ACTUAL PROBLEMS OF MODERN SCIENCE, EDUCATION AND TRAINING

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CONTENTS

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HISTORY OF THE FORMATION AND THEORETICAL AND METHODOLOGICAL BASIS OF PEDAGOGICAL ACTIVITY

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Annotatsiya. Mazkur maqolada pedagogik faoliyatning shakllantish tarixi va nazariy-metodologik asoslari masalasi yoritilgan. Pedagogikaning asl mohiyati bu keksa avloddan hayot uchun zaruriy qo‘llanmalar, tajribalarga asoslangan ta’lim tarbiyani yosh avlodga yetkazishdir. Pedagogikadagi tarbiya tushunchasi o‘sib kelayotgan avlodda hosil bo‘lgan bilimlar asosida aqliy kamolot, dunyoqarashni shakllantiradi. Pedagogika ta’lim va tarbiya sohasidagi tajribalarni umumlashtirib, tarbiyaning kelgusidagi rivojlanish istiqbollarini, ko‘rsatib beradi.

Kalit so‘zlar: *pedagogika, ta’lim, tarbiya, bilim, ko‘nikma, malaka, tjriba, fan tarmog‘i.*

Аннотация. В статье рассматриваются история становления и теоретико-методологические основы педагогической деятельности. Истинная суть педагогики заключается в том, чтобы передать молодому поколению необходимые жизненные инструменты и опыт, в которых нуждается старшее поколение. Концепция образования в педагогике формирует интеллектуальную зрелость и мировоззрение подрастающего поколения на основе полученных знаний. Педагогика обобщает опыт в области образования и воспитания и показывает перспективы дальнейшего развития воспитания.

Ключевые слова: *педагогика, образование, воспитание, знания, умения, навыки, квалификация, опыт, область науки.*

Abstract. This article discusses the history of the formation of pedagogical activity and the theoretical and methodological foundations of it. The essence of pedagogy is to transfer the necessary life-related applications and experiences from the older generation to the younger generation. The concept of education in pedagogy forms mental maturity and worldview based on the knowledge gained in the growing generation. Pedagogy summarizes the experiences in the field of education and upbringing and shows the prospects for the future development of upbringing.

Keywords: *pedagogy, education, upbringing, knowledge, skills, qualifications, experience, field of science.*

Introduction

Today, scientific and technological progress and achievements undoubtedly create the basis for the formation of a perfect young generation. The peak of scientific and

technological development in the 21st century has embodied a significant contribution of knowledge accumulated throughout the history of mankind. At the same time, the current stage of scientific and technological progress is also aimed at organizing a system of personnel training and retraining, in which the main emphasis is on radically reforming the activities of pedagogical personnel in modern society, freeing them from various overloads, ensuring their constant self-improvement and professional development.

The modernization of education, or rather, its adaptation to development, leads to the improvement of the professional activities of pedagogical personnel. A true pedagogue must have not only pedagogical skills, but also pedagogical abilities. In the conditions of rapidly developing science and technology, the demand for pedagogical personnel is increasing, along with the increasing complexity of the pedagogical profession, the need for additional perfection is also increasing. This, in turn, creates the need to conduct new scientific research in the field of pedagogy. In the current conditions of globalization, hundreds of thousands of books and journals on pedagogy are published in the world every year, and countless scientific works and dissertations are defended. Modern technologies of teaching, such as problem-based, modular, computer-based, etc., are developing.

Literature Review

The term “pedagogy” originated in ancient Greece (Grestia), and its roots mean “observer”, “lead”. That is, the Greek “pedagog”, “paidi” - child, “gogos” - leader, “child leads” means “child leads”. The fact that classes in today's secondary schools are organized by teachers in the form of a theory of teaching related to didactic discourses corresponds to the above definition. The science of pedagogy was initially formed on the basis of the science of philosophy, and later, that is, by the developed Middle Ages, pedagogy was separated from the structure of separate philosophical knowledge [1]. From that time on, pedagogy began to be recognized as a science of “guides for learning”.

The status of pedagogy as an independent science was strengthened by the works of Francis Bacon and the famous Czech educator Jan Amos Komensky. As a result, the theory of educational work related to pedagogy and the main issues of its organization gradually began to be developed.

The true essence of “pedagogy” is to transfer the necessary life-related practices and experiences from the older generation to the younger generation and to ensure their active assimilation by the younger generation. Therefore, in the development of society, each generation inherits the heritage left by its previous generation, enriches it, and passes it on to the next generation [2].

The subject of pedagogy is the process of development and formation of the human personality in the context of learning, education, and upbringing. Thus, the science of pedagogy, the science of studying the essence of the development and formation of the human personality, began to manifest itself in quality.

The methods used in pedagogy are also of particular importance. The word “methods” in pedagogy comes from the word “methodas,” which is derived from the Greek language and means “behavior,” “way.”

Today, the rapid development of science and technology places the following demands on the education system:

- develop skills in individual and independent work, working with scientific and technical information;
- develop original and non-standard decision-making and business skills;
- individualizing education based on the differences in learning abilities of young people;
- requires criteria such as mobility of knowledge, adaptability and creativity in critical thinking, and the formation of agility in response to rapidly changing production conditions [4].

Analysis and Results

In today's modern pedagogy, teaching methods are understood as a didactic category that provides a theoretical understanding of the organization and management of the activities of learners and the relationship between teacher and learner in order to achieve the goal of teaching. Teaching methods are understood as a didactic category that provides a theoretical understanding of the organization and management of the activities of learners and the relationship between teacher and learner in order to achieve the goal of teaching.

The object of the discipline of pedagogy is schoolchildren, and its subject is related to the theory and practice of education. The goal of pedagogical education is to study the changing needs of society and the age characteristics of students as they develop. Thus, pedagogy summarizes the experiences in the field of education and upbringing, showing the prospects for the future development of upbringing. It also equips all aspects of the education system with theoretical and advanced experiences. It demonstrates the interdependence of education and upbringing by improving the skills of young people to receive proper upbringing and become talented.

The concept of upbringing in pedagogy expresses the goal of creating intellectual maturity, worldview, human beliefs, duties and responsibilities, and moral qualities inherent in the people of our society based on the knowledge acquired in the growing generation. In this sense, it is said that “upbringing” is a systematic influence on the educator to instill the qualities he wants in the minds of the educated, to change their worldview, according to certain goals. Upbringing is actually a process that continues from the birth of a person to the end of his life. For this reason, in many studies, the concept of “upbringing” is considered to be in harmony with the concept of education [5].

Education is a process that reflects educational information and is conducted under the guidance of specially trained individuals, serves to improve the knowledge, skills, and competencies of students, and develops their knowledge and abilities.

If upbringing is formed and matured in the family, school and society from the moment a child is born until the end of his life, education is carried out in limited educational institutions under the guidance of a teacher-educator in certain defined periodic processes. The information obtained in the educational process generalizes systematized knowledge, skills and qualifications, forming a set of worldviews.

When education, upbringing, and information are combined to lead a student to maturity, the teacher-educator takes the lead in shaping young people into complete human beings. While teaching at school, the teacher keeps students informed about the latest developments in the world of science, and shapes and nurtures their human qualities.

By cultivating the intellectual, moral, physical, and hardworking qualities of students, it influences their daily behavior and character, teaches them to respect adults and children, to care for people, to complete any task on time, to observe etiquette and manners. Also, every teacher must know the history of his native country, be patriotic, and be aware of the history of education and pedagogy. In order to understand the theory of pedagogy more deeply, he must be aware of its past development. After all, it is the teacher who can systematically influence students in providing them with knowledge, educating them, and educating them. This, based on social factors, manifests the effect of the influence in the student's imagination, attention, and thinking process.

The development of science, which is aimed at training specialists with higher education, provides opportunities for the development of modern information flows, scientific and research skills, individual and independent work, skills in working with scientific and technical information and educational and scientific literature. The formation of sciences creates a kind of “tree of science,” and its branches operate on the example of the branches of that science. Today, in pedagogical activity, it is precisely the branch of science that is becoming both relevant and a requirement of the times.

Conclusion

In conclusion, the increasing trends of economic development, which are the basis of sustainable development in recent years, have led to an excessive increase in the number of technical vehicles among the population. As a result, due to the human factor, the impact of road traffic accidents on traffic safety has increased. It should also be noted that today, in the context of the tragic consequences of road traffic accidents involving children, it is necessary to start improving the knowledge, skills and qualifications of young people on road traffic safety precisely from school education. Because the sad statistics of road traffic accidents involving children today are significant due to the lack of their primary knowledge on road traffic safety and the need to include this branch of science in school education programs.

The establishment of such a new scientific field or scientific direction in the field of science involves the study of existing situations, problems, topics and scientific issues in society. It is no exaggeration to say that the training of talented graduates of higher education in this direction will serve as a means of solving problems related to road traffic activities. This, in turn, serves to form personnel who have mastered the ability to think original and unconventionally and work independently in the system that trains future pedagogical personnel.

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IMPROVING THE ORGANIZATION OF LECTURES AND PRACTICAL SESSIONS ON DIFFERENTIAL EQUATIONS

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Annotatsiya. Ushbu maqolada oddiy “Differensial tenglamalar”dan ma’ruza mashg‘ulotlarni axborot texnologiyalari vositalari va Case-Study texnologiyasidan foydalanish usuli, ularning samaradorlik darajasini aniqlashga oid tajriba-sinov ishlarini tahlili keltirilgan.

Kalit so‘zlar: *Differensial tenglama, axborot texnologiya vositalari, Case-Study texnologiyasi, teorema, ta’rif, matematik amaliy paket.*

Аннотация. В данной статье рассмотрен метод использования информационных технологий и технологии Case-Study на лекционных и практических занятиях по теме “Обыкновенные дифференциальные уравнения,” а также представлен анализ экспериментально-практических работ по определению эффективности этих методов.

Ключевые слова: *Дифференциальное уравнение, средства информационных технологий, технология Case-Study, теорема, определение, пакет прикладной математики.*

Abstract. This article presents a method of using information technology tools and the Case-Study approach in lecture and practical sessions on “Ordinary Differential Equations.” It also includes an analysis of experimental work aimed at determining the effectiveness of these methods.

Keywords: *Differential equation, information technology tools, Case-Study method, theorem, definition, mathematical software package.*

Introduction

One of the most pressing issues in higher education is the implementation of innovative teaching approaches to improve the quality and effectiveness of mathematics education [1, 2]. Therefore, in the course of this research, a systematic approach was applied to the teaching process of “Differential Equations” in higher education institutions. It is well known that the collaboration between professors and

students in the educational process is a key factor in achieving the intended didactic goals of this process.

Literature Review

Research has been conducted in our country and in the Commonwealth of Independent States on improving the methodology of teaching differential equations, developing mechanisms for shaping and enhancing students' competence in the subject, teaching the theory and practice of applying differential equations, and using mathematical software packages in the teaching process. Notable contributions have been made by scholars such as Makhmudova D., Sharipov E.O., Aslanov R.M., Bibikov Yu.N., Bezruchko A.S., Novikova I.S., Sycheva N.V., Kuzmina L.P., Kapustina T.V., Aslanova R.M., Gerbekova Kh.A., Naimanova B.A., and A.V. Sinchukova.

Although the research conducted by these scholars presents various approaches to improving the effectiveness of teaching "Differential Equations," there has been little to no investigation into the use of information technologies and interactive teaching methods - particularly the Case Study method - in higher education institutions. Therefore, the proposed research addresses one of the current and significant issues in contemporary education.

Research Methodology

In higher education institutions, lectures are the primary form of instruction for mathematics-related subjects. In this context, it is of great importance that professors and instructors conduct these lectures using innovative pedagogical methods and information technologies [5].

Therefore, to enhance the effectiveness of teaching lectures on the topic "Differential Equations with Separable Variables and Equations Reducible to This Form", which is part of the standard "Ordinary Differential Equations" course, we examine a teaching methodology that integrates electronic learning resources, mathematical software packages, and the Case Study method [7].

Before starting the lecture. Professor-teacher asks the students $y' = f(x)g(y)$ she asks them to write 3 examples that can be expressed in visual form.

After the students complete the task, the professor uses the board or presentation software to present the following differential equations to the students:

1. $y' = cos(x - y - 2)$
2. $(xy + y^4)dx + (x^2 - xy^3)dy = 0$

These differential equations $y' = f(x)g(y)$ she asks to express them in standard form. Since the students do not know the definitions related to these examples, they encounter difficulties in reducing any of them to products of single-variable functions, creating a problematic situation among them [4, 5, 7, 9].

After that, the professor presents the definition of differential equations with separable variables.

Definition:

$$y' = f(x,y) = f(x)g(y) \qquad (1)$$

An equation of the form — is called a differential equation with separable variables. This part here – $f(x)$ ва $g(y)$ the functions here are respectively $a < x < b$ and $c < y < d$ are continuous on the interval. Thus, the right-hand side of the differential equation (1) is as follows:

$$D = (a, b) \times (c, d) = \{(x, y) \in R^2 : a < x < b\,, c < y < d\,\}$$

The functions are defined and continuous in the domain. To find the solution of the equation in form (1), the professor, using information technology tools, presents the following cluster for finding the integral of the separable differential equation (Figure 1).

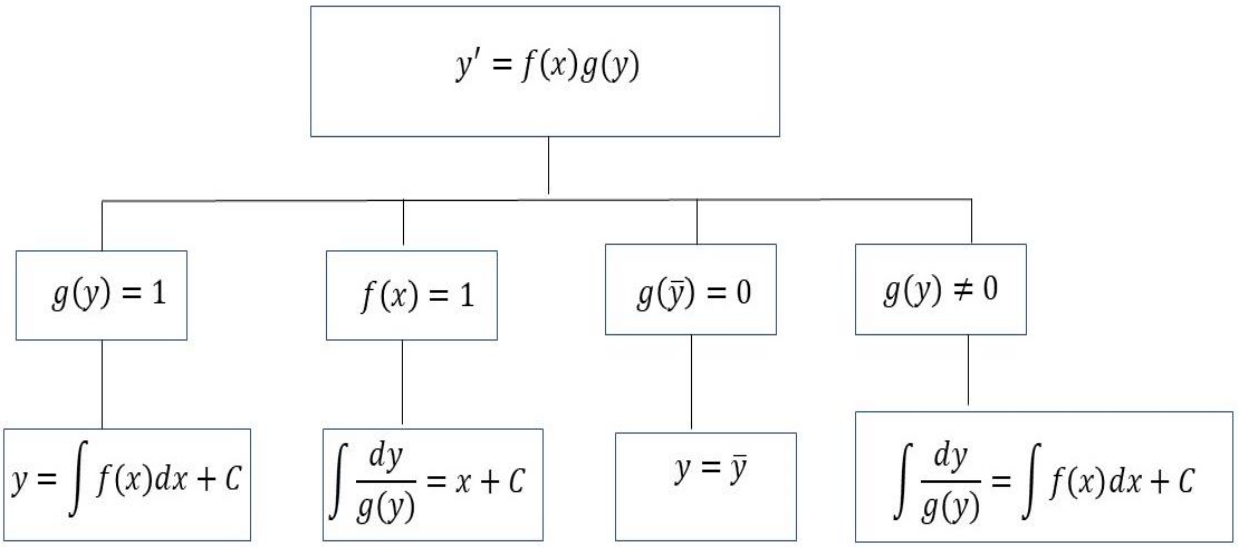

Figure 1. Cluster for finding the integral of the separable differential equation.

Students may have difficulty understanding this part of the cluster (Figure 2).

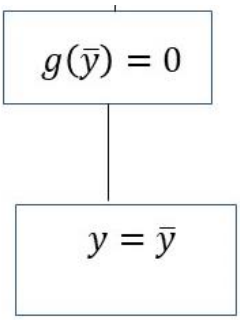

Figure 2. Cluster for finding the integral of the separable differential equation.

To resolve this situation, the professor $y(x) = \bar{y} \in (c, d)$ in a sentence $g(\bar{y}) = 0$ it explains the division. This is determined with the help of the root of the equation. $y(x) = \bar{y}$ it is explained that the constant function (1) is part of the solution to the differential equation [11].

Example. $y' = 3xy^2 - 5xy$ solve the equation.

Solving. Differential equation $\frac{dy}{dx} = xy(3y - 5)$ it is written in the form of. $f(x) = x$ va $g(y) = y(3y - 5)$ knowing that it is $g(\bar{y}) = \bar{y}(3\bar{y} - 5) = 0$ if we say so, then $\bar{y} = 0, \bar{y} = \frac{5}{3}$ we have solutions. Clearly, these constant functions can be solutions of

the differential equation. To find the general solution, the variables of the equation are separated and then integrated: $\int \frac{dy}{y(3y-5)} = \int xdx + C$

$$-\frac{3}{5}\left(\frac{1}{3y} - \frac{1}{3y-5}\right)dy = \int xdx + C, \quad -\frac{3}{5}ln\left|\frac{3y}{3y-5}\right| = \frac{x^2}{2} + C,$$

$\left|\frac{3y}{3y-5}\right| = C_1 e^{-\frac{5}{6}x^2}, C_1 > 0$ from the last equation $C_1 = 0$ when $y = 0$ it has a solution. The general solution of the equation is as follows [13]:

$$y = \frac{-5Ce^{-\frac{5}{6}x^2}}{3 - 3Ce^{-\frac{5}{6}x^2}}, \quad C \in R$$

After that, the professor presents a case bank for some differential equations that can be reduced to separable differential equations using presentation software (see Table 1).

Table 1.

Bank of cases	Differential equations	Substitutions	Separable differential equations
Case-1	$y' = f(ax + by + c)$ $a, b, c = const, y = y(x)$	-	-
Case-2	$xy' = x^{-n} f(x^n y)$ $n = const, y = y(x)$	-	-
Case-3	$y' = -\frac{n}{x} + f(x)g(x^n e^y)$ $n = const, y = y(x)$	-	-
Case-4	$y' = e^{mx-ny} f(ae^{mx} + be^{ny})$ $a, b, m, n = const, y = y(x)$	-	-
Case-5	$y' = y\left[\frac{\varphi'}{\varphi} - f(x)g\left(\frac{\varphi}{y}\right)\right]$ $\varphi = \varphi(x), y = y(x)$	-	-
Case-6	$M(xy)dx + N(xy)(xdy + ydx) = 0$	-	-
Case-7	$x^{2n}d(x^n e^{ay}) + e^{4ay}\left((d(x^n)e^{ay} - d(e^{ay})x^n\right) = 0$	-	-

The students understand that the answer to the question posed at the beginning of the lecture can be found by solving these cases, and they ask the professor questions such as how the equations in the cases can be transformed into separable differential equations [13].

The professor responds step-by-step to the arising situation: See the solutions of the cases in Table 2.

After the professor-instructor explains the topic using the above definitions, examples, and cases, she gives the students a mini case assignment.

Mini Case (English Translation): At the beginning of the lecture, a set of differential equations is given. For these equations:

1. Transform them into a separable form.
2. Find their solutions.

3. Verify the correctness of the obtained solutions using the Maple software package.

Table 2.

Bank of cases	Differential equations	Substitutions	Separable differential equations
Case-1	$y' = f(ax+by+c)$ $a,b,c = const, y = y(x)$	$ax+by+c = z(x)$	$\frac{dz}{dx} = bf(z) + a$
Case-2	$xy' = x^{-n} f(x^n y)$ $n = const, y = y(x)$	$x^n y = u(x)$	$\frac{du}{dx} = \frac{n}{x}(u + f(u))$
Case-3	$y' = -\frac{n}{x} + f(x)g(x^n e^y)$ $n = const, y = y(x)$	$x^n e^y = \omega(x)$	$\frac{d\omega}{dx} = \omega g(\omega) f(x)$
Case-4	$y' = e^{mx-ny} f(ae^{mx} + be^{ny})$ $a,b,m,n = const, y = y(x)$	$ae^{mx} + be^{ny} = \sigma(x)$	$\frac{d\sigma}{dx} = e^{mx}[ma + bnf(\sigma)]$
Case-5	$y' = y\left[\frac{\varphi'}{\varphi} - f(x)g\left(\frac{\varphi}{y}\right)\right]$ $\varphi = \varphi(x), y = y(x)$	$\frac{\varphi}{y} = \vartheta(x)$	$\frac{dv}{dx} = f(x)vg(v)$
Case-6	$M(xy)dx + N(xy)(xdy + ydx) = 0,$	$xy = t$	$\frac{dt}{dx} = -\frac{M(t)}{N(t)} = K(t)$
Case-7	$x^{2n} d(x^n e^{ay}) + e^{4ay}\left((d(x^n)e^{ay} - d(e^{ay})x^n\right) = 0$	$x^n e^{ay} = u(x)$ $\frac{x^n}{e^{ay}} = v(x)$	$\frac{du}{dv} = -\frac{u^2}{v^4}$

After solving the case, each group will present their report. The professor-instructor will evaluate the solutions proposed by the students.

Analysis and Results

One of the key components in researching the issue of improving the effectiveness of teaching “Differential Equations” in higher education institutions is conducting experimental work.

Therefore, within the framework of the study, a methodology was developed for using information technology tools and the CASE-STUDY method to enhance the effectiveness of teaching professional subjects — particularly the "Differential Equations" course — in lecture and practical sessions for mathematics specialists and future mathematics teachers at higher education institutions.

To determine the effectiveness of this developed methodology, experimental work was carried out. The experiments took place during 2019–2021 and involved 106 students from the Mathematics Department of the Faculty of Physics and Mathematics at Bukhara State University, 120 students from the Mathematics Teaching Methodology Department of the Faculty of Physics and Mathematics at Navoi State Pedagogical Institute, and 103 students from the Mathematics Teaching Methodology Department of the Faculty of Physics and Mathematics at Chirchik State Pedagogical Institute.

Of these students, 150 were assigned to the experimental group and 179 to the control group. The control group was taught using traditional lecture methods, while

the experimental group participated in lectures organized with the help of information technologies and the CASE-STUDY method.

Students' knowledge of differential equations in both the experimental and control groups was assessed using oral and written questions as well as tests. Their knowledge, skills, competencies, and qualifications were analyzed and summarized. The results of this analysis are presented in Table 3.

Table 3.

Groups	Number of students	The grades obtained by students in the experimental and control groups			
		5 – Excellent	4 – Good	3 – Satisfactory	2 – Poor / Unsatisfactory
Experimental group	150	28	90	29	3
Control group	179	23	93	53	10

In order to verify the reliability of the presented results, a mathematical-statistical analysis was carried out based on the Student-Fisher criterion. According to the analysis results, the performance of the experimental group was found to be 7.76% higher compared to the control group.

Conclusion and Recommendations.

In conclusion, based on the opinions of the researchers mentioned above and the results of the experimental work conducted in higher education institutions, it can be stated that the use of information technology tools and CASE-STUDY methodology in lecture sessions on differential equations is effective. Specifically, teaching the definitions and theorems related to differential equations, deriving Bernoulli equations, explaining the definitions of exact differential equations, applying nth-order first-degree differential equations to problems, and studying the essence of Lagrange, Clairaut, Riccati, and Euler equations, as well as the Cauchy problem and physical applications of higher-order differential equations benefit greatly from these approaches.

As a result, students develop motivation and cognitive skills by solving examples and problems, encounter problematic situations that encourage creative thinking, and fulfill illustrative and educational functions. Moreover, this approach aids in their overall development, including management skills, interdisciplinary and general educational abilities, and the formation of key competencies.

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THE ROLE OF COMPUTER PROGRAMS AND INNOVATIVE APPROACHES IN TEACHING CONSTRUCTION DRAFTING

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Annotatsiya. Mazkur maqolada qurilish chizmachiligini o‘qitish jarayonida zamonaviy kompyuter texnologiyalaridan foydalanishning didaktik imkoniyatlari va afzalliklari tahlil etiladi. AutoCAD, Revit, 3ds Max kabi dasturlar yordamida kasbiy ta’lim sifatini oshirish, talabalarning muhandislik fikrlashini shakllantirish va amaliy ko‘nikmalarini rivojlantirishga xizmat qiluvchi mexanizmlar ochib beriladi.

Kalit so‘zlar: *Qurilish chizmachiligi, kompyuter texnologiyalari, AutoCAD, muhandislik fikrlash, innovatsion metodlar.*

Аннотация. В данной статье анализируются дидактические возможности и преимущества использования современных компьютерных технологий

в процессе обучения строительному черчению. Раскрываются механизмы повышения качества профессионального образования с помощью таких программ, как AutoCAD, Revit, 3ds Max, формирования инженерного мышления и развития практических навыков студентов.

Ключевые слова: *Строительное черчение, компьютерные технологии, AutoCAD, инженерное мышление, инновационные методы.*

Abstract. This article analyzes the didactic possibilities and advantages of using modern computer technologies in the process of teaching construction drafting. It reveals mechanisms that serve to improve the quality of professional education, form engineering thinking and develop practical skills of students using programs such as AutoCAD, Revit, 3ds Max.

Keywords: *Construction drafting, computer technologies, AutoCAD, engineering thinking, innovative methods.*

Introduction

To learn how to read construction drawings, you must first learn how to draw them. Drawing construction drawings is slightly different from drawing mechanical drawings and mainly uses two types of lines. The contours that are cut are drawn on the main connecting lines, and the remaining contours, dimension lines are drawn on thin connecting lines. Construction drawings include images of buildings, plants, factories, engineering structures, etc. [1-5]

Literature Review

Architecture is the study of products that include drawings of buildings (residential, school, enterprise, hospital, and other places) in construction drawing. Accordingly, we will consider architectural construction drawings and their study. Any building elements have several functional purposes such as load-bearing. Since buildings are subject to loads, all loads are taken into account during their design. Barrier structures protect the building from atmospheric phenomena. Some structures perform both load-bearing and barrier functions at the same time. Each building consists of the following basic structural elements: foundation, walls and columns, ceilings, stairs, fences, roofs, windows, doors, etc. [3-6]

In today's era of globalization and digital transformation, the education system is faced with the task of integrating modern technologies into education. In particular, approaches to teaching drawing are being radically updated in the training of personnel for the construction industry. Along with traditional methods, visual, interactive teaching has become possible in schools, colleges, and higher education institutions using programs such as AutoCAD, Revit, and 3ds Max. This article provides an in-depth analysis of these opportunities and demonstrates mechanisms for effectively integrating computer technologies into the educational process [7-10].

Research Methodology

The study employs a qualitative and analytical approach to evaluate the effectiveness of modern computer technologies (AutoCAD, Revit, 3ds Max) in teaching construction drafting.

Analysis and Results

- Architectural drawings are represented by the general appearance of a building, its plans, sections, and facades.
- Structural drawings depict the main load-bearing elements: foundations, columns, beams, walls, and slabs.
- Engineering network drawings - drawings of electrical, water supply, heating, ventilation and sewage systems are provided.

Types of construction drawings and their function. There are the following main types of drawings in construction projects: Architectural drawings - depict the exterior appearance, plans, sections, and facades of a building [1]. Structural drawings provide information about the load-bearing elements of a structure (foundation, column, beam, slab). Engineering systems drawings - showing water supply, electrical supply, heating and air exchange systems. Working drawings contain precise dimensions and instructions intended for actual construction. These drawings complement each other, and the meaning of each must be understood in relation to the other drawings.

The importance of interdependencies. Although each drawing has its own significance, they reveal different aspects of a single design concept. For example, walls shown in an architectural plan are shown as load-bearing elements in a structural drawing. Discrepancies or misalignments between these drawings can cause problems during construction. To ensure consistency between drawings, the following factors should be considered:

Coordination: All members of the project team - architect, engineer, structural designer - must work in harmony with each other.

A uniform system of measurements and symbols: It is important that the unit of measurement is uniform and that symbols and graphic elements are standardized.

Drawing review and approval: At each stage, drawings must undergo technical review and approval.

Theoretical knowledge may not be enough when performing construction drawings. Therefore, practical experiences and methodological approaches are important. The following experiences and methods are recommended, especially for young designers and builders:

Real project-based learning. One of the most effective methods is to analyze existing design documents. This allows you to see the relationships between drawings, their content, and technical errors. For example, it is effective to analyze the 1st floor plan of a building and compare it with the related structural section and facade drawings.

Using AutoCAD and BIM technologies. AutoCAD software makes it easy to maintain consistency between drawings through layers, blocks, and measurement systems. It is also possible to create automatically linked, dynamic drawings using BIM (Building Information Modeling) software such as Revit and ArchiCAD [4].

Comparing a drawing with a real object. Comparing the actual situation on the construction site with the drawing helps to determine how accurate and realistic the project was. This experience increases the ability to read drawings and observation.

The role of computer technology in the educational process. Today, computer programs in the teaching of drawing have become a tool that not only enhances

students' knowledge, but also practical skills. With AutoCAD, students learn to create highly accurate drawings of buildings, infrastructure elements, and other construction details. Revit provides a modeling system that covers the entire life cycle of a building, that is, the design - construction - operation stages.

Motivating students and developing creative thinking. Teaching with the help of computer technology is an important factor in attracting students to science. 3D modeling allows them to work on projects that are close to real construction sites, express their ideas through drawings, and find practical solutions to problems. This encourages students to think creatively.

The role of the teacher and modern methodological approaches. Computer technologies also require a new pedagogical approach from teachers. Now the teacher is not only a provider of knowledge, but also a facilitator, project manager, and technological guide. Therefore, it is necessary to organize advanced training courses to improve the digital competence of teachers.

Practice-oriented learning projects. Learning to create drawings using computers is being done through modeling real construction projects. This not only teaches, but also develops students' critical thinking and technical literacy. In particular, students are prepared for real professional activities by modeling a building's electrical or sewage system based on a project taught in AutoCAD and Revit programs.

Conclusion

Proper organization of the relationship between construction drawings is the key to the success of the project. These relationships increase clarity for builders, reduce construction errors, and save time and resources. Modern civil engineering has become a constantly developing field, so it is necessary to constantly improve the culture of working with drawings. The introduction of computer technologies in the teaching of construction drawing is taking the quality of education to a new level. Pupils and students will get acquainted with the real professional environment and acquire digital drawing and modeling skills. This will help them become competitive in the labor market. The digital competence of a modern teacher, the innovation of teaching methods, and the technological integration of curricula are the main advantages. In the future, scientific research, methodological guides, and the expansion of digital platforms in this area will serve to further develop the field.

