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Astronomy

PHOTOMETRY OF THE STAR AG PEG BASED ON AAVSO DATA

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Abstract

The article provides information about symbiotic stars in the introduction. The procedure for downloading photometric data from the AAVSO (American Association of Variable Star Observers) database is shown. Using the AAVSO photometric database for the symbiotic star AG Peg, a light curve in the Vis filter for a 35-year period (1990–2025) was constructed, and the physical processes occurring in the star were studied.

Keywords: stars, symbiotic stars, stellar size, Ag Peg, photometry, light curve.

Introduction. Stars are the most common celestial bodies in the universe. They are objects composed of extremely hot gases that possess light and thermal energy. The brightness of a star is measured by a quantity known as stellar magnitude. The nature of stellar magnitude is such that as it increases, the star's brightness decreases, and vice versa. The faintest star visible to the naked eye has a magnitude of 6^m. Stars with a magnitude greater than 6^m, as well as other objects, can only be observed using a telescope [1].

Symbiotic stars are systems consisting of interconnected stars of different types. They are a specific type of binary star system, typically composed of a White Dwarf (WD) and a Red Giant (RG) [2, 3, 4, 5]. The red giant loses its mass through stellar winds, and this material usually flows onto the hot compact star, forming an accretion disk. The source of the nebula's material is the red giant, which loses its matter via stellar winds or pulsations, while the hot white dwarf serves as the energy source. Based on their photometric and spectral behavior, symbiotic stars are classified as cataclysmic and sometimes eruptive variable stars [6, 7].

The structure of symbiotic stars can be described in a generalized form as follows: Cold component + hot component + nebula = symbiotic star.

The cold component of a symbiotic star can be

- Red giant
- Yellow giant
- Supergiant (pulsating variable)

The hot component of a symbiotic star can be

- White dwarf star
- Neutron star.

Approximately more than 250 symbiotic stars are currently known. Among them, AG Peg continues to attract the attention of researchers due to its numerous unique characteristics [8, 9]. This star is a close binary system consisting of a red giant and a white dwarf. The entire system is enveloped in a gas-and-dust nebula.

AG Pegasi (AG Peg) is the oldest symbiotic nova which attracted astronomers' attention with the first spectral observations performed by Fleming [10]. Lundmark [11]

showed that in the mid of 19th century, when a brightness increase started, the star's visual magnitude was ~ 9 . The maximum at about 6 mag was reached around the year 1870. The subsequent, gradual decrease of the star brightness, reaching the level observed before the outburst, lasted for about 130 yr [8, 12, 13, 14]. The orbital period of the system is accepted to be approximately 818 days [8, 15, 16]. The mass of the red giant is 2.6 times that of the Sun ($2.6 M_{\odot}$), while the mass of the white dwarf is approximately 0.6 solar masses ($0.6 M_{\odot}$).

Despite the good study of the AG Peg symbiotic star, new observational materials are obtained every day, new methods of approach allow us to obtain new and more reliable results about the star, as well as to refine previously obtained values of the star's parameters.

Research method. To find the apparent magnitude of any star, photometric observations of the star are carried out in various filters (UBVR $\dot{I}$ JK, etc.). Observations of variable stars are usually given on a graph called a light curve. The light curve directly allows us to obtain information about the periodicity of the change in the brightness of the star. It allows us to find the orbital periods of eclipsing double stars, to judge whether the star is regular or irregular in its eruptions. A more detailed analysis of the light curve allows us to calculate the masses and sizes of stars. Observations over several years or decades allow us to detect changes in the star.

Our main goal in this work is to construct the light curve of the AG Peg symbiotic star over the last 35 years using the AAVSO photometric database and discuss the processes occurring there. To load the data, the following parameters are entered into the operating system: the name of the star, the selected photometric filters, the start and end dates are noted and the send command is executed (Figure 1).

The screenshot shows the AAVSO LCGv2 web interface. On the left is a form titled 'Plot a light curve' with the following fields and options:

- Star Name: AG Peg
- Standardized Magnitude: (dropdown menu)
- Calendar Date: yyyy/mm/dd (dropdown menu)
- From Date: 1990/01/01 09:12:44
- To Date: 2025/01/01 09:12:44
- Plot Previous: (checkbox)
- Observer(s): (text input)
- Obs Code(s): (text input)
- Buttons: Send, Cancel

On the right is a grid of photometric filters. The grid has columns labeled with filter names: Vis, B, V, R, I, U, J, H, K, CV, CR, TB, TG, TR, SU, SG, SR, SI, SZ, RJ, IJ, STU, STV, STB, STY, STHBW, STHBN, MA, MB, MI, NA, Blue, Green, Yellow, Orange, Red, ZS, Y, HA, HAC, and CBB. Each cell in the grid contains a small icon representing the filter's spectral response. The 'All Bands' checkbox is checked at the top of the grid.

Figure 1. Downloading photometric data.

As a result, a brightness curve of the AG Peg symbiotic star in the Vis filter was constructed for a 35-year period using the American Association of Variable Star Observers photometric database (Figure 2) [17].

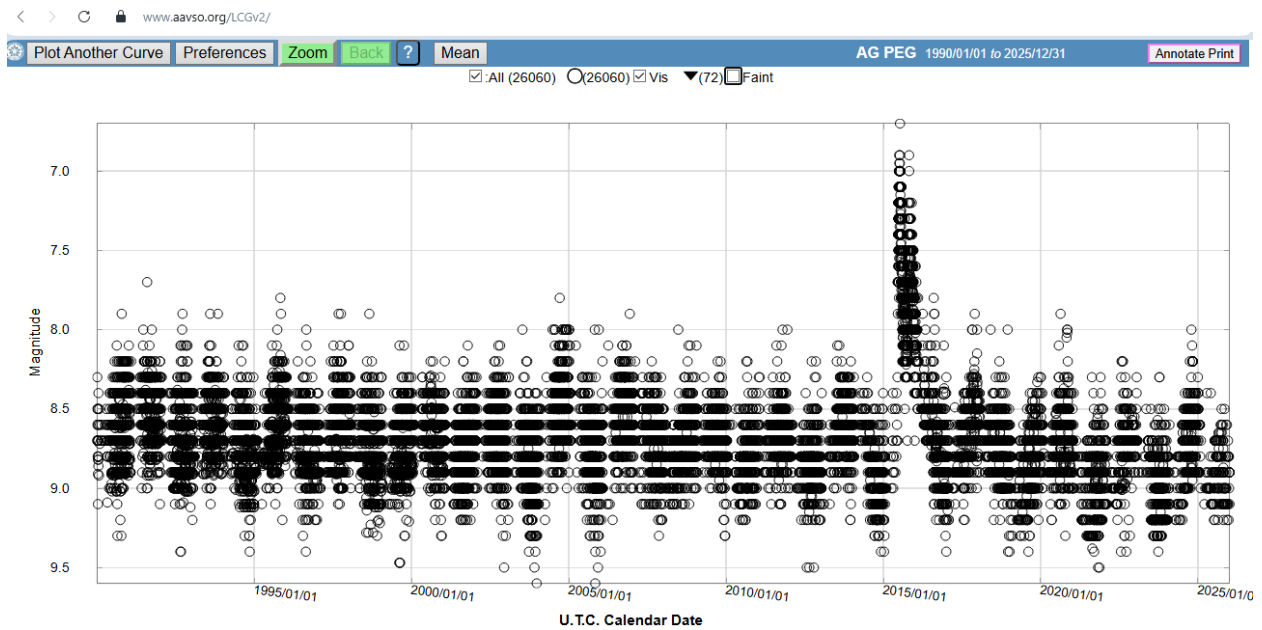


Figure 2. Photometric light curve of the symbiotic star AG Pegasi (Vis filter, 1990–2025) based on AAVSO data. The figure is taken from [17].

Due to the large number of observations shown in the figure, we downloaded the photometric data and constructed the light curve in a more comprehensible format. To retrieve the star's photometric observation data from the AAVSO database, a more researcher-friendly version of the 'Plot a light curve' program, developed by Khidir Mikailov, was utilized [3, 5, 15, 16].

Photometric data from the AAVSO database are downloaded in text format following the procedure below:

1. Select the time frequency: This determines the interval at which data is retrieved. For example, in Figure 3a, a time frequency of 1 day is selected.
2. After clicking the print button, the data is downloaded in text format (Figure 3b).

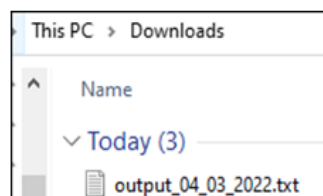
a)

Bin Size(Julian Days):

Final result:

Print

b)



```

output_04_03_2022.txt - Notepad
File Edit Format View Help
2451761.6087,12.2
2451771.6083,12.3
2451788.6923,12.3
2451799.6817,11.9
2451804.6523,12.2
2451814.5761,11.9
2451831.607,12.3
2451836.655,12.2
2451842.605,12.2
2451848.607,12.2
2451853.626,12.3
2451864.589,11.8
2452006.981,12.3
2452026.974,12.3
2452032.98,12.4
2452035.953,12.4
2452037.964,12.3
2452041.954,12.2
2452053.921,12.4
2452059.924,12.3
  
```

Figure 3. Procedure for retrieving photometric data in text format from the AAVSO database.

In Figure 4, we have constructed the light curve for the period 1990–2025 (Julian Date range: JD 2447000–JD 2460600) using the methodology described above. A time interval of 10 days was selected; in other words, each data point represents the averaged value of measurements over a 10-day period.

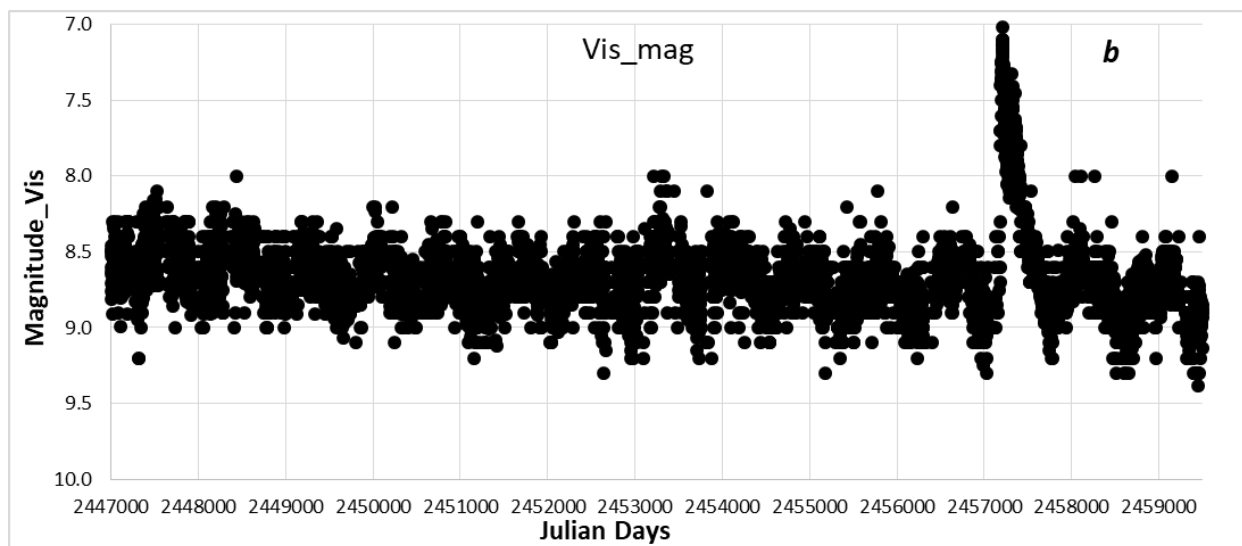


Figure 4. Photometric light curve of AG Pegasi (1990–2025) using AAVSO observations.

The fact that the symbiotic star AG Peg is sufficiently bright ($8^m \div 8.5^m$) has enabled it to be well-studied both photometrically and spectrally. As seen from the figure, variations in the star's brightness are clearly evident. As known from previous observations [14], during the outburst, the star's magnitude changed from 9 to 6. However, observing this graph, we can see that various magnitude fluctuations occur in the star's brightness. Notably, between June and August 2015, the star reached its brightest state within the observation period (1990–2025), with its magnitude brightening from 8.7 to 6.9. During this event, the magnitude changed by 1.8 magnitudes. Outside of this period, as seen from the light curve, small modulations or variations occurred within a range of 1^m to 1.5^m . By 2025, the magnitude was 8.5. This evolution of the light curve (LC), along with other spectrophotometric parameters, is characteristic of the slowest nova ever recorded [9, 16].

Conclusion. A light curve for the symbiotic star AG Peg was constructed covering a 35-year period (1990–2025). The observations revealed that recurring active processes occur within the star at various times. From the light curve, it was determined that an outburst took place during the observation period, resulting in a magnitude change of 1.8. These outbursts in the star may be associated with the accretion of mass, lost through the stellar wind of the red giant, onto the white dwarf.

Acknowledgements

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Biological sciences

UDC 82

WAYS OF IMPROVING THE CREATIVITY OF SCHOOLCHILDREN THROUGH CRITICAL THINKING TECHNOLOGY (GRADE 8)

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Abstract

Over the past decade, the world has changed incredibly and is changing at a very fast pace. The integration of educational content can become one of the effective tools for solving this problem. Critical thinking is currently the most important principle of the development of the modern education system, closely related to the principle of differentiation. Big changes are currently taking place in Kazakhstan. A developing society needs educated, moral, initiative people in modern conditions who can make decisions of their choice, anticipate their possible consequences, are capable of cooperation, are mobile, dynamic, constructive and feel responsible for the fate of the country. Education is becoming a powerful driving force for economic growth. The integration of sciences, the desire to accurately reflect the overall picture of the world is a characteristic feature of modernity.

Keywords: critical thinking, integration, biology, technology, creative thinking s, general skills, secondary school, innovation.

Modern life requires replacing the formula "education for life" with the formula "critical thinking skills for life". The main object is to determine the effectiveness of interdisciplinary connections in the process of teaching interdisciplinary integration in biology lessons. Comprehensive teaching methods the purpose of helping students: to teach them to learn; to teach them to do; to learn to live together; to learn to live in harmony with themselves. Such learning goals lead to the formation of children's not critical, but in the sense of choosing the optimal solution from a set of solutions. Now, when time demands from us and our children more interesting and non-standard solutions in order not to get lost in this world, to find our place in life, critical thinking is unlike any other[1].

Any teacher, using any technology, method, is looking for the most beneficial one for the child. The student studies theory to improve his knowledge in the lessons of natural science, physics, geography, etc.

Integrated learning implies not only the interconnection of knowledge in different subjects in one lesson, but also the unification of various technologies, methods and forms of one subject and even within one lesson. Integrated classes can be conducted throughout the school day using a variety of methods [2]. A number of classes can be held within the framework of a single topic. Classes are conducted by 2-3 teachers. 60-80% of the study time is devoted to the creativity of students, various methods of influencing the student, multimedia support are used. Integrated lessons have many advantages because they not only solve common educational problems, allowing students to form a more holistic view of the world. A great opportunity to use various technologies, methods, and forms in integrated lessons — in the conditions of our school — allows us to solve another important task - this is a health-saving approach to learning. The use of integration methods in the organization of the educational process contributes to the creation of conditions of psychological comfort, assuming the presence of an atmosphere. creativity, cooperation and mutual assistance, opportunities for self-expression and self-realization, successful personal development and preservation of children's health.

The effectiveness of integrated education depends on the correct, pedagogically sound choice of forms of educational organization, provided by a deep and comprehensive analysis of the educational, developmental, and educational capabilities of each of them. Integration between subjects is possible only with a healthy and healthy climate in the teaching staff, their fruitful cooperation based on mutual understanding and respect promotes the formation of consistency and integrity of knowledge, skills and

abilities of students, their views on the world, culture and its values[3]. In turn, to conduct an integrated lesson, the following conditions must be taken into account: first of all, the teacher must choose the object of study in the lesson and carefully analyze the content of the lesson.

During the implementation of the lesson, it is necessary to think over the technology of independent educational activities of students. The teacher should use problem-based teaching methods, as this activates the mental activity of students at all stages of the lesson. A thoughtful combination of individual and group forms of work is also an integral part of the integrated lesson. Of course, one should not forget to take into account the age-related psychological characteristics of students and their orientation towards a healthy lifestyle. An integrated lesson also cannot be implemented without knowledge of its types and forms. Such classes give the best results, teachers find different tasks, sort them according to their connections with different subjects. The number of embedded stems should not be large. On average, 2 classes per month will be optimal, so the method will not interfere with the assimilation of new material. The most successful in my practice are the following forms of integrated classes: research, excursions, travel. And methods are a lesson in learning skills and a lesson in repetition [4]. Integration as a means of learning contributes to the formation of consistency and integrity of knowledge, skills, skills of students, their attitude to the world, culture and its values. The greatest happiness of a teacher is to look at the joy of children from the small discoveries they have made in our built-in lessons.

The importance of biological education based on the improvement of the educational system space is currently possible with the use of technology. Based on the research problem, methods of theoretical literature analysis, research, survey, comparison, analysis, induction, synthesis, observation were used[5].

The survey questions were mainly intended to determine which technology could be used to develop a higher quality of knowledge. The vast majority of teachers, i.e. 75%, are integration technologies.

