Figure 5. Diagram of students' mastery of mathematics

The experimental results were processed on the basis of one of the methods of mathematical statistics, namely the $\chi^2$ – method.

It was found that: At the academic lyceum named after Muhammad al-Khwarizmi $T_{x_1} = 7.81 < 8.6 = T_{\text{кр}1}$, At the academic lyceum named after “Nuriston” $T_{x_2} = 7.81 < 8.4 = T_{\text{кр}2}$ and at the Academic Lyceum at the Polytechnic University of Turin $T_{x_3} = 7.81 < 9.1 = T_{\text{кр}3}$ (See Table 3).

Table 3
The results of mastering by students of the academic lyceum at the Polytechnic University of Turin

<table>
<thead>
<tr>
<th>Selections</th>
<th>Grade 5</th>
<th>Grade 4</th>
<th>Grade 3</th>
<th>Grade 2</th>
<th>Number of students</th>
</tr>
</thead>
</table>


<table>
<thead>
<tr>
<th>Experimental group</th>
<th>$Q_{11} = 9$</th>
<th>$Q_{12} = 13$</th>
<th>$Q_{13} = 7$</th>
<th>$Q_{14} = 1$</th>
<th>$n_1 = 30$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control group</td>
<td>$Q_{21} = 2$</td>
<td>$Q_{22} = 9$</td>
<td>$Q_{23} = 15$</td>
<td>$Q_{24} = 4$</td>
<td>$n_2 = 30$</td>
</tr>
</tbody>
</table>

$Q_{11} + Q_{21} = 11$  $Q_{12} + Q_{22} = 21$  $Q_{13} + Q_{23} = 22$  $Q_{14} + Q_{24} = 5$  $n_1 + n_2 = 60$

Thus, the research method proposed in the study proved to be more effective than the conventional traditional teaching method. The results of the experiment were analyzed and demonstrated using a mathematical-statistical method, and as a result, the proposed scientific hypothesis proved to be correct.

**VI. Recommendations and conclusions.**

Taking into account the tasks of deep reform of the education system, the issue of educating a well-educated, open-minded person really requires new work from teachers and imposes a great responsibility on them, and the following conclusions are drawn from the problems studied:

1. According to the analysis of the characteristics and current state of teaching the basics of mathematical analysis in academic lyceums, there are some shortcomings in the content, teaching and teaching methods of teaching the basics of mathematical analysis in academic lyceums, especially in designing lessons based on the principles of pedagogical technology.

2. The model of the methodical system of teaching the basics of mathematical analysis in mathematics is effective in improving the methodological system of teaching the basics of mathematical analysis based on the characteristics of academic lyceums as one of the factors to further improve the quality of teaching mathematics in academic lyceums.

Innovative approaches should be taken into account in improving the methodological system of teaching the basics of mathematical analysis in mathematics taught in academic lyceums. For example, in creating this methodological system, in contrast to the methodological system of traditional teaching, the main element of the methodical system is the project of lesson plans on the basics of mathematical analysis in mathematics taught in academic lyceums.

3. The role and importance of lesson plans in the organization of the process of teaching the basics of mathematical analysis in academic lyceums is a key factor.

Due to the fact that the purposeful and effective organization of the educational process depends on the perfection of teaching materials, as well as the level of knowledge and pedagogical skills of teachers, another important factor in the effective organization of the educational process in academic lyceums is the pre-design of lessons by qualified teachers. the design of the analysis bases was methodologically substantiated.

An important role in the design of lessons on the basics of mathematical analysis in academic lyceums plays an important role in the development of textbooks, teaching and learning manuals and literature on the subject of education on the basis of state educational standards, qualification requirements.

4. The formation of the purpose of teaching the basics of mathematical analysis in academic lyceums as part of the methodological system of teaching the basics of mathematical analysis was scientifically and methodologically substantiated and proposals were made to modernize the content of teaching the basics of mathematical analysis. tools have been improved.

5. A model for designing lessons on the basics of mathematical analysis in mathematics taught in academic lyceums has been developed.

Based on this model of designing the basics of mathematical analysis in mathematics taught
in academic lyceums, the teaching process is designed by qualified teachers, and special attention should be paid to each component of the model. Based on this, the course process on the topic “Understanding the limit of the sequence” was designed.

6. Methods of teaching the basics of mathematical analysis in academic lyceums and their introduction into educational practice have been developed.

To do this, in academic lyceums, the section “Fundamentals of Mathematical Analysis”, “Why teach?”, “What is studied?”, “What tools should be taught?” questions are on the agenda and as its solution is “Asymptote of a function graph”. The development of theoretical and practical lessons on “Continuity of function” is recommended.

7. Educational-methodical manuals on teaching the basics of mathematical analysis in academic lyceums, projects of lessons on the basics of mathematical analysis in the design of lessons of other mathematical disciplines, secondary special and vocational education, general secondary schools, their advanced training and retraining can be used to improve the quality and effectiveness of teaching mathematics, as well as in the development of science, education.

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