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USING CASE-STUDY TECHNOLOGY IN TEACHING MATHEMATICAL ANALYSIS TO STUDENTS

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Annotatsiya. Ushbu maqolada talabalarga matematik tahlil fanini o‘qitishda Case-Study texnologiyasidan foydalanish usullari hamda uning o‘quv jarayonidagi samaradorligini oshirishga qaratilgan natijalar taqdim etilgan. Case-Study metodi orqali nazariy bilimlarni amaliy misollar asosida o‘rgatish, talabalarning mustaqil fikrlash va tahliliy ko‘nikmalarini rivojlantirishga ko‘maklashadi.

Kalit so‘zlar: *Matematik tahlil, Case-Study texnologiyasi, o‘qitish metodikasi, o‘quv jarayoni, tahliliy ko‘nikmalar.*

Аннотация. В данной статье представлены методы использования технологии Case-Study при обучении студентов математическому анализу, а также результаты, направленные на повышение эффективности учебного процесса. Метод Case-Study способствует обучению теоретическим знаниям через практические примеры и развитию у студентов самостоятельного мышления и аналитических навыков.

Ключевые слова: *Математический анализ, технология Case-Study, методика преподавания, учебный процесс, аналитические навыки.*

Abstract. This article presents methods of using the Case-Study technology in teaching Mathematical Analysis to students, along with results aimed at improving the effectiveness of the learning process. The Case-Study method facilitates teaching theoretical knowledge through practical examples and helps develop students’ independent thinking and analytical skills.

Keywords: *Mathematical analysis, Case-Study technology, teaching methodology, learning process, analytical skills.*

Introduction

In the context of modern educational reforms, applying active learning approaches in teaching mathematics, particularly Mathematical Analysis, is considered one of the most promising components of the teaching methodology.

From the perspective of active learning, it is essential first to define the objectives of studying the subject to teach Mathematical Analysis effectively. The intellectual development of students proceeds simultaneously in two directions — understanding abstractions and concretizing those abstractions. The main difficulty in teaching Mathematical Analysis is not generalization (since concepts are usually presented in a sufficiently general and abstract form), but rather concretization — that is, helping students to visualize precise representations behind mathematical terms and their definitions, and to establish the properties of concepts and their interrelations.

Undoubtedly, the success of pedagogy in higher education institutions in helping mathematics students understand the foundations of Mathematical Analysis largely depends on how well students have mastered the concepts and their properties learned in secondary school, as well as general and specific information. Using problem-based learning technologies, including the Case-Study method, proves to be one of the effective approaches in establishing these connections [1].

Literature Review

Scholars such as L.K. Semenovna, E.V. Kruglov, M.N. Zhurayeva, S.S. Kruglova, D.A. Burlakova, Snezana Mirascieva, Agim Rushiti, and others have contributed to the improvement of teaching methodology for Mathematical Analysis, the development of students' competencies in this subject, and the teaching of its practical applications both in our country and abroad.

Although these researchers have proposed various approaches to enhancing the effectiveness of teaching Mathematical Analysis, their studies have not sufficiently explored the teaching of connections between concepts, definitions, theorems, and their properties specifically for mathematics students in pedagogical higher education institutions. Therefore, the present research addresses a pressing issue in modern education.

Research Methodology

The main forms of teaching Mathematical Analysis to mathematics students in pedagogical higher education institutions are lectures, practical sessions, and independent study. During our observations in Mathematical Analysis classes, the following topics were predominantly covered:

- Approximate calculation of the function value at a point;
- Constructing appropriate functions to verify given data;
- Proving equalities of forces;
- Using substitutions in solving differential equations.

To address these identified methodological issues, we employed innovative technologies, specifically the Case-Study method.

One of the fundamental concepts in Mathematical Analysis is the concept of a function. Students easily solve examples and problems related to functions and related notions (domain of definition, range, inverse function, etc.) and grasp these concepts

better than other topics in Mathematical Analysis. However, in the classes we observed, students demonstrated a lack of skills in verifying data by constructing corresponding functions and calculating approximate values. Therefore, we recommend using the Case-Study technology to overcome this methodological challenge [6].

As an example illustrating the above issue, we present the following Case Study.

Case: Which is greater: e^{π} or π^{e} ?

The first method of resolving the situation. Taking into account that π≈3.14 and e≈2.71, and letting x=3, y=3, we approximately calculate the values of e^{π} and π^{e} [4].

$\pi = 3{,}14, e = 2{,}71$ taking into account that $x = 3, y = 3$ that we approximately calculate the values of e^{π} and π^{e} [4].

$$f(x+\Delta x; y+\Delta y) \approx f(x;y) + \frac{\partial}{\partial x} f(x;y)\Delta x + \frac{\partial}{\partial y} f(x;y)\Delta y$$

$$e^{\pi} = (y+\Delta y)^{x+\Delta x}, \pi^{e} = (x+\Delta x)^{y+\Delta y}.$$

it is written in the form, where $\Delta x = 0{,}14;\ \Delta y = -0{,}29$

$$e^{\pi} = (y+\Delta y)^{x+\Delta x} \approx y^{x} + y^{x} lny\Delta x + xy^{x-1}\Delta y = 27 + 27 \cdot ln3 \cdot 0{,}14 + 27 \cdot (-0{,}29),$$

$$\pi^{e} = (x+\Delta x)^{y+\Delta y} \approx x^{y} + yx^{y-1}\Delta x + x^{y} lnx\Delta y = 27 + 27 \cdot 0{,}14 + 27ln3 \cdot (-0{,}29),$$

$$27 = 27;\ 27 \cdot ln3 \cdot 0{,}14 > 27 \cdot 0{,}14;\ \ 27 \cdot (-0{,}29) > 27ln3 \cdot (-0{,}29).$$

The following conclusion can be drawn from this: $e^{\pi} > \pi^{e}$

The second method to solve the situation is to construct a corresponding function to verify the data. $e^{\pi} \vee \pi^{e}$

$$\left(e^{\frac{1}{e}}\right)^{\pi e} \vee \left(\pi^{\frac{1}{\pi}}\right)^{\pi e}$$

Using the above, we can construct the function as follows: $y = x^{\frac{1}{x}}$

We find the extrema of the function: $lny = \frac{1}{x} lnx$

$$\frac{y'}{y} = -\frac{1}{x^2} lnx + \frac{1}{x^2}, y' = \frac{y}{x^2}(-lnx + 1) \Rightarrow y' = x^{\frac{1}{x}-2}(-lnx + 1),$$

$$y' = x^{\frac{1}{x}-2}(-lnx + 1) = 0,$$

$$lnx = 1, x = e,$$

$$0 < x < e, y' > 0 \vee e < \infty, y' < 0.$$

Since $x = e$, the function $y = x^{\frac{1}{x}}$ attains its maximum value at this point. From this, the following conclusion can be drawn[7]:

$$e^{\frac{1}{e}} > \pi^{\frac{1}{\pi}}$$

We raise both sides of the inequality to the power of πe.

$$\left(e^{\frac{1}{e}}\right)^{\pi e} > \left(\pi^{\frac{1}{\pi}}\right)^{\pi e}$$

$$e^{\pi} > \pi^{e}$$

The third method to resolve the situation is to construct a corresponding function to verify the data.

$$\pi^{e} \vee e^{\pi}$$

$$ln\pi^{e} \vee lne^{\pi}, eln\pi \vee \pi lne, eln\pi - \pi \vee 0,$$

$$f(x) = elnx - x, f'(x) = \frac{e}{x} - 1 = 0,$$

$$x = e, 0 < x < e \Rightarrow f'(x) > 0 \vee e < \infty \Rightarrow f'(x) < 0.$$
$$\pi > e \Rightarrow f(\pi) < f(e) \Rightarrow \pi^e < e^\pi.$$

The main object of mathematics is the set, and students can relatively easily solve operations performed on sets by illustrating them using Euler-Venn diagrams [2]. However, they encounter some difficulties when proving equivalences. Such methodological problems also arise in the subjects of mathematical analysis, algebra, and number theory. It is recommended to apply the Case-Study technology to address this issue. Through this approach, students develop competencies in working with concepts, definitions, and theorems. Below, we present an example of a Case used in the lecture session [3].

Case: $(A/B)/C = A/(B \cup C)$ prove the equivalence?

The first method to resolve the situation:

A-proposition (1 — true, 0 — false)

A-set (1 — element belongs, 0 — element does not belong)

From the relations, we construct the following correspondences.

$A \wedge B - A \cap B$, $A \vee B - A \cup B$, $A/B - A \cap \bar{B}$.

Table 1

A	B	C	A/B	$(A/B)/C$
1	1	1	0	0
1	1	0	0	0
1	0	1	1	0
1	0	0	1	1
0	1	1	0	0
0	1	0	0	0
0	0	1	0	0
0	0	0	0	0

Table 2

A	B	C	$(B \cup C)$	$A/(B \cup C)$
1	1	1	1	0
1	1	0	1	0
1	0	1	1	0
1	0	0	0	1
0	1	1	1	0
0	1	0	1	0
0	0	1	1	0
0	0	0	0	0

The second method to resolve the situation:

$\forall x \in A/(B \cup C) \Rightarrow x \in A \wedge x \notin B \cup C$. Consequently $x \in A/B \wedge x \notin C$ because, $x \in (A/B)/C$, in other words $A/(B \cup C) \subset (A/B)/C$ the relation is valid. Conversely $\forall x \in (A/B)/C$ let it be. In that case $x \in A/B \wedge x \notin C$. Therefore $x \in A, x \notin B \cup C$ because$x \in A/(B \cup C)$, namely $(A/B)/C \subset A/(B \cup C)$. From this, it follows that the given equations are valid [11].

The third method to resolve the situation is:

$$A/B \equiv A \cap \bar{B}$$
$$(A/B)/C \equiv (A \cap \bar{B}) \cap \bar{C} \equiv A \cap \bar{B} \cap \bar{C},$$
$$A/(B \cup C) \equiv A \cap (\overline{B \cup C}) \equiv A \cap \bar{B} \cap \bar{C},$$
$$(A/B)/C \equiv A/(B \cup C).$$

The methodological problem of applying substitutions in teaching differential equations occurs frequently in many topics. As an example, we present the following case used in practical sessions for teaching second-order differential equations.

Case: $xy'' - y' + 4x^3y = 0,\ x > 0$. Solve the differential equation.

The first method to resolve the situation is:

$$x = \sqrt{t},\ y' = \frac{dy}{dx} = \frac{dy}{dt} \cdot \frac{dt}{dx} = \frac{y'_t}{x'_t} = 2\sqrt{t}y'_t$$

$$y'' = \frac{dy'}{dx} = \frac{dy'}{dt} \cdot \frac{dt}{dx} = \frac{d\left(2\sqrt{t}y_t'\right)}{dt} \cdot 2\sqrt{t} = 4ty_t'' + 2y_t'$$

We substitute the results into the equation and simplify it.

$$\sqrt{t}(4ty_t'' + 2y_t') - 2\sqrt{t}y_t' + 4t\sqrt{t}y = 0$$

$$4t\sqrt{t}(y_t'' + y_t') = 0$$

$$4t\sqrt{t} = 0 \vee y_t'' + y_t' = 0 \Rightarrow \begin{bmatrix} t = 0, x = 0 \\ y_t'' + y_t' = 0 \end{bmatrix}$$

$$y_t = e^{kt} \Rightarrow y_t' = ke^{kt} \Rightarrow y_t'' = k^2e^{kt}$$

$$k^2 + 1 = 0; k = \pm i; y = C_1 cost + C_2 sint.$$

$$x = \sqrt{t};\ y = C_1 cosx^2 + C_2 sinx^2$$

2. The second method to resolve the situation is: $xy'' - y' + 4x^3y = 0$

$$y'' - \frac{y'}{x} + 4x^2y = 0$$

$$p = -\frac{1}{x}, q = 4x^2.$$

$$y'' + py' + qy = 0$$

The characteristic equation is as follows: $k^2 + pk + q = 0, k^2 - \frac{1}{x}k + 4x^2 = 0.$

$$k_1 = \frac{1 - \sqrt{1 - 16x^4}}{2x};\ k_2 = \frac{1 + \sqrt{1 - 16x^4}}{2x}$$

$$y(t) = C_1e^{k_1t} + C_2e^{k_2t} = C_1e^{\frac{1-\sqrt{1-16x^4}}{2x}t} + C_2e^{\frac{1+\sqrt{1-16x^4}}{2x}t}.$$

Analysis and Results

One of the main components for improving the effectiveness of teaching mathematical analysis in mathematics programs at pedagogical higher education institutions is conducting experimental and trial work.

Therefore, within the scope of this research, a methodology for using the Case-Study technology to enhance the effectiveness of lectures, practical sessions, and independent study in mathematical analysis for future mathematics teachers was developed. To determine the effectiveness of this developed methodology, experimental-trial work was conducted.

The experimental-trial involved 120 students from the Navoi State Pedagogical Institute. Of these, 60 students were assigned to the experimental group, and 60 to the control group. The control group received traditional lectures, practical sessions, and independent study, while the experimental group participated in lectures, practical sessions, and independent study organized based on the Case-Study technology.

The students' knowledge levels in mathematical analysis were assessed through oral and written questions as well as tests. Their acquired knowledge, skills, abilities, and competencies were analyzed and summarized.

To verify the reliability of the obtained results, mathematical-statistical analyses were performed based on the Chi-square (χ^2), Z, and U criteria. The analysis showed that the performance indicator of the experimental group increased by 11.2% compared to the control group.

Conclusion

In conclusion, based on the works of the aforementioned researchers and the results of the experimental studies conducted at higher education institutions, it can be stated that the use of the Case-Study technology in lectures, practical sessions, and independent study in mathematical analysis is effective. This is especially true for proving theorems, verifying data by constructing appropriate functions, applying substitutions in differential equations, and linking concepts and formulas.

As a result, students develop conceptual and procedural knowledge of the subject, enhance their problem-solving skills, and cultivate a creative approach when facing challenging situations.

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THE NECESSITY OF TEACHING SENTAURUS TCAD SOFTWARE TO FUTURE PHYSICS TEACHERS AND MASTER'S STUDENTS IN HIGHER EDUCATION INSTITUTIONS OF UZBEKISTAN

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Annotatsiya. Ushbu maqolada yarimo‘tkazgich qurilmalarini fizik asosda modellashtiruvchi Sentaurus TCAD dasturining ilmiy va ta’limiy ahamiyati, uni O‘zbekiston oliy ta’lim muassasalarida fizika fani o‘qituvchilari va magistrlarga o‘rgatishning dolzarbligi yoritiladi. Dasturdan foydalanish orqali ta’lim sifatini oshirish, talabalarda ilmiy-tadqiqot ko‘nikmalarini rivojlantirish, real tajriba natijalari bilan modellashtirish natijalarini kalibrovka qilish va integratsiyalashgan o‘qitish metodikasini ishlab chiqish imkoniyatlari ko‘rib chiqiladi.

Kalit so‘zlar: *Sentaurus TCAD, modellashtirish, yarimo‘tkazgich qurilmalar, fizik modellar, kalibrovka, fizik parametrlar, MOSFET, GAAFET, HEMT, STEM, texnologik simulyatsiya, oliy ta'lim, fan integratsiyasi.*

Аннотация. В данной статье рассматривается научное и образовательное значение программного обеспечения Sentaurus TCAD — инструмента для физически обоснованного моделирования полупроводниковых приборов. Подчеркивается актуальность его внедрения в процесс подготовки преподавателей физики и магистрантов в высших учебных заведениях Узбекистана. Показано, что использование данного программного обеспечения способствует повышению качества образования, развитию исследовательских навыков у студентов, калибровке результатов моделирования с реальными экспериментальными данными, а также разработке интегрированных методик преподавания.

Ключевые слова: *Sentaurus TCAD, моделирование, полупроводниковые приборы, физические модели, калибровка, физические параметры, MOSFET, GAAFET, HEMT, STEM, технологическое моделирование, высшее образование, интеграция науки.*

Abstract. This article explores the scientific and educational significance of the Sentaurus TCAD software, a tool for physics-based modeling of semiconductor devices. It highlights the urgency of incorporating it into the training of physics teachers and master’s students in higher education institutions of Uzbekistan. The use of this software is shown to enhance educational quality, foster students' research skills, enable calibration of simulation results with real experimental data, and facilitate the development of integrated teaching methodologies.

Keywords: *Sentaurus TCAD, modeling, semiconductor devices, physical models, calibration, physical parameters, MOSFET, GAAFET, HEMT, STEM, technological simulation, higher education, science integration.*

Introduction

The advancement of modern technologies demands approaches in the field of science that are based on in-depth analysis and model-based decision-making. In particular, branches of physics such as semiconductor physics, nanophysics, optoelectronics, and microelectronics require the assimilation of advanced simulation technologies. From this perspective, the Sentaurus TCAD (Technology Computer-Aided Design) software is emerging as a crucial tool for accurately modeling scientific and technical processes. This software enables the physical-level modeling, optimization, and control of semiconductor devices [1-3].

Currently, Uzbekistan's higher education system is undergoing significant transformations by integrating digitalization and modern technologies into the educational process. Alongside this, there is an increasing need to teach modern physics-based modeling tools to future physics teachers studying at the undergraduate and graduate levels. A physics teacher must not only possess theoretical knowledge but also the skills to create practical models, analyze simulation results, compare them with real experiments, and deliver the concepts to students in a comprehensible pedagogical format.

Sentaurus TCAD is a comprehensive tool that allows students to virtually observe how physical laws operate within real systems. This greatly enhances their didactic capabilities. In addition to traditional laboratory work, simulation-based methods significantly improve the effectiveness of learning physics concepts.

Through Sentaurus TCAD, students can deeply analyze phenomena such as quantum tunneling, carrier recombination, electric field distribution, electron and hole transport, and the physical principles of advanced transistors like GAAFETs and FinFETs. Therefore, mastering this software not only contributes to the training of scientific personnel but also facilitates the development of new teaching methods.

Today, physics teachers are considered the cornerstone of STEM (Science, Technology, Engineering, and Mathematics) education. As such, their level of knowledge must be aligned with advanced technologies. Modeling with Sentaurus TCAD helps them gain a deeper understanding of complex physical processes, thereby enhancing the effectiveness of their lessons. Moreover, initiatives led by the President of the Republic of Uzbekistan, such as the commercialization of science and the implementation of innovative ideas, underscore the urgency of teaching software like Sentaurus TCAD to future physics educators [4]. These tools support the modeling of physical processes, which is increasingly vital in modern scientific education. Certain shortcomings in the current higher education system—such as the lack of modern technical resources and insufficient courses in scientific modeling—highlight the necessity of integrating this software into the curriculum. Such integration will enhance the competitiveness of future educators. In addition, the use of TCAD modeling methods in preparing master's theses, graduation projects, and scientific articles

encourages students to conduct independent research. This plays a vital role in increasing Uzbekistan's scientific potential.

In this article, we aim to demonstrate the advantages of Sentaurus TCAD software for future physics teachers and master's students. We also present an effective methodology for integrating the software into the educational process and share experiences in calibrating its results. The goal is to mark the beginning of a new phase in pedagogical activity.

Research Methodology

To teach Sentaurus TCAD software effectively, a step-by-step methodological approach must be developed. Initially, both students and instructors should be provided with a general understanding: what TCAD is, what problems it solves, and how its interface and components are organized. Based on this, the first stage focuses on theoretical knowledge, reinforcing concepts such as semiconductor physics, charge carriers, PN junctions, MOSFETs, GAAFETs, HEMTs, tunneling effects, recombination processes, and quantum mechanics. In the second stage, students begin exploring the modules of Sentaurus TCAD. Modules such as SDE (Sentaurus Device Editor), Sprocess (Sentaurus Process), Svisual (Visualization), Inspect, and Workbench are introduced sequentially. The function, configuration, input, and output files of each module are explained separately. For example, using Sprocess, the geometry and layers of a device are constructed, while Sdevice is used to analyze its electrical properties. Throughout the learning process, each practical session is based on a real physical device—such as a PN junction diode, MOSFET, GAAFET, FinFET, or quantum dot diode. Students define the device geometry, select layer materials (Si, InP, GaN, SiGe, etc.), input doping concentrations, and determine the positions of electrical contacts. Then, simulation results are obtained: I-V characteristics, electric potential, charge density, current density, recombination zones, and heat distribution. Through this method, students can observe how each physical model is reflected in practice[5-8]. It is essential to explain the working principles of the physical models available in the software - such as Drift-Diffusion, Hydrodynamic, Quantum Potential, Mobility models (CVT, Philips, Lombardi), Recombination models (SRH, Auger), and Bandgap Narrowing models. The instructor should justify the selection of these models with relevant examples. For instance, in modeling an InP substrate, a nonlocal mobility model and SRH recombination model may be selected. One of the key elements of this methodology is reinforcement through laboratory exercises. After each theoretical topic, students are given independent tasks such as: create a new device, modify the doping concentration, study the effect of temperature, or increase the electric field. These hands-on tasks help reinforce their knowledge and develop skills in analysis, comparison, and scientific thinking. To support independent student work, template files are provided—for example, basic models of a PN diode, a MOSFET, and an InP-based HEMT transistor. This allows students to learn how to edit simulation input files. At the end of each session, students prepare a report including graphs, tables, analytical conclusions, and discussions. Since the software is complex, it is essential to create instructional materials such as textbooks, video tutorials, and step-by-step PDF guides. These encourage self-directed learning. Additionally, students develop skills in reading

technical texts in English, as the software interface is in English. The assessment system is another important aspect of the methodology. Assessment is based on correctly completing the modeling steps, selecting appropriate physical models with justification, analyzing results, visual interpretation of graphs, and identifying sources of error. These evaluation criteria should be clear, transparent, and distinctive for students. In conclusion, the teaching methodology must be step-by-step, interactive, practical, analytical, and focused on problem-solving [9, 10]. This approach not only enhances future teachers' technical knowledge but also develops competencies such as critical thinking, applying learned concepts in teaching, conducting scientific research, and validating experiments through simulation.

Analysis and Results

In the process of modeling semiconductor devices using Sentaurus TCAD software, the obtained results should not be limited to the graphical outputs shown by the program. Instead, reliability must be determined through calibration and comparison with real experimental data. The calibration process refers to adjusting simulation results to align with experimentally obtained data, allowing validation of the accuracy of the selected physical models, parameters, and boundary conditions used during modeling. For example, when modeling an InP-based HEMT device, the material properties—such as doping levels, temperature, and contact configurations—are initially chosen based on known experimental studies. Then, I–V characteristics are simulated and compared with experimental results. If discrepancies are observed, adjustments are made to model parameters: for instance, the carrier mobility model may be updated, recombination constants adjusted, or the device geometry refined.

The mobility model plays a crucial role in calibration. In InP materials, electron mobility varies significantly with temperature. Therefore, in simulations, mobility models such as Lombardi or Philips are used. To improve alignment with experimental data, specific parameters within these models—such as maximum mobility, critical electric field, and diffusion constants—are customized and fine-tuned. Recombination mechanisms also significantly impact the results. If the recombination effect is underestimated in the simulation, the current density will be too high and deviate from real device performance. Therefore, recombination parameters (τ_n and τ_p) are adjusted within the Shockley–Read–Hall (SRH) model to match experimental data [11-12]. Graphs showing electric field distributions are highly valuable for understanding the internal behavior of devices. For instance, the peak electric field at the p–n junction, the variation of gradients near contacts, or the extent of channel depletion in GAAFETs can be clearly observed. These visualizations help perform a deeper analysis of physical processes and identify necessary optimization strategies.

One of the essential calibration tools in simulation is the parameter sweep method. In this method, a specific parameter (e.g., channel length or doping concentration) is varied across multiple values, and separate simulations are run for each. This helps determine how the device responds under different conditions, making it a vital approach for device design optimization.

An important aspect of the discussion is the impact of simulation results on the learning process. Displaying results obtained through Sentaurus TCAD in graphical, tabular,

and analytical formats helps students develop a deeper understanding of physical phenomena. For example, by analyzing I–V curves, students can assess the influence of various parameters. They can independently explain how a change in contact potential affects current density.

Furthermore, calibration enables the creation of realistic models, facilitates rapid analysis, and supports the testing of new designs. This is particularly valuable for graduate-level research and scientific exploration.

Another critical aspect is comparing different physical models. By comparing results from the Drift–Diffusion (DD) and Hydrodynamic (HD) models, students learn the limitations of each. For instance, while the DD model may produce smooth current density curves, the HD model may exhibit "overshoot" effects, indicating the influence of carrier inertia under high electric fields.

Calibration is also required in transient simulations, where time-dependent responses of devices are analyzed. For example, under pulsed voltage, the time-dependent current graph is compared with oscilloscope results from real experiments. In case of discrepancies, time constants, transition characteristics, or capacitance parameters are adjusted.

Statistical methods are also used in analyzing results. Metrics like Root Mean Square Error (RMSE), R-squared coefficient, and chi-squared analysis help determine the accuracy and reliability of the model. These tools provide an objective assessment of how closely the model matches a real device.

It must also be noted that the learning pace of students is influenced by the accuracy of calibration. If simulation results closely reflect real-world behavior, it builds correct mental models in students and improves learning quality. Conversely, poorly calibrated models may lead to misconceptions and incorrect conclusions.

Through calibration, decisions can also be made to simplify or increase the complexity of physical models. Initially, the Drift–Diffusion model may be used; if discrepancies arise, the Hydrodynamic or Quantum models can be introduced. These stages help students understand the progressive nature of physical modeling.

The practical benefits of calibration include:

1. Improved model accuracy and reliability
2. Reduced need for costly experimental trials
3. Accelerated device optimization
4. Increased efficiency in the teaching process
5. Enhanced student skills in independent analysis

The calibration and discussion practices outlined above demonstrate that Sentaurus TCAD is not merely a simulation tool, but a strategic instrument for achieving high educational outcomes.

Conclusion

The analyses presented above demonstrate that the Sentaurus TCAD software must become an integral part of modern physics education. It provides an opportunity to explain to students how physical laws manifest in real devices. Through this software, students not only acquire theoretical knowledge but also develop skills in modeling

practical experiments, deriving new results through simulation, and drawing conclusions based on graphs and tables.

The teaching methodology based on this software is structured step-by-step, visual, analytical, and problem-solving oriented, helping to develop modern teaching competencies in future physics educators. Particularly at the master's level, modeling projects conducted with Sentaurus TCAD can lead to scientific publications, thesis work, and even patent-level innovations.

The calibration and discussion stages allow for evaluating how closely simulation results match real devices, thereby increasing the accuracy and reliability of the modeling process. The software contributes not only to scientific research but also significantly enhances the effectiveness of the educational process.

Therefore, it is essential to teach Sentaurus TCAD systematically to physics teachers and master's students in higher education institutions of Uzbekistan. This will help prepare technologically minded, modern educators who, in turn, will instill deep scientific thinking in the next generation.

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THE DISCIPLINE OF THE SELF IN THE WORKS OF JALALUDDIN RUMI

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Annotatsiya. Ushbu maqola tasavvufda ruhiy tarbiyasi tushunchasini yoritilgan. Tasavvuf ta'limotida nafsga erk bermaslik, uni o'z vaqtida boshqarishni o'rganish kerakligi ta'kidlanadi. O'rta asrlarda ko'zga ko'ringan islom ulamolari va tasavvuf olimlari rahbarligida turli tasavvufiy tariqatlar tashkil topgan. Ular o'z ta'limoti va g'oyalari orqali komil insonni tarbiyalab, asrlar osha umumjahon e'tirofiga sazovor bo'lganlar.

Kalit so'zlar: *tasavvuf, tariqat, Mavlaviyya, Naqshbandi, komil inson.*

Аннотация. В данной статье рассматривается концепция духовного образования в суфизме. Учения суфизма подчеркивают необходимость не давать волю эго, а учиться контролировать его своевременно. В средние века под руководством выдающихся исламских ученых и суфийских ученых были сформированы различные мистические ордена. Благодаря своим учениям и идеям они воспитали совершенного человека и на протяжении веков добились всеобщего признания.

Ключевые слова: *суфизм, орден, Мавлавия, Накшбанди, совершенный человек.*

Abstract. This article explores the concept of soul education in Sufism. In Sufi teachings, it is emphasized that one must not give free rein to their desires and should learn to control them in a timely manner. In the Middle Ages, various Sufi orders were established under the guidance of prominent Islamic scholars and mystics. These orders promoted the development of a perfect human being through their teachings and ideas, gaining universal recognition across civilizations.

Keywords: *Sufism, order, Mavlaviya, Naqshbandi, perfect human.*

Introduction

Sufism emerged in the Islamic world around the middle of the 8th century and has since held a significant place in the history of Eastern peoples. Initially, it appeared as a movement of asceticism (renunciation of worldly life). After the Prophet's death, during the caliphates, divisions arose within the Muslim community, and the pursuit of material wealth became widespread. This situation triggered dissatisfaction among Hadith collectors and companions of the Prophet. As a form of protest against the moral degradation of palace dwellers and the wealthy, they began to advocate Sufi ideas and

engaged in spiritual practices. This movement also attracted moralistic preachers, reciters of the Qur'an, and devout artisans and merchants.

Literature Review

Sufi teachings delve deeply into the subtlest changes within the human heart and cultivate empathy for inner human feelings. According to Sufi scholars, man must not surrender to the nafs (lower self or ego) but should control it. The ability to restrain the nafs is seen as a symbol of spiritual maturity. Knowledge is considered the antidote to base desires and anger—true knowledge alone can liberate a person from all forms of moral decay.

Sufi orders mainly promote teachings related to human perfection, placing great emphasis on overcoming bodily and egoistic desires. Attachment to worldly possessions enslaves a person to their nafs. Those who follow the Sufi path reject the nafs, viewing it as the root of all evil and spiritual destruction. The only correct path to liberation from these vices is through overcoming the desires of the nafs. Purification of the heart is achieved through spiritual discipline (riyozat), which entails not just patience but a voluntary commitment to spiritual goals and enduring hardship in pursuit of those goals.

Research Methodology

This article employs comparative analytical methods to examine the essence of Sufism and the theoretical and practical activities of different Sufi orders.