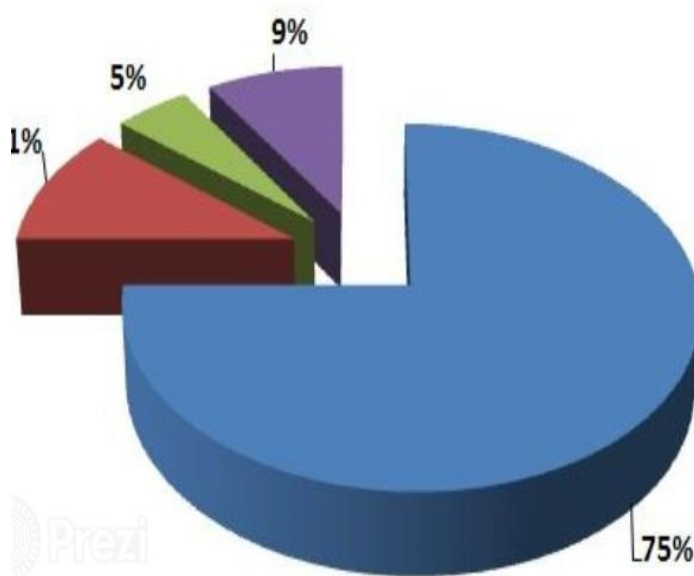


Figure 1: Ways to integrate biological critical thinking skills in general education schools

Critical thinking technology is an integrated approach to learning, i.e. it develops the student's skills of applying knowledge gained in theory in practice. We can say that STEM is a laboratory of modern innovative projects. After all, STEM is rapidly developing in modern foreign countries. As these countries develop, a competitive generation is also developing. In Kazakhstan, the education of a competitive generation is the task of every teacher. Thus, it is aimed at increasing interest in science.

1 American bacteriologist R.Colwell at a biology lesson, interdisciplinary communication, in turn, stimulates the student, develops a systemic need for an object of knowledge, forms skills for comparison, analysis of complex processes and phenomena of objective reality.

2 Kazakh encyclopedia in an integrated lesson, a skill is formed, thinking, memory, imagination are developed

The main objectives of the "integration technology" are:

1) Familiarization with the integrated system "integration technology duties

2) to consider global trends and experience of integration technologies in the countries of the

world;

3) study and evaluation of the advantages of integration technologies in the modern education system;

The main forms of improvement and development of education in biology are the ability to apply and demonstrate effective teaching methods and techniques in biology lessons in the process of developing cognitive, biological literacy of adolescents, defining its tasks and goals.

To present examples of educational projects implementing technologies in biological education as an integrated system. That is, when creating this object, for example, whether it is a small constructor, a small single hydraulic crane, he does it by combining the knowledge that he was able to calculate using chemistry, physics, mathematics, geometry. Thus, the student thinks that I am applying knowledge. That's how, working on techniques in biology class, the ability to apply it in life is very important for a children.

Elements of technologies used in biology lessons:

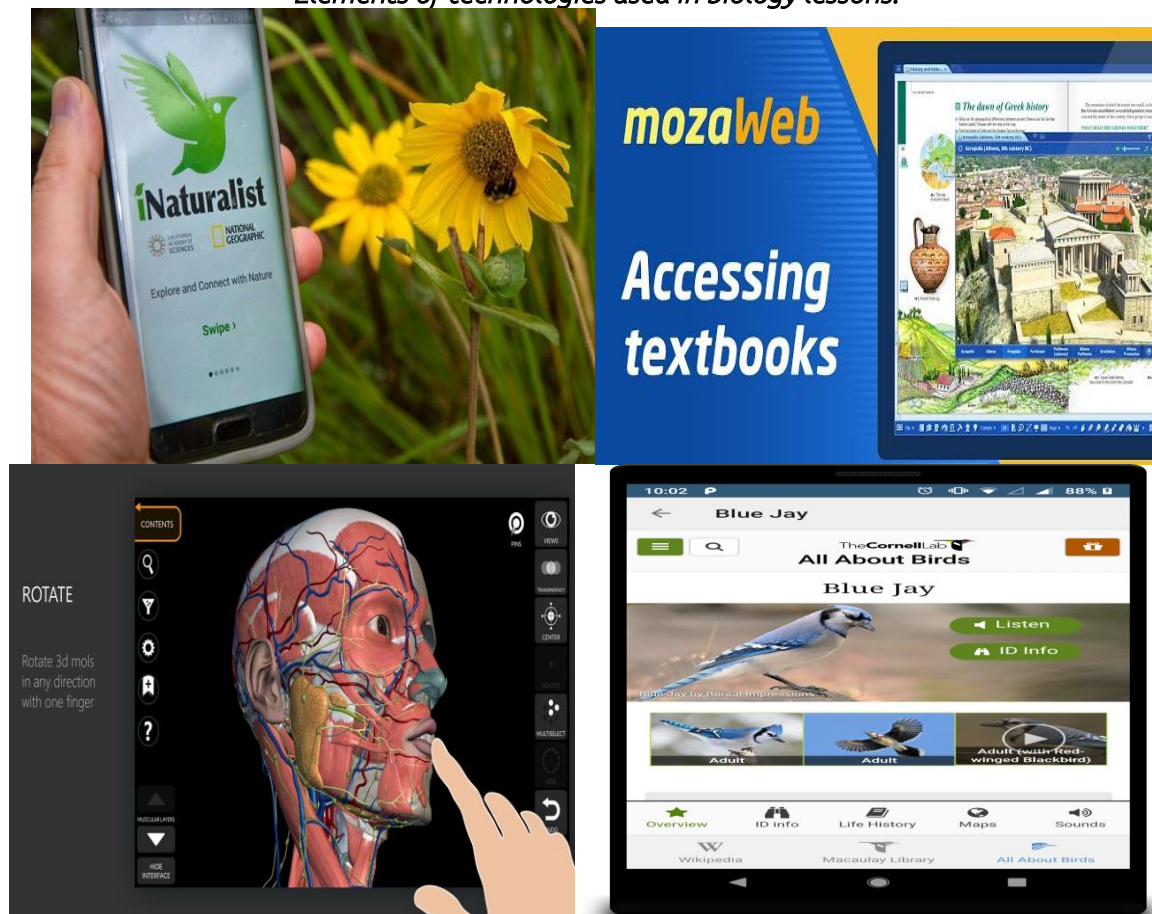


Figure 3.4: Elements of critical thinking technologies used in biology lessons

Conclusion

60-80% of the study time is devoted to the creativity of students, various methods of influencing the student, multimedia support are used. Critical thinking skills have many advantages because they not only solve common educational problems, allowing students to form a more holistic view of the world. A great opportunity to use various technologies, methods, and forms in integrated lessons — in the conditions of our school — allows us to solve another important task - this is a health-saving approach to learning. The use of integration methods in the organization of the educational process contributes to the creation of conditions of psychological comfort, assuming the presence of an atmosphere.

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APPROACHES OF DEVELOPING STUDENTS' ENVIRONMENTAL LITERACY VIA INTERDISCIPLINARY INSTRUCTION WITH ICT TOOLS

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Abstract

This article examines the issue of fostering students' environmental education through interdisciplinary instruction with digital tools. The study explores the environmental education system in Kazakhstan, educational and cognitive activities conducted in natural parks, as well as the importance of ecological expeditions and scientific research. Additionally, the role of ecological projects and volunteer initiatives in developing students' environmental awareness is analyzed. The research findings indicate that educational activities conducted in a natural setting are significantly more effective in fostering environmental culture compared to traditional methods. The integration of national parks into the educational process, the promotion of ecological projects, and the use of digital technologies can enhance the quality of environmental education.

Keywords: *environmental education, ecological culture, environmental awareness, sustainable development, nature conservation, ecological tourism, ecological projects, environmental sustainability, volunteer initiatives.*

Introduction.

Currently, environmental issues are relevant at the world level. Depletion of natural resources, reduction of Biological Diversity, climate change and environmental pollution are some of the most serious challenges facing humanity. To solve these problems, one of the main tasks is to raise the environmental awareness of society and form the responsibility of the younger generation for nature. Improving the system of environmental education in Kazakhstan and using national natural parks in this process is one of the most effective ways to form an ecological culture [1]. In this regard, the development of environmental education of students based on the National Natural Parks of Kazakhstan is considered as an urgent problem. The problem under study is currently being studied from a scientific and pedagogical point of view. The theoretical and methodological foundations of environmental education and upbringing are considered in the works of a number of scientists. Although Kazakh and foreign researchers have studied the importance and methods of forming an ecological culture, the problem of comprehensively considering national natural parks as a means of environmental education still needs a deeper study. In this regard, the scientific novelty of the study is the identification of effective methods and mechanisms for the formation of environmental education on the basis of National Natural Parks of Kazakhstan.

The problem under study is currently being studied from a scientific and pedagogical point of view. The theoretical and methodological foundations of environmental education and upbringing are considered in the works of a number of scientists. Although Kazakh and foreign researchers have studied the importance and methods of forming an ecological culture, the problem of comprehensively considering national natural parks as a means of environmental education still needs a deeper study. In this regard, the scientific novelty of the study is the identification of effective methods and mechanisms for the formation of environmental education on the basis of National Natural Parks of Kazakhstan. The main goal of the study is to identify effective ways of formation of environmental education and culture of students based on the National Natural Parks of Kazakhstan. To achieve this goal, the following tasks are set: to determine the role of national natural parks in the system of environmental education, to analyze the methods of environmental education on their basis and to propose scientific and methodological foundations for the formation of environmental culture in educational institutions. The importance of the study is determined by the development of effective methods for the formation of the ecological culture of students and their application in practice. Environmental education is effective only if it is carried out on a practical basis, and not limited to theoretical knowledge. National natural parks of Kazakhstan, as such a practical educational environment, can play an important role in the formation of ecological culture. The results of the study contribute to improving environmental education in the

education system, increasing the responsibility of future generations to protect nature and implementing the principles of sustainable development.

Materials and methods. The study used methods of theoretical analysis and pedagogical experiment. Scientific papers, legislative documents and international experience were analyzed to determine the role of environmental education and national natural parks in Kazakhstan. The experiment was carried out with 15 students studying in the 7th grade of a comprehensive school. Virtual trips and environmental events were organized for students in national natural parks (Zailiyskiy-Alatau, Borovoe, Katon-Karagay). In order to determine the level of knowledge, emotional relationships and practical actions, survey and control methods were used. The results obtained were analyzed quantitatively and qualitatively.

Results.

Experimental work was carried out on the formation of environmental education and culture of students using the potential of national natural parks of Kazakhstan (Zailiyskiy-Alatau, Borovoe, Katon-Karagay, etc.). Students' environmental knowledge, emotional attitude to nature, the level of participation in environmental activities and norms of environmental behavior were evaluated. Before the experiment, the majority of students showed low and medium levels of environmental literacy, and after the experiment, the indicator of high levels increased significantly.

Table 1 - Assessment of the effectiveness of the formation of environmental education

Nº	Evaluation criteria	Low level (%)	Medium level (%)	High level (%)
	<i>Before the experiment</i>			
1	Ecological knowledge level	40%	47%	13%
2	Interest and emotional attitude to nature	47%	40%	13%
3	Participation in environmental protection efforts	53%	40%	7%
4	Environmental culture and norms of behavior	60%	33%	7%
	<i>After the experiment</i>			
1	Ecological knowledge level	7%	33%	60%
2	Interest and emotional attitude to nature	0%	20%	80%
3	Environmental protection activities	13%	27%	60%
4	Environmental culture and norms of behavior	13%	27%	60%

As shown in the table, the indicators after the experiment increased significantly. Especially high results were obtained according to the criteria of "emotional attitude to nature" and "level of Environmental Education".

As a result of the experiment, the effectiveness of the work on the formation of environmental education and Culture on the example of National Natural Parks of Kazakhstan was proved. Students' responsibility for nature and environmental literacy increased, which improved their careful attitude to nature in everyday life.

Discussion

Based on the results obtained, it can be seen that the activities and classes carried out on the basis of national natural parks had a positive impact on the formation of environmental education and culture of students. Prior to the experiment, most students were not interested in environmental education and conservation activities or did not show activity in this direction. However, the work carried out aroused the interest of students and taught them to consciously and responsibly approach the problems of the environment.

On the other hand, positive dynamics were observed in terms of emotional attitude and practical actions aimed at protecting nature. This contributed to the increase in environmental awareness of students, as well as the formation of a true internal motivation for the protection of nature. The fact that students began to take care of nature was noticed in their behavior and habits in everyday life, which, in turn, became the basis for an increase in the overall ecological culture. The study also proves that the effective integration of national natural parks into the educational process is a real and effective method for the development of environmental education and culture.

Through this method, students begin not only to understand environmental issues more deeply, but also to understand their personal responsibilities in relation to nature. Our study, dedicated to the formation of environmental education and culture of students based on the National Natural Parks of Kazakhstan, showed the importance of environmental activities in the educational process. As a result of surveys and observations, it was found that the ecological culture of students is formed at different levels depending on age. Although the attitude of Primary School students to environmental education and the environment is relatively low, it has been observed that they are interested in nature and quickly perceive new information. In the middle and senior grades, as well as among students, it has been

observed that environmental awareness is formed at a higher level, which indicates that they tend to take a more conscious approach to the protection of nature and the environment [2].

In the course of environmental education, it was found that practical classes and excursions to natural parks have a positive impact on the ecological culture of students. After participating in environmental events, it can be seen that the ecological consciousness and attitude of students to nature have significantly changed. The results of this study coincide with the research of world and Kazakhstani scientists in the field of environmental education [3].

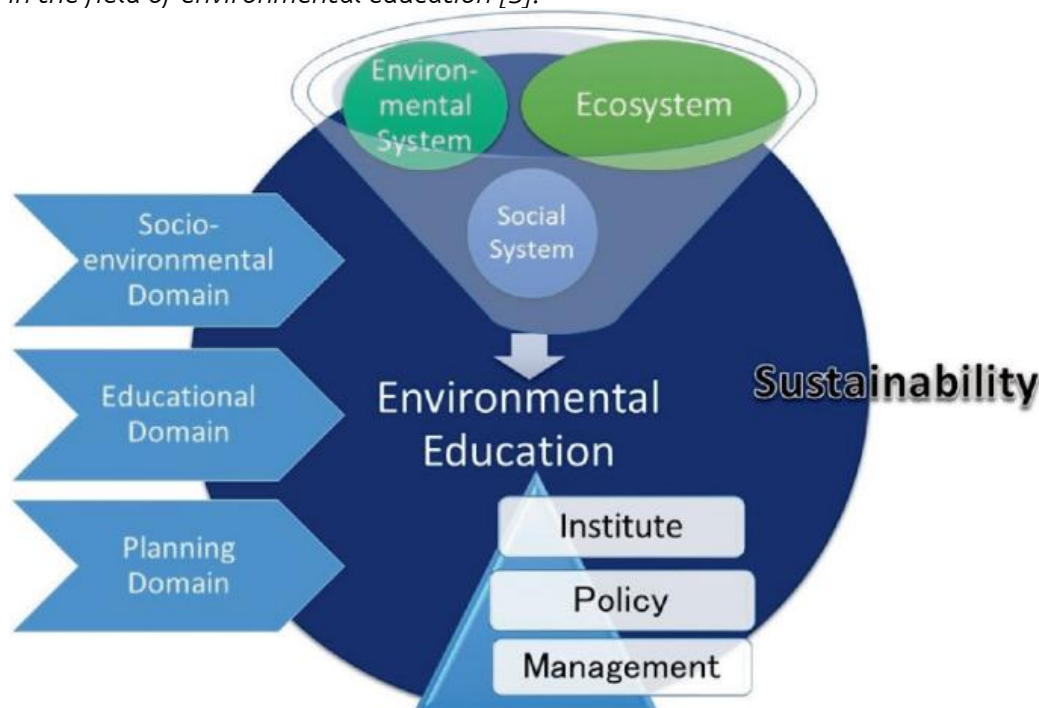


Figure 2-comparative analysis of Environmental education practices

In international practice, the use of natural parks and reserves in environmental education is widely used. For example, in the United States and Europe, environmental education programs for schoolchildren and students are organized in special natural reserves. Numerous studies have shown that education in the natural environment contributes to the rapid assimilation of environmental values by students. For example, in his work, Jensen emphasizes that one of the most effective ways to form an ecological culture is to connect students directly with nature. His study has proven that classes held in natural parks are much more effective than traditional ecology lessons at school. This conclusion fully coincides with the results of our study, since there was an increase in the environmental awareness of students after organized practical classes in natural parks [4].

Kazakh researchers also emphasize the need to strengthen environmental education. For example, Ospanova and Suleimenova in their research talk about the lack of practical methods in the system of environmental education in the country and emphasize the importance of ecological expeditions and practical classes held in natural parks. Our study supports this point of view, as work with students shows that knowledge gained in the natural environment forms their ecological consciousness more efficiently than traditional classroom lessons [5]. In Asian countries, innovative approaches to environmental education are widely used. For example, in Japan, environmental projects, expeditions to natural parks, and practical classes are included in school curricula to form an ecological culture. Research conducted by Japanese scientists shows that the combination of theory and practice plays a huge role in the development of environmental awareness. This echoes the results of our study, as it was found that students who participated in environmental activities had a significantly increased responsibility for the protection of nature [6].

The data obtained during the study showed that several main factors influence the formation of an ecological culture. First of all, the introduction of natural parks in the process of environmental education contributes to improving students' knowledge of the environment and the formation of their conscious vision of the need for nature protection. Secondly, the age of students affects the level of development of their environmental consciousness. Although the level of acceptance of environmental knowledge varies depending on age, the importance of practical activities has been observed in all age groups. One of the most important conclusions obtained during the study is the effectiveness of

environmental activities. The level of ecological culture of students who participated in environmental projects, practical classes in natural parks and volunteer movements was significantly higher. This conclusion indicates the need for widespread introduction of practical classes conducted in the natural environment in educational programs for the development of environmental awareness.

The impact of media and digital technologies on environmental education is becoming especially important today. Along with the development of Information Technology, the process of Environmental Education has also reached a new level. Social networks, mobile applications, and online platforms are widely used to disseminate information about environmental issues. Virtual excursions, mobile games and animated films developed for the purpose of Environmental Education play a significant role in the formation of the ecological culture of students. In addition, social networks make it possible to organize environmental movements and campaigns, involve the public in environmental issues. The importance of environmental education on the basis of national natural parks is growing. It is possible to form an ecological culture of students by improving the system of environmental education in Kazakhstan, conducting educational and educational events in natural parks, organizing environmental expeditions and developing ecotourism. There is an opportunity to increase the effectiveness of environmental education by introducing natural parks into curricula, supporting environmental projects and volunteer movements, as well as using media and digital technologies. Thus, for the formation of a culture of conservation, it is necessary to use integrated and systematic approaches, which will contribute to strengthening students' responsibility for the environment.

Conclusion.

The study of the problem of the formation of environmental education and culture of students based on the National Natural Parks of Kazakhstan once again proved the importance of education in the natural environment. Environmental education is a comprehensive process aimed at educating the younger generation to respect nature, protect it and adhere to the principles of sustainable development. The results of the study show that natural parks are the most effective platform for environmental education and education, as they allow schoolchildren and students to establish direct contact with nature, a deeper understanding of the importance of the environment and the formation of environmental awareness. The results of the study revealed the importance of active use of national natural parks in the educational process. To increase the effectiveness of environmental education, it is necessary to include natural parks in training programs, organize practical classes and Field Research. In addition, for the development of environmental awareness, it is proposed to support environmental projects, activate volunteer movements and use digital technologies in environmental education. The use of national natural parks as a center for environmental education will increase students' responsibility for nature and form their ecological culture. This has a positive impact not only on the protection of the environment, but also on the sustainable development of society. Therefore, the implementation of environmental education in the natural environment and the transformation of national natural parks into a key part of this process should be considered as an important direction of environmental education.

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Economic sciences

WOMEN'S EMPLOYMENT IN THE INDUSTRIAL SECTOR: CURRENT SITUATION AND DEVELOPMENT DIRECTIONS

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Abstract

The text analyzes the current state and development directions of women's employment in the industrial sector. In Azerbaijan, industry is one of the leading sectors of the economy and contributes a significant share to GDP. In recent years, the number of women employed in industry has increased, along with their overall share. Women's participation is especially high in the manufacturing sector, particularly in clothing, pharmaceuticals, and food production. However, declines are observed in some industries. Women's employment is notably growing in micro and small enterprises. Despite this progress, issues such as hazardous working conditions and wage disparities persist. Women's average wages remain lower than men's. Addressing these problems requires improving vocational training, working conditions, and ensuring gender equality. Technological progress is expected to enable women to move into safer and better-paid jobs in the future.

Keywords: *industry, women's employment, manufacturing sector, wage gap, working conditions, entrepreneurship, vocational training, gender equality*

Introduction

Industry is one of the leading sectors of the national economy and plays an important role in the country's socio-economic development. Currently, the industrial sector accounts for 35.9% of the Gross Domestic Product. At the same time, 13.7% of all employed persons in the economy, including 7.9% of women, work in industry. According to official statistics for 2024, out of 243.9 thousand employees in the industrial sector, 56.8 thousand, or approximately 23.8%, are women. This indicates the important role of women in the development of the country's industry.

Historical experience shows that industrial development plays a key role in involving women in social labor activity. The formation and development of large-scale machine industry coincided with the widespread participation of women in public production. In general, industrial development is accompanied by the expansion of the social division of labor, the emergence of new production fields and professions, as well as the mechanization and automation of production processes. These processes improve working conditions and expand opportunities for women's participation in industry.

Over the past five years (2020–2024), the number of employees in the industrial sector increased by 111.1%, rising from 219.5 thousand to 243.2 thousand. During the same period, the number of women employed in industry grew even faster, reaching 113.4%, increasing from 50.1 thousand to 56.8 thousand. This growth varies across different industrial sectors.

The highest increases in employment have been observed in the production of other industrial products, machinery and equipment manufacturing, water supply and waste management, paper and cardboard production, clothing manufacturing, furniture production, pharmaceutical production, and metal ore extraction. The highest growth in female employment has been recorded in machinery installation and repair, metal ore extraction, pharmaceutical production, paper and cardboard manufacturing, motor vehicle and trailer production, food production, and printing.

At the same time, decreases in both total employment and female employment have been observed in certain sectors, particularly mining, crude oil and natural gas extraction, beverage production, textile industry, chemical industry, construction materials production, and electrical equipment manufacturing.

As a result of these changes, the share of women in industrial employment increased from 22.8% to 23.3% between 2020 and 2024. In the manufacturing sector, women's share rose from 25.3% to 27.3%. However, a slight decrease in women's participation was observed in the electricity and water sectors.

Currently, the highest share of women in industry is found in the manufacturing sector. Women's participation is particularly high in clothing production (72.3%), pharmaceutical production (56.6%), leather and footwear production (40.7%), food industry (39.1%), paper and cardboard production (35.4%), textile industry (34.3%), and printing. The lowest rates are observed in metallurgy, construction

materials production, and machinery repair.

Changes in employment within business entities are also significant. Between 2020 and 2024, employment in industrial enterprises increased by 114.3%, while the number of employed women rose by 122.8%. Notably, there has been a significant increase in women's employment in micro and small enterprises.

Currently, most women in industry are concentrated in manufacturing: 65.3% work in manufacturing, 21.9% in water supply and waste management, and 5.7% in electricity and gas supply.

However, some women still work in conditions that do not meet sanitary and hygienic standards. According to statistics, 60% of such women work in manufacturing, 26.1% in mining, 7.2% in the energy sector, and 6.6% in water management. Among them, 49.3% are exposed to excessive levels of harmful chemicals, 35.3% to high noise levels, and over 16% to dusty environments.

This situation poses serious social and health risks, especially for pregnant women and mothers with young children. Hazardous working conditions can negatively affect maternal and child health and lead to various diseases. Therefore, protecting women's labor, improving working conditions, and ensuring sanitary standards are important socio-economic tasks.

Another important issue is the wage gap between men and women. According to 2024 statistics, women's average monthly salary in industry is about 69.5% of men's wages. This gap is particularly pronounced in the manufacturing sector.

Improving women's vocational qualifications can play a key role in addressing these issues. Over the past 15 years, the State Employment Agency has implemented significant measures to involve women in vocational training. Between 2010 and 2024, the number of participants in vocational training increased nearly fourfold, while the number of women increased more than fivefold.

In the future, effective use of women's labor in industry requires the development of sectors where women are more actively employed, the creation of new production areas, and the strengthening of highly qualified workforce training. With technological advancement, women are expected to gradually move away from heavy physical labor toward lighter and better-paid jobs.

Thus, the broad use of women's labor in industry is important not only for economic development but also for improving social welfare, raising healthy generations, and ensuring gender equality in the labor market.

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APPLICATION OF TECHNOLOGICAL INNOVATIONS IN ENTERPRISE MANAGEMENT: LEADERSHIP AND INNOVATIVE MANAGEMENT MODELS

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Abstract

This study empirically assesses the integration of technological innovations into corporate governance systems, focusing on leadership behavior, employee readiness and decision quality. Using a structured online survey of 203 respondents across multiple sectors, Pearson correlation, regression analysis and descriptive statistics were applied in SPSS. Results indicate that digital technology integration for decision-making speed ($p = 0.013$) and employee readiness for technological change ($p = 0.031$) are direct positive predictors of management decision quality. Leadership behaviors primarily exert indirect influence through employee adaptation, transparency and operational ROI. Findings underscore that successful technological innovation requires a multidimensional approach synthesizing technological, ethical, human capital and governance dimensions.

Keywords: technological innovation, digital leadership, innovative management, corporate governance, digital transformation, employee readiness

GEL: M12, M15, O31, O32, L86

1. INTRODUCTION

Digital technologies (artificial intelligence, big data analytics, cloud computing, and automation) are spreading fast and are fundamentally altering the structure of corporate governance across the world. The modern day management science does not contain the conventional administrative mechanisms, it is quite to the contrary, the science that has been closely wrapped with digital tools and models of leadership that are driven by innovations. This is especially applicable to the developing economies - such as Azerbaijan. These economies have to adjust to the global trends of digital transformation in the economy and still ensure that their ethical standards are upheld, their cybersecurity and their sustainable operations. In this regard, the Digital Development Concept of the Republic of Azerbaijan in 2025-2026 is the strategic guideline in the management system. The literature available has a tendency of looking at technological facets and leadership theories independently of each other. The combined and interactive impacts of these two directions are seriously missing in terms of understanding. There is a lack of empirical studies concerning the effectiveness of leadership behavior and employee training in affecting the quality of management decisions particularly in local business settings. It is the gap that this article strives to address. The study tries to address the following questions using an empirical methodology, which is based on correlation and regression analysis:

- (1) How are leadership behaviors associated with the outcome of technological innovation?
- (2) Which factors define directly the quality of decision making in digital management systems?

2. THEORETICAL BASIS

2.1. EVOLUTION OF MANAGEMENT THEORIES AND DIGITALIZATION

Contemporary management science is experiencing a shift of classical theories, the scientific management idea offered by Taylor, the idea of administrative theories as proposed by Fayol, the XY theory of management proposed by McGregor, to new ones that address the needs of the digital era. Over time, management practices have evolved to be more malleable in innovation-based approaches to management as opposed to the traditional, stringent approaches to management (Jonwal, 2025). The digital environment of running a business calls upon managers to possess management, human resource, and information technology professional expertise (Chernykh, Salmin, 2020). Digital transformation, in this case, is a not only a technological change, but also a reorganization of the business model, including customer relations, internal work, and the culture of the company (Rogers, 2016). Digital transformation has been divided into five major directions: (1) change in the process; (2) reconfiguration of the business model; (3) reconfiguration of the domain; (4) transformation of the organizational culture; (5) transition into the cloud technology (St-Jean, 2025). These directions are complementary to each other and their overall management is necessary in order to achieve successful digital transformation.

2.2. DIGITAL LEADERSHIP: CONCEPT AND MODELS

Digital leadership is not limited to conventional theories of leadership in the context of the Fourth Industrial Revolution (Industry 4.0). A digital leader is not concerned with the performance at the workplace, but with the competence in the domain and the goal achievement process; in contrast to a traditional leader, he is concerned with the plans of the talent development (Guler, 2023). The literature has identified seven digital leadership models that include (i) digital-oriented leader; (ii) innovator leader; (iii) supportive leader; (iv) mentor leader; (v) network leader; (vi) manager-like leader; (vii) digitally enabled leader (Goh, Mansor, 2024). The models are reactive to the needs of a certain organizational situation. The establishment of digital culture is at the center of digital leadership. The leader facilitates innovative work behaviour through several approaches that include encouraging teamwork, free flow of information, flexibility as well as engagement with new technologies. It has been found that a digital culture increases the rate of technology adoption, accountability, and employee creativity (Chetinkaya, Surucu, 2025).

2.3. DIGITAL TRANSFORMATION IN THE AZERBAIJANI CONTEXT

The Digital Development Concept of the Republic of Azerbaijan (2025) identifies a strategic management framework of the digital transformation. The Ministry of Digital Development and Transport is also charged with the responsibilities of applying the processes of the decision-making based on artificial intelligence, ensuring safe management of the state information systems, as well as conducting objective evaluation of the digital projects. The information and communication technology sector contributed to 2.8 percent of non-oil GDP in 2024. The financial sector has more than thirty FinTech firms. Over 88 percent of the population is an internet user. The forecast of 2026-2029 data states that the number of enterprises involved in the digital transformation programs will reach 300 and the economic effect generated due to the implementation of the use of GenAI will increase to 70 million AZN (Aliyev, 2025). Nevertheless, the present SWOT analysis also demonstrates several significant weaknesses: low digital literacy rates, lack of skilled ICT employees and standardization gaps in data management. These areas of weaknesses show that infrastructure preparedness is growing at a rate greater than human capital.

3. RESEARCH METHODOLOGY

The research was a quantitative study utilizing empirical research methodology. The collection of data was carried out through an online survey tool on the period of 7-10 December, 2025. 203 participants who were representatives of different fields of the local business environment, including finance, IT, manufacturing, services, took part in the research. Both senior and middle management were represented in the respondents; this gave the possibility to have more objective information on management decisions. As a measurement instrument a structured questionnaire with 13 items based on the 5-point Likert scale (1 strongly disagree; 5 strongly agree) was utilized. The survey questions were categorized into three content blocks (A) leadership and change management; (B) innovative management and quality indicators of implementation; and (C) the technical and ethical aspects of implementation. The statistical analysis was done with the SPSS software. Analytical methods involved (i) descriptive statistical analysis, (ii) Pearson correlation analysis, which was used to test the relationship between variables, and (iii) regression analysis, which was used to determine how the independent variables affect decision quality. The sample size was also considered sufficient to be powerfully statistically according to the formula of Green (1991) 100-150 respondents are needed to run a model with 5 independent variables.

4. RESEARCH RESULTS

4.1. LEADERSHIP BEHAVIOR AND TECHNOLOGICAL INNOVATION OUTCOMES (CORRELATION I)

The original correlation block was done to examine the relationship between the outcomes of technological innovation and the leadership behaviors. The summarized results are presented in the table below:

Changing pair	Pearson r	p-value	N
Active leadership ↔ Technological openness	$r = 0.225^{**}$	$p < 0.01$	203
Active leadership ↔ Resistance management	$r = 0.260^{**}$	$p < 0.01$	203
Technological openness ↔ ROI growth	$r = 0.227^{**}$	$p < 0.01$	203
Resistance management ↔ ROI increase	$r = 0.146^{*}$	$p < 0.05$	203
Employee training ↔ Decision quality	$r = 0.188^{**}$	$p < 0.01$	203

Table 1. Pearson correlations between leadership behavior, employee adaptability, and innovation outcomes

****** Significant at $p < 0.01$ level; ***** Significant at $p < 0.05$ level.

Below are the findings that indicate that leadership behaviors, active leadership, openness to new technologies, and the ability to manage employee resistance, are statistically significantly linked to

multiple outcomes in the area of technological innovation. The readiness of the employees was also found to be significantly related to the quality of decisions. Nevertheless, not all relationships turned out to be statistically significant, which points to the conclusion that leadership does not have a direct influence on the quality of decisions, but rather indirectly, via such channels as employee engagement and efficiency of digital processes.

4.2. TECHNOLOGICAL INNOVATION AND DIGITAL MANAGEMENT DIMENSIONS (CORRELATION II)

The second block of correlation analyzed the connection between technological innovations in management system and the major considerations in digital management:

Changing pair	Pearson <i>r</i>	<i>p</i> -value	N
Productivity growth ↔ Transparency/Accountability	<i>r</i> = 0.225**	<i>p</i> < 0.01	203
AI/Data Analytics ↔ Cybersecurity	<i>r</i> = 0.327**	<i>p</i> < 0.01	203
AI/Data analytics ↔ Technology infrastructure	<i>r</i> = 0.250**	<i>p</i> < 0.01	203
Ethical compliance ↔ Infrastructure adequacy	<i>r</i> = 0.307**	<i>p</i> < 0.01	203
Ethical compliance ↔ Labor productivity	<i>r</i> = 0.202**	<i>p</i> < 0.01	203

Table 2. Pearson correlation analysis between technological innovation and digital governance dimensions (N = 203)

The highest correlation was observed between decision-making and cybersecurity using artificial intelligence and data analytics (*r* = 0.327; *p* < 0.01). The latter result indicates the necessity to introduce complex digital decisions frameworks as well as a solid security infrastructure. The compliance with ethical standards is also strongly associated with the infrastructural sufficiency (*r* = 0.307) and human productivity (*r* = 0.202) - which confirms the idea that ethical governance is an inseparable component of sustainable digital transformation.

4.3. REGRESSION ANALYSIS: DETERMINANTS OF DECISION QUALITY

The total *F*-value of the regression equation was significant (*F* (5, 197) = 3.643; *p* = 0.004). The explanatory power of the model was, however, rather poor (*R*² = 0.085; adjusted *R*² = 0.061). The findings of the individual predictors are as illustrated in the table below:

Independent variable	<i>B</i>	<i>Beta</i>	<i>t</i>	<i>p</i>
Decision speed through digital technologies	0.192	0.179	2,499	0.013*
Employee readiness for technological change	0.148	0.151	2,177	0.031*
Active leadership/vision setting	0.038	0.039	0.537	0.592
Technological openness of leadership	0.031	0.029	0.404	0.687
Resistance management strategies	0.074	0.074	1,000	0.328

Table 3. Individual predictive effects of the regression model (dependent variable: quality of management decisions)

* Significant at *p* < 0.05 level.

The findings demonstrate that two statistically significant factors determining the quality of management decisions directly include the speed of decision-making using digital technologies (*b* = 0.179; *p* = 0.013) and willingness of the employees to technological changes (*b* = 0.151; *p* = 0.031). Other actions of leadership, such as active leadership, technological openness, resistance management, did not significantly influence it. To some extent, this supports the hypothesis: leadership is the factor that has an impact on the results of management but in an indirect manner, through the employees adaptation, organizational culture, digital process infrastructure. The *R*² of the model is 0.085 which implies that the other significant variables that influence the quality of management decisions such as the organizational environment, personal traits of the manager, external market conditions and so on are not included in the model. It is suggested that the further investigations should incorporate these variables, research the nonlinear correlations, and involve a larger sample.