Analysis and Results

Jalaluddin Rumi, a great representative of 13th -century Sufism, was a poet and a prominent figure in Sufi philosophy. His personal development and works have been studied in various languages by scholars of different nations. Born Muhammad ibn Bahā'uddīn Muhammad ibn Muhammad ibn Husayn al-Balkhi, he is revered as the sheikh of the Mavlaviya order.

Known by several titles such as "Jalaluddin," "Rumi," and "Mavlavi," he was affectionately called "Mavlana" by his friends and followers—a term meaning "master" or "lord" in Arabic. His epithet "Rumi" is attributed to his lifelong residence and creative work in Anatolia (Asia Minor).

Rumi's philosophical and poetic elevation is significantly credited to his spiritual encounters with Shams Tabrizi and Fariduddin Attar. He transcended sectarian divisions by promoting unifying divine ideas and enriched his legacy with teachings centered on faith, love, repentance, and purification.

After Rumi's death, his son Sultan Walad continued his legacy by composing Valadnama, which is considered a reliable source on Rumi's life and teachings. Special institutions named Darul Masnavi were later established in places like Iran, Central Asia, India, and especially Anatolia to study Rumi's spiritual heritage.

Based on his magnum opus Masnavi-ye Ma'navi, numerous collections and commentaries were created. From the 15th century onward, many thinkers drew inspiration from his works, producing extensive literature in Arabic, Persian, and Turkish.

Rumi's entrance into the Sufi world was foretold by Fariduddin Attar. On a pilgrimage to Mecca, Rumi and his father Bahā'uddīn Walad stopped in Nishapur, where Attar gave young Rumi a copy of his Asrarnameh, predicting the boy would one day "ignite the hearts of the world's seekers."

After entering the Sufi path, Rumi first became a disciple of poet Burhan al-Din, then bonded with the wandering dervish Shams Tabrizi, whom he declared his spiritual guide. Their first meeting on November 12, 1244, is described in sources as "the meeting of two seas." Shams instructed Rumi in philosophy and Sufi teachings for three years. Rumi himself wrote, "If Attar gave me the soul, Shams handed me the key to the mystery." Shams' sudden death deeply affected Rumi, who adopted Shams' name as his poetic pen name and began composing ghazals in his memory. He dedicated his major poetic work Divan-e Kabir (also known as Divan-e Shams-e Tabrizi) to him. Later companions included Salahuddin Zarkub and Husamuddin Chalabi.

Rumi's other monumental work is the six-volume philosophical and spiritual epic Masnavi-e Ma'navi. Completed around 1269, just before his death, this work has touched countless hearts with its meaningful and eloquent verses. More than 150 commentaries have been written on it. The Masnavi is one of the most read and revered works in the Muslim world. Those who engage with it attain deep understanding of life, moral conduct, self-awareness, and ethical discernment.

In this masterpiece, Rumi includes many parables from Eastern oral traditions and interprets Qur'anic verses and Hadiths. It is not only a moral guide but also a transformative text that elevates human thought. Rumi used symbolic animals (e.g., falcon, duck, goose, peacock, parrot, lion, fox) to convey his ideas and included numerous historical place names like Damascus, Baghdad, Samarkand, and Bukhara to enrich his narratives.

Rumi's Masnavi, described as "The Qur'an in Persian," gained global fame from the 17^{th} –18^{th} centuries onward as a spiritual encyclopedia. The book Open the Eye of Your Heart: Wise Sayings from Mawlana Rumi introduces readers to Rumi's inner world, urging reflection and self-realization.

Alisher Navoi praised Rumi in his Mahbub al-Qulub, categorizing poets into three groups and placing Rumi in the highest class: those who unveil divine secrets through verse. Navoi noted that Rumi glorified both God and humanity in his writings, embodying a deeply humanistic and spiritually rich philosophy.

Rumi examined human nature and inner states in his works. He analyzed the evils that stem from unchecked desires and proposed spiritual methods of overcoming them. He encouraged readers to seek self-awareness and to despise evil while taking pride in righteous deeds.

Rumi likened essence to a pearl hidden in the depths of the sea—he claimed that the more a person understands the essence of things, the closer they come to understanding themselves. Self-knowledge leads to happiness and is attained through the heart. Such an awakened soul then leads the body on the right path.

Conclusion

In conclusion, Jalaluddin Rumi asserted that humans are often led into hardship by their nafs. A person with faith who recognizes the Truth remains calm, peaceful, and patient. However, desire—sparked by the nafs—pulls the heart toward sin, placing individuals at risk of spiritual downfall. To be free of this trap is a rare gift. Submission to the nafs inevitably leads to destruction. Only patience brings salvation, for those who are patient are close to the Creator.

Rumi placed special emphasis on the purification of the heart, urging people to cleanse it from evil thoughts, restrain the nafs, enrich the soul with wisdom, and follow the guidance of the heart. He advises: "Consult with your heart."

Thanks to Jalaluddin Rumi, Sufi teachings penetrated folk poetry, infused it with humanistic ideas, and became a priceless part of our spiritual heritage.

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JADIDS AND THEIR ACHIEVEMENTS

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Annotatsiya. Ushbu maqolada Turkiston jadidlarining murakkab siyosiy sharoitda vujudga kelgan jadidchilik harakati va uning doirasida qilgan ishlari, ularning erishgan yutuqlari haqida ma'lumotlar yoritilgan.

Kalit so'zlar: *Ismoil G'aspirali, Buxoro, "Tarjimon" gazetasi, Behbudiy, Qodiriy, Cho'lpon, Munavvar qori, Jadid, Turkiston, "Sadoyi Turkiston", Toshkent, Xiva, XX asr, Qo'qon, Nijniy Novgorod, Moskva, Oziq ishlari.*

Аннотация. В статье дается информация о джадидском движении туркестанских джадидов, возникшем в сложных политических условиях, об их деятельности в нем и об их достижениях.

Ключевые слова: *Исмаил Гаспирали, Бухара, газета "Тарджиман," Бехбудий, Кодыры, Чулпон, Мунаввар кори, Джадид, Туркестан, "Садой Туркестан," Ташкент, Хива, 20 век, Коканд, Нижний Новгород, Москва, Пищевой комбинат.*

Abstract. This article highlights the emergence of the Jadid movement in Turkestan, which arose under complex political conditions. It explores the significant efforts of the Jadids within this movement and the achievements they attained.

Keywords: *Ismail Gaspirali, Bukhara, Tarjimon newspaper, Behbudiy, Qodiriy, Cho'lpon, Munavvar qori, Jadid, Turkestan, Sadoyi Turkiston, Tashkent, Khiva, 20th century, Kokand, Nizhny Novgorod, Moscow, educational reforms.*

Introduction

The independence of Uzbekistan was not only a socio-political transformation but also a powerful spiritual and educational process. This historical shift revived the invaluable works of our great scholars and re-established their role across all areas of life. These developments have contributed positively to the intellectual and spiritual worldview of the people and continue to play an essential role in national progress. These achievements are deeply connected with the historical legacy of our ancestors.

Literature Review

In the late 19th and early 20th centuries, the Jadid movement — a reformist and modernist initiative — emerged as a driving force that significantly enriched the spiritual and cultural life of the nation. The legacy and accomplishments of the Jadids remain a powerful example of self-awareness and national consciousness [1, 2].

It is crucial for us to study the heritage of these enlightened ancestors and their reformist movement. The more we engage with this intellectual treasure, the more answers we can find to the pressing questions of our time. Promoting this heritage helps our people, especially the younger generation, to appreciate the value of the peace and freedom we enjoy today. The Jadid movement initially appeared among the Crimean Tatars in the 1880s under the leadership of Ismail Gaspirali. They first referred to themselves as "reformers" and later as "Jadids." By the 1890s, this movement began to spread across Central Asia. Initially focusing on cultural and educational reforms, the Jadids advocated for progress, the development of Turkic languages, the enrichment of literature, the study of secular sciences, and the promotion of gender equality. Though fundamentally a political movement, Jadidism had distinct phases of formation and suppression, which can be conditionally divided into four stages across regions such as Turkestan, Bukhara, and Khiva: 1904–1905, 1906–1916, 1917–1930, and 1921–1929. The movement started through cultural and educational societies formed by progressive thinkers in cities such as Tashkent, Fergana, Bukhara, Samarkand, and Khiva [3-6].

Analysis and Results

Ismail Gaspirali, a Crimean Tatar intellectual, is recognized as the founder of the Jadid movement. Deeply knowledgeable in both religious and secular sciences, he was fluent in several foreign languages and well-acquainted with global intellectual trends. By comparing Eastern and Western philosophies, he sought pathways to development for Turkic peoples. In 1884, he founded the first Jadid school in Bakhchisarai (Crimea) and developed his own curriculum, known as the Usul-i Jadid or "new teaching method," which emphasized phonetic reading. He authored the book Rahbar Muallimin ("Guide for Teachers") in 1888, outlining instructional methods, classroom organization, and educational content. His newspaper, Tarjimon ("The Translator"), played a critical role in spreading Jadid ideas. His visit to Tashkent, Samarkand, and Bukhara in 1893 inspired the opening of the first Jadid school in Bukhara that same year [2-5].

One of the most prominent Uzbek Jadid poets was Chulpon. Born in 1897 in the Qoraterak district of Andijan, his father, Sulaymonqul, ensured he received a modern education. Even as a teenager, Cho'lpon was an avid reader of Turkic history and nationalist publications. By the age of 17, he had already established connections with Jadid publishers and contributed poems, short stories, and articles to journals across Turkestan, Crimea, and Tatarstan. His first published work appeared in the Sadoyi Turkiston newspaper in 1914. Later, he contributed to Sadoyi Farg'ona, publishing stories such as Qurboni Jaholat ("Victim of Ignorance") and Doktor Muhammadiyor, as well as essays on infrastructure and development. In 1917, he celebrated the declaration of the Turkestan Autonomy in Kokand by publishing his poem Ozod Turk Bayrog'i ("The Free Turk Banner") in the newspaper El Bayrog'i [4, 6].

Another foundational figure of the Jadid movement was Mahmudkhoja Behbudiy. As noted by writer Sirojiddin Ahmedov, Behbudiy did not simply seek abstract truth — he conveyed truth through literature, journalism, and education. Behbudiy's influence extended into pedagogy, journalism, printing, politics, and commerce. In 1913, he launched the Samarqand newspaper in Uzbek and Tajik, although it ceased publication after 45 issues due to financial challenges. He later published the illustrated weekly journal Oyina, which featured poems, essays, social commentaries, and editorials. Oyina gained readership across the Caucasus, Central Asia, Iran, Afghanistan, India, and even Turkey. In its first issue, Behbudiy emphasized the importance of multilingualism, recommending the study of Uzbek, Tajik, Arabic, Russian, and French. His political activism began in 1908 with participation in the Union of Russian Muslims in Nizhny Novgorod. In April 1917, during a congress of 150 Muslim delegates, Behbudiy delivered a powerful speech. On November 26, 1917, he was elected chairman of the Muslim Congress in Kokand, where the Turkestan Autonomy was declared the following day — a bold step toward self-governance. However, the autonomy was short-lived. The Bolsheviks launched a brutal attack, shelling the city and killing approximately 10,000 people. Disillusioned, Behbudiy moved to Samarqand and later Tashkent, trying in vain to negotiate with Soviet leaders. His dreams of a free and enlightened Turkestan remained unfulfilled.

Another bright representative of our Jadids was Munavvar qori Abdurashidkhanov, who was born in 1878 in the city of Tashkent into a well-known and scholarly family.He realized very early on that the freedom of the homeland, its economic and cultural development, primarily depended on reforming the nation's backward and fanatical education system and establishing a new educational structure—based on both religious and secular principles—covering primary, secondary, and higher education. In 1901, Munavvar qori Abdurashidkhanov became one of the first in Turkestan to open a Jadid school in his own home. There, children learned to read and write within just six months and became fully literate. He was also the first to develop curricula and textbooks specifically for Jadid schools. Abdurashidkhanov had to carry out his mission under the harsh oppression of a highly authoritarian and anti-human labor regime, in a time of great hardship and conflict, all while fighting for the nation's interests and the independence of his homeland. As a result, he became a victim of repression and was martyred in 1931, at the age of 53.

Conclusion

In conclusion, it is fair to say that the Jadids left behind not only material wealth during their time but also an invaluable spiritual heritage that remains highly relevant today. Thanks to their legacy, we now have a clear understanding of the literary field and the historical past, which can be studied without difficulty. As a result of their tireless efforts at the beginning of the 20th century, they were even able to establish awareness in cultural fields such as theater and significantly elevate the nation's intellectual consciousness. Today, there exists a vast body of both explored and unexplored scientific and spiritual heritage left by the Jadids of Turkestan. Through studying these, we can potentially discover the "Jadids" of the 21st century. It would not be an exaggeration to say that many of the achievements and milestones reached through today's reforms are deeply rooted in the difficult path paved and the sacrifices made by the Jadids.

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PATRIOTISM AS THE MOST IMPORTANT VIRTUE OF HUMANITY

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Annotatsiya. Ushbu maqolada vatanparvarlik tushunchasining mazmun mohiyati yoritilgan. Vatanni sevish uchun bag‘rikenglik kerak. Bunday bag‘rikenglik insonni haqiqiy jasoratga, kerak bo‘lsa jonini fido qilishga tayyorlaydi. Bugungi kunda har tomonlama mukammal ichki ishlar organlari xodimlarini vatanparvarlik ruhida tarbiyalashda ma’naviyat eng ta’sirchan va qudratli qurol vazifasini o‘taydi.

Kalit so‘zlar: *vatanparvarlik tuyg‘usi, urf-odat, meros, ma’naviyat, jasorat, globallashuv jarayoni.*

Аннотация. В данной статье раскрывается сущность понятия патриотизма. Чтобы любить свою родину, нужна толерантность. Такая толерантность готовит человека к настоящему мужеству, даже к жертве своей жизнью, если это необходимо. Сегодня духовность является самым эффективным и мощным оружием в воспитании сотрудников правоохранительных органов в патриотическом духе.

Ключевые слова: *патриотизм, традиция, наследие, духовность, мужество, процесс глобализации.*

Abstract. This article sheds light on the essence of the concept of patriotism. To love one’s homeland, one needs tolerance. Such tolerance prepares a person for true courage, and if necessary, to sacrifice one’s life. Today, spirituality serves as the most effective and powerful weapon in educating all-round excellent internal affairs officers in the spirit of patriotism.

Keywords: *patriotic feeling, tradition, heritage, spirituality, courage, globalization process.*

Introduction

As humanity progresses, the development of the most modern types of military weapons, the creation of weapons designed to mass exterminate people and capable of completely destroying Mother Earth in an instant, has been recorded in the annals of history, which has led to a kind of "arms race" between countries. Later, not only the usual, that is, open attacks with weapons, but also ideological wars began to appear, which gradually eat away at states from within, completely undermine their development. Today, it is becoming difficult to foresee the areas where the danger of such ideological wars will spread and to take adequate measures. The only way to protect against such wars is to educate the younger generation to love the Motherland and be patriotic through education and self-awareness.

Our country has a long, centuries-old history. The ever-beautiful nature of our country, its material and spiritual wealth, and its hardworking people have captivated the world. Therefore, we should not forget that the conquest of the ancient Turanian land is the eternal dream of all hidden forces, and there are forces ready to use any situation to achieve it. We must preserve and cherish the national cultural heritage created by our ancestors, great thinkers and scientists.

Literature Review

Many studies have documented the many bloody wars and conflicts in human history, struggles for the freedom of the homeland. It is no secret that these wars and conflicts have resulted in the destruction of millions of people, large and small cities, and in many cases even countries, and in most cases, civilians. Wars have crippled the economies of countries and destroyed the history, religion, national cultural traditions, and heritage of nations that have been formed over many years.

Patriotism is a concept that expresses the love and loyalty of people to their homeland, where their umbilical cord blood was shed. Patriotism is one of the highest, universal feelings that have been cultivated for centuries by humanity, all peoples and nations. Patriotism has been perfected in the process of people's struggle for the independence of their homeland, the fate of the land where their umbilical cord blood was shed. Patriotism is manifested in a person’s pride in the past and present of his homeland, in protecting the interests of the homeland on all fronts. After all, it is not for nothing that they say that loving the homeland is part of faith [1-5].

Patriotism is a social, spiritual trait and quality that expresses a person's love and relationship with the place, land, and home where he was born, raised, and matured. Self-sacrifice is considered the main sign of patriotism, and its highest manifestation is courage.

As humanity progresses and science advances, the increasing number of ideological polygons and information attacks creates the need to change people's minds and build an enlightened world. In such a dangerous situation, we need to understand that the unity of people is the main tool that determines the future of the nation. After all, today we are witnessing the emergence of those who sometimes wrap their intentions in glossy paper and sometimes openly declare their intentions in the media and various social networks.

Today, as our country enters a new era of development, we should especially emphasize the need to strengthen the sense of love for the Motherland, involvement in the future of our country, and appreciation of a peaceful, free, and prosperous life in the minds of our people and youth [2].

The feeling of love for the homeland is not alien to us. Our ancestors, who sacrificed their lives for the homeland, have been immortalized in languages for thousands of years. For example, the courage of Jalaluddin Manguberdi against the oppression of Genghis Khan, the courage of Amir Temur, the innocent blood shed by our Jadids, the sacrifice of Abdulla Avloni for freedom of speech, the advice of Mahmudkhoj Behbudi on educating young people, raising their literacy, and teaching them a foreign language are many examples. It should not be forgotten that the root of this courage and courage

was not self-interest, but patriotism for the future of the Motherland, serving its future, even at the cost of sacrificing one's life.

Patriotism is a great feeling, the Motherland is in the blood, soul, and spirit of each of us, so we must raise the flag of patriotism high and prove our love for the Motherland not only in words but also in deeds. All sections of society, especially those in official positions, must faithfully fulfill all the duties assigned to them, contribute to our development by filling in the gaps, contribute to the development of the nation and the country, increase civic responsibility, and unconditionally obey every law and regulatory document adopted by the state and society. These are the principles of true patriotism.

Research Methodology

The research methodology for this study on patriotism emphasizes qualitative analysis, literature review, and case studies to provide a comprehensive understanding of the concept and its implications for societal development, particularly in the context of educating internal affairs officers to embody patriotism.

Analysis and Results

In our people, the spirit of patriotism is used in harmony with our national values. If the sense of patriotism is an expression of the material culture of our people, then our national values are the spiritual symbol and embodiment of this Motherland. The continuity of our national culture, which has been formed over the years and survived the stages, preserving its national characteristics, being polished over time and enriching its national gloss with new qualities, is in harmony with such a sense of patriotism. Therefore, the sense of patriotism is lifelong. The sense of patriotism is a spiritual and moral experience that occurs due to love and devotion to the homeland, manifested not only in words, but also in deeds. Today, more than 130 nationalities live in our country, and this duty that unites these nations and people and mobilizes them towards a common goal is the duty of patriotism.

To love the Motherland, to serve it faithfully, to sympathize and be a partner in its troubled and joyful days is the spiritual and moral responsibility of every person. The great Uzbek writer Alikhantora Soguniy, writing about the Motherland and the feeling of patriotism, emphasized that "every person should have five sacred things, namely, the Motherland, religion, property, family, and soul. "We, the people of this Motherland. This is a layer of our Motherland of Uzbekistan, we - the Uzbek people, were raised by the bones of our ancestors. So, this Uzbekistan - Turkestan, which we carried on our shoulders, kept in our bosom, and educated with white milk, is our own Motherland" [3, 4].

Today, peace-loving humanity wants an enlightened world. In an enlightened world, spiritual harmony arises between states, political forces, and oppositions. Spiritual harmony is the level of interest in respecting the identity of countries and peoples, and harmonizing their goals for common development, regardless of the level of development, continent, population, social orientation, views, culture, and religion.

A great heart is needed to love one's homeland. Such a heart always inspires a person to true courage and prepares him to sacrifice his life, if necessary, to avoid anything for the sake of the homeland [4].

As the feeling of patriotism develops in every person, it forms a filial and civic duty to the Motherland where he was born and raised, where his umbilical cord blood was shed. Patriotism is not just loving the Motherland, writing poems about it, singing songs, and speaking beautifully, but also showing it in practice, sacrificing one's own interests for its development. Ideas about patriotism should first affect people's healthy beliefs, then their practical actions, and be reflected in their material, economic, and spiritual state for the prosperity of this Motherland.

Patriotism is a social and spiritual-moral character, qualities that express a person's love and relationship with the place, land, and country where he was born, raised, and matured. Patriotism is formed in a specific environment, on the basis of existing spiritual and moral values. A person does not create a sense of patriotism, but rather accepts it ready-made and gradually instills it in his consciousness. Because patriotism is a social feeling that is formed in the process of long historical development [5].

In today's world, where threats that promote patriotism and disaffection are increasing, and various countries and international organizations interpret their specific goals in beautiful words and attractive forms that appeal to people with low levels of knowledge and experience, preserving identity and the Motherland and showing examples of high patriotism in this way is becoming the most urgent issue.

Conclusion

In conclusion, spirituality serves as the most effective and powerful weapon in educating a fully mature and well-rounded employee of the internal affairs bodies who understands the goals and interests of society for the honor of the Motherland and the honor of the nation. Since the sense of patriotism is manifested in a person's relations with society, his worldview, morality, his perception of the world, people, and himself, it awakens a high sense of patriotism in a person, nourishes him spiritually, and becomes a force that drives him to a healthy faith. Although this feeling is important for the personal and social development of a person, it is also important for strengthening his relationships with himself and society, and expanding the opportunities for the younger generation to be an example in total activity.

We must instill in the minds of the future generation, especially future internal affairs officers who are committed to serving the Motherland, a sense of love for their country, and educate truly patriotic officers who will defend our country with all their might when necessary. After all, the stronger their sense of patriotism, the stronger their sense of remaining an integral part of the Motherland, sacrificing their lives for it, and protecting the entire nation as if they were protecting their own family.

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ANALYSIS OF AMIR TEMUR’S ASCENSION TO THE THRONE, MILITARY CAMPAIGNS, AND PERCEPTIONS OF HIS PERSONALITY

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Annotatsiya. Ushbu maqolada Sohibqiron Amir Temurning Temuriylar davlatiga asos solishi va taxtga kelishi, hamda davlat boshqaruvidagi yuzaga kelgan dolzarbliklarga qarshi qo‘llagan choralarining ahamiyati haqida ma‘lumotga ega bo‘lishingiz mumkin.

Kalit so‘zlar: *Amir Temur, Movarounnahr, Kesh, Samarqand, Nasaf, Xuroson, Sharafiddin Ali Yazidiy, Fransiya, Boyazid, To ‘xtamishxon.*

Аннотация. В этой статье можно получить информацию о значении мер, предпринятых Сахибгироном Амиром Темуром, основавшим государство Тимуридов и взошедшим на престол, а также о проблемах, возникших в государственном управлении.

Ключевые слова: *Амир Темур, Моварунnахр, Кеш, Самарканд, Насаф, Хорасан, Шарафуддин Али Езиди, Франция, Баязид, Тохтамышхан.*

Abstract. In this article, you can get information about the importance of the measures taken by Sohibqiron Amir Temur to establish the Timurid state and ascend to the throne, as well as against the emerging issues in state administration.

Keywords: *Amir Temur, Movarounnahr, Kesh, Samarkand, Nasaf, Khorasan, Sharafuddin Ali Yazidi, France, Bayazid, Tokhtamishkhan.*

Introduction

It is known that in the 14th –15th centuries, various political situations arose in Mawarannahr. The region was under Mongol rule. The local population suffered greatly under the Mongol domination. Most of the local rulers did not dare to rise against the Mongols. In such a situation, in the last quarter of the 14th century, Amir

Temur entered the political arena. This article attempts to thoroughly analyze Amir Temur's rise to power and the different views regarding his personality.

Literature Review

In studying the history of Sahibqiron Amir Temur, a critical methodological approach was used. That is, the sources written about Amir Temur and the Timurid state—including Bo'riboy Ahmedov's *"History of Amir Temur,"* Ibn Arabshah's *"History of Amir Temur,"* I. Mo'minov's *"The Role and Place of Amir Temur in Central Asia,"* I. Karimov's *"High Spirituality is an Invincible Force,"* and several other works and research studies—were examined on a critical basis. I believe that the information presented in this article is suitable for scholars of all levels [1-9].

Analysis and Results

In the name of Allah, the Most Gracious, the Most Merciful! All praise be to Allah! In accordance with His will and plan, the scattered affairs of this world are connected, and the flood of ages and eras flows from the source of His decree to the whirlpool of destiny. Allah has made mankind taste certain trials and hardships to test which of them would do better in deeds. Indeed, He is Almighty and Forgiving. In the eighth century of the Hijra, He sent upon them (mankind) a sea of turmoil and chaos, which emerged like a fragment of a pitch-black night and turned toward the people. No one could comprehend what it was. That turned out to be Temur [2].

Amir Temur, also known as Temurbek, was born on April 9, 1336, in the picturesque ancient village of Khoja Ilghor near Kesh (present-day Shahrisabz). His full name was Amir Temur ibn Amir Taraghay ibn Amir Barkul. His father, Amir Taraghay (Taraghaybek), whose birth year is unknown and who died in 1360, was a prominent elder of the Barlas tribe. His ancestors held estates and ruled in the regions of Kesh and Nasaf. His mother, Takina Khotun, came from a respected noble family of Kesh. From an early age, Temur was naturally calm, sharp-minded, and thoughtful. Temurbek first studied at a local school, becoming literate. Under the supervision of teachers, he thoroughly learned the skills of archery, spear handling, horse selection, horseback riding, and swordsmanship [5]. The life and activities of Amir Temur bin Taraghay Bahodir (1336–1405) can be clearly divided into two distinct periods. The first period spans from 1360 to 1386. During this time, Temur fought to establish a strong, centralized state independent from Mongol rule in Mawarannahr. He allied with various social forces such as Turkic and Tajik nobles, aristocrats, and other influential groups who were interested in the unification of Mawarannahr. Together, they resisted feudal lords who acted independently, opposed centralization and unity, and incited internal conflicts. The second period of Temur's activities began in 1386 and lasted until 1402. This phase is marked by his famous military campaigns—referred to as the Three-Year, Five-Year, and Seven-Year campaigns—or, as Sharaf ad-Din Ali Yazdi called them, military expeditions. These campaigns were characterized by his conquests of regions including Hindustan, Iran, Iraq, the Caucasus, Turkey, Egypt, and the southern territories of Russia [3].

At the end of 1370 and the beginning of 1371, Amir Temur launched a campaign toward Eastern Turkestan to liberate the eastern regions from Mongol influence. He

delivered a crushing blow to the Mongol Khan Kepak, seizing Fergana and several other territories. Soon after, the northern Afghan region of Sheberghan also came under his control. Historical sources mention that Amir Temur conducted seven military campaigns toward Moghulistan. His prolonged wars with Amir Qamariddin, one of the most powerful Mongol rulers, aimed to liberate the eastern territories from Mongol domination and establish peace and stability in the land. Amir Temur fought life-and-death battles with Qamariddin, who had unified Kashgar, Issyk-Kul, and the Semirechye region and had overthrown Ilyas Khoja to become the Khan of Moghulistan in 1369. These battles lasted from 1370 to 1389. As a result, the main eastern regions of Mawarannahr were annexed, playing a decisive role in the formation of a centralized state in the region. Before and after coming to power, Amir Temur conducted a number of campaigns. These include:

- The war against Ilyas Khoja, son of Moghulistan Khan Tughlugh Temur (1361–1365),
- The campaign against Amir Husayn in Balkh (1370),
- The subjugation of Fergana, Otrar, Yassi, Tashkent, Hisar, Badakhshan, and Kunduz (1370–1371),
- The subjugation of Herat, Sistan, Mazandaran, Sarakhs, and Sabzavar (1381),
- Seven campaigns against Amir Qamariddin of Moghulistan from 1371 to 1389,
- The wars against the Sufi dynasty rulers of Khwarazm—Husayn, Yusuf, and Sulaymon Sufi (1371, 1373, 1375, 1379, and 1388), resulting in the annexation of Khwarazm.

Following the final Khwarazm campaign in 1388, the rule of Sulaymon Sufi was overthrown, and the region was fully incorporated into Amir Temur's empire. Through years of bloody struggle, major reforms, and skillful diplomacy, Amir Temur successfully freed the country from Mongol oppression and eliminated political fragmentation and internal conflicts. He unified the territories of Mawarannahr and Khorasan, laying the foundation for a centralized state. In addition to building a strong and centralized state, Amir Temur sought to project his power internationally and expand his territories. From the 1380s onward, he launched numerous foreign campaigns, including the "Three-Year" (1386–1388), "Five-Year" (1392–1396), and "Seven-Year" (1399–1404) military campaigns. During these expeditions, he conquered Iran, the Caucasus, Northern India, Syria, Iraq, and much of Asia Minor. Thus, a powerful empire emerged, and his fame spread across the world. However, it is important to note that Amir Temur's conquests cannot be viewed from a single perspective. Some of these campaigns were launched in response to foreign aggressions, others to defend the ideals of Islam from those who insulted them, or as a last resort against persistent foreign hostility. For example, Temur's wars against the Golden Horde Khan Tokhtamysh (1389, 1391, and 1395) were primarily aimed at securing peace and territorial integrity. Tokhtamysh's claims over Khwarazm were a key reason behind these conflicts. The destruction of the Golden Horde by Amir Temur had significant consequences, including paving the way for independence in territories under its control—most notably, the Russian principalities. Furthermore, the life-and-death battle near Ankara in 1402 between Temur's forces and those of Ottoman Sultan Bayezid I occurred largely due to Bayezid's arrogance, intransigence, and refusal to

pursue justice. Amir Temur emerged victorious in this fierce battle, thereby asserting his dominance not only in the East but also in the West. Following this great victory, powerful Western European nations—such as England, France, and Spain—and their monarchs sought diplomatic and commercial relations with him. This clearly reflects the extent of his foresight. His correspondence with European rulers, including Charles VI of France (1380–1422), Henry IV of England (1399–1413), and Henry III of Castile and León (1390–1407), is evidence of his vision. In a letter to Charles VI of France, he proposed establishing trade relations, stating, "The world will flourish through commerce." The French king, in his reply dated June 15, 1403, expressed his satisfaction with the proposal and accepted it gladly [6].