5. DISCUSSION

The theoretical and practical implication of the empirical findings of this study are many. First, the fact that the direct statistical significance of the effect of leadership on the outcomes of technological innovations is in most cases small indicates that the role of leadership is indirect, and the indirect mechanism is mostly not taken into account in classical studies. The leader provides good conditions to digital transformation, which include an open culture, the willingness of employees to change, and ethical management norms, which directly positively affect the quality of decisions. Second, the close relationship between the application of AI and data analytics in decision-making and cybersecurity (*r* = 0.327) suggests the technological innovation is also another important aspect in the risk management. Cybersecurity is no longer a technological concern but a strategic management challenge in the world where the average time to succumb to ransomware is 11 seconds and AI-based attacks cost billions of dollars every year (Khan, 2025). Third, correlation results of ethical compliance and infrastructural adequacy and productivity show how digital governance is multidimensional. The normative, but also

strategic economic imperative is ethical governance of AI, i.e. transparent human control, explicable models, protection of data. Last but not least, the Azerbaijani context, as the available empirical evidence indicates, the digital infrastructure preparedness is progressing more rapidly than human capital maturity. This difference prevents the full performance of the economic potential of technological innovation. The independent value of the preparedness of employees toward technological change on the quality of the decisions ($p = 0.031$) indicates that bridging the gap is a strategic priority.

6. CONCLUSION AND SUGGESTIONS

The paper has empirically evaluated the application of technological innovations to the corporate governance system with respect to leadership behaviour, readiness of the employees and quality of decision making. The key results might be summarized in the following way:

Leadership performances are positively, yet mostly indirectly, associated with the results of technological innovations; the effect is achieved through the mediating variables of employee engagement, transparency enhancement and ROI.

The quality of management decisions is directly dependent on the introduction of digital technologies into the speed of decisions ($p = 0.013$) and the willingness of employees to a technological change ($p = 0.031$).

The correlation between AI application and cybersecurity ($r = 0.327$) is high, implying that proper use of technological innovation is impossible without a well-developed security system. The correlation between ethical compliance and infrastructure adequacy ($r = 0.307$) and labor productivity ($r = 0.202$) are significantly correlated which proves that ethical governance is a strategic means of sustainable digital transformation.

The practical recommendations proposed are based on the outcomes of the research and include:

- ✓ Invest in digital workforce development: Firms need to find digital skills development courses as a strategic objective. As much as infrastructure is invested in by an individual manat, the investment in employee training should be made.

- ✓ Digitalization of the decision-making process: Since the direct relationship between the speed of decisions and the implementation of digital technologies is positive, the opportunities of management decision-making with the use of data analytics and automation tools are to be increased.

- ✓ Refocusing leadership development programs: Leadership programs must shift beyond the symbolic digital assistance and concentrate on structural problems, including building a digital culture, adapting the employees and defining ethical management practices.

- ✓ Making cybersecurity a strategic choice: Within the framework of accelerating AI-related attacks, cybersecurity investments must be part and parcel of the budget of technology innovations.

- ✓ Standardize an ethical governance model: Firms need to introduce transparency, explainability, and responsibility in the utilization of artificial intelligence in official governance sources.

The sample is the most significant weakness of the study because the geographical and sectoral focus is limited to the Azerbaijani business environment. It is suggested that future research should increase the sample size, provide comparative analysis of the regions, longitudinal design, and direct quantitative indicators in the decisions of management. To sum up, the present research demonstrates that technological innovation in corporate governance is successful not only in goodwill of the management but also in the training of the workforce, ethics, cybersecurity, and technical infrastructure. The technical, human, ethical, and organizational factors can be dealt with in a combined governance system to provide sustainable digital transformation.

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*HYDROGEN MOBILITY TRANSITION: A SYSTEMATIC LITERATURE REVIEW OF B2B ENERGY ADOPTION**Lamia Gasimzada**Poznań University of Economics and Business,
Al. Niepodległości 10, 61-875 Poznań, Poland***Abstract**

By supporting eco-innovation, organizations and communities can contribute to a more sustainable future by decreasing their environmental effect and promoting sustainable growth. Fuel cells are devices that convert the chemical energy of hydrogen and oxygen into electrical energy without emitting greenhouse gases and pollutants. Fuel cells can be used in vehicles to reduce emissions and improve efficiency.¹

This research presents systematic literature review analysing business customers' perspective towards adopting new energy sources. It focuses on various key business customers: automobile companies, tourism companies, transportation companies, gas stations, government entities, other stakeholders. While the hydrogen solutions have been widely discussed from economical, ecological, technological and infrastructure development points, in contrast, limited attention has been paid to business-to-business (B2B) actors involved in the adoption process. I will use exploratory approach for this research study.

Analysing academic literature between year 2020 and March 2026, initial research was conducted on more than 300 articles from various sources including all papers published in scholarly journals. Following established guidelines for systematic literature reviews, the keyword selection was based on its relevance to the topic, and the search focused on variables endeavoring to explain customers' behavior in both spellings "behavior" and "behaviour." The words "customers" and the "buyers", "green energy", "hydrogen transition", "hydrogen value", "green transition" were used to incorporate the different decision makers, as we face transactions involving organizations. Final search query was used as follows 'business customer behavior in the context of green energy and hydrogen fuels'.

To understand the state-of-the art and identify specific gaps the systematic literature review has been conducted focusing on the transitioning to green energy in the transport sector and the role of hydrogen as a clean and sustainable fuel. Research has followed the guideline from Snyder⁵ for literature review that combine perspectives from different fields.

The sequential reading of titles, abstracts and articles allowed the identification of the final 300 articles independently reviewed by me, assuring the focus on this review topic. Only studies that meet all the inclusion criteria specified in the review were included:

- *A survey was conducted with 470 FCV owners and 1,550 battery electric vehicle (BEV) owners in California²*

- *A survey conducted in Europe with 582 participants analyzed which sustainability information attributes of products are prioritized by consumers and how these attributes influence their willingness to pay a premium price*

- *A representative survey was carried with approximately 1000 people. In Germany³*

- *Research envisages using a sample of 1126 respondents for the validation of a theoretical model that highlights the complex relationship between specific variables, such as concern for the environment, knowledge about renewable energy (RE), perceived utility regarding RE usage, ease of use regarding RE, attitude toward RE utilization and behavioral intentions to use RE.*

All the articles have been analyzed in regards to the topic. I was examining how business customers perceive and evaluate hydrogen technologies within the broader context of the green energy transition in the transport sector. Additionally, the search for hydrogen-related policies in force worldwide that include hydrogen production and supply, transportation, and storage will be conducted to include the increasing significance of hydrogen in future energy scenarios⁶.

Results of a literature review show that most researchers approach the adoption of hydrogen fuels from an individual perspective. However, this study will take a different approach, focusing on obtaining results through the applied methodologies.

Based on qualitative insights, it will be possible to develop customized value propositions highlighting benefits, cost savings, and competitive advantages of sustainable transportation solutions. Messaging frameworks, value proposition canvases, and storytelling techniques will be utilized to effectively communicate these propositions to B2B customers.

Methods such as thematic analysis and content analysis will be employed to identify key themes

and patterns related to technological barriers and preferences in value proposition among B2B customers.

Change management strategies including stakeholder engagement, communication plans, and training programs to facilitate adoption of tailored value propositions will be developed based on the results of the research. Collaboration with internal and external stakeholders will address resistance to change, build trust, and overcome adoption barriers.

Business customer behavior types will be researched based on Everett M. Rogers's *Diffusion of Innovations*⁷

Green hydrogen, safer and more environmentally friendly than fossil fuels, enjoys public favor and strong willingness-to-pay among potential users, enhancing its adoption prospects. This growing interest is prompting significant attention from policymakers and businesses, driving efforts toward market entry and commercialization⁴.

The findings of this study clearly show that the transition to hydrogen fuel in the B2B transport sector presents both opportunities and challenges. Reflecting on the research process, outcomes, and lessons learned, this discussion evaluates the implications for business customers' specific needs, preferences, and motivations in adopting hydrogen fuel technologies. Drawing upon the literature, this study underscores the critical gaps in current research.

This study urges more research to explore the potential for expanding hydrogen technologies and making them profitable. The aim is to boost their advantages and make them more competitive in the transportation industry for business customers.

The future study will have to:

- Conduct an in-depth review of existing literature on the technological challenges associated with hydrogen storage, transportation, and fueling infrastructure, highlighting the need for innovation and investment.

- Discuss theories and frameworks related to developing tailored value propositions for B2B customers, focusing on understanding their unique needs and preferences

- Synthesize findings to generate new insights, theories, or practical recommendations in the field of adopting to hydrogen fuels.

- Publish research findings in peer-reviewed journals, conference proceedings, and technical reports.

- Present research outcomes at academic conferences, workshops, and seminars to share knowledge and receive feedback from peers.

- Engage with stakeholders, policymakers, and industry professionals to communicate the relevance and potential impact of the research.

Acknowledging limitations and offering recommendations, this discussion concludes with a call to continually refine research methodologies and engage stakeholders to promote the uptake of hydrogen technologies, shaping the future of sustainable transportation.

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THE ROLE OF THE QUALITY MANAGEMENT SYSTEM IN ENSURING THE COMPETITIVENESS OF CONSTRUCTION ENTERPRISES

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Abstract

In the contemporary global economic landscape, the construction industry confronts a unique configuration of challenges characterized by capital-intensive investments, high-risk operational profiles, and extended project execution lifecycles. Within this dynamic environment, the implementation of a Quality Management System (QMS) compliant with international ISO 9001 standards has evolved from a voluntary benchmark into a strategic imperative for ensuring sustainable competitiveness. This study analyzes how the effective integration of QMS serves as a critical structural backbone, harmonizing complex operational processes to guarantee consistent service delivery. By enforcing the standardization of workflows across diverse project phases, the system minimizes variability and significantly enhances internal efficiency. This is achieved primarily through the reduction of "non-quality costs", specifically the mitigation of defects, material wastage, and the financial burden of rework which often erodes profit margins. Simultaneously, ISO certification acts as a powerful external signal of reliability, strengthening customer trust and corporate reputation in a market where stakeholder confidence is paramount. Beyond static compliance, QMS empowers the enterprise to flexibly adapt to market volatility by institutionalizing "Risk-Based Thinking" and the principle of Continuous Improvement through the Plan-Do-Check-Act (PDCA) cycle. This iterative approach ensures that organizational methodologies are constantly refined in response to emerging regulatory and environmental demands. Consequently, the research concludes that QMS is not merely an administrative management tool, but a fundamental prerequisite for achieving long-term market advantage, serving as the essential foundation for operational resilience, financial stability, and the successful navigation of competitive international tenders.

Keywords: *Quality Management System (QMS), ISO 9001 Standards, Sustainable Competitiveness, Construction Enterprise Management, Continuous Improvement.*

Review of recent research and publications. *The strategic role of the Quality Management System (QMS) in fortifying the competitiveness of construction enterprises has emerged as a central theme in both global and local economic discourse. The foundational theoretical architecture of this field, particularly the integration of project management frameworks with quality metrics, is deeply rooted in the pioneering contributions of J. Juran, A. Godfrey, and H. Kerzner, whose work remains essential for defining strategic quality benchmarks. Furthermore, the operational dimensions of the industry-specifically the optimization of production costs and the automation of construction processes-have been extensively examined by scholars such as V. Byba, I. Milenko, A. Pavelyeva, and T. Kushnirova, providing a technical roadmap for resource efficiency. Within the specific context of the Azerbaijani construction market, the transition toward international ISO standards and the pursuit of innovative development trends as primary competitive levers have been rigorously analyzed by E. Yusifov and A. Sarkarli. A comprehensive synthesis of these diverse scholarly perspectives suggests that a robust QMS transcends mere technical compliance; it functions as a decisive economic instrument that secures cost leadership and long-term institutional resilience in an increasingly volatile market environment.*

Purpose of the article. *The main purpose of the study is to analyze the mechanisms of influence of the Quality Management System on the competitiveness of construction enterprises, and to determine this role based on quality and trust indicators.*

Presentation of the main material. *A fundamental strategic factor ensuring the sustainable competitiveness of companies in the construction industry is the effective implementation of a quality management system (QMS). This system is based on the fundamental principles of quality theory, along with international standards such as ISO 9001:2015 [1]. The process-based approach and risk-based thinking required by the standard ensure the consistent standardization and documentation of all*

operations from the beginning of the project to the final execution stage. This approach creates the necessary basis for the integration of the quality planning, control and improvement functions proposed by Juran [2]. The main economic advantage that a QMS brings to operational excellence is measured by the minimization of defects, reworks and additional costs. This is fully consistent with Crosby's thesis "Quality is Free" [4]; ensuring quality correctly at the initial stage dramatically reduces the failure costs that will arise later. As a result, construction companies increase internal efficiency through optimal resource utilization, effectively reduce financial losses, and thus achieve cost leadership in the market [5]. The principle of Continuous Improvement, i.e. the Plan-Do-Check-Act (PDCA) cycle, which is the basis of the system, is a practical expression of Deming's quality philosophy [3]. This mechanism allows enterprises to systematically evaluate process performance, test innovative methods, and integrate the acquired experience into the institutional knowledge base. This continuous learning capability ensures flexible adaptation to the dynamic technological and economic conditions of the construction market. In addition, ISO 9001 certification formalizes the enterprise's compliance with international standards, which creates trust and high reputation capital, which are crucial for participating in tenders for high-capital-intensive projects [1, 5]. Thus, the comprehensive implementation of the QMS both strengthens the operational control of the construction company and strategically strengthens its market position [12].

The contemporary construction industry operates within an increasingly volatile economic framework, requiring resilient management models. Longitudinal analysis of the European Union's construction sector reveals a significant divergence between production costs and producer prices over the last two decades. As illustrated in Figure 1, there is a persistent upward trajectory in construction costs, which reached a critical inflection point post-2021, showing a sharp escalation [13, 14]. This trend is mirrored in the Azerbaijani market, which shows remarkable vitality despite global pressures [7]. According to official data from the Ministry of Economy of the Republic of Azerbaijan for the first three quarters of 2025, the construction sector demonstrated a 5.0% real growth rate, contributing approximately 6,325.1 million AZN in value-added to the national GDP [10, 15]. Sustaining this growth requires firms to adopt advanced organizational frameworks like ISO 9001:2015 to mitigate rising factor prices [1, 6].

The practical application of management standards in Azerbaijan is evidenced by the certification data from the national Certification Body for Management Systems. Analysis of the registry for the period 2022-2023 reveals a significant institutional shift toward international standards. Specifically, the list of organizations certified under AZS ISO 9001:2020 (Quality Management Systems. Requirements and Guidelines for Use) and AZS ISO 14001:2021 ("Environmental Management Systems. Requirements and Guidelines for Use") underscores a dominant trend within the infrastructure sector. Out of the 53 organizations successfully certified during this timeframe, a predominant majority are companies operating within the construction industry. This sectoral concentration confirms that Azerbaijani construction enterprises are increasingly viewing ISO certification not merely as a regulatory formality, but as a primary strategic tool for maintaining competitive advantage. By integrating environmental management requirements with quality standards, these firms aim to mitigate ecological risks and comply with international "Green Construction" norms, which are essential for participating in high-value tenders [7, 9, 11].

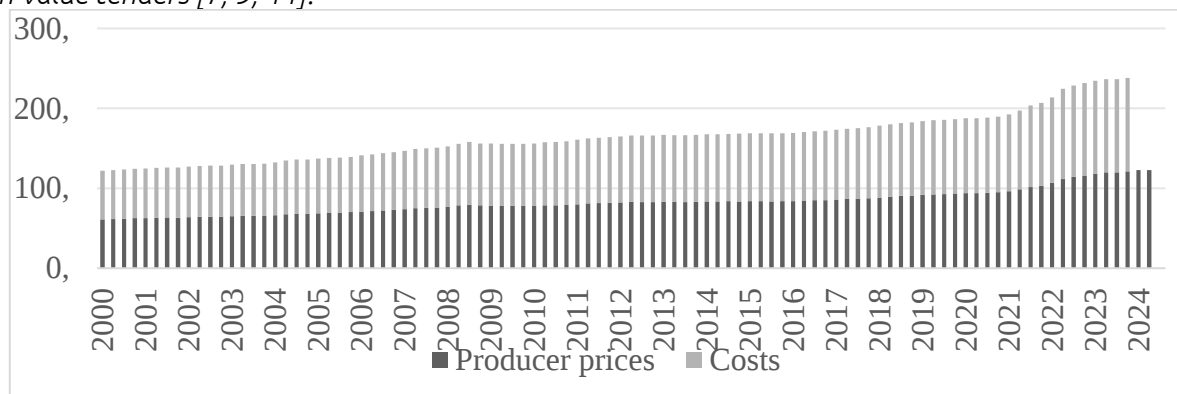


Fig. 1. Construction producer prices and costs, EU, 2000-2024
(2021=100 unadjusted quarterly data)

Source: [13]

The structural breakdown of construction pricing, as illustrated in Figure 2, highlights the critical intervention points for a Quality Management System. The process begins at Level A (Contractor), where

'Factor Prices'-comprising materials, labor, and equipment-form the base of the project's financial structure [8]. In the absence of a robust QMS, this stage is highly susceptible to 'hidden costs' caused by material waste and labor inefficiencies. By the time the project reaches Level B (Client), these inefficiencies are compounded by profit margins and productivity variables, forming the 'Producer Prices.' Finally, at Level C (Final Owner), the selling price is finalized. The visual evidence suggests that the competitiveness of a construction enterprise is determined by its ability to control variables at Level A. A QMS compliant with ISO 9001 standards acts as a corrective mechanism that stabilizes these initial factor prices, preventing the inflation of the final selling price [11]. Consequently, ensuring quality at the source is not merely a technical requirement but a financial strategy to protect profit margins and deliver value to the final client in a cost-volatile market.

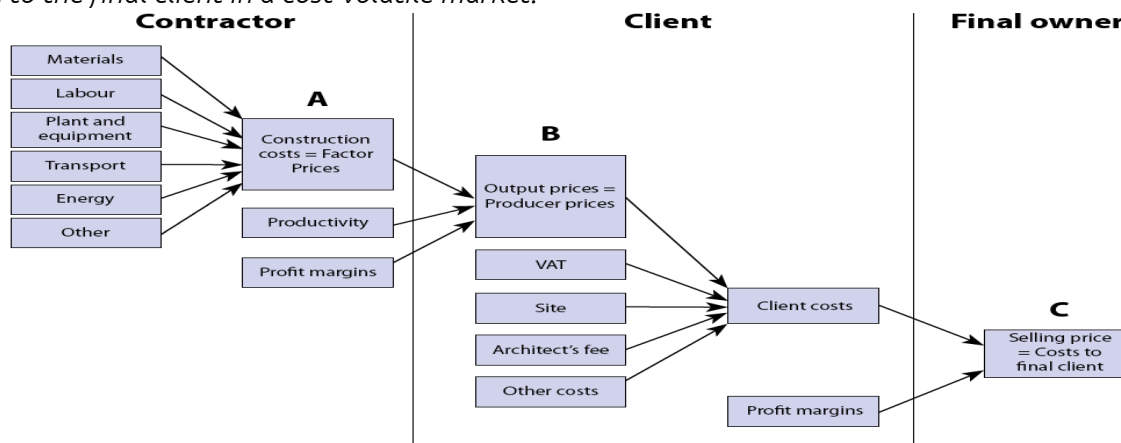


Fig. 2. The structural breakdown of construction pricing
Source: [14]

Conclusions from the study and prospects for further research in this area. The longitudinal analysis of the construction sector within both the European Union and the Republic of Azerbaijan confirms that the institutionalization of a Quality Management System (QMS) serves as a hierarchy-defining factor for sustainable competitiveness. The study reveals that while global production costs have experienced a sharp escalation post-2021, the Azerbaijani construction industry has maintained a resilient 5.0% real growth rate, contributing 6,325.1 million AZN to the national economy in 2025. This macroeconomic stability is directly correlated with the strategic adoption of AZS ISO 9001:2020 and AZS ISO 14001:2021 standards, as evidenced by the high concentration of construction firms among the 53 newly certified organizations in the 2022-2023 period. By implementing the quality-based planning and cost management model enterprises effectively mitigate "non-quality costs" at the contractor level, validating Crosby's "Quality is Free" thesis by proving that initial defect prevention is more economically viable than retroactive correction. Ultimately, the synergy between Juran's planning functions and Deming's PDCA cycle allows firms to transform operational efficiency into reputation capital, ensuring success in high-capital international tenders.

Future academic inquiries should focus on the transition toward Quality 4.0, specifically investigating how the integration of Building Information Modeling (BIM) and Artificial Intelligence (AI) can automate the Plan-Do-Check-Act cycle for real-time risk mitigation. Additionally, given the rising trend in ISO 14001 certifications, there is a critical need for research into the cost-benefit ratios of "Green Construction" and its direct impact on securing ESG-compliant (Environmental, Social, and Governance) investments in the region.

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Historical sciences

INTEGRATION OF HISTORY TEACHING WITH STEAM PROJECT

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Abstract

The article examines the issues of integrating history with the STEAM (science, technology, engineering, arts and mathematics) approach in the teaching process. It is shown that the application of the STEAM approach in history lessons creates conditions for students to more deeply master historical knowledge and understand events in a complex way. The article analyzes the possibilities of organizing STEAM projects in history, their impact on the learning process and their role in the development of students' research and creative activity skills.

Examples of STEAM projects that can be implemented in history lessons based on the study of historical monuments and events are presented. Because of the study, it is determined that the integration of history with the STEAM approach allows for a more interactive and practically oriented organization of the learning process, has a positive effect on strengthening students' historical knowledge and developing their analytical thinking skills.

Keywords: history, integration, STEAM projects, project-based learning, teaching method.

In the modern education system, one of the main goals is not only to acquire theoretical knowledge, but also to develop analytical thinking, creativity and problem-solving skills. In this regard, the interaction and integration of various subjects is of importance. The STEAM approach (Science, Technology, Engineering, Art, Mathematics), which has been widely used in the world in recent years, allows for a more practical and creative organization of teaching. The word "STEAM" is an acronym for Science, Technology, Engineering, Art, and Mathematics [2]. The STEAM teaching method involves teaching mathematics, technology, engineering, and art in a coherent way. Each letter represents a specific field, but they are taught in a certain unity:

What do...

SCIENCE

TECHNOLOGY

ENGINEERING

ART &

MATHEMATICS

have to do with

HISTORY???

1. **Science** – a set of observations and experiments to understand the world.

2. **Technology** – a Greek word, meaning art, skill, is a set of techniques, skills and methods used to carry out scientific research.

3. **Engineering** – an Arabic word, is the systematic mastery of scientific and theoretical knowledge.

4. **Art** – implies a high level of human skill in any field of activity. Creativity, design and aesthetic approach belong here.

5. **Mathematics** – covers topics such as calculations, logical modeling, quantitative indicators.

This method, which was first developed in the 1950s, is currently most widely used in the United States, Germany, and England. The main goal of this method is to develop 21st century

skills in students, namely logical, critical, and creative thinking, collaboration, effective communication, and innovative problem-solving skills. The STEAM teaching method makes great contributions to education. In this way, students can easily solve various problems they encounter in their daily lives, work in teams, and develop their logical thinking. Since they apply what they learn, they better absorb knowledge and can retain it in their memory for a longer period. Lessons organized using the STEAM teaching method are more interesting and attractive for students, and they participate in lessons more actively and enthusiastically.

Students learn to apply their theoretical knowledge in practice by working on projects aimed at solving real-life problems. This project creates conditions for students to develop their skills using innovative tools such as Information Communication Technologies, 3D modeling, etc. STEAM teaching method gives students freedom in solving problems in the modern educational process, promotes independent thinking skills, because when developing a project, the student is not dictated to, he is given

the chance to realize his own ideas, which leads to the harmonious development of their personality.

The STEAM-based organization of lessons requires special knowledge and skills from the teacher. The STEAM project envisages the development of not only students, but also teachers, and training is conducted in this direction. The purpose of such training is to encourage teachers who will teach STEAM lessons to develop and improve their ability to use innovative technologies.

Today, steps are being taken in the Republic of Azerbaijan to adapt the education system to the requirements of the future. The strategic line of the steps taken is STEAM education. The education model has been implemented in our country since 2019 under the name of the "STEAM Azerbaijan" project. [7] This project is implemented by the Ministry of Education of the Republic of Azerbaijan with the support of the Heydar Aliyev Foundation. [3] One of the main goals of the project is to use educational innovations applied in developed countries in our country based on modern educational challenges. In 2022, a study was conducted by the Institute of Education of the Republic of Azerbaijan on STEAM education. According to the research, all assessed skills of students studying in classes where STEAM lessons are taught are superior to students studying in classes where this method is not taught. The participation of the President of the Republic of Azerbaijan Ilham Aliyev and the First Vice-President of the Republic of Azerbaijan Mehriban Aliyeva in the opening of the "STEAM Innovation Center" in Baku on January 5, 2023 is a great example of the attention paid to the development of this educational model.

Currently, students in STEAM centers in Baku, Sumgayit, Guba, Ismayilli, Barda, Ganja, Shamakhi, Mingachevir and other regions of Azerbaijan benefit from training programs on "Creativity and Art", "Artificial Intelligence", "Learn with Robots" designed for different age groups based on various programs. There are 21 STEAM Centers operating across the country.

Changes in the modern education system necessitate the application of new approaches in the teaching process. Because of globalization and the development of the information society, it is no longer enough to provide only theoretical knowledge in schools. Today, the main goal of the education system is to develop students' analytical thinking, research, creative approach and problem-solving skills. In this regard, the application of interdisciplinary integration in the learning process is of importance.

Integration is one of the important pedagogical approaches that allows for the establishment of connections between different subjects and the comprehensive acquisition of knowledge. History has extensive connections with other subjects in terms of content. Geographical, economic, political and cultural factors play an important role in the study of historical events. Therefore, the application of interdisciplinary integration in history lessons helps to organize the learning process more efficiently. It is very important to include STEAM projects in teaching. One of the subjects where this project can be integrated is the history curriculum. Many students consider history to be boring, thinking that it is not important to learn about events that happened in the past. Of course, this is not the case, because the past shapes our present. Teachers should try to use practical learning activities to make history more interesting for students.

The connection between history and the STEAM teaching method allows students to learn by reliving the past in their own impressions. The integration of history into STEAM subjects allows for a deeper study of these subjects and a better understanding of history in general. One of the most successful approaches when implementing STEAM projects in history lessons is the "Problem Solving" model. For example, instead of simply telling students to "fix this castle," a teacher can give the task "build this castle so that the enemy's cannonballs cannot destroy it" [1, p.22].

Integrating history with a STEAM approach allows students to not only learn about historical events as facts, but also to explore them through a variety of scientific and creative activities. This approach develops students' historical knowledge as well as their research and project-making skills. Although history is a humanities subject, its content is closely related to other subjects. When studying historical events, fields such as geography, economics, culture, architecture and technology are used. The STEAM approach brings these connections to a more practical level. For example, when studying the structure of ancient buildings or historical monuments, students examine not only historical information, but also their engineering features, architectural style and mathematical dimensions. This helps to organize the learning process more interesting and effective.

STEAM projects allow students to conduct research, think creatively, and work in teams. This approach can be implemented in history lessons through a variety of projects. For example, when preparing a project about a historical monument or city, students may work in the following areas [4]:

- Science – studying the properties of materials used in the construction of historical buildings*
- Technology – preparing presentations, videos or digital models*
- Engineering – preparing models of historical monuments*

- *Art* – describing architectural styles and decorative elements
- *Mathematics* – calculating the dimensions and proportions of buildings

Such projects allow students to more deeply absorb historical information and connect it with practical activities. Project-based activities allow students to connect the knowledge they have acquired to real life. This serves to form functional literacy, one of the main principles of the modern curriculum.

An example of the application of the STEAM approach in history lessons can be a project on the study of historical monuments. For example, students can be given a project assignment on the Shirvanshahs Palace, one of the historical architectural monuments of Azerbaijan. Within the framework of this project, students work on various STEAM directions.

In the first stage of the project, students collect information about the history of the palace. They conduct research on the period of construction of the palace, its architectural features and its significance in the history of Azerbaijan. This stage serves to form knowledge about the content of the history subject. Within the **Science** direction of the STEAM approach, students investigate the materials used in the construction of the palace and their properties. For example, the strength of stone materials and the reasons for their long-term preservation are studied.

In the **Technology** direction, students prepare presentations or short video materials using various digital tools. Currently, they develop their skills in using information technologies.

Within the **Engineering** field, students can prepare a model of the palace. For this purpose, cardboard, wooden sticks and other simple materials are used. The structure and architectural features of the building are considered when preparing the model.

In the **Art** direction, students study the architectural style and decorative elements of the palace and prepare their description. This activity helps to develop students' aesthetic taste and creative abilities.

In the **Mathematics** direction, the dimensions, symmetry and architectural proportions of the palace are studied. Students use these dimensions when preparing the model.

At the end of the project, students present their work to the class. During the presentation, they both explain historical information and demonstrate the model and other materials they have prepared. This process has a positive impact on the development of students' communication and presentation skills.

Thus, the implementation of STEAM projects in history lessons allows students to more deeply absorb historical knowledge, while at the same time developing their creative and research skills.

The application of the STEAM approach in history creates conditions for a more interactive and interesting organization of the learning process. This approach allows students to be active participants, not passive listeners. Project-based activities help students independently acquire their knowledge and connect it with practical activities. The STEAM approach also has a significant impact on the formation of research skills in students. Students learn to collect information from various sources, analyze it and draw conclusions. This creates conditions for the development of their scientific thinking skills.

In addition, this approach also helps to develop students' creative abilities. Presenting historical topics in the form of projects allows students to freely express their ideas. They prepare models, create presentations and use various visual aids. This makes the learning process more interesting and motivating.

The application of STEAM projects in history lessons can be carried out through various forms of activities. These activities allow students to work both individually and in groups. One of these projects is the preparation of models of historical monuments. Students select a specific historical building and prepare its model. In this process, they study the architectural features of the building, calculate its dimensions and model its structure. Such activities both strengthen students' historical knowledge and develop their engineering and creative skills.

Another form of activity is related to the digital presentation of historical events. Students can prepare presentations, video materials or virtual excursions using various technological tools. Such activities help develop students' skills in using information technologies. In addition, the use of maps and graphs in history lessons can also be considered an example of the application of the STEAM approach. Students identify the areas where historical events occurred on the map, analyze various statistical data and draw conclusions.

The application of the STEAM approach in history lessons has several important advantages. [5] First, this approach makes the learning process more interesting and interactive. Students do not just listen to the teacher's explanation, but also acquire knowledge through various projects and activities. In addition, the STEAM approach has a positive effect on the development of students' research skills.

During project-based activities, students learn to collect information from various sources, analyze it and present their results. Another advantage of this approach is the formation of cooperation skills in students. During group projects, students exchange ideas with each other, make decisions together and look for different ways to solve problems.

At the same time, the STEAM approach also helps to develop students' creative thinking skills. Presenting historical topics through various creative activities allows students to freely express their ideas.

The application of the STEAM approach in history lessons may be accompanied by certain difficulties. [6] One of these difficulties is the lack of enough methodological preparation of teachers regarding this approach. To effectively organize STEAM projects, it is important for teachers to have knowledge in various fields and use innovative teaching methods. Another difficulty is related to the limited technical capabilities in some schools. The implementation of STEAM projects sometimes requires additional materials and technological tools. The limited capabilities can make the implementation of



projects difficult. Nevertheless, the creative approach of teachers and the efficient use of available resources can help overcome these difficulties.

The study shows that integrating history with the STEAM (science, technology, engineering, arts, mathematics) approach allows for a more efficient and modern organization of the learning process. The introduction of STEAM projects in history lessons strengthens students' creativity, problem-solving and teamwork skills, and allows them to see the connections between different subjects. The STEAM approach allows for a more complex and multidisciplinary study of historical

events. The use of technology and engineering elements provides modeling of historical processes, and the art component provides creative presentation of historical material. This leads to a deeper understanding of the subject by students and an increase in their interest in learning. Thus, the integration of history with the STEAM approach is an innovative learning model that meets modern educational requirements and makes a significant contribution to the formation of research, creativity and functional literacy skills in students.

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CARDIOTOXICITY OF CONTEMPORARY ANTICANCER THERAPY: CLINICAL RELEVANCE, DIAGNOSIS, AND PREVENTION

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Abstract

Cardiotoxicity is one of the most significant limiting factors in modern anticancer therapy, significantly impacting its safety and long-term outcomes. The increasing use of anthracyclines, targeted agents, and immune-mediated therapies increases the risk of myocardial dysfunction, arrhythmias, myocarditis, and other cardiovascular complications. Of particular clinical significance is the fact that cardiotoxic effects can manifest both during treatment and years after its completion. Improved early diagnostic methods enable the detection of early signs of myocardial damage and prompt adjustment of treatment strategies. Assessing individual risk factors, such as age, comorbidities, and cumulative doses of cardiotoxic drugs, is crucial. Advances in cardio-oncology and a multidisciplinary approach ensure more effective prevention and treatment of cardiac complications. Therefore, the problem of cardiotoxicity requires further research and the integration of cardiological strategies into oncology practice.

Keywords: oncology, cardiology, cardio-oncology, cardiotoxicity, cardiac complications, cardiovascular complications, cardiovascular disease, anticancer therapy, chemotherapy, radiotherapy, biomarkers, cardio-miRNAs, cardiac risk factors.

In recent decades, oncology has experienced rapid progress, driven by the introduction of new classes of anticancer drugs, refined surgical approaches, and the development of radiation therapy and personalized medicine. These advances have significantly increased the life expectancy of patients with various forms of malignancy, and for many patients, cancer has become a chronic, potentially manageable condition. However, alongside the increased effectiveness of anticancer therapy, the problem of its adverse effects is becoming increasingly pressing, with cardiotoxicity being the key and most clinically significant. Cardiovascular damage caused by chemotherapy, targeted agents, immune drugs, and radiation exposure is now considered one of the most serious limitations to treatment effectiveness and a cause of decreased quality of life for surviving patients.

The relevance of cardiotoxicity research is driven by several factors. First, the number of cancer patients is steadily increasing worldwide due to increasing life expectancy and improved diagnostic methods. Secondly, modern therapy is becoming increasingly intensive and multi-component, increasing the risk of cumulative toxic effects on the myocardium. Thirdly, improved survival creates a new set of clinical challenges related to the long-term consequences of treatment, which manifest themselves years after remission. Cardiac complications are becoming one of the leading causes of late morbidity and mortality among cancer patients, making the problem interdisciplinary and requiring the collaboration of oncologists, cardiologists, rehabilitation specialists, and primary care physicians.