When Amir Temur began governing his state, he started by promoting the Islamic faith. "I have also heard," he said in his *Autobiography*, "that when God honors someone, He bestows His mercy upon him. A person who has attained such divine mercy must be just and compassionate. From the moment I ascended the throne of the sultanate, I always followed these principles and embraced these qualities" [7].

From the very beginning of his career, Amir Temur followed the advice and guidance of his mentors and spiritual leaders. For instance, when Tughlugh Temur Khan, a descendant of Chinggis Khan, was preparing to invade Mawarannahr, he sent a letter to Amir Temur, Khoja Barlas, and Amir Bayazid Jalayir, demanding that they appear before him. At that moment, Amir Temur advised them to go and meet Tughlugh Temur. However, they ignored his advice and fled to Khorasan. Temur himself became uncertain and turned to the Qur'an for guidance. He later wrote: "Whenever I intended to do something, after consulting others, I would then seek a sign from the Qur'an and act according to its ruling. Before going to Tughlugh Temur Khan, I acted in accordance with the decree of the Holy Qur'an" [8].

During Amir Temur's lifetime, the empire was divided into four regions:

- Khorasan, Jurjan, Mazandaran, and Sistan (with Herat as the center) were assigned to Shah Rukh;
- Western Iran, Azerbaijan, Iraq, and Armenia (centered in Tabriz) to Miranshah;
- Fars, or southern Iran (with Shiraz as the center) to Umar Shaykh;
- Afghanistan and Northern India (initially centered in Ghazni, later in Balkh) were granted to Pirmuhammad as fiefs.

During Temur's reign, the nominal heads of state were Chinggisid descendants—Suyurgatmish (1370–1380) and Sultan Mahmud Khan (1380–1402)—but in reality, all power rested in Amir Temur's hands.

Amir Temur died on February 18, 1405, in the city of Otrar during the harsh winter, shortly before setting out on a campaign to China. After his death, the tradition of appointing a khan from the Chinggisid lineage was abolished, and supreme rulers began declaring themselves as kings. Governance in provinces and districts was carried out by *dorughas* appointed by the central government. State affairs were primarily handled by various administrative institutions (*divans*). Matters related to religion and Islamic law were under the authority of the qadi and shaykh al-Islam [1].

The foundation of Amir Temur's state was built upon twelve distinct social classes, as listed in the *Temur's Code* (*Tuzuk-i Temuri*). These were:

1. Sayyids, scholars ('ulama), and virtuous religious figures (mashayikh);

2. Skilled and wise individuals;
3. Devout ascetics and those who had renounced worldly life;
4. Military leaders—*nuyans* (commanders of 10,000 troops), *amirs*, and *mingboshis* (commanders of 1,000);
5. Soldiers (*sipah*) and the general tax-paying population (*ra'iyat*);
6. Special trusted individuals;
7. Viziers and chief secretaries;
8. Scholars and philosophers (*hakims*);
9. Experts in Qur'anic exegesis (*tafsir*) and Hadith studies;
10. Artisans and craftsmen;
11. Sufis;
12. Merchants and travelers.

Amir Temur passed away in the city of Otrar, in a room specially prepared for him in the palace of Governor Berdibek, as he was preparing for his campaign to China. This event occurred on the 17th of Sha'ban in the year 807 AH, corresponding to February 18, 1405 CE. The great founder of the empire departed this life between the evening and night prayers, repeatedly reciting the phrase of monotheism, *"La ilaha illallah"* ("There is no god but Allah") [2]. Some historians attempt to portray us as descendants of Chinggis Khan, even claiming that Amir Temur himself carried Chinggisid blood and belonged to the Mongol nation. But let us reflect: to which nation did our ancestor Amir Temur truly belong? Moreover, during the Soviet era, Soviet publications referred to Amir Temur's forces reaching the outskirts of Moscow by saying, *"the Mongol-Tatar armies besieged Moscow."* In reality, it was only after Sahibqiron (Amir Temur) defeated Tokhtamish Khan and liberated Russia from Mongol domination that the region around Moscow came into prominence. Unfortunately, the truth was only acknowledged in Russian media in 1995. Otherwise, what connection is there between Amir Temur and the Mongols? Where is the devotion, the patriotism in this distortion? Where is the national pride and dignity? The point is, every nation must safeguard its history from foreign influence and distortion [4].

Conclusion

Our great ancestor, Sahibqiron Amir Temur, ruled over the Timurid Empire for 35 years. During his reign, the borders of the state expanded significantly. Along with conquering other lands, he also initiated reconstruction and beautification efforts in those regions. It is well known that he even named certain areas within our homeland after famous foreign cities—such as Damascus and Baghdad. Through these actions, Sahibqiron became known not only within our own country but also abroad for his humanitarian values and contributions to civilization. However, there are varying opinions about Amir Temur's personality. Nevertheless, we are confident that Amir Temur, with his multifaceted achievements, is a great historical figure who can serve as a role model for future generations. Based on the information presented above, let us analyze the different perspectives on Amir Temur's character.

- According to Ibn Arabshah's *History of Amir Temur*, the campaigns Temur conducted in southern Russian territories were extremely harsh. This may explain why,

in those regions, the local population came to view Amir Temur as a ruthless ruler. However, it should not be forgotten that his victory over Tokhtamish Khan freed the Russian people from paying tribute to the Mongols—something they had been subjected to for over 300 years.

- Amir Temur's triumph over Bayezid Yildirim played a key role in saving many European countries from a major threat. It is well documented that several European states, including Germany, France, and the Kingdom of Castile, sent multiple diplomatic missions to establish relations with him. The French, in particular, crafted a golden statuette in his honor with the inscription "To the Savior of Europe"—a clear sign of the respect he commanded and his humanitarian character.

- Amir Temur did not invade territories without warning. He often spared regions that paid tribute (moli amon) and implemented reconstruction and development projects in conquered areas. His efforts extended beyond foreign lands to his own homeland, where he also undertook beautification and urban improvement projects. He even named some domestic areas after famous foreign cities, such as Damascus and Baghdad.

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THE EFFECT OF VARIOUS FACTORS ON THE REACTION YIELD OF BENZOYL CHLORIDE WITH SOME 5-SUBSTITUTED AMINO-1,3,4-THIODIAZOLINE-2-THIONES

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Annotatsiya. 5-almashgan amino-1,3,4-tiodiazolin-2-tionlarning benzoilxlorid bilan reaksiyasi o‘rganildi. Erituvchi va asos turi, harorat va vaqt kabi omillarning reaksiya sharoitlariga ta'siri tahlil qilindi. Eksperimental natijalarga ko‘ra, 40 °C haroratda 4 soat davomida dixlorometan erituvchisi va piridin asosi ishtirokidagi reaktsiyalar eng yuqori mahsulot unumiga (85-88%) ega bo‘ldi. Sintezlangan S- va N^3-benzoil hosilalarining tarkibi FTIR-spektral analizi yordamida o‘rganildi. Olingan birikmalar keyingi biologik faol moddalar sintezida oraliq mahsulot sifatida foydalanish uchun istiqbolli hisoblanadi.

Kalit so‘zlar: *1,3,4-tiodiazolin; benzoil xlorid; sintez;erituvchi; asos; FTIR-spektri.*

Аннотация. Изучена реакция 5-замещенных амино-1,3,4-тиодиазолин-2-тионов с бензоилхлоридом. Проанализировано влияние таких факторов, как тип растворителя, тип основания, температура и время на условия реакции. Согласно экспериментальным результатам, реакции в присутствии растворителя дихлорметана и основания пиридина при 40 °C в течение 4 часов имели наибольший выход продукта (85–88%). Состав синтезированных S- и N^3-бензоильных производных был изучен с помощью ИК-Фурье-спектрального анализа. Полученные соединения перспективны для использования в качестве промежуточных продуктов в синтезе дальнейших биологически активных веществ.

Ключевые слова: *1,3,4-тиодиазолин; бензоилхлорид; синтез; растворитель; основание; ИК-Фурье спектр.*

Abstract. The reaction of 5-substituted amino-1,3,4-thiodiazoline-2-thiones with benzoyl chloride was studied. The effects of factors such as solvent type, base type, temperature, and time on the reaction conditions have been analysed.

According to the experimental results, reactions in the presence of dichloromethane solvent and pyridine base at 40 °C for 4 hours had the highest product yield (85–88%). The composition of the synthesised S- and N^3-benzoyl derivatives was studied using FTIR-spectral analysis. The obtained compounds are promising for use as intermediates in the synthesis of further biologically active substances.

Keywords: *1,3,4-thiodiazoline; benzoyl chloride; synthesis; solvent; base; FTIR-spectrum.*

Introduction

Currently, heterocyclic compounds containing nitrogen and sulfur atoms, in particular 1,3,4-thiodiazole derivatives, are of great importance in the fields of pharmaceuticals, agriculture, materials science, and the synthesis of biologically active substances [1-3]. 5-substituted amino-1,3,4-thiodiazoline-2-thiones have high reactivity, and they can be reacted with various carboxylic acid chlorides through the ambifunctional thioamide group, which is the main synthesis point, to synthesise S- or N^3-benzoyl derivatives [4, 5, 11-15].

These derivatives have many biologically active properties and have been found to exhibit antibacterial, antifungal, antitumor, and other types of activity [6, 7, 16]. Also, research is being conducted to increase the biological efficacy of 1,3,4-thiodiazole derivatives through chemical modification [8].

However, the effects of factors such as solvent, temperature, reaction time, and base type on the acylation reactions of 5-substituted amino-1,3,4-thiodiazoline-2-thiones have not been thoroughly studied [17, 18]. We focused our research on a thorough analysis of this chemical system and on the identification of conditions for obtaining practically important S- or N^3-benzoyl derivatives in high yields.

In addition, modified molecules based on 1,3,4-thiodiazoline may serve as a promising platform for the development of new generation antibiotics and antitumor agents [9].

Research Methodology

100 ml ground-glass flask, Forshtoss, reflux condenser, magnetic stirrer, heating oven, dropping funnel, thin-layer chromatography paper, chromatography column, dropping funnel, vacuum pump, 50-100 ml beakers, pipette, shaker, FTIR-4600 JASCO spectrometer.

In a 100 ml flask equipped with a reflux condenser, 1.11 g (5 mmol) of 5-substituted-amino-1,3,4-thiodizoline-2-thiones were dissolved in 40 ml of solvent (dichloromethane, acetone, ethanol, THG) at 20, 40 and 60°C with stirring using a stirrer, and triethylamine (5 mmol) was added thereto (in other experiments, pyridine and sodium bicarbonate were used). After that, a solution of 0.63 ml (0.77 g; 5.5 mmol) of benzoyl chloride dissolved in 10 ml of solvent (dichloromethane, acetone, ethanol, THG) was added dropwise to the reaction mixture over 10 min. The reaction mixture was then maintained at 20, 40 and 60°C for 4 to 8 h.

Then, a sample of the reaction mixture was taken and thin-layer chromatography was performed (eluent benzene:alcohol 4:1) to determine whether a new compound was formed and whether the reaction had proceeded. After the reaction was complete,

the chloride salt of the reaction mixture was filtered off. The solvent of the filtrate was evaporated, the residue was recrystallized, the crystals were isolated, the liquidus temperatures were determined, and the reaction yields were determined.

Analysis and Results

During the study, a series of 5-substituted amino-1,3,4-thiodiazolin-2-ones were synthesized and reacted with benzoyl chloride. The reaction conditions (solvent, temperature, type and amount of base) were studied step by step, and the yields of the resulting compounds were compared.

The reactions were carried out in solvents such as ethanol, dichloromethane (CH_2Cl_2), tetrahydrofuran (THF) and acetone; according to the experimental results, dichloromethane was found to be the most effective solvent. Dichloromethane ensures a faster reaction and helps to precipitate the main product in a crystalline state, while in ethanol, the reactions were slower, and sometimes additional by-products were formed.

The results obtained on the effect of the nature of the solvents on the reaction yield are presented in Table 1.

Table 1. The effect of the nature of solvents on the reaction yield.

Solvent	Yield (%)
Dichloromethane	82–88
THF	75–80
Ethanol	60–70
Acetone	65–72

Pyridine, triethylamine, and sodium bicarbonate ($NaHCO_3$) were tested as basic compounds for the reaction. According to the results, the highest reaction efficiency was observed in the presence of pyridine, attributed to its ability to effectively neutralize the acidic properties of benzoyl chloride. In contrast, the product yield was relatively low with triethylamine and $NaHCO_3$. The results regarding the effect of temperature and time on the reaction yield are presented in Table 2.

Table 2. The effect of temperature and time on reaction yield.

Temperature (°C)	Reaction time (hours)	Yield (%)
20	8	65–70
40	4	85–88
60	4	70–75

The reaction temperature was studied at temperatures of 20–60°C. Optimal results were observed at 40°C. At 20°C, the reaction proceeded slowly, and at 60°C, it was found that some compounds began to decompose.

The composition of the obtained compounds was studied by FTIR spectra. Peaks in the region of 1650-1680 cm^{-1} are characteristic of C=O, peaks in the region of 3200-3400 cm^{-1} are characteristic of N–H. This indicates that the benzoylation was successfully carried out.

According to the results of the general discussion, under optimal conditions, i.e., dichloromethane solvent, pyridine base, at a temperature of 40°C and for 4 hours, the reactions proceed in high yields (85–88%); the choice of solvent and the base has a

significant impact on the reaction efficiency. They directly depend on the polarity of the reaction medium, its acidic/basic properties, and its interaction with substrates. Increasing the temperature activates the kinetics of the reaction and increases its rate, but at excessively high temperatures, there is a risk of decomposition of the main products. As a result, the synthesized derivatives can be used as promising intermediates for the synthesis of biologically active compounds or pharmaceutical substances.

Conclusion

It was observed that high efficiency can be achieved when the synthesis is carried out in dichloromethane solvent, pyridine, and at a temperature of 40 °C for 4 hours to obtain S- or N^3-derivatives based on the reaction of 5-substituted amino-1,3,4-thiodiazoline-2-thiones with benzoyl chloride. Under such conditions, the reactions proceed with a yield of 85–88%, forming pure crystalline products. The synthesis of these substances allows them to be used in the future as promising intermediates for substances with high biological activity or pharmacological studies.

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UDC: 5, 543, 543.4

IMMOBILIZATION MECHANISM AND SPECTROSCOPIC ANALYSIS OF THE ORGANIC REAGENT ERIOCHROME BLACK T ON A FIBROIN SUPPORT

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Annotatsiya. Maqolada erioxrom qora T tuzining mahalliy ipak chiqindisidan olingan fibroin tolaga immobillanishining optimal sharoitlari, kimyoviy bog‘lanish mexanizmi, IQ tahlili, nur qaytarish spektroskopik va nur yutish xususiyatlari tahlil etilgan. Fibroin tolasiga immobillangan erioxrom qora T tuzi pH 2,11-5,65 oralig‘ida, 25-30 °C haroratda, 0,2 gramm tola 30 daqiqa davomida 114,7 milligramm reagentni immobillashtirishi aniqlandi. Ushbu erioxrom qora T tuzini fibroin tolasiga immobillash orqali chiqindi suvlar tarkibidagi metall ionlarini aniqlashda qo‘llaniladigan kimyoviy sensor ishlab chiqildi. Mazkur kimyoviy sensor ilk bor yaratildi.

Kalit so‘zlar: *erioxrom qora T, fibroin tola, IQ tahlil, nur qaytarish spektroskopiya, nur yutulish spektroskopiya, chiqindi suv.*

Аннотация. В статье анализируются оптимальные условия иммобилизации соли эриохрома черного Т на фиброиновое волокно, полученное из отходов местного шелка, механизм его химического связывания, а также его характеристики, определенные методами ИК-анализа, спектроскопии диффузного отражения и поглощения. Установлено, что при оптимальных условиях (pH 2,11–5,65 и температуре 25–30 °C) 0,2 грамма фиброинового волокна иммобилизуют 114,7 миллиграмма реагента эриохрома черного Т в течение 30 минут. Путем иммобилизации соли эриохрома черного Т на фиброиновое волокно был

разработан химический сенсор для определения ионов металлов в сточных водах. Данный химический сенсор создан впервые.

Ключевые слова: *эриохром черный Т, фиброиновое волокно, ИК-анализ, спектроскопия диффузного отражения, абсорбционная спектроскопия, сточные воды.*

Abstract. This article analyzes the optimal conditions for the immobilization of Eriochrome Black T salt onto fibroin fiber derived from local silk waste, its chemical bonding mechanism, and its characterization through IR analysis, diffuse reflectance spectroscopy, and absorption properties. It was determined that 0.2 grams of fibroin fiber immobilizes 114.7 milligrams of Eriochrome Black T reagent within 30 minutes under optimal conditions of pH 2.11–5.65 and a temperature of 25–30 °C. By immobilizing Eriochrome Black T salt onto the fibroin fiber, a chemical sensor for the determination of metal ions in wastewater was developed. This chemical sensor has been created for the first time.

Keywords: *Eriochrome Black T, fibroin fiber, IR analysis, diffuse reflectance spectroscopy, absorption spectroscopy, wastewater.*

Introduction

Water is one of the most essential elements for human life. However, with the increasing demand for water, humanity is facing serious challenges regarding water quality. This is primarily due to the contamination of wastewater with heavy metal ions from industrial and manufacturing processes [1]. Today, one of the most pressing issues is the complete removal of heavy metal ions from wastewater, as well as treating it to a level that poses no risk to the environment and all living organisms. Heavy metal ions have been found to have adverse effects on living organisms, even at very low concentrations [2]. Metal ions such as Cu(II), Co(II), and Ni(II) are still used in many technological processes [3, 4], and therefore, aqueous effluents often contain significant concentrations of these metal ions. The release of such waste into the environment has serious negative consequences for the quality of ecosystems, mainly because metal ions are considered persistent pollutants that cannot be destroyed or degraded and have a tendency to accumulate [5, 6]. The accumulation of such metal ions in the human body can lead to various serious diseases (e.g., neurological, cardiovascular, renal, digestive, etc.) [7, 8].

Numerous modern and sophisticated methods (e.g., flame atomic absorption spectrometry, inductively coupled plasma-mass spectrometry, inductively coupled plasma optical emission spectrometry, neutron activation analysis, anodic stripping voltammetry, etc.) have been developed for the rapid detection and analysis of Cu(II), Co(II), and Ni(II) ions in aqueous media. These methods are applied to various types of samples in single or multi-component systems [9–13]. Unfortunately, many of these methods are not suitable for detecting metal ions in industrial analytical laboratories. This is due to their high maintenance costs, expensive equipment, multi-step and complex sample preparation, time-consuming procedures, and the need for meticulously controlled experimental conditions. In this context, the development of a

rapid, simple, and inexpensive method applicable for routine analysis in the industrial sector remains an area of significant interest.

UV-Vis molecular absorption spectrometry (or spectrophotometry) is an effective tool for developing simple, fast, and affordable analytical methods for detecting various analytes [14–17]. This method is based on the ability of colored solutions containing the analyte to absorb radiation at a specific wavelength [18]. Its key features (simplicity, short analysis time, flexibility, applicability over a wide concentration range, accuracy, low-cost equipment, and low price) [19] make this method convenient for detecting various analytes, including metal ions, in industrial laboratories. In this study, a natural polymer was used to immobilize an organic reagent for the determination of Cu(II), Ni(II), and Co(II) ions. The amount of polluting gases released into the environment during the production of synthetic fibers is significantly higher than that for natural fibers [20]. In many applications, including home furnishings, light vehicle tires, door panels, cargo shelves, and packaging pallets, the demand for natural fibers instead of synthetic ones is steadily increasing [21, 22]. Natural fibers have several advantages over synthetic fibers: low cost, low density, biodegradability, recyclability, being non-harmful to the skin, relatively high strength and stiffness, environmental friendliness, and ease of processing, among other properties [23, 24]. The functional $-NH_3^+Cl^-$ groups on the organic polymer sorbent, activated by HCl acid, form a strong bond with the $-OSO_2^-Na^+$ functional groups of the organic reagent. Such chemical sensors are important for the determination of metal ions in solutions.

To study the optimal conditions and immobilization mechanism of Eriochrome Black T, used for the detection of metal ions, with fibroin fiber obtained from local silk waste, and to analyze the spectra obtained from IR and diffuse reflectance spectrometers.

Research Methodology

Standard solutions of analytical reagents. Eriochrome Black T (systematic name: Sodium 1-(1-hydroxy-2-naphthylazo)-6-nitro-2-naphthol-4-sulfonate salt) was selected as the immobilized analytical reagent. It was purchased from "Khimreaktivinvest" LLC, Tashkent, Uzbekistan (CAS No: 1787-61-7). A 1×10^{-3} M stock solution of Eriochrome Black T was prepared using distilled water. Subsequent experiments were performed by diluting the 1×10^{-3} M solution to prepare a 1×10^{-4} M working solution. This standard solution was used in the immobilization processes. The molecular structure of Eriochrome Black T is shown in Figure 1.

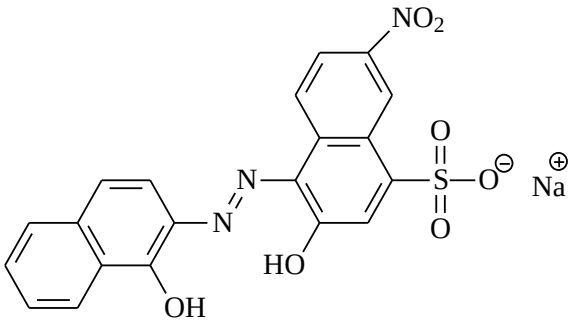

Figure 1. Molecular structure of analytical reagent, Eriochrome black T salt.

Buffer solutions. Acetate-ammonia buffer solutions ($H_3PO_4 + H_3BO_3 + CH_3COOH$) were used to maintain the acidity and basicity of the investigated systems. This buffer solution was prepared from 0.04 M H_3PO_4, H_3BO_3, and CH_3COOH solutions (pH = 1.31).

Preparation of Ammonia Buffer Solution. 5.4 g (0.1 mol) of NH_4Cl was weighed out and dissolved in 200 mL of distilled water. Approximately 17 mL (0.25 mol) of a 25% ammonia solution was added. The solution was mixed thoroughly. The solution was then diluted to a final volume of 500 mL with distilled water.

Preparation of Citrate Buffer Solution. The buffer was prepared by mixing 210 mL of a 0.1 M citric acid solution with 290 mL of a 0.1 M sodium citrate solution. The mixture was stirred, and the pH was verified with a pH meter if necessary. The final volume of the solution was brought to 500 mL with distilled water.

Preparation of the Polymer Matrix. In this study, the organic reagent Eriochrome Black T was immobilized onto fibroin fiber isolated from local silk waste. The purpose of the immobilization was to enhance the analytical efficiency of the Eriochrome Black T salt for the determination of metal ions such as Cu^{2+}, Ni^{2+}, and Co^{2+} in solution. The fibroin fiber was extracted from silk cocoon waste. The main chain of silk fibroin and the lysine amino acid residues contain $-NH_2$ groups. The $-NH_2$ groups in the fibroin fiber facilitate the immobilization process.

Apparatus and Methods. All experiments were conducted using high-precision instruments. Reagents were weighed on an AS 220.R2 Plus analytical balance (manufactured in Poland). Deionized water required for solution preparation was obtained using an EASYpure RoDI system (manufactured in the USA). The pH of the solutions was measured with a FiveEasy F20 pH meter (Mettler-Toledo GmbH, Switzerland). The absorption wavelength of the reagent, as well as the absorbance of the solutions before and after sorption, were determined using SPECORD 50 and UV-1900i spectrophotometers (manufactured in Germany).

Analysis and Results

The spectrophotometric properties of Eriochrome Black T salt immobilized on the fibroin support were investigated. The immobilization efficiency of the Eriochrome Black T organic reagent on the fibroin support was studied. Figure 1 shows the absorption spectra of the Eriochrome Black T organic reagent solution before (1) and after (2) immobilization on the fibroin support. The results showed that the absorbance of the Eriochrome Black T salt solution was 0.913. After immobilization on the fibroin support, the absorbance decreased to 0.225. This decrease in absorbance indicates that the Eriochrome Black T salt was successfully immobilized onto the fibroin support. The immobilization efficiency of Eriochrome Black T on the fibroin support was evaluated using the following equation:

$$R\% = 1 - \frac{A}{A_0};$$

where A_0 is the absorbance of the Eriochrome Black T reagent solution before immobilization, and A is the absorbance of the Eriochrome Black T reagent solution after immobilization. The immobilization efficiency of Eriochrome Black T on the fibroin support was determined to be 75.3%, which indicates that 75.3% of the Eriochrome Black T was immobilized onto the matrix. The Eriochrome Black T salt

interacted with the fibroin support through the formation of coordinate bonds between the amino groups of the fibroin and the oxygen atoms of the sulfonate group of the analytical reagent. The resulting immobilized reagent is thermodynamically stable under harsh conditions. Effect of pH on the Immobilization of Eriochrome Black T onto Fibroin Fiber. It was determined that the immobilization of the Eriochrome Black T organic reagent onto the fibroin fiber was maximal in the pH range of 2.11 to 5.65. The optimal pH environment is of great importance for the immobilization of organic reagents onto fibers, as it converts both the reagent and the fiber into their ionic forms, which in turn affects the immobilization process [19]. The concentration of hydrogen ions in the solution is a critical factor. Most of the organic reagents and chelating sorbents used for the separation and determination of metal ions in solution are weak acids. The results of the effect of pH on the immobilization onto the fiber are presented in Table 1.

Table 1. Optimal pH results for immobilization of eriochrome black T organic reagent on fibroin carrier [λmax, nm = 530, l=1.0 cm, t=20±50 °C].

Buffer solution		pH	1	2	3	4	5	6	7	8	9	10	11	12
OR	Carrier	R%												
Eriochrome black T	Fibroin	Universal	45	74,8	75,2	75,3	74,5	60	57	51	42	33	-	-
		Citrate	-	63,5	68,7	71,2	65.3	55	-	-	-	-	-	-
		Ammoni-acal	-	-	-	-	-	-	-	34	45	47	32	30

As is evident from the table, the effect of pH on the immobilization is significant. It can be concluded that in a weakly acidic medium, the Eriochrome Black T organic reagent was effectively immobilized onto the fibroin fiber with an efficiency of 75.3%.

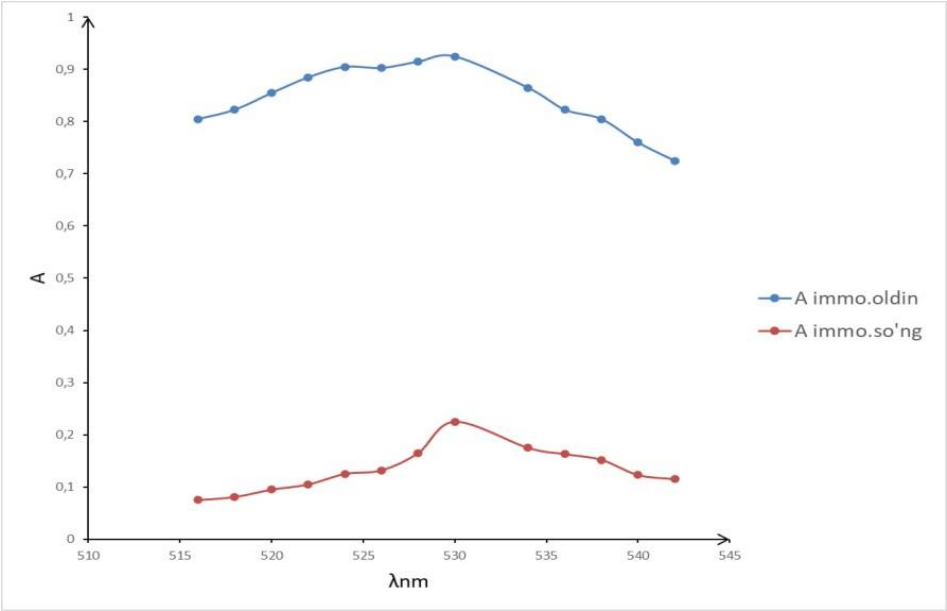

Figure 2. The absorption spectra of the Eriochrome Black T salt before and after immobilization.

It was determined that at a wavelength of λ = 530 nm, the absorbance of the Eriochrome Black T organic reagent solution was A = 0.913 before immobilization. After immobilization, the absorbance of the solution at the same wavelength was found to be A = 0.225. This indicates that the Eriochrome Black T salt was successfully immobilized on the fibroin support.

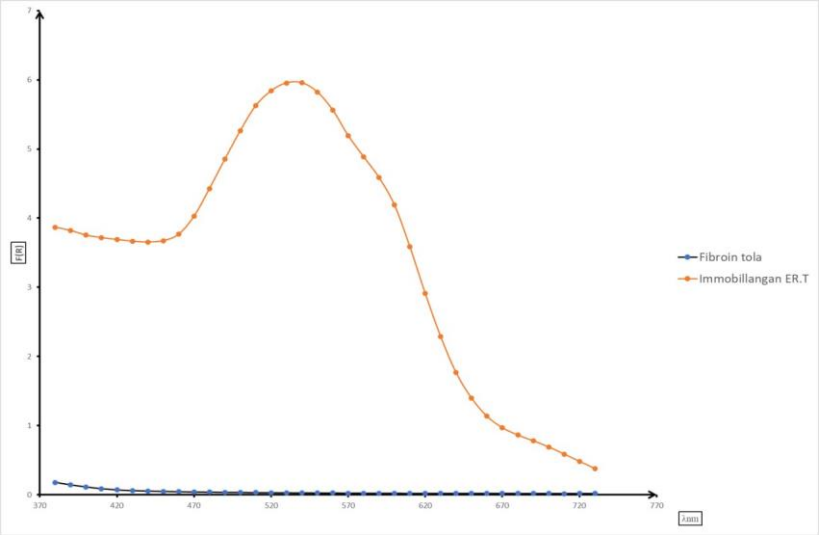

Figure 3. Diffuse reflectance spectra of the fibroin fiber and the immobilized fibroin fiber.

When the degree of immobilization was determined using diffuse reflectance spectrometry, it was observed that the wavelength of maximum absorption for the immobilized fiber exhibited a bathochromic shift of 8 nm, resulting in an absorption maximum at 538 nm (Figure 3). All subsequent investigations on the fiber were conducted at 538 nm. The immobilization efficiency was determined to be 76.2%. The concentrations of the reagent and metals on the fiber can be determined using the described method.

The immobilization process of Eriochrome Black T onto the fibroin fiber, and the functional groups through which the reaction occurred, were confirmed using infrared (IR) spectroscopy (Figures 4-5). The infrared spectrum of the Eriochrome Black T organic reagent is presented.

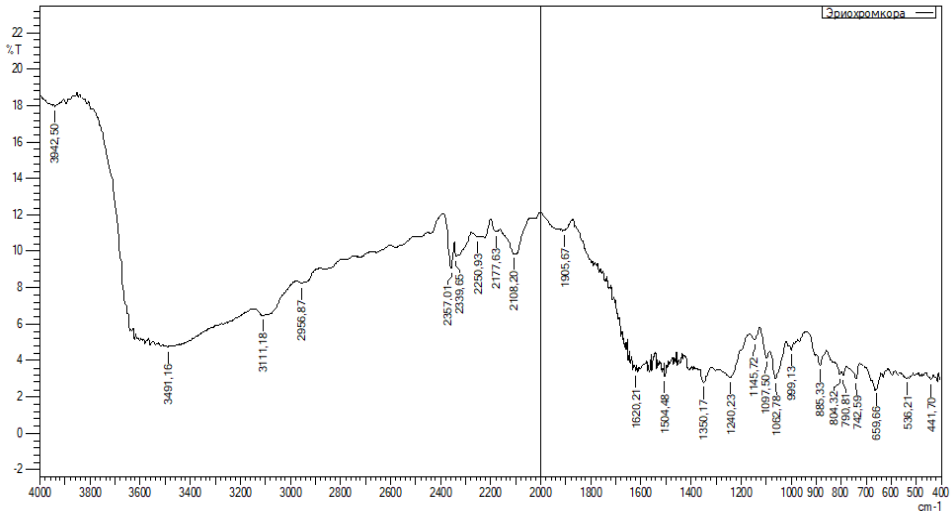

Figure 4. IR spectrum of the Eriochrome Black T organic reagent.

According to the analysis, the absorption band in the 3200–3600 cm^{-1} range is attributed to the -OH group bonded to the aromatic ring. In the IR spectrum of Eriochrome Black T, the absorption band observed at 3491.16 cm^{-1} indicates the presence of the -OH group. The absorption band in the 1440–1410 cm^{-1} range indicates the presence of the -N=N- (azo) bond linked to the aromatic ring.

The absorption band in the 1510–1570 cm^{-1} region is assigned to the asymmetric stretching of the Ar-NO_2 group, while the band in the 1320–1360 cm^{-1} region corresponds to its symmetric stretching. The absorption band at 1350.17 cm^{-1} in the IR spectrum of Eriochrome Black T confirms the presence of the symmetric Ar-NO_2 group in the salt. The absorption bands in the 1278–1027 cm^{-1} region are characteristic of the -SO_2-O-R- (sulfonate) group, and the band around 640 cm^{-1} is attributed to the -O-Na group. The band at 1240.23 cm^{-1} in the IR spectrum of Eriochrome Black T is characteristic of the -SO_2-O-R- group.

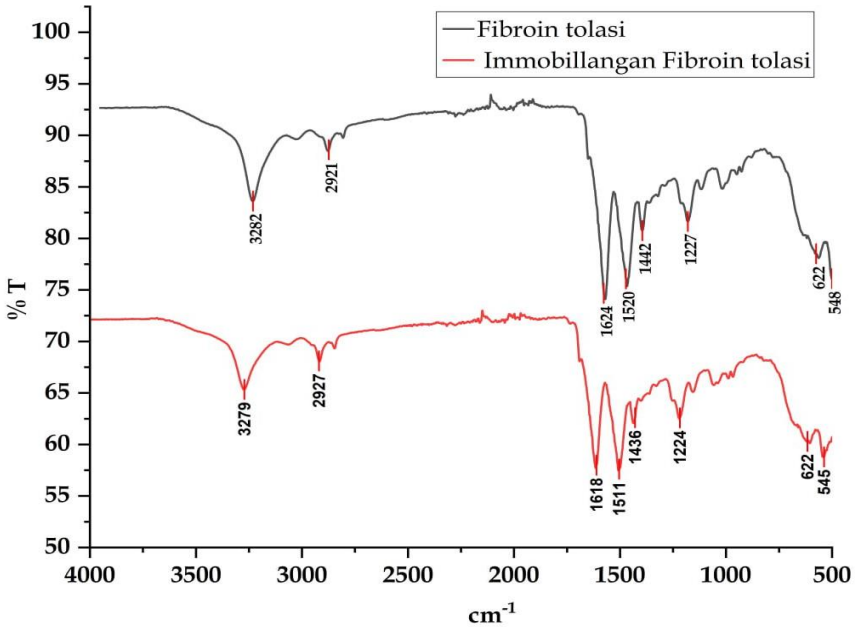

Figure 5. IR spectra of fibroin fiber (black line) and the immobilized fibroin fiber (red line).

Figure 5 presents the infrared spectrum of the Eriochrome Black T organic reagent immobilized onto fibroin fiber. According to the spectrum, the absorption intensity in the 3562.8–3736.4 cm^{-1} region is characteristic of free -OH groups [25]. The absorption band at 3285.14 cm^{-1} is attributed to the -NH- bond of the peptide linkage. The shift of this band from 3282 cm^{-1} in the native fibroin sample to 3279 cm^{-1} in the immobilized fiber indicates an interaction involving the -NH- group. The shift of the absorption band from 2921 cm^{-1} in the fibroin sample to 2927 cm^{-1} in the immobilized fiber, accompanied by an increase in intensity, indicates that the methyl group moieties have undergone a change.

In the IR spectrum, the absorption band at 1624 cm^{-1} in the fibroin sample is observed to shift to 1614 cm^{-1}. This suggests an interaction involving the -COOH (carboxyl) groups. The absorptions in the 1550–1485 cm^{-1} region are attributed to the -NH_2 groups of the amino acids. The shift of the band from 1520 cm^{-1} in the IR spectrum of the fibroin sample to 1511 cm^{-1} in the immobilized fiber provides evidence that the immobilization occurred via the -NH_2 groups of the fibroin fiber. The

absorption frequency at 1240 cm^{-1} in Eriochrome Black T, characteristic of the -SO_2-O-R- group, shifts to 1224 cm^{-1} in the immobilized fibroin fiber, which further confirms the immobilization of the Eriochrome Black T reagent.

Conclusion

The optimal conditions for the immobilization of Eriochrome Black T salt onto fibroin fiber were determined, and its chemical bonding mechanism, IR analysis, diffuse reflectance spectroscopic, and absorption properties were analyzed. The binding of Eriochrome Black T to the fibroin fiber in the pH range of 2.11–5.65 was confirmed by infrared spectrometry, and diffuse reflectance and absorption spectra were obtained. It was demonstrated that at 25–30 °C, 0.2 g of the fiber immobilizes 114.97 mg of the reagent within 30 minutes. For the first time, a chemical sensor for the determination of Cu^{2+}, Ni^{2+}, and Co^{2+} metal ions in wastewater has been developed by immobilizing Eriochrome Black T salt onto a fibroin fiber support.

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UDC: 5, 551, 910.3

THE SIGNIFICANCE OF ARCHITECTURAL MONUMENTS IN THE TASHKENT REGION

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Annotatsiya. Ushbu ilmiy ishimizda birinchi marta Toshkent viloyatining madaniy-tarixiy rekreatsion va turistik resurslari tasnifi amalga oshirildi, so‘ngra ularning daryolar havzalari va terrasalarida tarqalishi va joylashishi o‘rganildi. Daryo havzalarining o‘ng va chap terrasalarida madaniy, tarixiy, rekreatsion va turistik resurslarni taqsimlashda farqlar aniqlandi.

Kalit so‘zlar: *rekreatsiya resurslari, turistik resurslar, tabiiy va madaniy-tarixiy rekreatsion va turistik resurslar, arxeologik, me’moriy, monumental ob’ektlar, ziyoratgohlar, ziyoratgohlar.*

Аннотация. В работе впервые проведена классификация культурно-исторических рекреационных и туристских ресурсов Ташкентской области, затем изучено их распределение и размещение в бассейнах рек и их террасах. Выявлены различия в распределении культурно-исторических рекреационных и туристских ресурсов на правых и левых террасах бассейнов рек.

Ключевые слова: *рекреационные ресурсы, туристские ресурсы, природные и культурно-исторические рекреационные и туристские ресурсы, археологические, архитектурные, монументальные объекты, святыни, места паломничества.*

Abstract. In the work, the cultural and historical recreational and tourist resources of the Tashkent region were first classified, then their distribution and location in river basins and their terraces were studied. Differences in the distribution of cultural and historical recreational and tourist resources on the right and left terraces of river basins were revealed.

Keywords: *recreational resources, tourist resources, natural and cultural-historical recreational and tourist resources, archaeological, architectural, monumental sites, shrines, pilgrimage sites.*

Introduction

In every science or practical field, classifying the object of research is of great importance, because through classification, the content, essence, and uniqueness of each subject, event, and phenomenon become clearer.Classification – (from the Latin words classis – class, rank, and facio – I separate, I form, I sort) is one of the methods of systematization, arrangement, dividing objects of one category into classes based on features that distinguish them from objects of another category and are more characteristic of objects of this category [1].

From the definition, it is clear that recreational and tourist resources can be divided or combined into groups based on certain characteristics, in a certain order, while maintaining the status or scope of each.

The science of recreation and tourism geography, like other geographical sciences, classifies recreational and tourist facilities and resources, which are numerous and diverse, but have their own unique characteristics.

There are several approaches among scientists on the classification of recreational-tourist resources. Among them, the Polish scientist M. Troisy, the French scientist P. Deferem (2006), the Russian T.T. Khristov (2007) and A.D. Chudnovsky (2018) specifically focused on the solutions to this problem.In these works, a territorial approach is taken depending on the taxonomic units that are the object of recreational and touristic research [2-6].

According to the classification of recreational and tourist resources in our country Geographers such as Soliev A., Usmonov M.R., Usmonova R., Nigmatov A.N., Shamuratova N.T., Yakubjonova Sh.T., Kamolov B.Kh., Shomurodova Sh.G'. The work of the Ministry of Tourism of the Republic of Uzbekistan, which mainly focused on the issues of using the tourism potential of our country, has been partially discussed. However, no separate studies have been conducted on the classification of recreational

and tourist resources. In general, the existence of different approaches to the classification of recreational and tourist resources requires further improvement in this area.

Recreational-tourist resources cannot be used directly for tourism purposes. These resources can be used in tourism activities only by using many additional services, such as accommodation, meals, travel and transportation services. For this reason, it can be seen that there are one-sided approaches in the above classifications.

The main part. The development of science and technology and the passage of time have given rise to a growing interest in the magnificent buildings built by our ancestors in the past, and in the palaces built by famous leaders of mankind, which have now given rise to a type of tourism known as historical monument tourism and architectural tourism.Anthropogenic recreational-tourist objects consist of historical and cultural monuments, architectural monuments, etc.

The territory of Tashkent region has a rich cultural and historical heritage, of which 684 were studied. Including 522 archaeological monuments, 7 architectural monuments, 57 monumental art monuments, and 98 pilgrimage sites and shrines. The distribution and location of these cultural and historical recreational and tourist resources in the region were studied along river basins and terraces.

Archaeological monuments: There are a total of 270 (51.7%) in the Chirchik river basin, 115 (22.0%) are located on the left-side terraces, and 69 (13.2%) are located on the right-side terraces. The remaining 86 (16.5 %) are located in the conical spreads and terraces of streams on the mountain slopes, of which 65 (12.4 %) are located on the right side of the mountain slopes, and 20 (3.8 %) are located on the left side of the mountain slopes.

There are a total of 234 (44.8%) (5 of which belong to the Gijigen network) in the Ohangaron river basin, 124 (23.8%) are located on the left-side terraces, and 46 (8.8%) are located on the right-side terraces. All 5 (0.9%) archaeological sites in the Gijigen network are located on the right-hand terraces. The remaining 59 (11.3 %) are located in the conical expansions and terraces of streams on the mountain slopes, 34 (6.5 %) of them are located on the slopes of the Qizilnura ridge on the right side, and 25 (4.8 %) are located on the slopes of the Kurama ridge on the left side.

There are a total of 21 (4.0%) in the Syrdarya basin, 1 (0.2%) is located on the left-side terraces, and 20 (3.8%) is located on the right-side terraces. Researching the role of such architectural shrines, which have been carefully preserved for centuries, in the history of our national spirituality is considered one of the current issues.

One such monument is the architectural monument: there are 4 (57.1%) in the Chirchik river basin, one (14.3%) is located on the left terraces, 2 (28.6%) are located on the right terraces, and 1 (14.3%) is located on the slopes of the Ugom ridge (on the right).

There are only 2 (28.6%) in the Akhangaran River basin, both of which are located on the right side of the low mountains on the slopes of the Kyzylnura mountain, and are not present on the terraces.

There is only 1 (14.3%) in the Syrdarya basin, located on the right-hand terraces, and none on the left-hand terraces.

Historical monuments tourism - interest in seeing historical monuments in the cities of Bukhara, Khiva, Samarkand, Shakhrisabz, Tashkent, Kokand and in the districts of our Republic.

Architecture tourism– interest in the remains of ancient cities, the ruins of ancient fortresses, and archaeological finds about the life of ancient peoples.

Architectural monuments in Tashkent region It is found in all regions of the region. This fact indicates that the region is one of the most ancient inhabited regions in our Republic.

There are madrasahs, mosques, mausoleums, caravanserais, bridges and other architectural monuments in Tashkent region. The most preserved architectural monuments in the city are:the ancient Zangi Ota complex: Anbar Bibi Mausoleum, (XV-XVI), Darvoza Khana (1914-1915), Kizil Mazar (XVI-XVIII century) mausoleum, Sardoba (XIX century), Sarmozor (XIX century) towerarchitectural monuments have been preserved. We will describe some of them.

Zangiota (Mausoleum of Black Grandfather Khoja)-architectureis an architectural monument, named after the famous scholar and great ascetic Oikhoja ibn Tajhoja, who lived and worked in the 12th -13th centuries. This monument is one of the largest pilgrimage sites not only in Uzbekistan, but also in Central Asia. The MausoleumBuilt in the 15th century. Located on the right side of the Chirchik River, on the third terrace of the upper ridge, near the village of “Khoja Mazar” in the Zangiota district. Geographic coordinates:41°20'18.86" N, 69°15'97.51" east. Absolute height is 394m, rectangular in shape, area 95.7 sq.m., diameter 196.6 x 190.3 m.

Figure 1. Mausoleum of Black Grandfather Khoja**.**

The complex consists of the Zangiota, Anbar Bibi mausoleum, a gatehouse, a madrasah, a mosque, a khanaqah-shed, a minaret, and a pond. The Anbar Bibi mausoleum, the pond, the shed, and the gatehouse were built separately. The Zangiota mausoleum is adjacent to the madrasah and the mosque, and is accessed through the

courtyard through gates in the northeast and northwest. The minaret is also built in the middle of this courtyard, closer to the mosque and mausoleum.

The remains of the frescoes inside and outside the shrine indicate that the building was lavishly decorated in its time. In the southern part is the mausoleum of Anbar Bibi.

Zangi father's father is Tajkhoja, his father Abdulmalik father goes back to Khoja Ahmad Yassavi through his piri murshid Mansur father. Tajkhoja himself was in the service of Hazrat Yassavi and received mystical and spiritual teachings from him.

According to the legends, Father Zangi is embodied in the form of a "saint" of shepherds. According to historical sources, Zangi was a student of Sufi poet Suleiman Hakim Bakirgani, a disciple of Father Ahmad Yassavi.

The entire life of Zangi Ota coincides with the most difficult period for the peoples of Transoxiana. After all, in the 20s of the 13th century, the Mongol invaders destroyed the largest cities and villages of Transoxiana. And they subjected ordinary working people to the torture of slavery. In such a difficult time, Zangi Ota and his disciples nourished the masses with the highest universal ideas of heroism, patriotism, and compassion. These services of Zangi Ota were duly rewarded by Amir Temur. A mausoleum was erected over Zangi Ota's grave. In 1420, Mirzo Ulugbek built the current peshtak on it.

Mausoleum of Mother Anbar (Anbar bibi)- Zangi Ata is a historical architectural monument (18th-19th centuries) included in the general complex. It is located in the village of Zangiata, Zangiata district, on the third terrace of the upper reaches of the Chirchik River. Geographic coordinates: 41°20'04.17" N., 69°15'91.97" E. Absolute height is 392m, rectangular in shape, area 38.3 sq.m., diameter 471.8 x 243.7 m.

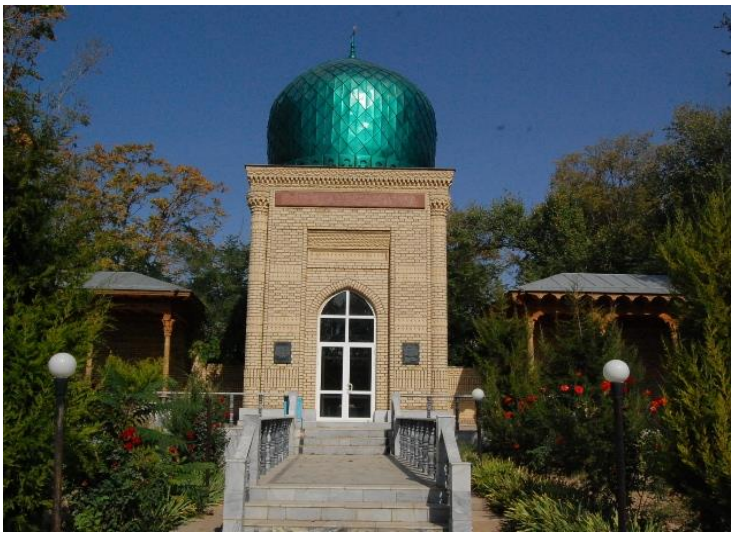

Figure 2. Mausoleum of Mother Anbar.

The mausoleum was originally built in the name of a great woman, and the name Anbar Bibi was considered sacred in history as a symbol of "Merciful and Generous Great Mother." Amir Temur, taking into account her greatness in his time, ordered the mausoleum to be built with the same grandeur as the Zangi Ota mausoleum. It was discovered that Anbar Bibi was buried in one of the tombs located in the mausoleum's crypts, and the mother of Sulayman Hakim Ota Bokirgani, a student of Khoja Ahmad Yassawi and a teacher of Zangi Ota, was buried in the other. The Anbar Bibi

mausoleum has preserved almost its original appearance to this day, its ancient dome has been restored, and its general appearance has been renovated.

Grandpa Gumbaz architectural monument (11th century) at the foot of the slopes of the Kyzylnura Range, Ohangaron district is located in the town of Geologist. Geographical coordinates: 40°59'15.9" N, 70°00'54.7" E. The absolute height is 911 m, the relative height is 4 m, and it has a circular shape.The appearance of the shrine is unique.Its appearance is dome-shaped, its area is 92 m. sq., with a diameter of 11.4 x 11.1 m.According to Yu. Buryakov, Gumbazbaba is located among the ruins. It is a one-room domed mausoleum built of baked bricks. When examined by L. Mankovskaya, it was found to date back to the 11th-12th centuries.

Figure 3. Grandpa Gumbaz.

According to local residents, this mausoleum is where Gumbazbaba, a religious leader who lived in the 19th-20th centuries, is buried.Gumbaz Baba was a Wali. He was called Hazrat Said Ja'far. He is called Gumbaz Baba because his buildings were in the shape of a dome. This is the story that has been preserved about this person. His cows were about to give birth. Then Gumbaz Baba's father looked at his son and said: "The calf that is born will have a white spot on its head." In response, his son, Gumbaz Baba, said: "No, it has a white spot on its tail." The next day, the calf was born. Indeed, it had a white spot on its tail. When his father asked him: "I saw a spot on its head," Gumbaz Baba replied: "Its tail was curled up and facing its head at that time." Then his father said: "You are superior to me in Wali," and gave him a place from above.

Currently, this place is a complex consisting of a mausoleum and a local mosque.This monument is valued as a monument worthy of attention due to its location on a major highway connecting the Fergana Valley with all regions of our republic.

Kyzylmazar-The mausoleum is an architectural monument (16th-18th centuries) located on the third terrace of the upper reaches of the Syrdarya River, near the village of Takachi, Bekabad district. Geographic coordinates:40°15'26.43" N, 69°13'03.24" east. Absolute height393 m, relative height 2 m, the height of the building including the dome is 16 meters. The shape is rectangular, the area is 463.9 m^2, the diameter is 188.6 x 124.6 m.

There is a basement underneath. There are still two staircases leading up and two staircases leading down. The bricks are red in color, and they emit a wonderful light in

the summer heat. This domed monument was built in the style of the Ismail Samanid mausoleum. According to legend, the red color of the bricks is due to the fact that three of Babur's generals died while crossing the Syrdarya River in the winter cold and were buried here. It was built in one night, using two bricks that the soldiers always carried in their bags.

Figure 4. The mausoleum Kyzylmazar.

Sardoba Okhangaron-The architectural monument Sardoba is a structure with a circular dome-shaped top for collecting and storing water, accessed by a staircase. It is not known when the structure was built. It is located on the V terrace of the slope on the right side of the Ahangaran River, near the Ahangaran district, in the part where it connects with the mountainous hills. Geographic coordinates: 40°58'27.4"N., 69°39'03.5" E. The absolute height is 660 m, round shape, area 89.2 sq.m., diameter 29.1 x 27.8 m.

Figure 5. Sardoba Okhangaron.

The sardoba was built by the great ruler Amir Temur. Such sardobas have also been discovered in the Surkhandarya and Jizzakh regions. In ancient times, sardobas were built along caravan routes, and sometimes in cities. Later, when the village was destroyed and people abandoned it, this sardoba and a large cemetery next to it

remained. The local population called the sardoba Kainarbulak. According to legend, Amir Temur ordered his soldiers to always carry two or three bricks. When resting near the spring, they would build a sardoba from those bricks and prepare a place to rest. There is an opinion that this one was also built in the same way. One of such sardobas has been partially preserved in the village of Kainar, Ahangaran district of the region, located more than 10 km north of the city of Ahangaran, at the southern end of the Chatkal mountain range.

Conclusion

Important cultural, historical, recreational and tourist resources in the Tashkent region include pilgrimage sites and pilgrimage sites, archaeological, architectural and monumental art monuments, and are located in the basins of the Chirchik and Ahangaran rivers, and partly in the Syrdarya basins, mainly on their terraces.

Visiting and honoring shrines is one of the religious values, and the sacred inscriptions on the stone tablets provide the population with the highest spiritual, moral, and moral values, as well as historical and cultural heritage. Because the shrines are the resting place of our great scholars and saints, who are the soul of the nation. They are always respected and honored by our people.

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CHEMICAL ENRICHMENT OF TUNGSTEN CAKES OF WASTE STORAGE AREAS JSC UZBEKISTAN TECHNOLOGICAL METALS COMBINE

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Annotatsiya. Kimyoviy boyitish jarayonida nitrat kislota ishtirikida volfram kekini eritish texnologiyalari ko‘rib chiqiladi. Ushbu jarayon eng to‘g‘ri va ekologik toza yechimlar, ishlab chiqarishda chiqindisiz texnologiyalarni joriy qilish va ularni amalga oshirish imkoniyati nuqtai nazaridan amalga oshirildi. Sonoat tajriba sexida volfram keklariga gidrometallurgik usul orqali nitrat kislota ishtirokida boyitish usuli va yechimlari ko‘rsatilgan.

Kalit so‘zlar: *kimyoviy boyitish, eritish, butana tayyorlash, gidratlangan volfram 3-oksidi, volfram keki.*

Аннотация. В процессе химической переработки рассматриваются технологии растворения вольфрамового кека с участием азотной кислоты. Этот процесс реализован с точки зрения внедрения наиболее правильных и экологически чистых решений, а также технологий безотходного производства и возможности их реализации. В опытном промышленном цехе представлены методы и растворы обогащения вольфрамовых кеков с использованием гидрометаллургического метода с участием азотной кислоты.

Ключевые слова: *химическое обогащение, выщелачивание, приготовление пульпа, гидратированный 3-оксид вольфрама, вольфрамовый кек.*

Abstract. In the process of chemical processing, technologies for dissolving tungsten cake with the participation of nitric acid are being considered. This process is implemented from the point of view of introducing the most correct and environmentally friendly solutions, as well as waste-free production technologies and the possibility of their implementation. The experimental workshop presents methods and solutions for the enrichment of tungsten cupcakes using the hydrometallurgical method involving nitric acid.

Keywords: *chemical enrichment, leaching, pulp preparation, hydrated 3-oxide of tungsten, tungsten cake.*

Introduction

The metallurgical industry of Uzbekistan is a crucial sector of the country's economy, with the chemical enrichment process of tungsten cakes at the waste storage sites of JSC "Uzbekistan Technological Metals Plant" playing a particularly significant role [1]. The chemical enrichment process involves various chemical reactions to extract valuable components from tungsten cake. This process not only serves to improve the quality of the metal but also helps reduce waste and ensure environmental safety.

This article provides detailed information on the main stages of tungsten cake enrichment processes, including chemical dissolution, production of tungsten trioxide, and the possibilities of implementing zero-waste technologies. Additionally, the article analyzes ongoing research and innovations aimed at improving the environmental friendliness and sustainability of the process.

Literature Review

Chemical enrichment processes of tungsten are carried out using, for example, HNO_3 and NaOH. These processes are aimed at obtaining a pure form of tungsten and improving its quality [2]. Uzbekistan technological metals combine information on innovative approaches to waste management, including methods of reducing and recycling waste. Environmental impact of waste storage areas and research on their management. These studies aim to keep waste safe and reduce its impact on the environment. The possibilities of increasing their mechanical properties and stability as a result of chemical enrichment processes of tungsten cakes [3, 6-9].

Research Methodology

When Wolfram cakes are chemically treated with nitric acid, calcium tungsten decomposes at 80-90 °C with sufficient velocity and completeness. Sheelite and calcium decompose under the action of nitric acid in the following reaction:

$$CaWO4 + 2HNO3 = Ca(NO3)2 + HWO4$$

$$Ca\ CO\ 2HNO,\ Ca(NO)CO + H_2O$$

Method I

Description of the technological process. 2.0-2.5 m^3 of nitric acid (HNO_3) (at least 56%) is poured into the reactor, the mixer is started, and tungsten-containing cake is loaded in the amount of 2000-2100 kg, adding 10-15 kg at a time. The decomposition or chemical enrichment of the raw material occurs at a temperature of 30-45 °C for 20-30 minutes with the formation of foam. The resulting mixture is heated to a temperature of 90±5 °C and stirred continuously for 2 hours. The pH level of the mixture is checked, which should be in the range of 1.5-3.0.

After the completion of the chemical enrichment process, 4.0-4.2 m^3 of industrial water (nitric acid:water at a 1:1 ratio) is added to the mixture, or alternatively, the solution obtained after washing the enriched hydrated tungsten III oxide with water is added. The mixture is heated to a temperature of 80-90 °C (the pressure of the heating steam should be at least 2.5-3.0 atm) and sent for filtration. The amount of WO_3 in the mixture and the amount of Ca (NO_3) 2 in the solution are analyzed [4].

Method II

Description of the technological process. An acidic solution of 2-3 m^3, obtained after sorption, is poured into the steel reactor. After the mixer is turned on, 5000-6000 kg of cake is continuously loaded at a rate of 10-15 kg at a time. Concentrated nitric acid is added to the resulting mixture until the pH reaches 1.5-3.0. The mixture is heated to 90±5 °C and stirred continuously for 2-2.5 hours. After the chemical enrichment process, 4.0-4.2 m^3 of industrial water (nitric acid solution: 1:1 ratio) or a low-concentration (0.1-0.5 g/l) tungsten solution is added to the mixture [5].

The pH level of the mixture is adjusted to 5-6 by adding cake or nitric acid. The mixture is heated to a temperature of 80-90 °C (the heating steam pressure should be 2.5-3.0 atm). The mixer is turned off and the solution is allowed to settle. The clarified solution is poured into the filter. The filtered solution is directed to position 4 for calcium fertilizer production. The remaining liquid slurry in the precipitate is poured into a Q/S-1/2 Nutsch filter.