In clinical practice, cardiotoxicity manifests itself in a wide range of conditions – from subclinical reduction in myocardial contractility to severe chronic heart failure, arrhythmias, ischemia, arterial hypertension, and thromboembolic complications. Various drugs can cause myocarditis, vasculitis, conduction disturbances, pericarditis, and resistant hypertension, which often progresses rapidly and requires urgent diagnosis and treatment.

A separate area of research is the study of radiation therapy cardiotoxicity. Despite improvements in irradiation technologies and reductions in doses to critical structures, radiation-induced cardiac damage remains a pressing problem for patients with lymphomas, breast cancer, and chest tumors. Radiation exposure can lead to late changes, such as valve fibrosis, coronary artery disease, restrictive cardiomyopathy, and conduction system abnormalities, which manifest decades after completion of treatment.

The growing interest in cardio-oncology reflects the understanding that successful cancer treatment is impossible without managing associated risks. Current research focuses on developing strategies for early identification of high-risk patients, optimizing cardiac monitoring methods, and implementing programs for the prevention and treatment of cardiac complications. However, despite the accumulated data, a unified strategy for monitoring and long-term risk management of cardiotoxicity is still being developed, underscoring the importance of further research.

Understanding the mechanisms of cardiotoxicity remains an important task. The molecular pathways of cardiac tissue damage caused by antitumor agents are extremely diverse and include oxidative stress, mitochondrial dysfunction, cardiomyocyte apoptosis, impaired angiogenesis, immune responses, and inflammation. Understanding these mechanisms opens the way to personalized approaches – the use of cardioprotectors, dosage optimization, selection of drugs with a lower risk profile, and individualized adjustment of concomitant therapy. A particularly promising area is the development of biomarkers of predisposition, allowing for the prediction of the development of cardiac complications before treatment and the adjustment of the therapeutic regimen in advance.

The problem of cardiotoxicity extends beyond purely medical considerations. It affects socioeconomic aspects, as complications associated with cardiac damage require expensive and lengthy treatment, increase the number of hospitalizations, and impact patient productivity. With the growing number of cancer survivors, the need for specialized cardio-oncology centers providing a multidisciplinary approach to patient care is growing. The development of such services facilitates the timely diagnosis of complications, improves prognosis and quality of life, and reduces the risk of interruption or modification of anticancer therapy for cardiac reasons.

An additional layer of complexity is created by the fact that many patients begin treatment with pre-existing cardiac risk factors, such as hypertension, dyslipidemia, obesity, diabetes, genetic predisposition, and others. These conditions increase the likelihood of developing cardiotoxicity and require comprehensive intervention. Thus, modern approaches to cancer treatment require not only the

selection of optimal anticancer therapy but also active primary and secondary prevention of cardiovascular complications.

As noted by Belenkov Y.N. et al. [1], over the past few decades, due to the extensive implementation of cancer screening programs, up-to-date early diagnostic methods, and effective combinations of antitumor therapy, it has become possible to significantly improve survival of cancer patients. At the same time, despite the effective treatment of malignancies, most patients face adverse and often life-threatening effects of specific treatment on the heart and blood vessels. All this resulted in active development of a new field in cardiology, cardio-oncology.

In the work of Chan M.F. et al. the authors say that they conducted a comprehensive database search to review and consolidate data regarding chest radiotherapy and effects on the heart as well as techniques to minimize exposure to the heart. The research findings demonstrate associations between radiation exposure to cardiac substructures and subsequent cardiotoxicity. At the same time, advanced cardiac-sparing techniques, notably respiratory motion management, have emerged as pivotal strategies to minimize the likelihood of cardiac events. Radiation-induced heart disease is a known potential toxicity in patients undergoing chest radiotherapy and thus there is a need to understand the associated risks and find methods to minimize them. Our colleagues focus on the fact that proton therapy can spare the heart and other vital organs while still delivering high radiation doses to tumors, potentially making it a superior option for treating breast and lung malignancies. Ongoing studies with longer follow-ups are needed to further elucidate its cardiac sparing advantage. Additionally, we need to investigate the effects of concurrent radiotherapy and immunotherapy on the heart, as existing research indicates that immunotherapy can lead to cardiac issues such as myocarditis, arrhythmias, and heart failure. The combination of these therapies may exacerbate these negative effects, so they should be used cautiously. Lastly, we need to further study how patient specific factors, such as pre-existing coronary artery disease or reduced ejection fraction, can help tailor radiation therapy more effectively [2].

Advances in cancer treatment have improved in patient survival rate. On the other hand, management of cardiovascular complications has been increasingly required in cancer patients. Thus, cardio-oncology has attracted the attention by both oncologists and cardiologists. Cardiovascular imaging has played a key role for non-invasive assessment of cardiovascular alterations complementary to biomarkers and clinical assessment. Suitable imaging selection and interpretation may allow early diagnosis of cardiovascular injury with potential implications for therapeutic management and improved outcomes after cancer therapy. Echocardiography has been commonly used to evaluate cardiac dysfunction in cardio-oncology area. Cardiac computed tomography is valuable for assessing structural abnormalities of the myocardium, coronary arteries, and aorta. Molecular imaging has an important role in the assessment of the pathophysiology and future treatment strategy of cardiovascular dysfunction. Cardiac magnetic resonance imaging (MRI) is valuable for characterization of myocardial tissue. Positron emission tomography (PET) and Single Photon Emission Computed Tomography molecular imaging has potential roles for quantitative assessment of cardiovascular disorders. Particularly, Fluorodeoxyglucose-PET is considered as an elegant approach for simultaneous assessment of tumor response to cancer therapy and early detection of possible cardiovascular involvement as well. Cardio-oncology represents an important new area that should be covered by multiple specialist teams, including medical and radiation oncologists, cardiologists, diagnostic radiologists, technologists, nurses, and pharmacists. Interdisciplinary cooperation among these specialists is mandatory for accurate and timely diagnosis and also suitable management for each cancer patient. Cardiologists should be knowledgeable about the strengths and limitations of various imaging modalities, including echocardiography, cardiac MRI, and nuclear imaging. They should select the appropriate modality based on the clinical scenario and the specific information needed. Many oncologists should understand various cardiotoxic effects after new cancer treatments. In addition, radiologists should play an important role for selecting suitable imaging modalities and interpreting not only the tumor itself but also the condition of the heart when viewing tumor images in order to provide important messages from these images for both cardiologists and oncologists. Radiologists should be aware of the critical role that imaging plays in the diagnosis, monitoring, and management of cardiotoxicity in cancer patients. Understanding the appropriate use of each imaging modality is essential for providing comprehensive care. Radiologists should stay informed about the latest advancements in imaging technologies and techniques, such as cardiac MRI and nuclear imaging, to ensure accurate assessment and timely detection of cardiotoxic effects. Cardiovascular imaging has evoked as a key role for this purpose, allowing non-invasive evaluation of cardiovascular alterations complementary to biomarkers and clinical assessment. Suitable imaging selection and interpretation may permit not only for early diagnosis of cardiovascular injury but also accurate

assessment treatment effects. Thus, the imaging will provide impact on therapeutic management and improved outcome after cancer therapy [3].

A very indicative and interesting study in the clinical and prognostic aspect was conducted by Klotzka A. et al. [4]. The purpose of this study was to gather information on respondents' knowledge of their treatment, awareness of cardiovascular risks associated with cancer therapy, and the factors associated with these outcomes. The level of awareness was related to age, education, as well as health behaviors and communication with the physician. As the authors note cardio-oncology is a relatively young but rapidly developing branch of medicine. It combines cardiology and oncology. Both of these fields are associated with the largest number of morbidity cases in the world, and thus the largest number of deaths. Cardio-oncology addresses the cardiac complications of oncological treatment at every stage of cancer therapy. Cardiovascular complications have become increasingly common among cancer survivors, largely due to improved treatment outcomes and longer survival. As events like myocardial infarction and heart failure now significantly affect long-term health, assessing patients' awareness of these risks is essential. Cardio-oncologic complications extend beyond the duration of oncologic treatment. Chemotherapy, radiotherapy, or immunotherapy, which are widely used in oncology, can lead to adverse cardiovascular events both during and years after oncological treatment.

A cross-sectional study was conducted among 243 patients attending an outpatient cardio-oncology clinic in Poznan, Poland. Participants were informed about the aim of the study while in the clinic waiting room. Subsequently they completed an anonymous questionnaire voluntarily after the visit to the office. Completing the paper-and-pencil survey took an average of 10-15 min. If necessary, patients could count on professional assistance in completing the questionnaire. They could ask questions while completing the survey and withdraw from the study at any time. Eligibility criteria included being an adult and having a confirmed diagnosis of any type of cancer. Data collection was carried out between October 2023 and April 2024. According to the statement KB-919/22 issued by the Bioethics Committee of the Poznan University of Medical Sciences (Poznan, Poland) the study did not constitute a scientific experiment.

Based on a review of the literature and relevant recommendations, a structured questionnaire was developed, comprising three sections: (1) questions related to cardio-oncology, (2) questions related to health behaviors, and (3) sociodemographic items. 37 items were single-choice, and 3 were multiple-choice. The tool was reviewed by four subject-matter experts in the fields of cardiology, public health, patient education, and healthcare.

The following questions examined patients' awareness of cardiac complications:

What is cardio-oncology?

In your opinion: Can chemotherapy "damage" the heart?

In your opinion: Should the heart be monitored during chemotherapy?

In your opinion: Should one go to a cardiologist for follow-up after cancer treatment?

In your opinion: Should the heart be monitored after radiation therapy to the chest?

In your opinion: Can radiation therapy to the chest "damage" the heart?

Other questions concerned examinations and providing information by the doctor:

Did your doctor inform you about possible cardiac complications caused by cancer drugs?

Did your doctor inform you about possible cardiac complications caused by radiation therapy to the chest?

Did a cardiologist examine you during cancer treatment?

Did you have an echocardiogram, known as a cardiac echo, during your cancer treatment?

The response options "no" and "I don't know" or "I don't remember" were combined during the statistical process because we wanted to obtain a clear classification of respondents in terms of their knowledge. Differentiating between a lack of knowledge and an uncertainty about one's knowledge did not result in a significant statistical difference [4].

The response rate was 80%. The majority of participants were women, comprising 75.7% of the total sample. The mean age of respondents was 51.2 years ($SD = 9.8$), and the mean Body Mass Index (BMI), calculated based on self-reported weight and height, was 27.0 ($SD = 18.7$). More than half of the participants (53.5%) were classified as having an elevated BMI. The largest educational subgroup included individuals with secondary education (38.7%). Additionally, over half of the sample resided in large urban areas (53.5%) and were actively employed (61.7%). Only a small proportion of respondents (9.1%) rated their financial situation as good or very good. Breast cancer was the most commonly reported cancer type, accounting for 55.6% of cases. In terms of treatment, approximately 32% of patients reported receiving both chemotherapy and radiotherapy, whereas nearly 27% were unaware of

the specific oncological treatment they had undergone. Patients' awareness of cardiac complications associated with their cancer treatment and the relationship with various demographic variables were analyzed. In questions concerned patients' awareness, examinations and providing information by the doctor the response options "no" and "I don't know" or "I don't remember" were combined during statistical process. The researchers wanted to obtain a clear classification of respondents in terms of their knowledge. The respondents were divided into two groups - those having knowledge and the rest - in order to examine the differences between them. As a result, we observed a statistically significant difference between these groups. Patients were asked to select the correct definition of cardio-oncology. Only 23.5% of respondents knew what cardio-oncology is. Statistical significance was identified in age, education level, BMI and type of oncological therapy received by the patient. Among patients under 40 years old, awareness of cardiac complications was the highest. This awareness declined with increasing age and increased with the level of education. Additionally, most individuals with obesity and those unaware of the type of oncological therapy they were receiving also lacked knowledge of cardio-oncology. Statistical significance in relation to financial situation was identified only in questions concerning complications after chemotherapy. Patients who declared an average financial situation were least likely to say that the heart should be monitored. A significant correlation was also noted between patient awareness and physician actions. Only 24.3% of patients were informed by their oncologist (or remember being informed) about possible cardiac complications caused by cancer drugs. An even smaller proportion (12.4%) remembered that their doctor informed them about possible cardiac complications caused by chest radiotherapy. Nearly 32% of patients were not examined by a cardiologist during cancer treatment, and more than half (53.5%) underwent echocardiography during cancer treatment. However, 95.5% of patients believed that every patient undergoing cancer treatment should have a cardiology consultation. Patients who were informed about possible complications and underwent cardiological examinations had better knowledge about complications and the need to monitor their heart after cancer treatment. The results from Health Behavior Scale domains showed that out of a possible 45 points, respondents scored an average of 24.21 (SD = 8.18) points. Preventive behaviors related to the healthcare system received the lowest score (1.33 out of 3 possible), which indicates that patients diagnosed with cancer relatively rarely underwent preventive prostate cancer screening or smear test. On the other hand, patients scored highest in the Unhealthy behaviors domain, which indicates that they rarely consume tobacco or alcohol products (2.05 ± 0.46). The Mann-Whitney U test indicated a statistically significant association between patients' health behaviors and cardio-oncology knowledge ($p < 0.001$). Individuals who knew what cardio-oncology is and provided correct answer declared healthier behaviors ($M = 27.9 \pm 6.0$) than those who did not have this knowledge ($M = 23.1 \pm 8.5$). Patients who were aware that chemotherapy and radiotherapy could have negative cardiac consequences also exhibited better health behaviors related to diet, physical activity or healthcare system. Among those who completed our questionnaire, 54 participants (22.22%) reported receiving chemotherapy, while 79 (32.51%) received both chemotherapy and radiation therapy. Radiation therapy alone was used in 45 individuals (18.52%). Notably, 65 participants (26.75%) did not know what type of cancer treatment they had undergone. As the authors note it is concerning that such a large group of patients, despite having undergone potentially cardiotoxic therapy, were not aware of the need for regular follow-up. Nearly half of them had received chest radiotherapy, and it is well known that its complications increase over time - coronary artery disease or valvular dysfunction may appear even 20 years after treatment. In the absence of follow-up, patients often present to a cardiologist only at an advanced stage of disease. Even more striking are the data showing that more than 26% of patients in the cardio-oncology clinic did not know what type of oncologic therapy they had received. It is difficult to determine whether this results from denial of the cancer diagnosis, lack of interest in their health despite the disease, or concomitant depression [4].

Summarizing the conducted research, our colleagues state that cardio-oncology is becoming an indispensable component of comprehensive care for oncology patients. As cancer treatments continue to improve in effectiveness, they are increasingly associated with a risk of cardiovascular complications that can significantly impair patients' quality of life and affect overall prognosis. The early involvement of a cardiologist at the stage of planning oncological therapy allows for individualized risk assessment and timely implementation of preventive measures. Unfortunately, as demonstrated by study, the level of knowledge among oncology patients regarding potential complications of chemotherapy and radiotherapy remains insufficient. There is a clear need to implement effective educational programs aimed at increasing awareness of these risks and fostering stronger interdisciplinary collaboration between oncologists, cardiologists, and primary care physicians. Greater emphasis should be placed on

prevention through the control of comorbidities that already increase baseline cardiovascular risk, such as hypertension, diabetes, and obesity, even before the initiation of cancer treatment. Regular cardiac monitoring during and after therapy should become the standard of care. Patients must also receive clear and comprehensible information about the potential adverse cardiovascular effects of oncological treatment. Improved patient education may enhance patient engagement in the treatment process and facilitate the early detection of cardiac complications. As shown in survey, patients who were informed by their physician about the potential cardiotoxicity of oncological therapies demonstrated more health-conscious behaviors. Early identification of cardiotoxicity enables timely intervention, reducing the likelihood of long-term complications. This proactive approach not only enhances treatment safety but also strengthens patients' trust in the healthcare system as a whole [4].

Yang M. et al. [5] in their work emphasize that with the increase of aging population and prevalence of obesity, the morbidity of cardiovascular disease (CVD) and cancer has also presented an increasing tendency. These two different diseases, which share some common risk factors. Relevant studies in the field of reversing cardio-oncology have shown that the phenotype of CVD has a significant adverse effect on tumor prognosis, which is mainly manifested by a positive correlation between CVD and malignant progression of concomitant tumors. This distal crosstalk and the link between different diseases makes us aware of the importance of diagnosis, prediction, management and personalized treatment of systemic diseases. The circulatory system bridges the interaction between CVD and cancer, which suggests that we need to fully consider the systemic and holistic characteristics of these two diseases in the process of clinical treatment. The circulating exosome-miRNAs has been intrinsically associated with CVD-related regulation, which has become one of the focuses on clinical and basic research (as biomarker). The changes in the expression profiles of cardiovascular disease-associated miRNAs (Cardio-miRNAs) may adversely affect concomitant tumors. In this article, we sorted and screened CVD and tumor-related miRNA data based on literature, then summarized their commonalities and characteristics (several important pathways), and further discussed the conclusions of cardio-oncology related experimental studies. The cellular regulatory processes and mechanisms between miRNAs and CVD have been well studied, but the role of miRNAs as a systemic influence in the synthesis of cross-talk between different diseases is still less. Especially, some typical biomarkers reflected by changes of expression profile for Cardio-miRNAs in circulation. The authors sorted out the relevant mechanism of Cardio/Onco-miRNAs involved in CVD phenotype on tumor regulation according to the objective background of reverse cardio-oncology. These mechanisms will be key to revealing the systemic or holistic effects of CVD on tumors, which is also an important value for the application of precision medicine in the diagnosis and treatment of systemic diseases. These mechanisms might serve as evidence to supplement the importance of predictable diagnosis and personalized treatment between CVD and tumors, and it also provides a reference for developing systemic principles of improve individual outcomes. Based on the reported contribution of related miRNAs to the regulatory mechanism of malignancy process of tumor cells, combining with the fact that exosome-derived Cardio-miRNAs can regulate tumors via circulation, the researchers have deeply analyzed and summarized the different signaling pathways involved in Cardio-miRNAs. The aim is to predict and evaluate the impact on adaptive survival of tumor cells based on the regulatory mechanisms of different pathways and related Cardio-miRNAs as markers. Different expression levels of circulating Cardio-miRNAs predict the progression of concomitant tumors and can be used to develop personalized treatment options. Concludes that CVD and tumors can be linked through miRNAs, and these miRNAs may have a dual role (Cardio-/Onco-miRNAs). However, with aging, the dysfunctions of cardiovascular system may appear and changes of systematic phenotypes of circulating miRNAs showed the adverse effects of Cardio-miRNAs for middle-aged and elderly or obese tumor patients. Furthermore, the dual properties of Cardio-/Onco-miRNAs suggest that CVD is systemic and holistic problem or risk factor affect distant tumor cells via the circulation, which may be a potential target for treatment and intervention. Therefore, based on the perspective of CVD phenotyping in oncologic disorders, we need a systemic evaluation, prediction and diagnosis of the patients with concomitant tumors, which may provide a reference for avoiding poor prognosis.