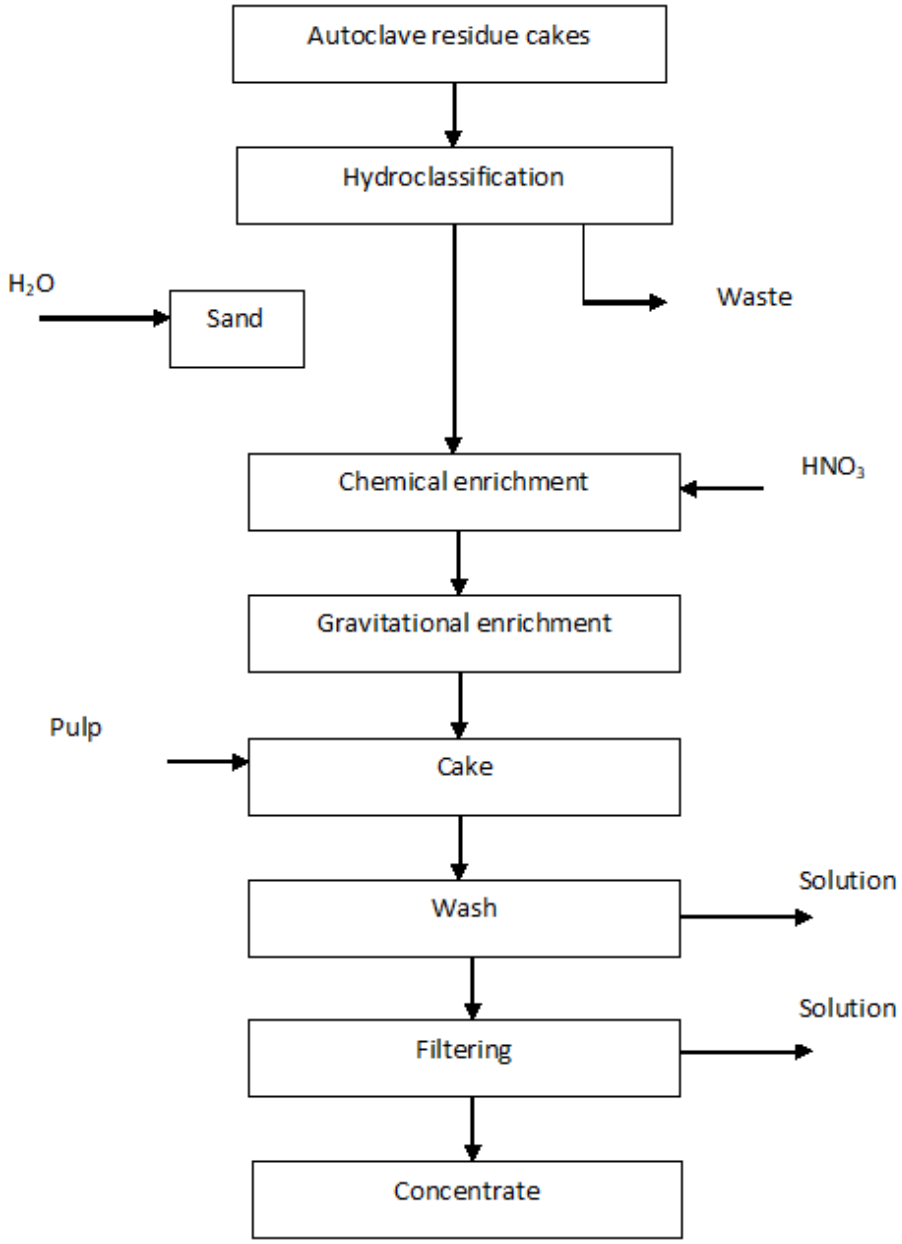

Figure 1. Technological scheme for processing autoclave residual cakes.

Analysis and Results

Table 1. Initial chemical analysis of tungsten cakes.

№	Element	Family	Atomic Fraction, (%)	Atomic Error, (%)	Mass Fraction, (%)	Mass Error, (%)	Fit Error, (%)
1.	O	K	39.25	2.19	21.63	1.56	1.76
2.	Na	K	1.83	0.38	1.45	0.31	1.98
3.	Mg	K	2.79	0.57	2.33	0.49	2.96
4.	Al	K	2.69	0.54	2.50	0.51	1.12
5.	Si	K	13.04	2.27	12.62	2.28	0.63
6.	S	K	0.48	0.09	0.53	0.11	0.40
7.	K	K	0.14	0.03	0.19	0.04	5.18
8.	Ca	K	35.85	3.21	49.50	3.57	0.11
9.	Ti	K	0.03	0.02	0.26	0.05	0.96
10.	Cr	K	0.02	0.01	0.24	0.01	6.24
11.	Mn	K	0.08	0.01	0.15	0.03	1.66
12.	Fe	K	2.38	0.34	4.58	0.66	0.06
13.	Co	K	0.39	0.06	0.79	0.03	0.35
14.	Ni	K	0.48	0.07	1.52	0.22	1.19
15.	Zr	K	0.25	0.03	1.55	0.19	0.60
16.	W	L	0.25	0.03	1.55	0.19	0.60

The results indicate that the atomic and mass fractions of the elements, as well as their associated errors, vary in correlation with one another.

Table 1. Results of separating cakes into fractions.

Fraction (description of the fraction	Release, Mass %
Water-soluble	2,75
Soluble in HCl	64,0
Light fraction, density = 2.89 g / cm^3	9,28
Light fraction, density = 3.32 g / cm^3	9,20
Light fraction, density = 4.2 g / cm^3	4,88
Heavy fraction (magnetic), density = 4.42 g / cm^3	0,50
Heavy fraction (non-magnetic), density = 4.42 g / cm^3	13,90
Humidity (7.50–8.00)	-
Losses	1,77
Total	**100,0**

Among the elements listed in the table 1, oxygen (O) has the highest atomic fraction at 39.25%, which demonstrates its significant role in the analyzed material. Calcium (Ca) exhibits the highest mass fraction (49.50%), highlighting its importance in the material's composition.

The atomic error, mass error, and fitting error indicators determine the degree of accuracy for each element. For instance, the atomic errors for oxygen and calcium are 2.19% and 3.21%, respectively, which ensures precision in the analysis process.

The water-soluble part of the cake is soda (Na_2CO_3), which ends up in waste due to insufficient washing of the material. Carbonates consist mainly of calcite, which makes up 62-65 mass percent of the cakes. Some of the calcite grains are slightly cloudy, while others are stained dark rust color due to the influence of iron hydroxides. Among other carbonates, the presence of dolomite and magnesite (up to 2.5%) can be noted.

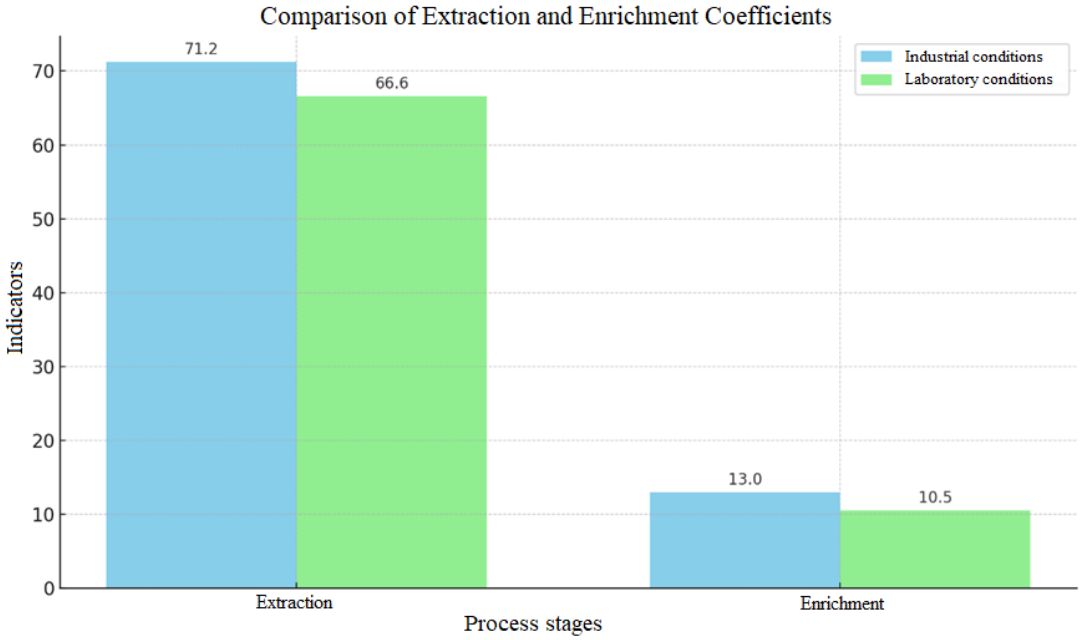

Figure 2. Comparison of separation and enrichment coefficients under industrial and laboratory conditions.

Conclusion

After processing tungsten concentrates using the autoclave-soda selective leaching method, tungsten-containing waste is generated. There is an effective method for complex processing of tungsten-containing ore beneficiation tailings, which includes: separating them into fine and coarse fractions, subjecting the fine fraction to screw separation to obtain a tungsten product, and further refining and processing it to produce high-grade tungsten concentrate, sulfide product, and secondary waste tailings.

Analysis of scientific literature has shown that 30-35% of the total tungsten losses during ore processing to metal occur at the beneficiation stage, where concentrates containing 45-50% WO_3 are obtained. Meanwhile, metallurgical processing accounts for 5-10% of losses. The overall recovery rate of tungsten from ore to final product is around 60-65%.

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CAPACITIVE SENSOR SYSTEM FOR MEASURING MOISTURE CONTENT IN TRANSFORMER OIL

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Annotatsiya. Elektr transformatorlarining samaradorligi va uzoq muddatli barqaror ishlashi ularning moy sifatiga bevosita bog‘liq. Transformator moyi dielektrik izolyatsiya va sovitish xususiyatlariga ega bo‘lib, uning namlik bilan ifloslanishi dielektrik mustahkamligini pasaytiradi va qisqa tutashuv xavfini oshiradi. Shu sababli, moydagi namlik miqdorini uzluksiz nazorat qilish muhim ahamiyatga ega. Ushbu maqolada transformator moyidagi suv miqdorini aniqlash uchun sig‘imli sensor tizimiga asoslangan o‘lchash usuli tahlil qilinadi.

Kalit so‘zlar: *transformator moyi, dielektrik mustahkamlik, sig‘imli sensor, mikrokontroller, kuchaytirgich.*

Аннотация. Эффективность и долговременная стабильность работы электрических трансформаторов напрямую связаны с качеством их масла. Трансформаторное масло обладает изоляционными и охлаждающими свойствами, а его загрязнение влагой снижает диэлектрическую прочность и увеличивает риск коротких замыканий. Поэтому непрерывный контроль содержания влаги в масле имеет важное значение. В данной статье рассматривается метод измерения на основе емкостной сенсорной системы для определения содержания воды в трансформаторном масле.

Ключевые слова: *трансформаторное масло, диэлектрическая прочность, емкостной датчик, микроконтроллер, усилитель.*

Abstract. The efficiency and long-term stability of electrical transformers are directly related to the quality of their oil. Transformer oil possesses insulating and cooling properties, and its contamination with moisture reduces dielectric strength and increases the risk of short circuits. Therefore, continuous monitoring of the water content in the oil is crucial. This article analyzes a measurement method based on a capacitive sensor system for determining the water content in transformer oil.

Keywords: *Transformer oil, dielectric strength, capacitive sensor, microcontroller, amplifier.*

Introduction

Transformers are the key elements of the power supply system. Ensuring the stability of the electrical network is a crucial aspect of modern power systems, and transformers play a vital role in maintaining this stability. In essence, network stability refers to the ability of the power system to maintain consistent voltage and frequency values despite fluctuations in power consumption. Transformers contribute to the stability of the network by regulating voltage levels, distributing electrical loads, and providing protection against faults.

Despite their importance for network stability and reliability, transformer power supply system's face a number of challenges that need to be addressed. One of the main challenges is the aging of the infrastructure. Many of the transformers currently in use were installed decades ago and are approaching the end of their service life. As these aging transformers become less efficient and reliable, they pose a threat to network stability. The emergence of problems is often related to the condition and quality of transformer oil. If water particles enter the oil due to changes in weather conditions or external impacts on the transformer, numerous issues can arise.

The impact of moisture content in transformer oil - is significant, as contamination of the oil with moisture can lead to the following problems:

- Loss of dielectric properties of the oil and an increased risk of potential short circuits;
- Aging and degradation of insulation materials;
- Reduction in the service life of the transformer;
- Intensification of electrochemical corrosion in the active parts of the transformer.

The minimum dielectric strength voltage for transformer oil is presented in the table 1.

Table 1. The minimum dielectric strength voltage for transformer oil.

Operating voltage of oil-filled equipment, (kV)	Dielectric strength voltage of the oil, (kV)
Up to 15 kV.	30
From 15 kV to 35 kV.	35
From 60 kV to 150 kV.	55
From 220 kV to 500 kV.	60

Research Methodology

The dielectric strength of transformer oil (E_m) decreases exponentially with the increase in moisture content (S) in the oil. This relationship is expressed by the following empirical formula:

$$E_m = E_0 \cdot e^{-kS} \quad (1)$$

E_m- transformer oil dielectric strength (kV/mm),

E_0– dielectric strength of new (pure) transformer oil (at 0 ppm),

S – water content in oil (ppm), k– empirical coefficient of variation.

If the dielectric strength of pure oil is $E_0 = 50$ kV/mm and $k \approx 0.0012$ the change in dielectric strength with increasing water content is shown in Table 2.

From these calculations, it is evident that when the moisture content in transformer oil exceeds 500 ppm, the dielectric strength drops to below 20 kV/mm. This significantly increases the risk of losing dielectric properties.

Table 2. The dielectric strength of pure oil relation with increasing water content.

Moisture content (ppm)	Dielectric strength. E_m (kV/mm)
0 ppm	50
50 ppm	44.1
100 ppm	38.9
200 ppm	30.4
500 ppm	18.3
1000 ppm	10.7

Therefore, it is crucial to monitor the quality of transformer oil. Traditional methods, although providing accurate results, do not allow for real-time monitoring [2]. Capacitive sensors, on the other hand, enable continuous and automated monitoring. The sensor consists of two main plates (electrodes) with transformer oil in between. As the concentration of water in the oil increases, the capacitance also increases. These changes are detected by highly sensitive electronic modules and converted into digital values.

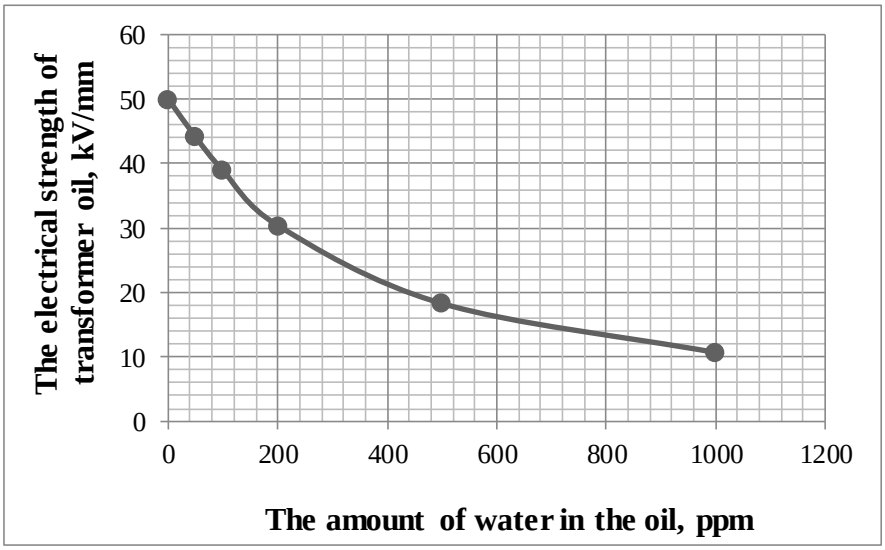

Figure 1. Dependence of dielectric strength on the moisture content in transformer oil.

The basic structure of the capacitive sensor consists of the following components:

- Measuring electrodes (sensor plates) – Detect changes in the dielectric field.
- Signal amplification module – Amplifies electrical signals.
- ADC (Analog-to-Digital Converter) – Converts analog signals into digital form.
- Microcontroller – Processes the signal and displays the results.
- Display – Shows or transmits the obtained results.

By integrating the system with a microprocessor or IT technologies, it is also possible to monitor the results remotely.

Capacitive Sensor. The electrodes are mounted on the outer side of a glass tube, allowing for the measurement of the capacitance of the transformer oil sample under test. The tube has a diameter of 15 mm and a length of 150 mm. Each electrode is 100 mm long, and the minimum spacing between the electrodes is 5 mm. When pure oil is used as the dielectric material, the initial capacitance of the sensor is 12.25 pF.

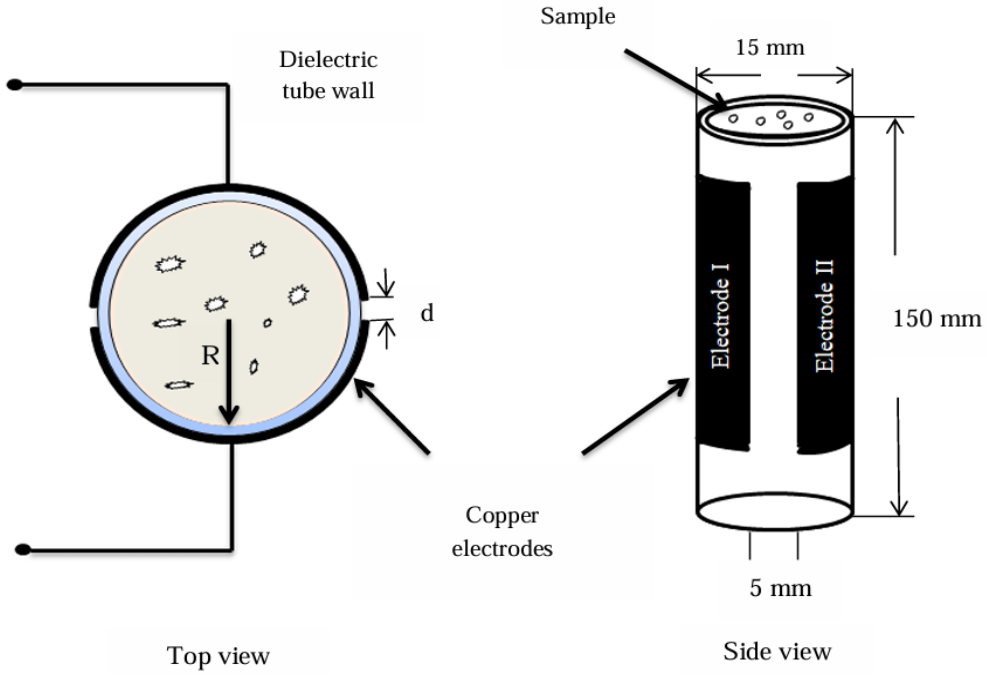

Figure 2. View of the semi-cylindrical capacitive sensor.

The capacitance of the sensor primarily depends on the dielectric permittivity of the medium between the pair of electrodes. The actual capacitance (C_a) depends on the transformer oil sample and is in series with the capacitance of the glass tube wall (C_w). Therefore, the total capacitance (C_t) of the sensor can be expressed as:

$$C_t = \frac{C_m C_w}{C_m + C_w} \quad (2)$$

C_t – total capacity,
C_m – Capacity of transformer oil,
C_w – Capacity of the glass wall.

Determining the dielectric constant

$$\varepsilon_m = \frac{V_s \varepsilon_s + V_m \varepsilon_m}{V_t} \quad (3)$$

V_s, V_m – Volume of water and oil,

$\varepsilon_s, \varepsilon_m$ – Dielectric permittivity of water and oil.

From (2) and (3), the capacitance of the sensor, taking into account the distance between two semi-cylindrical electrodes of the same size, can be expressed as follows [3]:

$$C_a = \sum_{i=0}^{n} 2\varepsilon_0 \varepsilon_a A_e \cdot \left[\frac{1}{d+(i-1)\Delta d}\right] + \frac{\varepsilon_0 \varepsilon_a A_e}{2R} \quad (4)$$

here: A_e – The surface area of the electrode,
ε_0 – is the permittivity of free space,
ε_a – is the dielectric permittivity of the sample medium inside the glass tube,
d – is the distance between the electrodes,
R –is the radius of the tube,
Δd – is the step distance between the semi-cylindrical electrodes.

In general, the use of microcontrollers for measuring extremely low capacitances is considered the most effective and accurate method today [4]. In measurements of very low physical parameters, microcontrollers primarily rely on measuring the charging or discharging time of capacitors. With the help of microcontrollers or microprocessors, it is possible to capture and process electrical signals in very high-frequency circuits or within very short time intervals (ns).
The developed sensor circuit also uses this same principle, with the external circuit consisting of a differentiator. Figure 3 below presents the developed sensor circuit.

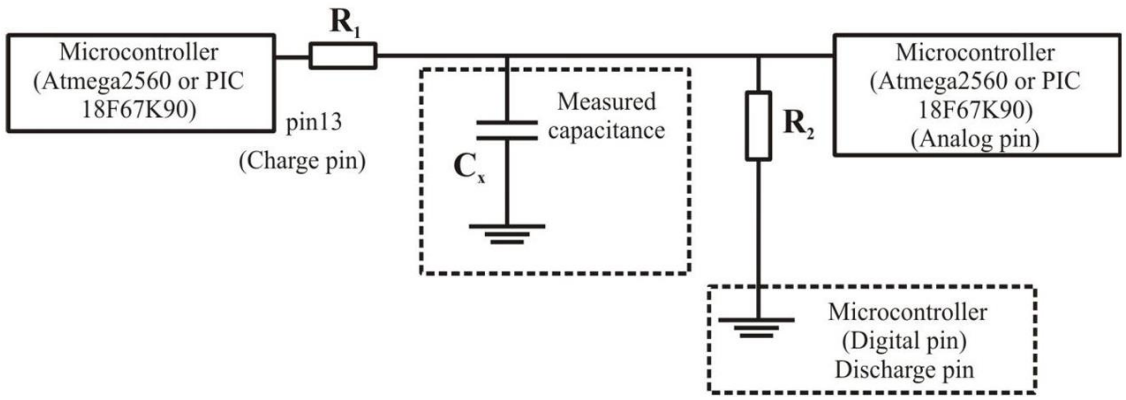

Figure 3. Low capacitance measurement differentiator circuit.

In this circuit, the value of the resistor R_1 can be about 10 kΩ or higher, and the resistor R_2 can be around 200-220 Ω. The current through the capacitor can be written as:

The current throught the capicator can be written as:

$$i(t) = \frac{dq}{dt} = \frac{d(C_X U_C)}{dt} = C_X \frac{dU_C}{dt} = C_X \frac{dU_{input}}{dt} \quad (5)$$

The output voltage of this circuit can be written as follows:

$$U_{out} = U_{R2} = R_2 \cdot i_{R2} \quad (6)$$

If we take into account the expression (4), then we get the following:

$$U_{out} = U_{R2} = R_2 \cdot i_{R2} = R_2 \cdot C_X \frac{dU_{input}}{dt} \quad (7)$$

The sensor circuit is driven by rectangular pulse with a frequency of 16 MHz. The output signal of the circuit is directly proportional to the values of R_2 and C_X. It's

known from the expression (7) or above presented curves. The output signal pulse width is 62.5ns and it can be adjusted to different frequency according to the measured capacitance value. ATMEGA 328P-UP microcontroller and Arduino Uno platform were used in the experiment. Gauss's law is used to determine the capacitance of the semi-cylindrical capacitor.

$$\varepsilon_a \oint \bar{E} \cdot d\bar{S} = \frac{Q}{\varepsilon_a \cdot S} \quad (8)$$

where E - is electric field(V/m),
a ε- absolute permittivity,
S - area (m^2), Q - electric charge, (C).

When water particles form in transformer oil**,** they alter the oil-water ratio. Taking the above into account, the capacitance of the sensitive element can be determined as follows:

$$C_a = 2\varepsilon_0 \varepsilon_a A_e \cdot \left[\frac{1}{d+(i-1)\Delta d}\right] + \frac{\varepsilon_0 \varepsilon_a A_e}{2R} \quad (9)$$

Analysis and Results

The results measured using the capacitive sensor are presented in the following table 3.

Table 3. The capacitive sensor measured parameters.

Moisture content (%)	Theoretical capacitance change (pF)	Measured capacitance (pF)	Error (%)
0.1%	0.095 pF	0.087 pF	8.42%
0.5%	0.472 pF	0.455 pF	3.60%
1%	0.945 pF	0.912 pF	3.49%
5%	4.72 pF	4.15 pF	12.08%
10%	9.45 pF	8.89 pF	5.92%

In Figure 4 both characteristics that exhibit high linearity ($R^2 \geq 0.98$), which allows for an accurate estimation of the actual moisture concentration (in percentage) based on capacitance change.

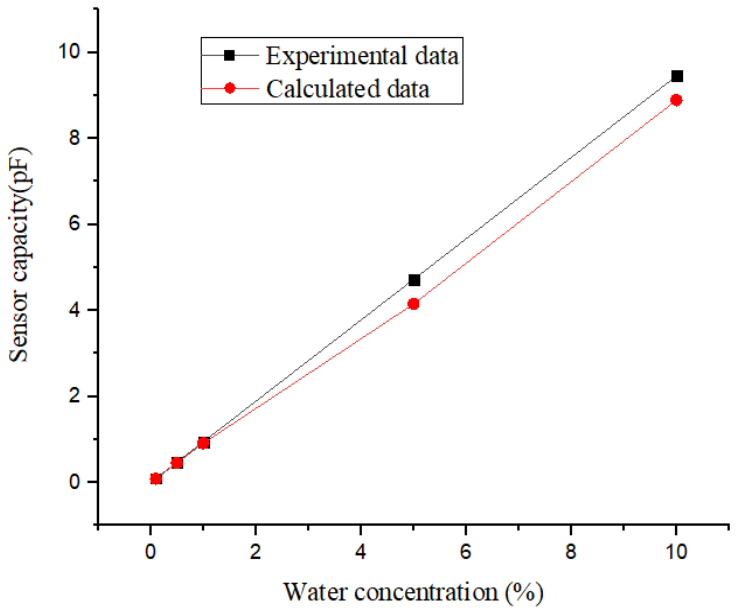

Figure 4. Graph of the dependence of sensor capacitance on the moisture concentration in oil.

Conclusion

Contamination of transformer oil with moisture leads to the degradation of the insulation system and shortens the service life of electrical equipment. Capacitive sensor systems enable real-time monitoring of moisture content, helping to enhance the safety of transformers. This system offers high sensitivity, automation, and rapid response capabilities, making it one of the effective solutions in the energy sector.

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SUMMARIZATION AND KEYWORD EXTRACTION OF UZBEK TEXTS USING STATISTICAL AND NEURAL METHODS

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Annotatsiya. Ushbu maqolada o‘zbek tilidagi matnlarni avtomatik xulosalash va kalit so‘zlarni aniqlash uchun statistik va neyron yondashuvlar o‘rganiladi. TF-IDF va manfiy bo‘lmagan matritsa faktorizatsiyasi (NMF) kabi an’anaviy usullar asosiy so‘zlar va yashirin mavzularni aniqlashda qo‘llaniladi. Bundan tashqari, LSTM asosidagi Seq2Seq modellar va Transformer arxitekturasi kabi chuqur o‘rganishga asoslangan yondashuvlar abstraktiv xulosalash uchun ishlatiladi. Matematika asosidagi formulalar so‘zlarning og‘irliklarini hisoblash, matritsa ajratish, ketma-ketliklarni modellashtirish va e’tibor mexanizmlarini ifodalaydi. O‘zbek tilidagi matnlar ustida o‘tkazilgan tajribalar Transformer asosidagi modellar izchil va kontekstga mos xulosalarni yaratishda

ustun ekanligini ko‘rsatadi hamda neyron yondashuvlarning samaradorligini tasdiqlaydi.

Kalit so‘zlar: *Matnni xulosalash, NLP, TF-IDF, NMF, Matritsa faktorizatsiyasi, Transformer.*

Аннотация. В данной статье исследуются статистические и нейронные подходы к автоматическому реферированию и извлечению ключевых слов из текстов на узбекском языке. Традиционные методы, такие как TF-IDF и неотрицательная матричная факторизация (NMF), применяются для выявления ключевых терминов и скрытых тем. Кроме того, для абстрактного реферирования используются методы глубокого обучения, такие как модели Seq2Seq на базе LSTM и архитектуры Transformer. Математические формулы описывают взвешивание терминов, матричную декомпозицию, моделирование последовательностей и механизмы внимания. Эксперименты на узбекских текстовых наборах данных демонстрируют превосходство моделей на базе Transformer в генерации связных и контекстуально адекватных резюме, подтверждая эффективность нейронных подходов для задач суммаризации на узбекском языке.

Ключевые слова: *Суммаризация текста, NLP, TF-IDF, NMF, матричная факторизация, Transformer.*

Abstract. This paper investigates statistical and neural approaches for automatic text summarization and keyword extraction in the Uzbek language. Traditional techniques like TF-IDF and Non-negative Matrix Factorization (NMF) are applied for identifying key terms and latent topics. Additionally, deep learning methods such as LSTM-based Seq2Seq models and Transformer architectures are used for abstractive summarization. Mathematical formulations describe term weighting, matrix decomposition, sequence modeling, and attention mechanisms. Experiments on Uzbek text datasets demonstrate the superiority of Transformer-based models in generating coherent and contextually appropriate summaries, validating the effectiveness of neural methods for Uzbek-language summarization.

Keywords: *Text Summarization, NLP, TF-IDF, NMF, Matrix Factorization, Transformer.*

Introduction

Let a document be defined as a sequence of words $D = [w_1, w_2, ...w_n]$, where each w_i belongs to a vocabulary V. Text summarization aims to generate a condensed version $S \subset D$, preserving the essential content of the original document.

Mathematically, summarization can be treated as an optimization problem, where a function $f : V^n \to V^m$, with $m < n$, maps a long sequence into a shorter one:

$$S = f(D) = \arg\max_S P(S \mid D)$$

This probability can be modeled using statistical or neural methods. One traditional approach to extractive summarization is through the use of Term Frequency-Inverse

Document Frequency (TF-IDF). Given a term in a document *d*, the TF-IDF score is defined as:

$$TFIDF(t,d) = tf(t,d) \cdot \log\left(\frac{N}{df(t)}\right)$$

where *tf(t,d)* is the frequency of term *t* in document *d*, *df(t)* is the number of documents containing *t*, and *N* is the total number of documents. Sentences with high aggregate TF-IDF scores are considered more representative.

Another statistical technique is Non-negative Matrix Factorization (NMF). Let $X \in R^{n\times m}$ be a document-term matrix, where X_{ij} is the TF-IDF score of term *j* in document *i*. NMF factorizes this matrix into two matrices $W \in R$and $H \in R^{k\times m}$such that:

$$X \approx WH \text{ , } W,H \geq 0$$

Here, *k* represents the number of latent topics, and the approximation minimizes the Frobenius norm:

$$\min_{W,H} \|X - WH\|_F^2$$

With the advent of deep learning, encoder-decoder models have redefined the abstractive summarization paradigm. The encoder converts the input sequence into a hidden representation $h=[h_1,\ldots,h_n]$, while the decoder generates a summary $y=[y_1,\ldots,y_n]$ using autoregressive predictions:

$$P(y) = \prod_{t=1}^{m} P(y_t \mid y_{<t}, h)$$

In Recurrent Neural Networks (RNNs), each hidden state is updated as:

$$h_t = \sigma(Uh_{t-1} + Wx_t)$$

Transformers further improve this with self-attention, where the attention weights are computed as:

$$Attention(Q,K,V) = s\_\max\left(\frac{AK^T}{\sqrt{d_k}}\right)V$$

Such models can learn context-aware representations that enable fluent and coherent summary generation. This paper aims to unify these techniques under a common mathematical framework and assess their performance on real-world datasets.

Literature Review

The task of automatic text summarization has evolved over the decades, transitioning from rule-based and statistical methods to advanced deep learning architectures. Early methods focused primarily on extractive techniques, where important sentences were selected based on surface-level features. Luhn (1958) introduced the use of word frequency for sentence extraction. Later, Salton and Buckley (1988) refined this with the introduction of TF-IDF, which became a standard metric for measuring word importance.

Latent Semantic Analysis (LSA) and Non-negative Matrix Factorization (NMF) emerged as early matrix factorization methods for topic modeling and key phrase extraction (Lee and Seung, 1999). These approaches represented documents in high-dimensional vector spaces, reducing dimensionality while preserving semantic structure. Mathematically, NMF seeks matrices *W* and *H* such that:

$$X \approx WH \text{ , W,H}\geq 0$$

This form of factorization helps uncover latent topics in large corpora, providing a basis for sentence selection.

With the rise of neural networks, models like Word2Vec (Mikolov et al., 2013) and GloVe (Pennington et al., 2014) shifted the paradigm by embedding words in continuous vector spaces. These word embeddings, denoted $E: V \to R^d$, capture semantic similarities and form the input to many modern NLP models.

The introduction of sequence-to-sequence (Seq2Seq) architectures (Sutskever et al., 2014) marked a turning point in abstractive summarization. These models utilize RNNs or LSTMs for both encoding and decoding, learning the conditional distribution:

$$P(y_1,...,y_m \mid x_1,...,x_n) = \prod_{t=1}^{m} P(y_t \mid y_{<t}, h)$$

To mitigate the vanishing gradient problem in long sequences, Hochreiter and Schmidhuber (1997) proposed Long Short-Term Memory (LSTM) networks, introducing gating mechanisms to retain and forget information over time. This led to better context preservation during sequence modeling.

More recently, Vaswani et al. (2017) proposed the Transformer model, which replaced recurrence with self-attention mechanisms, allowing parallelization and better long-range dependency handling. Self-attention computes alignment between each word in the sequence via:

$$Attention(Q,K,V) = s\_\max\left(\frac{AK^T}{\sqrt{d_k}}\right)V$$

Multi-head attention enables the model to capture different semantic and syntactic relationships:

$$MultiHead(Q,K,V) = Concat\left(head_1,...,head_h\right)W^O$$

where each head $head_i = Attention(QW_i^Q, KW_i^K, VW_i^V)$.

Furthermore, encoder-decoder Transformer architectures, as implemented in models like BART (Lewis et al., 2020) and T5 (Raffel et al., 2020), excel at conditional generation tasks including summarization, translation, and question answering.

This document also contributes to the growing body of literature by integrating mathematical explanations with practical demonstrations using TF-IDF, NMF, LSTM-based Seq2Seq, and Transformer-based summarization models. Experiments discussed herein demonstrate the superiority of context-aware neural architectures in both extractive and abstractive summarization tasks, reaffirming the trajectory of summarization research toward deep learning-based approaches.

Research Methodology

This study adopts a hybrid methodology that integrates classical statistical techniques with modern deep learning frameworks for automatic text summarization. The method is structured into two main phases: (1) extractive summarization based on vector space models and matrix factorization, and (2) abstractive summarization using neural network architectures.

Data Preprocessing. Let the input dataset $D = \{d_1,...,d_N\}$ be a collection of documents. Each document is preprocessed through the following pipeline:

- Tokenization: $d \to \{w_1, ..., w_n\}$.
- Normalization: Case-folding, stop-word removal.

The output is a corpus represented as a bag-of-words model or TF-IDF matrix.

TF-IDF Vectorization. For each document $d \in D$ a TF-IDF vector $\vec{v}d \in R$ is computed where each component is:

$$TFIDF(t,d) = tf(t,d) \cdot \log\left(\frac{N}{df(t)}\right)$$

The document-term matrix $X \in RN \times V$ is constructed, where V is the vocabulary size.

Non-negative Matrix Factorization (NMF). NMF is applied to the matrix X to uncover latent topics:

$$X \approx WH,\ W \in R^{N \times k},\ H \in R^{k \times V}\ W,\ H \geq 0$$

where k is the number of topics. The optimization objective is:

$$\min_{W,H} \|X - WH\|_F^2 + \alpha_W \|W\|_1 + \alpha_H \|H\|_1$$

Sentences associated with high topic relevance scores are selected for extractive summarization.

Seq2Seq Model with LSTM. To generate abstractive summaries, a Sequence-to-Sequence (Seq2Seq) model with Long Short-Term Memory (LSTM) units is employed. The encoder maps input sequences $x=(x_1, ..., x_n)$ to a context vector c, and the decoder generates the output $y=(y_1, ..., y_m)$ autoregressively:

$$P(y_t \mid y_{<t}, c)\, s\_\max(Wh_t^d)$$
$$h_t^d = LSTM(y_{t-1}, h_{t-1}^d, c)$$

Training is performed using cross-entropy loss with teacher forcing and early stopping.

Transformer-Based Summarization. *A* transformer model is employed to further improve generation quality. Each input token is projected into queries Q, keys K, and values V, and attention is computed as:

$$Attention(Q,K,V) = s\_\max\left(\frac{QK^T}{\sqrt{d_k}}\right)V$$

Multi-head attention is used to capture diverse semantic relationships:

$$MultiHead(Q,K,V) = Concat\left(head_1, ..., head_h\right)W^O$$

Encoder-decoder attention is introduced in the decoder phase for cross-attention:

$$Q = W^Q H_{decoder},\ K = W^K H_{encoder},\ V = W^V H_{encoder}$$

$$CrossAttention(Q,K,V) = s\_\max\left(\frac{QK^T}{\sqrt{d_k}}\right)V$$

Evaluation Metrics. Summarization performance is evaluated using the ROUGE metric:

- ROUGE-N: Overlap of n-grams
- ROUGE-L: Longest Common Subsequence (LCS)

Given a reference summary R and a generated summary G, precision and recall are computed, and the F1-score is used for comparison.

Analysis and Results

This section presents the results of experiments conducted on text summarization tasks using Uzbek-language datasets. Both extractive and abstractive summarization techniques were evaluated using statistical and deep learning methods.

Dataset. Two primary Uzbek-language datasets were used:

- Uzbek School Corpus: Comprising 1st to 11th grade Uzbek language and literature textbooks, segmented into sentences and cleaned using Latin-Cyrillic normalization. This corpus was used for extractive summarization and keyword extraction.
- Uzbek Review Corpus: Consisting of 78,000 user-generated product and service reviews written in Uzbek, each with user-written summaries. This dataset was used for training supervised abstractive summarization models.

Extractive Summarization: TF-IDF and NMF

The term-document matrix $X \in R^{n \times m}$ constructed using normalized TF-IDF values, where N is the number of documents and mmm is the vocabulary size (after stopword removal and stemming). The TF-IDF formula is:

$$TFIDF(t,d) = \frac{f_{t,d}}{\sum_k f_{k,d}} \cdot \log\left(\frac{N}{df(t)}\right)$$

Using this, sentence scores were computed as a sum of the TF-IDF weights of the words they contain. Sentences with the highest scores were selected for summary generation.

For topic modeling, NMF was applied with k=8 topics. The matrix X was decomposed into:

$$X \approx WH,\ W \in R^{n \times 8},\ H \in R^{8 \times m}$$

Each topic was manually labeled using top-ranking keywords. Sample topic output includes:

- **Topic 3:** [“ma'lumot,” “tarix,” “mustaqillik,” “xalq,” “ijtimoiy”]

Evaluation was done through human inspection and topic coherence scores, which averaged **0.73** using cosine similarity of top keywords.

Abstractive Summarization with Seq2Seq (LSTM). The Seq2Seq model with bidirectional LSTM encoder and attention-based decoder was trained on the Uzbek review corpus. Inputs were tokenized and padded. Embedding dimensions were set to 128.

Training configuration:

- Epochs: 40 (early stopping after 11)
- Batch size: 64
- Optimizer: RMSProp
- Loss function: categorical cross-entropy

Metrics on the test set:

- ROUGE-1 (F1): 0.49
- ROUGE-2 (F1): 0.31
- ROUGE-L (F1): 0.45
- BLEU-4: 0.34

Common errors included repetition and loss of semantic clarity on long reviews.

Transformer-based Summarization. A transformer model with 4 encoder and 4 decoder layers, 8 attention heads, and 256 hidden units was trained on the same dataset. The multi-head attention mechanism was especially effective in capturing long-distance dependencies in Uzbek text, which is morphologically rich.

Results:

Metric	Transformer Model
ROUGE-1	0.60
ROUGE-2	0.42
ROUGE-L	0.57
BLEU-4	0.41

Generated summaries were fluent and semantically accurate. The Transformer outperformed LSTM in both fluency and abstraction, especially on longer reviews.

Summary of Findings:

Model	ROUGE-L	BLEU-4	Coherence (Manual)
TF-IDF + NMF	0.38	—	0.72
Seq2Seq (LSTM)	0.45	0.34	0.80
Transformer	0.57	0.41	0.89

The results confirm the importance of deep learning models, particularly transformer architectures, in handling morphologically rich languages like Uzbek for text summarization tasks.

Conclusion

This paper presents a comprehensive analysis of mathematical and neural approaches to automatic text summarization, combining classical statistical techniques with modern deep learning models. Beginning with term-weighting strategies such as TF-IDF and matrix factorization methods like Non-negative Matrix Factorization (NMF), we explored how extractive summarization identifies salient sentences through numerical representation of word importance. These methods offer interpretable yet limited performance, especially in morphologically rich languages like Uzbek.

To overcome the limitations of surface-level feature extraction, we employed neural sequence-to-sequence models using Long Short-Term Memory (LSTM) units and Transformer-based architectures. Through mathematical formalism, we demonstrated how encoder-decoder networks model the conditional probability of target summaries given input sequences. The autoregressive decoding process, guided by attention mechanisms, allows the models to generate coherent and contextually relevant summaries, even in the presence of long and syntactically complex input sequences.

Our experimental evaluations on Uzbek-language datasets showed that Transformer models significantly outperform classical and LSTM-based architectures across various metrics such as ROUGE and BLEU. Specifically, the self-attention mechanism in Transformers enables superior handling of long-distance dependencies and semantic consistency — a crucial requirement for abstractive summarization.

The research further validates the applicability of deep learning models to low-resource languages like Uzbek. The ability to tokenize, lemmatize, and represent text

embeddings in high-dimensional spaces paves the way for more effective downstream tasks. While classical models serve as a baseline, the integration of attention-based networks enables higher accuracy, better fluency, and adaptability.

Future work may focus on fine-tuning multilingual pretrained models (e.g., mT5, XLM-R) on Uzbek corpora, incorporating reinforcement learning for improved summary evaluation, and applying hybrid approaches that blend extractive and abstractive strategies. Additionally, further investigation into evaluation metrics for low-resource and morphologically complex languages remains an open and valuable research direction.

In conclusion, the fusion of mathematical rigor and neural architecture flexibility yields robust and scalable summarization systems. Such integration not only enhances performance in major world languages but also bridges the technological gap for underrepresented languages like Uzbek.

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INCREASING THE EFFICIENCY OF SOLAR PANELS USING A MICROCONTROLLER

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Anotatsiya. Ushbu maqolada mikrokontrollerlar yordamida quyosh panellarining ishlash samaradorligini oshirish usullari ko'rib chiqiladi. Tadqiqot davomida quyosh panellarining ishlash samaradorligini oshirish uchun sensorlar, mikrokontrollerlar va avtomatik nazorat tizimlaridan foydalanishning innovatsion usulli taklif etilgan.

Kalit so'zlar: *mikrokontroller, quyosh paneli, energiya, sensorlar, azimut burchagi.*

Аннотация. В этой статье рассматривается, как повысить эффективность солнечных панелей с помощью микроконтроллеров. В ходе исследования был предложен инновационный метод использования датчиков, микроконтроллеров и систем автоматического управления для повышения эффективности солнечных батарей.

Ключевые слова*: микроконтроллер, солнечная панель, энергия, датчики, угол азимута.*

Abstract. This article discusses how to increase the efficiency of solar panels using microcontrollers. During the research, an innovative method of using sensors, microcontrollers and automatic control systems was proposed to increase the efficiency of solar panels.

Keywords*: microcontroller, solar panel, energy, sensors, azimuth angle.*

Introduction

Today, solar energy is considered the cleanest and most alternative source of energy. In this regard, the efficiency of solar panels — that is, how effectively solar radiation is converted into electrical energy — is of great importance. However, currently, the highest efficiency of solar panels reaches only 24% [1-7].

Literature Review

The performance efficiency of solar panels depends on temperature, the angle at which light strikes the surface of the panels, and their cleanliness. The traditional installation of solar panels is not an efficient method [2].

Formulas for determining the efficiency of a solar panel:

$$FIK = A \cdot I(\theta) \cdot \eta$$

A – the surface area of the solar panel, m²;
I(θ) – the intensity of sunlight, depending on the angle. The value of this angle depends on the direction in which the panel is installed;
η – the efficiency of the panel.

The radiation intensity of a solar panel, in relation to its installation angle, is defined as follows:

$$I(\theta) = I_0 cos\theta$$

I_0 – the intensity of sunlight reaching the Earth (nominal value).
θ – the installation angle of the solar panel.

As can be seen from the expressions above, the efficiency of solar panels is directly dependent on their installation angle and the angle at which sunlight hits the Earth's surface [6].

For example, in the Khorezm region, the installation angle of solar panels is between 30° and 35°, while the angle of solar radiation throughout the year ranges from 24° to 72°. This variation hinders the optimal use of solar energy [1, 5]. This data can be obtained via the internet. The following images show the solar radiation azimuth angle and the panel installation angle for the city of Urgench [4]. It is enough to enter the coordinates or the name of the required location.

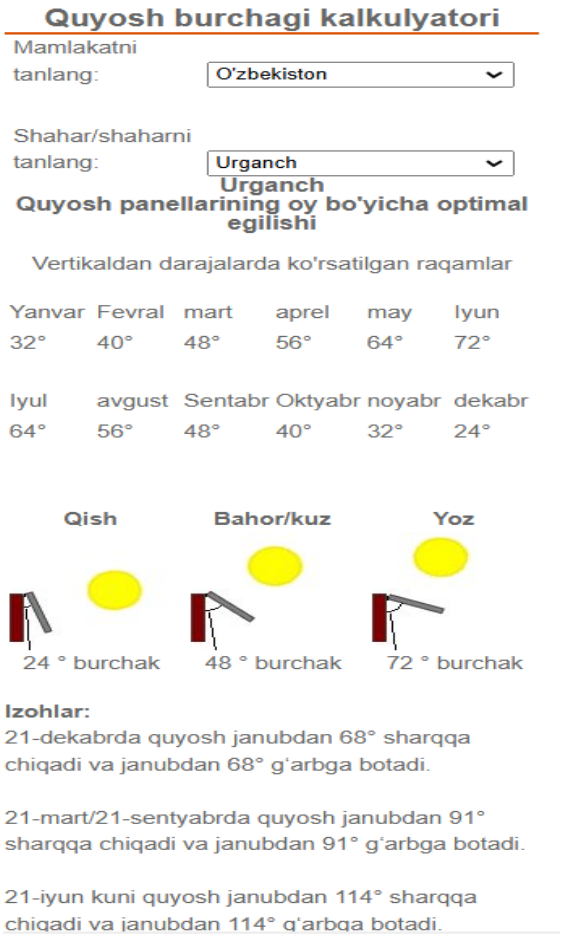

Figure 1. Calculator for determining the solar incidence angle on the Earth's surface (by month).

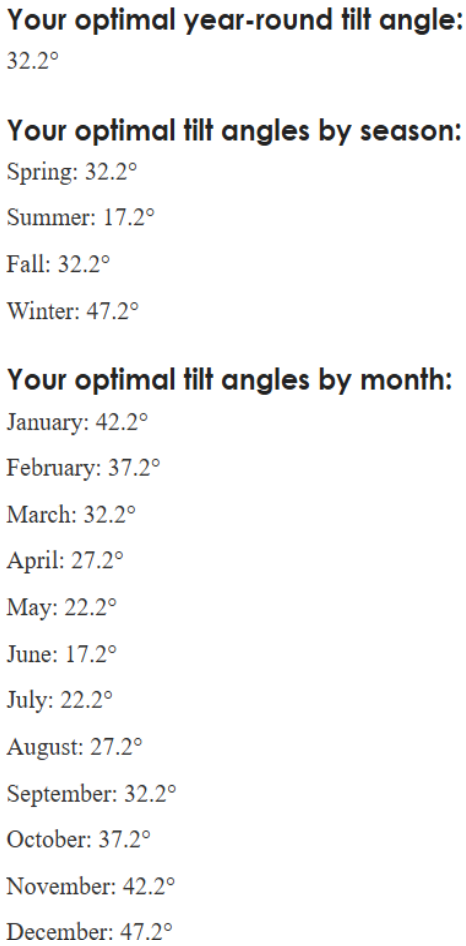

Figure 2. Installation angle of the solar panel (by month).

Research Methodology

Currently, there are several methods for controlling the installation angle of solar panels: single-axis mechanical method, and single- and dual-axis automatic control methods.

In this article, the dual-axis control method using a microcontroller is studied. Sensors that measure the angle of the panels are installed and collect data in real-time. Using Arduino microcontrollers, the data from the sensors is analyzed and appropriate control signals are generated. Based on the level of light, the panels are automatically optimized—meaning they continuously adjust to remain perpendicular to the sunlight [3].

Using the above method, the possibility of increasing the efficiency of solar panels has been examined. By maintaining the optimal angle of sunlight, energy production can be significantly increased—in short, the "sunflower method" is applied.

Analysis and Results

Experimental results showed that systems controlled by a microcontroller enable the development of an algorithm for an automatic solar panel rotation mechanism, which allows for more efficient use of sunlight.

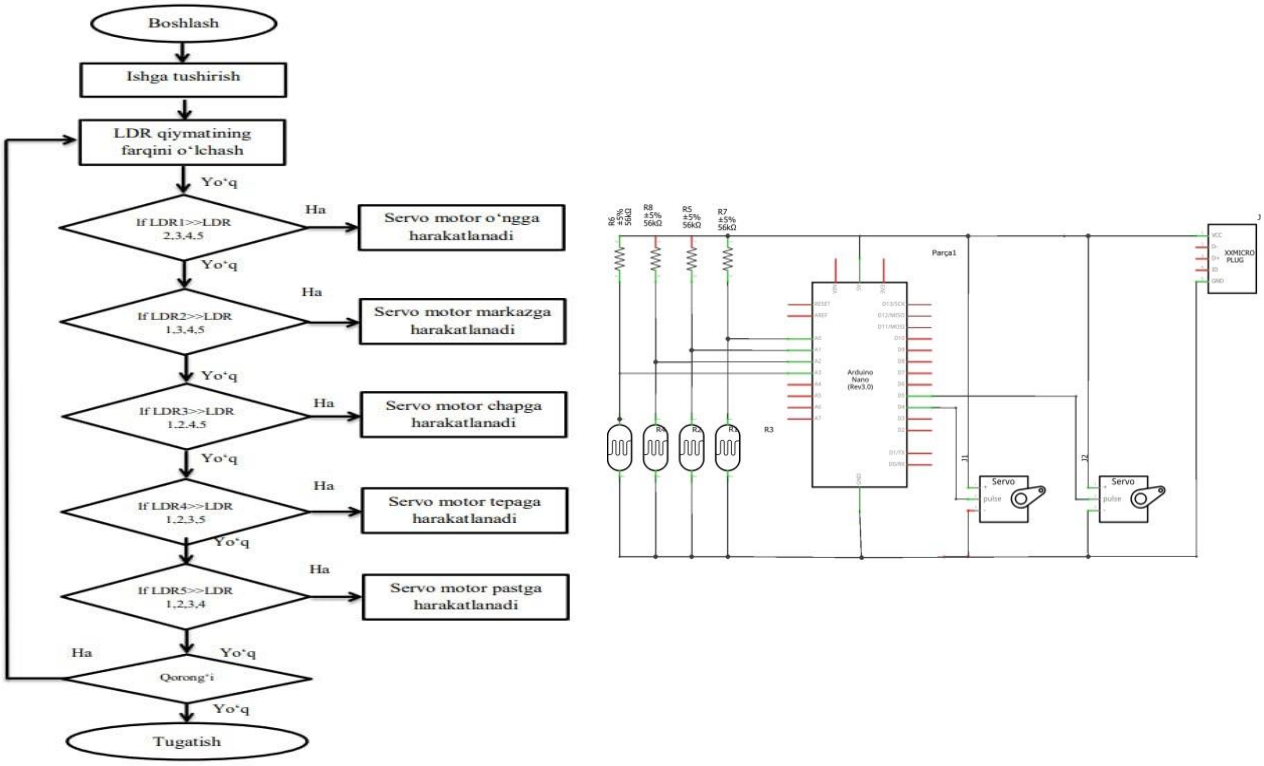

Figure 3. Developed algorithm and electrical circuit

Using the device operating based on the developed algorithm, the following results were obtained. The experimental data were recorded from measurements taken in September and October, comparing the performance of fixed-position solar panels with that of dual-axis adjustable solar panels.

Table 1. Measurements taken in September and October.

Measurement results for the month of September		
Time	**Solar panel in stationary position (6W)**	**Solar panel operating in the designed system (6W)**
7.00	0.697	1.477
8.00	0.792	2.804
9.00	1.779	3.203
10.00	3.167	3.990
11.00	3.456	4.130
12.00	4.604	4.800
Measurement results for the month of October		
Time	**Solar panel in stationary position (6W)**	**Solar panel operating in the designed system (6W)**
7.00	0.176	1.487
8.00	0.210	1.839
9.00	0.196	2.933
10.00	0.567	3.783
11.00	0.816	3.798
12.00	2.297	3.969

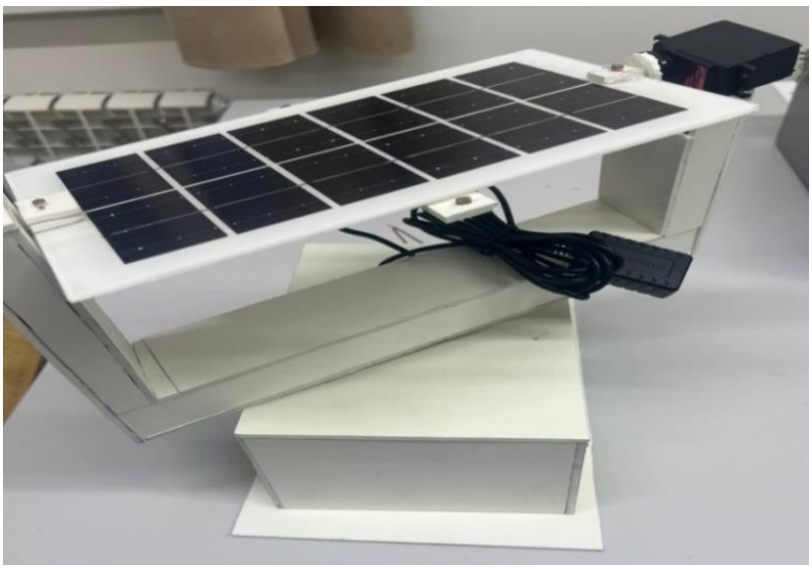

Figure 4. Dual-axis controlled solar panel.

Conclusion

The technology of maximizing the efficiency of solar panels using microcontrollers is considered an effective and promising solution. The results of this study will contribute to more efficient use of solar energy in the future.

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THE IMPORTANCE OF DISCURSIVE COMPETENCE IN TEACHING ENGLISH TO NON-PHILOLOGICAL STUDENTS, PARTICULARLY THOSE IN THE FIELD OF PHYSICAL EDUCATION

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Annotatsiya. Ushbu maqolada diskursiv kompetensiyaning mazmun-mohiyati, uning nofilologik yo‘nalish talabalari, xususan jismoniy madaniyat ta’lim yo‘nalishidagi ahamiyati ilmiy-uslubiy nuqtai nazardan yoritiladi. Diskursiv kompetensiyani rivojlantirish orqali talabalar xorijiy tilda erkin fikr bildirish, muloqotga kirishish va kasbiy faoliyat kontekstida o‘z fikrini aniq ifoda etish ko‘nikmalarini shakllantiradi. CLIL, TBL, CBL, ABL metodlari doirasida ushbu kompetensiyaning ahamiyati ochib beriladi.

Kalit so‘zlar: *diskursiv kompetentsiya, kommunikativ kompetentsiya, integratsiya, ko‘nikma, madaniyatlararo bog‘liqlik, sotsiolingvistik, strategik, koherensiya.*

Аннотация. В данной статье с научно-методологической точки зрения раскрываются сущность и содержание дискурсивной компетенции, а также её значение для студентов непрофильных (нефилологических) направлений, в частности, специальности “Физическая культура”. Развитие дискурсивной компетенции способствует формированию у студентов навыков свободного выражения мыслей на иностранном языке, вступления в коммуникацию и чёткого выражения собственных суждений в профессиональном контексте. Значение данной компетенции рассматривается в рамках применения методов CLIL (предметно-языковое интегрированное обучение), TBL (обучение на основе выполнения заданий), CBL (обучение на основе кейсов) и ABL (деятельностный подход).

Ключевые слова: *дискурсивная компетенция, коммуникативная компетенция, интеграция, навык, межкультурная взаимосвязь, социолингвистический, стратегический, когерентность.*

Abstract. This article explores the essence and significance of discursive competence from a scientific and methodological perspective, with particular emphasis on non-philological students, especially those studying physical education. By developing discursive competence, students acquire the ability to express their thoughts freely in a foreign language, engage in meaningful communication, and articulate their ideas clearly within the context of professional activity. The importance of this competence is revealed through the implementation of CLIL (Content and Language Integrated Learning), TBL

(Task-Based Learning), CBL (Case-Based Learning), and ABL (Activity-Based Learning) methods.

Keywords: *discursive competence, communicative competence, integration, skill, intercultural connectedness, sociolinguistic, strategic, coherence.*

Introduction

Learning foreign languages is becoming more and more crucial in today's globalized society, not just for students in philological fields, but also for those in nonphilological fields. English is especially crucial for students majoring in physical education since it helps them communicate professionally, comprehend scientific data, and engage in international collaboration. One of the fundamental language skills necessary for students to articulate their ideas in a logically and contextually appropriate manner is discursive competence. In language acquisition, discursive competence includes skills like producing sensible intertextual links, communicating material clearly, generating context-appropriate thoughts, and considering cultural and pragmatic factors. Because of socioeconomic and scientific advancements, the idea of English for Specific Purposes (ESP) needed to be brought into language instruction in the latter half of the 20th century.

Literature Review

The importance of the learning process starting with the learner rather than the teacher was organized by Tom Hutchinson and Alan Waters, as well as by Canale and Swain (1980). In other words, lessons should be organized according to the student's needs, drive, skill, and background. They suggested the following steps in creating ESP courses: Needs Analysis, Syllabus Design, Materials Development, Instruction, and Assessment [1]. From this perspective, D.M. Isroilova also emphasizes in her research the importance of developing interactivity, a communication-based approach, and contextual knowledge in the process of learning English. In particular, through her concept of "the field of needs in learning General English and English for Specific Purposes," she substantiates the significance of identifying learners' professional, personal, and social needs, and organizing the language teaching process based on those needs [2].

Since these steps are interconnected, they must be carried out in accordance with the individual learner's unique needs. This procedure acknowledges that discursive competence is a crucial aspect of communicative competence. The main reason for learning a language with particular objectives is to acquire professional communicative skills, which they described as follows: grammatical, sociolinguistic, strategic, and discursive competences make up communicative competence. Discursive competence, in particular, refers to cohesion (linking) and coherence (logic)—the way that words, phrases, and sentences are combined to produce meaningful communicative forms like newspaper articles, speeches, interviews, or electronic messages [3].

Discourse competence encompasses a student's ability to comprehend and produce texts through listening, speaking, reading, and writing. It is closely linked to textual coherence and cohesion [4]. Discourse competence facilitates the construction and interpretation of texts. However, it often presents challenges for students, as they encounter difficulties in understanding due to differences in the structures of texts and

speech between their native language and the target language. A contextual model formed on the basis of knowledge produced in the mind by language is how T. Van Dijk describes discourse [5]. As components that connect and organize conversation, discourse markers are essential for language learners in Deborah Schiffrin's (1987) theoretical framework [6].

In his monograph "Teaching and Assessing Intercultural Communicative Competence" Michael Byram discusses the theoretical and practical underpinnings of fostering intercultural communicative competence in language instruction [7]. The author contends that language acquisition should include not just the growth of grammatical, vocabulary, and pronunciation skills, but also the capacity to comprehend and adjust to cultural differences as well as communicate effectively. Byram dissects intercultural competence into its constituent parts and offers a theoretical and practical basis for the integration of language, culture, and communication skills in foreign language instruction. Especially for those working in a worldwide context, where good intercultural communication is paramount, this ability is crucial.

Research Methodology

In Communicative Language Teaching (CLT), a language teaching methodology based on the communicative approach, people often refer to two different concepts and definitions. This leads to ambiguity and confusion in terminology. Such a situation gives rise to differences and complexities in interpreting the essence of communication and the methodological approaches within the language teaching process [8].

In S.F. Shatilov's methodological approach, lexical skill consists of two main components. The first is the ability to use words correctly in speech, in accordance with the context and communicative purpose. The second is the ability to derive new lexical units from existing ones within the linguistic process — in other words, word formation skills. These two components — the sense of semantic appropriateness and morphological creativity — are regarded as methodologically inseparable elements in the development of lexical competence. Particularly in foreign language teaching, the integrated development of these skills significantly enhances language acquisition effectiveness by teaching students not only to memorize ready-made phrases, but also to use and generate them independently in new communicative contexts [9].