Kojic A. et al. indicate that [6] heart disease and cancer share common risk factors, genetic predispositions, and metabolic and inflammatory components. Metabolic reprogramming can drive disease progression in both, with cardiometabolic syndrome - marked by obesity, insulin resistance, dyslipidemia, and hypertension - contributing to cancer development. Studies link around 20% of cancer cases to obesity, while elevated glucose and triglyceride levels increase the risk of liver, thyroid, and respiratory cancers. Beyond treatment-related cardiotoxicity, cancer patients often have pre-existing

CVD at diagnosis, highlighting their bidirectional relationship. Patient-specific induced pluripotent stem cells (iPSCs) offer a powerful platform to study these links at a personalized level. iPSC models help explore shared molecular mechanisms, metabolic dysregulation, inflammation, and cardiotoxicity.

The authors state that as cancer therapies continue to extend survival, patients are increasingly facing long-term cardiovascular consequences – not only from the treatments themselves but also from cancer-related inflammation and metabolic disruption. This is especially true for individuals with underlying cardiometabolic disease, who may experience synergistic effects on cardiac function. In this context, cardio-oncology must evolve beyond reactive management toward a proactive, integrative approach. Preventative strategies targeting metabolic risk factors (e.g., statins, glycemic control, etc.) hold promise for improving both cancer and cardiovascular outcomes. These considerations set the stage for translational efforts, including dietary interventions and patient-specific iPSC-based strategies, to optimize therapy and minimize harm. Several lines of evidence support the central role of metabolism in the development of both CVD and cancer. Targeting specific metabolic signatures – whether through direct enzyme inhibition or dietary modulation – can influence tumor growth, improve therapy tolerance, and reduce cancer-associated cardiovascular risk. These efforts are exemplified by the clinical use of inhibitor of mutant isocitrate dehydrogenase 1 and 2 inhibitors. Additionally, preclinical studies have shown that intermittent fasting can delay tumorigenesis and reduce growth factor signaling, offering another potential avenue for systemic metabolic intervention. Furthermore, the investigation into how risk factors for both cancer and CVD such as obesity, diabetes, and dyslipidemia might provide new avenues for systemic solutions to both diseases through dietary interventions. Fasting has been shown to have positive effects on cancer prevention and treatment in mice. Just 1 day of fasting per week delays tumorigenesis in p53-deficient mice, with other effects including decreased plasma levels of glucose, insulin, and insulin-like growth factor 1. Periods of fasting are also followed by high cellular proliferation, characterized by cellular repair pathway activation and driven by the replenishment of growth factors during refeeding that can reverse atrophic cellular remodeling. iPSC technologies offer a versatile and powerful platform for accurately modeling CVDs, metabolic disorders, cancer, and their complex interactions. By providing an essentially unlimited supply of targeted cell types derived from either healthy controls or patients, these models enable the recapitulation of disease-specific phenotypes influenced by genetic and environmental factors. As an accessible, precise, and highly adaptable system, iPSCs can enable groundbreaking discoveries in disease mechanisms and toxicity progression while also facilitating the development of effective therapeutic strategies. iPSCs' ability to reflect the unique genetic background of the individual from which they are derived positions them as a cornerstone for advancing personalized precision medicine. In cardio-oncology, iPSCs provide a robust platform to assess individual responses to anticancer therapies, enabling the identification of treatment combinations that maximize tumor suppression while minimizing detrimental side effects. This approach holds immense promise for tailoring treatments to the unique needs of each patient with transformative implications for improving outcomes in cancer survivors, who face heightened risks of developing CVD. To fully realize the potential of these technologies, cross-disciplinary research integrating cardio-oncology, oncology, and cardio-metabolism is essential. Such collaboration can bridge the critical gap between molecular studies and clinical applications, leveraging patient-derived samples for mechanistic insights and risk stratification, and promote the development of novel therapeutic strategies. Ultimately, this integrated approach promises the advent of a new paradigm to transform patient care, by effectively treating both cancer progression and its cardiovascular consequences [6].

A fundamental study concerning the assessment of global trends in publications and the identification of the most cited scientific articles on cardio-oncology was conducted by Suero-Abreu G.A. et al. [7]. They note that as novel cancer therapies continue to improve patient outcomes, there is an increased need for prevention and management of the cardiovascular side effects of these therapies. For this reason, the field of cardio-oncology has experienced significant scientific growth, particularly during the last decade. A bibliometric analysis of the literature in the field of cardio-oncology was performed using the multidisciplinary databases Scopus, Pubmed, and Web of Science Core Collection. The terms "cardio-oncology", "onco-cardiology", "cardio-onco-hematology" and "cardio-immuno-oncology" were searched (both hyphenated and non-hyphenated) for all languages for the years 1864 to 2020. The final search was conducted on March 31, 2021, and the terms were queried as "abstract title, abstract, and keywords" for Scopus and Pubmed, and as "topic" for Web of Science Core Collection. All articles from the search results were independently verified by two reviewers and were included in the analysis if they addressed cardio-oncology as a field of study in the keywords, title, or abstract. Articles that did not focus on cardio-oncology were excluded. Each article was reviewed for its number of citations, year of

publication, and journal of publication. When duplicates were found, the entry with fewer citations was eliminated. For those articles that were co-published in two or more journals, the entry with the highest citations was kept and the citations from the other entries were added to this entry. Publication output for each year was analyzed and a list of the 50 most cited articles in the field was generated, as well as a list of journals publishing cardio-oncology articles. The top 50 most cited articles were reviewed for their citations, year of publication, type of article (i.e., original article, position paper/society guideline, review, systematic review, conference paper, letter to the editor, and case report), journal, and characteristics of the corresponding author (i.e., field of study and country of origin). Due to the public nature of the data used in the study, informed consent for this study was not obtained and it was exempt from Institutional Review Board approval. This study was conducted in compliance with all applicable institutional ethical standards for human study. As of March 31, 2021, a total of 1,294 publications related to cardio-oncology as a field with a total of 14,494 citations were found. There was a consistent increase in the number of articles referring to cardio-oncology and the number of citations over the past two decades. The articles per year were 1 in 1996, 1 in 2003, 2 in 2008, 7 in 2010, 14 in 2011, 12 in 2012, 28 in 2013, 47 in 2014, 75 in 2015, 115 in 2016, 176 in 2017, 184 in 2018, 261 in 2019, and 371 in 2020.

Cardio-oncology was the first term used to describe the field and has remained the most used in the literature compared to the other names associated with the field. In this regard, we identified additional terms referring to the field which arose later in the literature such as: onco-cardiology (in 2008), cardio-onco-hematology (in 2017), and cardio-immuno-oncology (in 2018). There was no further mention of the term "cardio-oncology" until 2003 (one article, one citation), and then later in 2008 (two articles, one and 25 citations). After 2010 and particularly between 2015 and 2020, there has been a significant growth in the number of publications referring to cardio-oncology as a field, likely triggered by the increased recognition of cardiac-related side effects of novel cancer treatments, such as targeted and immunomodulating therapies. The top 50 most cited articles in the field of cardio-oncology had a combined total of 7,192 citations as of March 2021. The number of citations per publication ranged from 49 to 986 (mean 143 ± 157). The most cited articles to date were published between 2010 and 2020, with the majority between 2015 and 2020 ($n = 31,62\%$). All articles were in English and most article types were reviews ($n = 28,56\%$, with 3,208 citations), followed by guidelines and position papers ($n = 9,18\%$, with 2,299 citations) and original articles ($n = 9,18\%$, with 1,451 citations). The rest of the articles were one letter to the editor, one systematic review, one case report, and one conference paper. The authors found that the three journals with the most articles on the 50 most cited list were Journal of the American College of Cardiology (eight publications with 1,347 citations), European Heart Journal (four publications with 1,372 citations), and Circulation (four publications with 241 citations). The researchers point out that cardio-oncology has blossomed as a field and its impact is expected to continue to expand. At the same time, despite the growth of the field, there is a need to expand our research efforts towards more original basic and translational research studies and to adopt standard terms for the indexing of research related to the field [7].

Ng C.T. et al. [8] note in their work that in recent years, there has been growing interest in the subspecialty of cardio-oncology worldwide. Cardio-oncology is an emerging multi-disciplinary field, which aims to reduce morbidity and mortality of cancer patients by preventing and managing cancer treatment-related cardiovascular toxicities. With the growth in cardiovascular and cancer burden in Asia, there is a greater need for cardio-oncology awareness among physicians managing this unique group of patients and need to develop country-specific cardio-oncology initiatives. Our colleagues emphasize that in Asia, the top priority is to boost cardio-oncology services to cope with the upcoming cancer and CVD pandemic. The timely and appropriate intervention of cancer patients who experience CV toxicity can potentially help to reduce both CVD and cancer mortality. Concurrently, establishing a regional registry or joining an international registry such as Global Cardio Oncology Registry would facilitate the collection of country-specific data to better understand the disease prevalence and outcomes of cardioprotective strategies, and provide feedback for improving existing cardio-oncology programs. Based on the epidemiology of cancer therapy-related cardiovascular toxicity (CTR-CVT) in Asian patients, as well as ongoing research into the pharmacogenetics/pharmacokinetics of cancer and cardio-protective agents, customized guidelines for the Asian population can be developed. Given that there is significant healthcare and socio-economic disparity in Asia, countries with established cardio-oncology services should take the lead in mentoring upcoming centers by sharing their experiences and knowledge. The field of cardio-oncology is transforming the way cardiologists, oncologists, and hematologists screen for and manage CTR-CVT. While it is still in the developing phase, the various cardio-oncology

communities in Asia and across the world are working closely together to advance the field by optimizing clinical care, education, and research, with a united mission of allowing cancer patients to complete their treatment and lead quality lives with minimal CVD burden thereafter.

I would also like to touch upon such an important aspect as the participation of mid-level medical personnel in cardio-oncological care.

Fadol A. et al. [9] say that with early detection and improvements in systemic and local therapies, millions of people are surviving cancer, but for some at a high cost. In some cancer types, cardiovascular disease now competes with recurrent cancer as the cause of death. Traditional care models, in which the cardiologist or oncologist assess patients individually, do not address complex cancer and cardiovascular needs. Nursing disciplines should be an integral part of holistic assessment in cardio-oncology care. To learn what educational needs nurses perceive important for provision of competent cardio-oncology nursing care, authors undertook an international survey, aiming to understand their learning needs and preferred learning modalities. As the researchers note cardio-oncology is a relatively new field of study and the nursing knowledge standard to provide holistic care has not been established. Moreover, nurses commonly have knowledge based in either cardiology or oncology but rarely both. For competent cardio-oncology nursing care to be fostered, accessible and acceptable educational opportunities must be readily available. Accordingly, they undertook an online survey to assess the learning needs of nurses in the competent care of cardiovascular issues in patients with cancer, aiming to understand their learning needs and preferred learning modalities.

A cross-sectional survey was developed by members of the International Cardio-Oncology Society (IC-OS) Nursing Research group, with invitations distributed through IC-OS as well as national and international nursing societies and associations. The survey was in English and consisted of 23 questions which include demographic information, clinical specialty (oncology, cardiology, or cardio-oncology), multiple-choice questions related to clinical topics that nurses might be interested in learning, and preferred methods of instruction. No identifying information was requested thus participants remained anonymous. The survey qualified for exempt status by institutional board review and completion was considered implied consent of participation. The survey was conducted online via the IC-OS website with submissions accepted between the dates of December 1, 2023, to February 29, 2024. The secure Research Electronic Data Capture program was utilized to administer the survey which took approximately five minutes to complete [10]. Survey questions were purposefully developed to describe potential cardio-oncology events across the treatment and survivorship continuum. Depending on the format of the question, respondents could choose as many areas of interest as desired. Aiming for the broadest perspectives and representation of different health care systems, participants were recruited by convenience sampling in multiple countries and were currently working in cardiology, oncology or cardio-oncology programs [9].

Three hundred and twenty-nine responses were received during the study time frame. The majority of respondents reported as residing in the United States ($n = 206$), Canada ($n = 45$), United Kingdom ($n = 14$) China ($n = 12$), Qatar ($n = 5$), Australia ($n = 1$), Ireland ($n = 2$), Poland ($n = 2$), Turkey ($n = 1$) and Italy ($n = 1$). The majority were female ($n = 290, 93\%$) with 49% educated to Bachelor's level ($n = 151, 49\%$) and working in oncology ($n = 218, 70\%$) in direct patient care roles ($n = 260, 85\%$). A total of 201 (65%) nurses stated they had cardio-oncology experience. In terms of previous education and training in cardio-oncology, the majority stated that they had no formal education ($n = 268, 88\%$) and approximately one-third have formal cardio-oncology programs in their workplace ($n = 110, 36\%$). The majority of respondents expressed an interest in learning more about cardio-oncology related topics, primarily via pre-recorded webinars ($n = 206, 67\%$) and live virtual meetings ($n = 192, 63\%$). Formal programs leading to certification were highly endorsed ($n = 247, 80\%$). Respondents were asked about training topics categorised into cardio-oncology, oncology and cardiology. In relation to specific cardio-oncology topics, there was a strong interest in learning more about cardiovascular toxicities and their management ($n = 205, 66\%$) along with interest in cardio-oncology programs and cancer therapeutics. The survey authors conducted described the sample's characteristics, identified cardio-oncology learning needs and preferred methods of delivery. A cardio-oncology core curriculum based on the survey responses can offer convenient, accessible and learner-directed education for nurses worldwide. Ultimately, as our colleagues point out, development of cardio-oncology nursing expertise will benefit cancer patients and survivors worldwide [9].

Now, regarding the Cardio-Oncology Rehabilitation and Exercise (CORE) programmes. Adams S.C. et al. [11] focus on the fact that there is an urgent need to reinforce and extend the evidence informing the cardiovascular care of cancer survivors. CORE is an attractive model that is potentially scalable to

improve the cardiovascular health of cancer survivors as it leverages many of the existing frameworks developed through decades of delivery of cardiac rehabilitation. However, there are several challenges within this burgeoning field, including limited evidence of the efficacy of this approach in patients with cancer. CORE incorporates a model like cardiac rehabilitation programmes, including medical evaluation, prescriptive exercise, cardiovascular risk factor modification, education, counselling, and nutritional support. This intervention potentially has diverse and complementary patient-, HCP-, and system-level benefits and may be a leading strategy to address the current care gaps and optimize long-term cardiovascular outcomes for oncological patients and survivors. Close collaboration of CORE stakeholders (e.g. oncologists, cardiologists, primary care physicians, nursing, exercise physiologists/therapists, nutritionists, etc.) is required to accelerate discovery, improve the quality (e.g. rigour and reporting) and scope (e.g. targeting high risk and highly vulnerable populations) of CORE research, and support widespread implementation in the field.

Thus, cardiotoxicity remains a key issue in modern anticancer therapy, impacting both immediate treatment outcomes and the long-term quality of life of patients. Increasing cancer survival rates make maintaining optimal cardiovascular health an integral part of comprehensive oncology care. The development of cardio-oncology as an interdisciplinary field provides the foundation for the early detection of cardiac complications, optimized therapy, and a personalized approach to each patient. A combination of modern diagnostic methods, risk stratification, and cardioprotective strategies can significantly reduce the likelihood of severe cardiovascular complications. Close collaboration between oncologists, cardiologists, and related specialists, based on unified clinical protocols and timely monitoring, remains crucial. Further advancement of cardio-oncology requires expanding the evidence base, implementing innovative technologies, including biomarkers, and raising awareness among the medical community about the risks of cardiotoxicity. This approach will not only improve the tolerability of anticancer treatments but also provide patients with a longer, better quality of life after completion of anticancer therapy.

In recent years, the development of clinical guidelines and standards for the management of patients at risk of cardiotoxicity has been actively discussed in the scientific literature. International documents already exist that unite the efforts of oncologists and cardiologists, but their implementation in practice requires adaptation to the specifics of national healthcare systems. An important step is the training of specialists, including mandatory nursing staff, raising awareness among physicians at all levels, and developing interdisciplinary communication. This is especially important in resource-limited regions where access to modern monitoring methods may be difficult.

Thus, the relevance of cardiotoxicity testing during anticancer therapy is determined by a combination of factors: the increasing prevalence of cancer, increasing patient life expectancy, the expanding range of anticancer agents toxic to the heart, the presence of delayed cardiac complications, and the high clinical significance of timely diagnosis. Success in modern oncology is impossible without increased attention to maintaining patients' cardiovascular health. Research into the mechanisms of cardiotoxicity, the development of preventative methods, improved monitoring, and the development of personalized treatment approaches are important areas shaping the future of cardio-oncology and improving the quality and length of life for patients.