One of the key needs of scientific progress is the development of discursive competence in students in nonphilological areas, especially those studying in sports-related fields. In the field of physical education, the relevance of discursive competence is closely related to the professional tasks that students face, such as participating in sports competitions, working in teams, engaging in international sports forums, and interacting with foreign specialists. These processes cannot be accomplished only through grammatical or lexical knowledge; they also require speech competency at the discursive level. Students learning English in the field of sports are frequently expected to deal with health-related issues, sports methodology, international competition rules, and professional terminology. They are also expected to communicate effectively, express thoughts, and comprehend others in a foreign language.

As a result, it's critical to employ a successful technique in the creation of this element.

Methods of fostering discursive competence (within an integrative approach):

a) CLIL (Content and Language Integrated Learning): This approach combines language acquisition and subject matter by using English to teach about sports-related subjects, hence fusing linguistic and domain-specific discourse. For instance, an engaging English lesson on the subject of "Muscle groups and their functions in physical training" The main problem for CLIL applied to PE is that this methodology cannot be implemented if first we do not observe this field from the perspective of critical pedagogy. Such a critical perspective, however, is missing in both PE and CLIL as a methodology to teach language and culture [9].

b) Case-Based Learning (CBL): By examining and debating real-world situations involving athletes or coaches, students learn how to communicate in a contextually relevant manner. "You're a coach at an international camp", you might say, "How would you describe the warmup routine in English?"

c) Task-based Learning (TBL): Students improve their discursive proficiency by using language in intentional, goal-oriented settings through the execution of particular activities in English. For instance, arranging the program for a sports competition in English, giving a speech, or making an announcement. The second direction of the integrated skills approach, known as Task-Based Learning (TBL), is considered one of the most effective methods of teaching a language through various exercises, games, and negotiations. This approach emphasizes learning through practical tasks [10]. The scholar N. Prabhu demonstrated that incorporating Task-Based Learning into foreign language lessons and enabling students to acquire the language through task completion yields highly effective results [11].

d) Project-Based Learning (PBL): Students are encouraged to participate in more in-depth discussion practice and long-term engagement by creating English-language projects around sports and healthy lifestyles. An illustration would be "A presentation about healthy lifestyle for athletes" which would include slides, speeches, videos, and written materials.

In addition to improving language skills, these approaches also encourage the capacity to communicate effectively, rationally, and contextually in professional and academic sports settings.

It is recommended that the process be carried out in the following steps in order to establish and foster discursive competence in students' minds:

1. Reproductive Phase: Using Prepared Phrases for Speech: Students employ straightforward or memorized structures to express basic concepts. For instance, "I like football. I play every day".

2. Reorganizing Phase – More Freedom in Sentence Building with Logical Connections: Pupils start to create their own sentences with greater syntactic and semantic command. For instance, "Playing football every day helps me stay healthy".

3. Constructive Phase – Logical Communication with Arguments and Explanations: Pupils improve their capacity to articulate complicated ideas with rationale and thorough explanations. For example: "Physical activity increases blood circulation, which is essential for an athlete's performance".

4. Cognitive-Discursive Stage – Contextually Appropriate and Professionally Relevant Speech: Students are able to communicate effectively and fluently in

professional settings, tailoring their language to the context and role. In professional sports, I think that mental preparation is just as important as physical training for future coaches. This progression guarantees a methodical improvement in discursive ability, going from simple articulation to sophisticated, context-sensitive professional communication. J. Bruner, one of the leading figures in cognitive psychology and educational theory, emphasized that learning is not a passive reception of information, but rather an active process of constructing meaning based on prior knowledge, social interaction, and logical reasoning [12].

Analysis and Results

During the learning process, it is crucial to maintain coherence and consistency in the interaction between teacher and student, especially in the proper use of chosen learning activities. These should be consistent with the national education standards (DTS) and the standards of the CEFR (Common European Framework of Reference for Languages). The real-world application of discursive competence in the realm of sports has been fully demonstrated in our suggested textbook, "Successful English Learning in Sport". The following kinds of activities are deemed appropriate and beneficial:

• Producing and delivering dialogues about subjects related to sports.

• Talking about and analyzing sports news in English

• Using role-playing between the coach and the athlete to verbally describe exercises.

• Writing essays or delivering presentations on topics such as healthy lifestyles in sports;

• Engaging in question-and-answer discussion, such as pretending in English that an athlete is speaking with a referee;

• Engaging in argumentative speech, such as taking part in a discussion on the question, "Why is stretching important before training?"

• Offering advice and direction, such as describing workout activities in English during coaching practice;

• Offering opinions and analyzing sports articles in English, among other things, as a way of commenting on sports texts.

By fostering the use of language in genuine, professional, and context-specific contexts, these actions help learners develop their discursive skills regularly. In particular, the empirical and diagnostic assessments carried out at the Fergana Branch of the Uzbek State University of Physical Education and Sport during the 2023–2024 academic year in the "Foreign Language in Sport" courses revealed the following outcomes: Students who were taught using discursive and integrative approaches saw a 27% improvement in speech logic, a 22% increase in the use of professional terminology, and a 25% improvement in their ability to explain sports exercises in English. These results support the validity and significance of the aforementioned techniques.

Conclusion

In the field of physical education, as well as in other nonphilological disciplines, discursive competence is essential to teaching English to students. In addition to aiding

language learning, this ability allows for productive professional communication, active involvement in international athletic events, and interaction with worldwide scientific data. This talent may be systematically developed via integrative methods like CBL, TBL, CLIL, and ABL. Sports students gain the capacity for discursive competence, which enables them to express themselves effectively in professional English, engage in unrestricted communication during international competitions, and form meaningful connections with coaches and athletes from other countries. One of the primary goals of contemporary foreign language instruction is to foster this proficiency through integrative strategies. In addition to learning the language's structure (grammar, vocabulary), it's also important to be able to communicate well in real-world, professional settings. To put it another way, language is a tool, with the aim of facilitating effective communication. The theoretical and methodological basis for moving from a conventional "teacher-centered" paradigm to a "learner-centered" strategy in ESP (English for Specific Purposes) courses is the use of real materials, interactive methods (such case studies and project-based learning), and the promotion of active learner participation. The ESP sector is now conducting a great deal of study in the areas of curriculum development, needs assessment, and successful teaching strategies.

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THE STRUCTURE OF THE INDUSTRIAL SECTOR OF THE LOWER AMU DARYA, THE STATE OF USE OF EXISTING OPPORTUNITIES

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Annotatsiya. Maqolada Quyi Amudaryo iqtisodiy rayoni sanoat ishlab chiqarishini rivojlantirish imkoniyatini beradigan tabiiy va iqtisodiy resurslar, hamda sanoat tarmoq tarkibi tavsiflangan.

Kalit so'zlar: *mineral resurslar, mehnat resurslari, sanoat, sanoat tarmoq tarkibi.*

Аннотация. В стате описываются природные и экономические ресурсы, а также промышленная структура Нижне-Амударинского экономического района, которые предоставляют возможности для развития промышленного производства.

Ключевые слова: *минералные ресурсы, трудовые ресурсы, промышленност, структура промышленного сектора.*

Abstract. The article describes natural and economic resources, as well as the industrial structure of the Lower Amu Darya River economic region, which provide opportunities for the development of industrial production.

Keywords: *mineral resources, labor resources, industry, industrial structure.*

Introduction

The Lower Amu Darya Economic Region, consisting of the Republic of Karakalpakstan and the Khorezm region, is located in the northwestern part of Uzbekistan, bordering Kazakhstan to the north and west, Turkmenistan to the south, and Navoi and Bukhara regions of Uzbekistan to the east and southeast. Although the economic region is the largest in terms of territory in the republic, its economy, including industry, is one of the least developed.

Literature Review

The economic district industry was studied in more depth by R.Khudoyberganova, and E. Umarov studied it within the framework of the study of the productive forces of the Republic of Karakalpakstan. A. Abdullayev studied the issue of creating a separate sector of the food industry clusters in the Khorezm region [3, 7].

Research Methodology

Analysis of scientific and statistical sources, comparative balance methods are generally used in the study of the economic district industry.

Analysis and Results

With an area of 172.6 thousand square kilometers, the economic region accounts for almost 40 percent of the territory of the Republic of Uzbekistan and 10.8 percent of its population (Table 1).

Table 1. Some macro indicators of the Lower Amu Darya economic region (2024, in percent).*

Indicators	Share in Uzbekistan, %	Including:	
		Republic of Karakalpakstan	Khorezm region
Square	38,4	37,1 / 96,5	1,4 / 3,5
Population	10,8	5,4 / 50,0	5,4 / 50,0
Gross domestic product	7,2	3,1 / 47,0	3,5 / 53,0
Industrial product	6,0	2,7 / 45,2	3,3 / 54,8
Agricultural product	9,7	3,8 / 36,7	6,5 / 66,3

*Note: the numerator refers to the Republic of Uzbekistan, the denominator refers to the Lower Amudarya Economic Region.

The economic region is closer (500-1000 km) to the oil-rich Caspian regions of Kazakhstan than the eastern regions of the republic, and there is an opportunity to go to Iran and Southwest Asia through Turkmenistan. It is somewhat close to the countries of Eastern and Western Europe, but the territory is located on the far periphery of the republic and the developed regions of Central Asia.

The district has agro-climatic and mineral raw material resources that allow the development of some branches of the light, gas-chemical, heat and alternative energy, mining industry (table salt, iron ore). Inexpensive and abundant labor resources allow the development of the machine-building industries with light labor demand. In particular, there are large Tebinbulok titanium-magnetite, Ustyurt gas-oil region, Sultonuvais and Ustyurt ore and construction materials, mining and chemical mineral deposits in the region. Due to the discovery of dozens of deposits of minerals and building materials in the Sultan Uvays region, it is often called the “Little Urals” [1, 3, 5].

The mineral raw materials of the economic region are not evenly distributed. The Republic of Karakalpakstan has fuel and energy raw materials, metallurgical raw materials, chemical raw materials, building materials, and mineral resources used for food. About 30 oil and gas fields have been discovered in Ustyurt, one of the 5 largest

oil and gas regions in Uzbekistan, such as Shokhpakhta, Kuvanish, Berdakh, Akshalak, Urga.

A plant producing 1 million tons of enriched iron ore has been built on the basis of the large Sultanovays titanium-magnetite deposit. In the Karatov region, construction materials such as cement, lime, limestone, vermiculite, talc, marble, and raw materials used in various industries and agriculture are mined.

There are giant salt deposits in Karakalpakstan such as Borsakelmas, Karaumbet, Kushkhanatog, and Tumruk. They create opportunities for the development of the chemical industry. In Kungrad district, the only technical soda plant in Uzbekistan, operating on the basis of Borasakelmas salt and limestone, and the new town of Elabad have been built.

In the right-bank oasis part of the Khorezm region, only construction raw clay, sand, and gravel are found [1, 2]. Oil and gas exploration is being carried out in the region, but so far no economically significant reserves have been found.

The Lower Amu Darya region is rich in mining, mining, chemical, and gas minerals, but most of them fall on the territory of the Republic of Karakalpakstan, which has a large and naturally relatively geologically diverse territory. They allow the development of mining, chemical, and petrochemical energy production cycles. As we have seen above, these opportunities have been used to a certain extent in Karakalpakstan [3]. In the Khorezm region, it is also currently planned to build a gas and chemical complex in the Tuprokkala district.

The agro-industry of the economic region specializes in cotton processing. The economic region is one of the northernmost cotton-growing regions [1-3, 7]. The region's primary industry, light industry, is based on cotton ginning, textile and knitwear, and partly carpet weaving. 30-35 percent of cotton fiber is processed, mainly yarn and some types of raw fabrics or knitwear are localized [3].

The district has a power industry based on fuel and fuel products (Tahiatash, Yangiarik TPPs). Due to the lowland of the Lower Amu Darya, the hydropower potential is low. Therefore, the only Tuyamoyin power plant in the district with a capacity of 70 thousand kWh was built on the territory of the reservoir - the hydroelectric dam. The district has great potential for using alternative energy sources - solar and wind energy. In particular, the construction of a new solar power plant with a capacity of 100 MW was announced in the Khorezm region. The valuable subtropical crops grown in the economic district and a somewhat diversified and developed livestock farming, supplemented by a powerful light and food industry, allow for the further development of the industrial energy production cycle. The economic district produces 100 thousand tons of yarn and 0.5 billion sq. m. It is possible to organize processing facilities for yarn spinning and wool products in the relevant fields of agriculture in the volume of preparation of these products [6].

In the development of industry in the economic region, labor resources play a special role, and in this regard, the Khorezm region is distinguished by its high territorial concentration (the main part of the population is concentrated in the left-bank part). At the same time, the population of the southeastern part of Karakalpakstan is also located in the Khorezm oasis. Taking into account the characteristics of the location of the population and labor resources of the region and a number of other

factors, the Khorezm Automobile Plant, which produces passenger cars, was built in the city of Pitnak [1-3]. Transport infrastructure is also of particular importance in the development and location of industrial sectors in the economic region. The internal transport of the region mainly consists of railways and automobiles. Karakalpakstan has the opportunity to communicate with neighboring countries via railways. In particular, the fact that both entities of the economic region are being connected by new railways and highways across the Amu Darya River will enhance the ability to use the labor resources of the Khorezm region in the development of the resources of the Sultanovays industrial zone.

The natural and socio-economic potential of the Lower Amu Darya region allows for the development of industrial sectors. Today, 6.0% of the republic's industrial output is produced in the region (Table 1). This is very small for a region with 10.8% of the country's population, and it requires more complete use of its resources and increasing employment by attracting foreign investment to the sector.

The region specializes in the production of mechanical engineering, gas and chemical, light and food products. There are industrial points and centers, but industrial nodes and regional production complexes have not been formed. Due to the weakness of industrial production, large enterprises such as the Ustyurt Gas and Chemical Complex and the Khorezm Automobile Plant have been able to make significant changes in the structure of production (Figure 1).

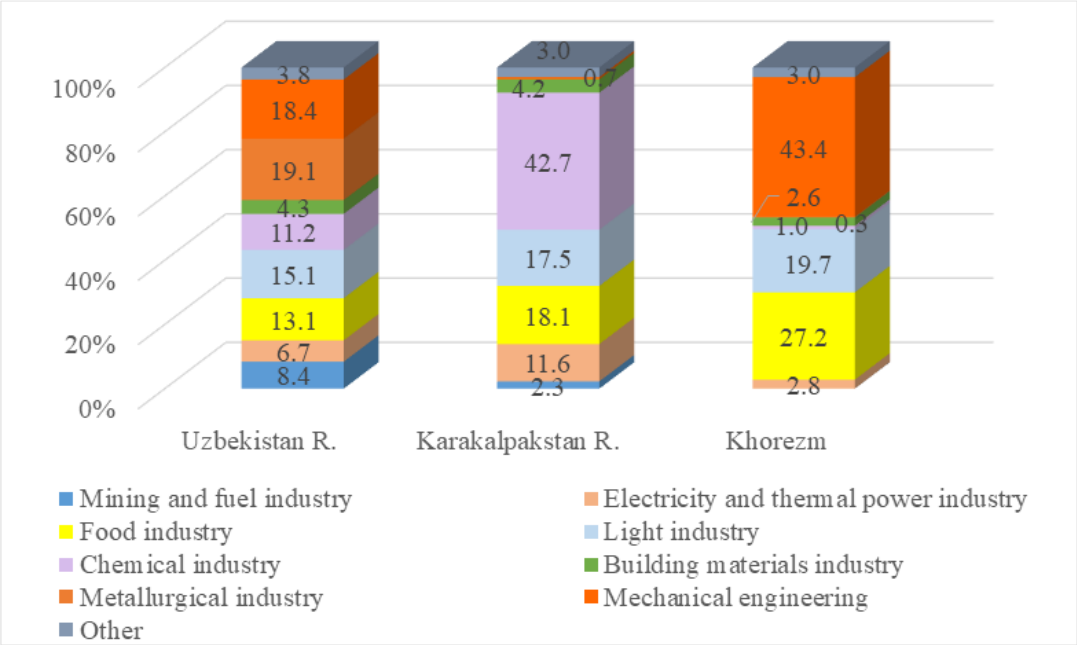

Figure 1. Sectoral structure of the industry of the Lower Amu Darya River (2023, in percent).

The figure is based on materials from the State Statistics Committee of the Republic of Uzbekistan. Karakalpakstan is rich in raw materials for the chemical industry. More than 30 oil and gas fields have been discovered on the Ustyurt plateau. The largest of them are the Kuvanish and Shokhpakhta, Surgil, and Urga fields. About 10 percent of Uzbekistan's natural gas and about 9 percent of oil products are extracted in Karakalpakstan. Based on gas condensate, polyethylene and polypropylene products are produced at the UzKorgaz Chemical LLC. In Kungrad district, the next largest chemical industry enterprise, the Kungrad Soda Plant, produces caustic soda, rock

(technical) salt, sodium chloride, and sodium sulfate. The plant has a capacity of 160 thousand tons and produces pure sodium chloride [3].

The food industry is the second largest sector of the economic region. The food industry produces fats and oils, meat and bakery products, canned fruit, and confectionery. The industry is developing rapidly, especially in the Khorezm region (Figure 1). Mechanical engineering occupies a leading position in the industry of the economic region (Figure 1). In particular, the Uzbek-Chinese joint venture UzXCMG, based on the Urgench excavator plant, and the enterprise in the city of Pitnak with a capacity of 100 thousand passengers and special vehicles per year form the basis of mechanical engineering. Other branches of the industry are poorly developed or have local significance.

Conclusion

The region has large mineral resources, which create favorable opportunities for the development of industrial production. Using the available mineral resources, the economic region allows the development of fuel and energy, chemical, metallurgical, mechanical engineering and building materials industries with high production potential.

In this regard, the formation of industrial growth poles in the form of free industrial zones in the industrial zone of the Karatov settlement of Karakalpakstan (Karauzak district) and around the city of Pitnak in the Khorezm region will allow solving socio-economic problems, as well as increasing the industrial potential of the economic region.

In general, the specialization of industrial production in the economic region is very narrow and highly centralized. Currently, the sectors in the region that have the potential to create an energy cycle in an evolutionary, i.e. traditional way are gas chemistry, mining chemistry, mining and metallurgy (ferrous and partially non-ferrous metallurgy), especially the light and food industries with high export potential, which provide the population with consumer goods, have not completed their cyclical cycle or have not created a lower cycle at all.

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ON THE NEGATIVE ORDER MATRIX MODIFIED KORTEWEG-DE VRIES EQUATION WITH A SOURCE

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Annotatsiya. Ushbu maqolada moslangan manbali matritsaviy manfiy tartibli modifitsirlangan Korteveg-de Friz (KdF) tenglamasi integrallangan. Dirak operatori sochilish berilganlarining vaqt bo‘yicha o‘zgarish qonuniyatlari keltirib chiqarilgan.

Kalit so‘zlar: *integral tenglama, simmetriya, rekursiya operatori, tez kamayuvchi funksiya.*

Аннотация. В данной статье интегрируется матричное модифицированное уравнение Кортевега-де Фриза (КдФ) отрицательного порядка с самосогласованным источником. Выведена временная зависимость данных рассеяния оператора Дирака.

Ключевые слова: *интегральное уравнение, симметрия, рекурсивный оператор, быстроубывающая функция.*

Abstract. In this paper, we integrate the negative order matrix modified Korteweg-de Vries (KdV) equation with a self-consistent source in the class of rapidly decreasing functions. We derive the temporal dependence of the scattering data of the Dirac operator.

Keywords: *integral equation, symmetry, recursive operator, rapidly decreasing function.*

Introduction

The foundational concept in the theory of solitons is the solitary wave solution, a wave that travels without changing form, a property made possible by a balance between nonlinearity and dispersion in certain evolution equation. Prototypical examples of integrable nonlinear evolution equations (NEEs) supporting solitons include Korteweg-de Vries (KdV) equation, modified KdV (mKdV) equation, nonlinear Schrödinger (NLS) equation, and sine-Gordon equation. The mKdV equation, in particular, modifies the nonlinear term of the classical KdV and describes sharper, more peaked, solitary structures. It plays the crucial role in the study of plasma waves, internal waves in stratified fluids, and nonlinear electrical transmission lines. Since nonlinear equation studies have been thriving in recent years, more methodologies have been developed and more encouraging results regarding solution structures and solitons characteristics have been attained.

A key analytical instrument in the study of NEEs is the development of the Inverse Scattering Transform (IST) method. Introduced in the context of the KdV equation [1], IST allows certain nonlinear partial differential equations to be solved exactly by transforming them into a linear scattering problem [2].

Literature Review

In theory and experiments, the completely integrable equations are extensively studied by numerous researchers. Specifically, Zakharov V.E. and Shabat A.B. firstly demonstrated complete integrability of NLS equation using the IST method [3]. Building on this foundational ideas, Wadati M. successfully applied similar techniques to the mKdV equation [4], revealing its integrable structure. Subsequently, Ablowitz M.G., Kaup D.G., Newell A.C., and Segur H. [5] generalized the approach of Zakharov V.E. and Shabat A.B. by developing AKNS scheme. This framework unified the treatment of a wide class of integrable equations, including NLS and mKdV , through the scattering theory associated with the Dirac operator on the line. Following these foundational advancements in the integrability theory of nonlinear equations of positive order, the field experienced significant growth and attracted extensive research efforts from numerous authors [6-9]. Particularly, in the work [6], it was provided the exact solution to mKdV equation by the matrix triplet method, in [7, 8] it was studied the mKdV equation with additional term in the different classes. Furthermore, it was integrated the matrix mKdV equation with a self-consistent source via the IST method in [9-10].

Along with NEEs with positive order, the analogs of these equations with negative powers has also became a central part in the field of complete integrable systems. Verosky J.M. [11] firstly derived the negative order KdV (nKdV) using the Olver's idea in negative direction. Wazwaz A.M. was established negative order mKdV (nmKdV) in focusing and defocusing forms [12]. In the works [13-15], it was investigated nmKdV with and without a source in the class of periodic and "rapidly decreasing" functions.

Research Methodology

In the present study, we investigate an extended form of the negative order matrix modified Korteweg–de Vries (nmmKdV) equation by employing the IST method associated with the Dirac operator. For finding the explicit form of the solution to considered problem it can be used the matrix triplet technique.

Analysis and Results

We analyze the following problem

$$\begin{cases} \rho_x(x,t)=\upsilon(x,t)\upsilon_t(x,t)+\upsilon_t(x,t)\upsilon(x,t) \\ \upsilon_{xt}(x,t)+\upsilon(x,t)\rho(x,t)+\rho(x,t)\upsilon(x,t)+\upsilon(x,t)=2\sum_{n=1}^{2N}(f_{1,n}\otimes\hat{f}_{2,n}^{T}+f_{2,n}\otimes\hat{f}_{1,n}^{T}), \\ Lf_k=\xi_k f_k, \quad k=1,2,\dots 2N, \end{cases} \tag{1}$$

under the initial condition

$$\upsilon(x,t)|_{t=0}=\upsilon_0(x), \tag{2}$$

where $\upsilon(x,t)$ and $\rho(x,t)$ are $(m\times m)$ square matrices and the matrix norm is defined as $\|H\|=\max_i \sum_{j=1}^{N}|H_{ij}|$. Besides, let the matrix $\upsilon_0(x)$ is a real and symmetric $(m\times m)$ matrix having the following properties:

1. $\int_{-\infty}^{\infty}(1+|x|)\|\upsilon_0(x)\|dx<\infty$; (3)

2. Matrix operator $L(0)=-iJ\frac{d}{dx}-U_0(x)$ has exactly $2N$ simple eigenvalues $\lambda_1(0),\lambda_2(0),...,\lambda_{2N}(0)$. Here $U_0(x)=\begin{pmatrix}0 & i\upsilon_0(x)\\ i\upsilon_0(x) & 0\end{pmatrix}$.

Let matrix functions $\upsilon(x,t)$ and $\rho(x,t)$ belong to the class

$$\Lambda=\left\{\begin{array}{c}\upsilon\in C^2,\ \rho\in C^{1,0};\ \lim\limits_{x\to\pm\infty}\rho(x,t)=0,\ t\in \mathrm{R};\\ \int_{-\infty}^{+\infty}[(1+|x|)(\|\upsilon(x,t)\|+\|\upsilon_x(x,t)\|+\|\upsilon_t(x,t)\|+\|\upsilon_{xt}(x,t)\|)]dx<\infty\end{array}\right\}.$$

Furthermore, $f_n=\begin{pmatrix}f_{1,n}\\ f_{2,n}\end{pmatrix}$ are column eigenvector functions that corresponds to the eigenvalue λ_n and $\hat{f}_n(\lambda_n,x,t)=\sigma f_n(-\lambda_n,x,t)$ corresponds to the eigenvalue $-\lambda_n$, which are normalized by the following conditions

$$\int_{-\infty}^{\infty}\hat{f}_n^T(x,t)f_n(x,t)dx=a_n^2(t),\quad n=1,2,...,2N. \tag{4}$$

The system is equivalent to the following Lax equation

$$L_t=[L,B]+\frac{1}{2\lambda}\begin{pmatrix}0 & \sum_{n=1}^{2N}\left[J,f_n\otimes\hat{f}_n^T\right]\\ -\sum_{n=1}^{2N}\left[J,f_n\otimes\hat{f}_n^T\right] & 0\end{pmatrix},$$

where

$$L(t)=-iJ\frac{d}{dx}-U(x,t), \tag{5}$$

$$B(t)=-\frac{i}{2\lambda}\left(\frac{1}{2}J+\mathrm{P}J\right)+\frac{U_t}{2\lambda}.$$

Here $U(x,t)=i\begin{pmatrix}0_m & \upsilon(x,t)\\ \upsilon(x,t) & 0_m\end{pmatrix}$ and $\mathrm{P}(x,t)=\begin{pmatrix}\rho(x,t) & 0_m\\ 0_m & \rho(x,t)\end{pmatrix}$ are $2m\times 2m$ matrices $J=\begin{bmatrix}I_m & 0_m\\ 0_m & -I_m\end{bmatrix}$, I_m is the unit matrix, $\sigma=\begin{pmatrix}0 & I_m\\ I_m & 0\end{pmatrix}$ and $a_n^2(t)$, $n=\overline{1,N}$ are nonzero continuous scalar functions.

The work is devoted to find the solution $\{\upsilon(x,t), \rho(x,t), f_n(x,t), n=1,\ldots,2N\}$ to the problem (1)-(4) in the class Λ by IST method. Note, that analogous problem for positive order matrix mKdV with the similar self-consistent source is considered in [8].

Inverse scattering theory.

The considered problem is associated to the following matrix Zakharov-Shabat system

$$LY(x,\lambda) = -iJY'(x,\lambda) - UY(x,\lambda) = \lambda Y(x,\lambda), \tag{6}$$

where $Y(x,\lambda) = [y_j]_{j=1}^{2m}$ column vector functions or square matrix of order $2m$. We assume that the matrix function $\upsilon(x,t)$ satisfy the condition

$$\int_{-\infty}^{\infty} (1+|x|)\|\upsilon(x)\|\,dx < \infty. \tag{7}$$

According to the condition (7), the equation (6) has the Jost solutions $\Psi(x,\lambda)$ and $\Phi(x,\lambda)$, which are unique $(2m)\times(2m)$ matrix functions satisfying the asymptotic conditions

$$\Psi(x,\lambda) = \left[\bar{\psi}(x,\lambda)\ \psi(x,\lambda)\right] = \begin{pmatrix} e^{i\lambda x}I_m & 0_m \\ 0_m & e^{-i\lambda x}I_m \end{pmatrix} + o(1), \quad x \to +\infty$$

$$\Phi(x,\lambda) = \left[\phi(x,\lambda)\ \bar{\phi}(x,\lambda)\right] = \begin{pmatrix} e^{i\lambda x}I_m & 0_m \\ 0_m & e^{-i\lambda x}I_m \end{pmatrix} + o(1), \quad x \to -\infty$$

where $\lambda \in R$ and $\bar{\psi}(x,\lambda)$, $\psi(x,\lambda)$, $\phi(x,\lambda)$ and $\bar{\phi}(x,\lambda)$ are submatrices with $2m$ rows and m columns, respectively.

For $\lambda \in R$ there exists $2m\times 2m$ matrix $S(\lambda)$ such that

$$\Psi(x,\lambda) = \Phi(x,\lambda)S(\lambda),$$

where $S(\lambda)$ consist of block matrices such as $Y = \begin{pmatrix} Y_1 & Y_2 \\ Y_3 & Y_4 \end{pmatrix}$, Y_l, $l=\overline{1,4}$ are $m\times m$ matrices.

There exist matrices C_j such that

$$\bar{\varphi}(x,\lambda_j)\eta_j = \bar{\psi}(x,\lambda_j)C_j, \quad j=\overline{1,N},$$

The reflection coefficient $\lambda \in R$ is defined as

$$R(\lambda) = -S_1^{-1}(\lambda)S_2(\lambda).$$

Definition 1. The collection $\{R(\lambda), \lambda_j, C_j, j=1,\ldots,N\}$ is called the scattering data for (6).

Theorem 1. If $\{\upsilon(x,t), \rho(x,t), f_n(x,t), n=1,\ldots,2N\}$ solves the problem (1)-(4) in the class Λ, then the scattering data for the operator (5) evolve in time t by the formulas

$$\dot{R}(\lambda) = \frac{i}{2\lambda}R(\lambda),\ \lambda \in R,$$

$$\frac{d\lambda_j}{dt}=0, \quad \frac{dC_j(t)}{dt}=\left(\frac{i}{2\lambda_j}+a_j^2(t)\right)C_j(t), \quad j=\overline{1,N}.$$

Conclusion and Recommendations

The derived evolution equations completely specify the time dependence of the scattering data for the operator $L(t)$ which allow using the IST method for the problem (1)-(4) in the class Λ.

1) The obtained results can be implemented using the MatLab software package.
2) The approach presented in the current paper can be extended to analogous problem involving self-consistent source of integral type.
3) The present investigation allows to determine the asymptotic behavior of the potential $\upsilon(x,t)$ in sufficiently large t.

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