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Pedagogical sciences

THE IMPORTANCE OF WRITING COMPETENCE IN THE PROFESSIONAL FORMATION OF PRE-SERVICE ENGLISH LANGUAGE TEACHERS: A THEORETICAL PERSPECTIVE

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Abstract

Writing competence plays an important role in the professional development of pre-service English teachers. Future teachers are expected not only to have a good command of English, but also to help their students develop communication skills effectively. However, in many teacher education programs, especially in EFL contexts, writing does not always receive enough attention. This paper focuses on the importance of writing competence from several perspectives, including linguistic, cognitive, pedagogical, and professional aspects. It argues that writing should not be seen as a simple or basic skill, but rather as a complex ability that supports academic learning, reflective thinking, and teaching practice. In addition, the paper considers some of the common difficulties that learners face when developing writing skills and emphasizes the need for a more structured and balanced approach in teacher education. Overall, strengthening writing competence can help prepare more confident, reflective, and professionally competent English teachers.

Keywords: *writing competence, pre-service teachers, academic literacy, teacher education, EFL, professional development*

1. Introduction

In modern education, writing competence has become an important part of both academic and professional development. For pre-service English teachers, writing is not only used for communication, but it also helps them learn, prepare lessons, and reflect on their work. As future teachers, they are expected to use English effectively, especially in writing, because it plays a key role in their studies and future careers.

At the same time, writing is still one of the most difficult skills to develop in many EFL contexts. In many cases, teaching focuses mainly on grammar rules instead of real communication. Because of this, students often do not have enough opportunities to practice meaningful writing. As a result, many pre-service teachers complete their education without strong writing skills, which can later influence their teaching and professional growth.

For these reasons, it is important to pay more attention to writing in teacher education. Writing competence should be seen as an essential part of becoming a professional teacher, not just as a secondary skill.

2. Writing competence as a multidimensional skill

Writing competence is not just a simple skill. It is a complex ability that includes different aspects of language use. As Ken Hyland explains, writing is a social activity where the writer, the reader, and the context all play an important role. This means that effective writing requires more than just knowing grammar and vocabulary. Writers also need to know how to organize their ideas and communicate them clearly.

When we look at the structure of writing, it includes grammar, vocabulary, and sentence patterns. However, these elements alone are not enough to create clear and meaningful texts. As Stephen Bailey points out, academic writing also requires logical organization, clear arguments, and the correct use of style.

Writing competence also includes higher-level skills, such as cohesion, coherence, and understanding different types of texts (genres). These skills help writers produce texts that are suitable for different situations and audiences.

3. Cognitive and psycholinguistic aspects of writing

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4. Writing competence in teacher professional development

Writing competence plays an important role in developing the professional identity of pre-service English teachers. It helps them grow as future educators and supports different areas of their professional development.

4.1 Academic literacy

Pre-service teachers need to write different kinds of academic texts, such as essays, reports, and research papers. Good writing skills help them explain their ideas more clearly and organize their thoughts in a logical way. This also allows them to take part more actively in academic discussions and improve their overall academic results.

4.2 Pedagogical competence

Writing is an important part of teaching practice. Teachers use writing when they prepare lesson plans, create teaching materials, and evaluate students' work. When teachers have strong writing skills, they can give clearer instructions and more useful feedback. This makes the learning process easier and more effective for students.

4.3 Reflective practice

Writing can also help teachers reflect on their work. By writing about their teaching experience, they can better understand what works well and what needs improvement. This kind of reflection helps teachers develop their thinking skills and become more professional over time.

4.4 Research competence

Today, teachers are also expected to be involved in research. Writing competence helps them carry out research, write academic papers, and share their ideas with others. In this way, writing not only supports their personal growth but also helps improve the field of education.

Writing is very important, but many pre-service teachers still have difficulties when they try to learn it. These problems can make writing feel harder and less interesting for students. Because of this, their progress may become slower.

If these challenges are not addressed in time, learners may not be able to develop strong writing skills. This can later affect their future work as teachers, especially when they need to use writing in their professional activities.

5. Challenges in developing writing competence

5.1 Linguistic limitations

Many students have problems with grammar, vocabulary, and sentence structure. They may not know enough words or correct grammar forms to express their ideas. Because of this, their writing often includes many mistakes and may be unclear. Sometimes students understand ideas in their mind, but they cannot write them correctly in English.

5.2 Lack of writing practice

In many schools, students do not have enough opportunities to practice writing. Writing tasks are often limited to short exercises or copying sentences. Students rarely write full texts such as essays or reports. Without regular practice, it is very difficult to improve writing skills and gain confidence.

5.3 Insufficient feedback

Feedback is very important for improving writing skills. However, many students do not receive enough or useful feedback from teachers. Sometimes feedback is too general, for example "good" or "check grammar," and does not explain the mistakes. In other cases, feedback comes too late. This makes it hard for students to learn from their errors and improve their writing.

5.4 Overemphasis on accuracy

In traditional teaching, teachers often focus mainly on grammar rules and correct forms. Students try to avoid mistakes, but they do not learn how to express their ideas freely and creatively. As a result, their writing may be correct but not interesting or meaningful. This can also make students afraid of writing.

5.5 Low motivation and writing anxiety

Many students feel nervous or stressed when they write. They may think their writing is not good

enough or worry about making mistakes. This reduces their confidence and motivation. Some students avoid writing tasks completely. Without motivation and emotional support, it is very difficult for learners to improve their writing skills.

6. Discussion

The analysis of this study makes it clear that writing competence plays a very important role for pre-service English teachers. It is not only about language skills. It also includes thinking ability, understanding of social context, and teaching skills. When teachers write well, they feel more confident and can work more professionally.

At the same time, it can be seen that many students still face different difficulties in writing. Common problems include grammar mistakes, limited practice, and low motivation. Because of these issues, teacher education programs should rethink how writing is taught and try to use more effective and modern approaches.

One important step is to give students more chances to practice real writing. Instead of only doing short exercises, they should also work on longer texts such as essays, reports, and reflections. Regular practice like this can help students develop their writing skills gradually.

Another important point is helping students think more about their own writing. For example, they can write about their learning experience or teaching practice. This kind of activity helps them see what they do well and what they still need to improve.

It is also important to pay attention to students' feelings. Many learners need encouragement and support while writing. When teachers give positive and clear feedback, students feel more confident. In a comfortable learning environment, they usually write better and make faster progress.

Technology can also be useful in the learning process. Online tools can help students notice grammar mistakes and offer suggestions. At the same time, these tools should be used carefully. They should support learning, not replace it. Students still need to think independently and develop their own writing skills.

Overall, writing competence should be taught in a balanced and practical way. It is important to combine regular practice, reflection, and support. This approach can help pre-service teachers become more confident, skilled, and better prepared for their future profession.

7. Conclusion. To sum up, writing competence plays an important role in teacher education. It helps pre-service teachers do better in their studies, develop their teaching skills, and become more reflective and professional in their work.

Writing is not only about language. It also supports learning, thinking, and teaching. Teachers with strong writing skills can explain their ideas more clearly, prepare more effective lessons, and give better support to their students.

The discussion in this paper suggests that writing competence should be treated as a key part of teacher training programs. It should not be limited to grammar exercises only. Instead, students need regular practice, opportunities to reflect, and proper support from teachers.

With a balanced and well-organized approach, teacher education programs can help future teachers become more confident and better prepared for modern education. Strong writing skills will support them both in their academic life and in their future careers.

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USING PROJECT TECHNOLOGIES IN THE DEVELOPMENT OF INTERCULTURAL COMMUNICATIVE COMPETENCE IN ENGLISH LESSONS IN HIGH SCHOOL

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Abstract

In the context of globalization and increasing intercultural interaction, the development of intercultural communicative competence (ICC) has become one of the key objectives of foreign language education. Traditional approaches to teaching English often emphasize grammatical accuracy and vocabulary acquisition, while insufficient attention is paid to the formation of students' ability to communicate effectively in multicultural environments. This article explores the theoretical foundations of using project-based technologies (project-based learning, PBL) as an effective pedagogical tool for developing intercultural communicative competence among high school students.

The study examines the concept of ICC, its structural components, and the pedagogical conditions necessary for its development. Special attention is given to the role of project technologies in fostering students' cognitive, communicative, and socio-cultural skills. Theoretical analysis demonstrates that project-based learning promotes learner autonomy, critical thinking, collaboration, and authentic language use, all of which are essential for successful intercultural communication.

The article also outlines the didactic potential of project technologies in English language teaching, including their ability to integrate language learning with cultural exploration. It is argued that project-based approaches create meaningful learning contexts that simulate real-life intercultural situations, thereby enhancing students' motivation and engagement.

The findings of the theoretical analysis provide a foundation for further empirical research aimed at comparing traditional and project-based approaches in the development of intercultural communicative competence in high school settings.

Keywords: *intercultural communicative competence, project-based learning, English language teaching, high school students, communicative approach, globalization, pedagogy.*

1. INTRODUCTION

In recent decades, the rapid development of globalization, international cooperation, and digital communication has significantly increased the importance of intercultural interaction. English, as a global lingua franca, plays a crucial role in facilitating communication between representatives of different cultures. Therefore, modern foreign language education is no longer limited to teaching linguistic knowledge; it must also prepare students for effective participation in intercultural communication.

One of the key objectives of English language teaching today is the development of intercultural communicative competence (ICC). This competence enables learners not only to use a foreign language correctly but also to understand cultural differences, interpret meanings in diverse contexts, and interact appropriately with people from other cultural backgrounds.

However, traditional methods of teaching English in high school often focus on grammar, vocabulary, and reading comprehension, with limited opportunities for authentic communication and cultural exploration. As a result, students may demonstrate a high level of linguistic knowledge but lack the ability to apply this knowledge in real-life intercultural situations.

In this context, project-based learning (PBL) emerges as a promising pedagogical approach. Project technologies allow students to engage in meaningful, student-centered activities that integrate language learning with cultural content. Through projects, learners can explore real-world issues, collaborate with peers, and develop both linguistic and intercultural skills.

The purpose of this article is to examine the theoretical foundations of using project technologies in the development of intercultural communicative competence among high school students in English lessons. The study analyzes key concepts, identifies essential components of ICC, and explores the pedagogical potential of project-based learning.

2. THE CONCEPT OF INTERCULTURAL COMMUNICATIVE COMPETENCE

2.1 Definition and evolution of ICC

The concept of communicative competence was first introduced by Dell Hymes, who emphasized that effective communication involves not only grammatical correctness but also the ability to use language appropriately in social contexts. Later, this concept was expanded to include intercultural aspects, leading to the development of intercultural communicative competence

Intercultural communicative competence can be defined as the ability to communicate effectively and appropriately with people from other cultures, taking into account cultural differences in values, beliefs, behaviors, and communication styles.

Scholars such as Michael Byram have made significant contributions to the theory of ICC. According to Byram, intercultural communicative competence includes not only linguistic skills but also attitudes, knowledge, and critical cultural awareness.

2.2 Components of Intercultural Communicative Competence

Intercultural communicative competence is a multidimensional construct that consists of several interrelated components:

1. Linguistic competence – knowledge of vocabulary, grammar, and pronunciation.
2. Sociolinguistic competence – the ability to use language appropriately in different social contexts.
3. Discourse competence – the ability to produce coherent and cohesive texts.
4. Intercultural knowledge – understanding of cultural norms, values, traditions, and perspectives.
5. Attitudes – openness, curiosity, tolerance, and respect for cultural diversity.
6. Skills of interpreting and relating – the ability to interpret cultural phenomena and relate them to one's own culture.

7. Critical cultural awareness – the ability to evaluate cultural practices critically.

These components highlight that ICC goes beyond language proficiency and involves cognitive, affective, and behavioral dimensions.

2.3 Importance of ICC in High School Education.

The development of ICC is particularly important in high school, as this stage represents a critical period for shaping students' worldview, values, and social skills. Adolescents are more capable of abstract thinking, reflection, and empathy, which are essential for intercultural understanding.

Moreover, high school students are increasingly exposed to global information through the internet, social media, and international communication. Therefore, they need to be equipped with the skills necessary to navigate cultural diversity and avoid misunderstandings.

3. PROJECT BASED LEARNING AS PEDAGOGICAL APPROACH

3.1 Definition and Principals of Project-Based Learning.

Project-based learning is a student-centered instructional approach in which learners acquire knowledge and skills by working on complex, meaningful tasks over an extended period of time. These tasks typically involve solving real-world problems, conducting research, and presenting results.

The key principles of PBL include:

- Learner autonomy
- Collaboration
- Authenticity
- Integration of skills
- Process-oriented learning
- Reflection

Unlike traditional methods, PBL emphasizes active learning and student engagement.

3.2 Historical development of Project Technologies

The origins of project-based learning can be traced back to the works of John Dewey and William Kilpatrick, who advocated for experiential and activity-based learning. They believed that education should be connected to real-life experiences and that students should learn through doing.

In modern pedagogy, project technologies have gained renewed attention due to their alignment with 21st-century skills, such as critical thinking, creativity, communication, and collaboration.

3.3 Types of Projects in Language Learning.

Projects used in English language teaching can vary in format and objectives:

- Research projects (e.g., studying cultural traditions)
- Creative projects (e.g., creating videos, presentations)
- Problem-solving projects (e.g., addressing global issues)
- Role-play and simulation projects
- Digital and multimedia projects

Each type of project provides opportunities for students to use language in meaningful contexts.

4. THE ROLE OF PROJECT TECHNOLOGIES IN DEVELOPING ICC

4.1 Integration of Language and Culture

One of the main advantages of project technologies is their ability to integrate language learning with cultural content. Through projects, students can explore topics such as traditions, lifestyles, values, and social issues in different countries.

For example, a project on "Cultural Diversity Around the World" may require students to research various cultures, compare them with their own, and present their findings. This process fosters both linguistic and intercultural development.

4.2 Development of Communicative Skills

Project-based learning creates authentic communicative situations in which students must use English to:

- *discuss ideas,*
- *negotiate meaning,*
- *ask questions,*
- *present information,*
- *collaborate with peers.*

These activities enhance fluency and confidence, which are essential for intercultural communication.

4.3 Formation of Intercultural Attitudes

Projects often involve exposure to different perspectives, which helps students develop tolerance, empathy, and openness. By engaging with diverse cultural materials, learners become more aware of cultural differences and similarities.

4.4 Critical thinking and Reflection

PBL encourages students to analyze information, evaluate sources, and reflect on their learning. These skills are crucial for developing critical cultural awareness.

5. PEDAGOGICAL CONDITIONS FOR EFFECTIVE IMPLEMENTATION OF PBL

5.1 Teacher's Role

In project-based learning, the teacher acts as a facilitator, guide, and mentor rather than a traditional instructor. The teacher:

- *designs meaningful tasks,*
- *supports students,*
- *monitors progress,*
- *provides feedback.*

5.2 Learning Environment

- *An effective learning environment for PBL should be:*
- *collaborative,*
- *supportive,*
- *resource-rich,*
- *flexible.*

5.3 Assessment

- *Assessment in PBL should be continuous and multifaceted, including:*
- *self-assessment,*
- *peer assessment,*
- *teacher evaluation,*
- *project outcomes.*

6. ADVANTAGES AND CHALLENGES OF USING PROJECT TECHNOLOGIES

6.1 Advantages

- *Increased motivation and engagement*
- *Development of real-life communication skills*
- *Integration of language and culture*
- *Promotion of autonomy and responsibility*

6.2 Challenges

- *Time constraints*
- *Need for teacher training*
- *Assessment difficulties*

- *Unequal participation among students*

Despite these challenges, the benefits of PBL outweigh its limitations when implemented effectively

7. CONCLUSION

The theoretical analysis confirms that project-based learning is a powerful pedagogical tool for developing intercultural communicative competence in high school students. By integrating language learning with cultural exploration, PBL creates meaningful and authentic learning experiences.

Intercultural communicative competence is a complex construct that requires the development of linguistic, cognitive, and affective skills. Traditional teaching methods are often insufficient for achieving this goal, as they focus primarily on language form rather than communication and cultural understanding.

Project technologies address this limitation by promoting active learning, collaboration, and critical thinking. They provide students with opportunities to engage in real-life intercultural situations, thereby preparing them for communication in a globalized world.

The theoretical findings presented in this article serve as a foundation for the practical part of the study, which will compare the effectiveness of traditional and project-based approaches in developing intercultural communicative competence among high school students.

8. PRACTICAL (EXPERIMENTAL) PART: IMPLEMENTATION OF PROJECT TECHNOLOGIES IN DEVELOPING INTERCULTURAL COMMUNICATIVE COMPETENCE

8.1 Research Design and Methodology

The practical part of the study was aimed at empirically verifying the effectiveness of project-based learning (PBL) in the development of intercultural communicative competence (ICC) among high school students in English lessons.

*The research was conducted in a secondary school setting among **10th grade students**. A total of **16 students** participated in the experiment and were divided into two groups:*

- *Control group (CG) – 8 students (traditional teaching methods)*
- *Experimental group (EG) – 8 students (project-based learning)*

It should be noted that due to irregular attendance, the number of students present during lessons varied between 6–8 students, which reflects real classroom conditions.

Objectives of the Experiment

The main objectives of the experimental study were:

- 1. To assess the initial level of intercultural communicative competence in both groups.*
- 2. To implement project-based learning in the experimental group.*
- 3. To compare the effectiveness of traditional and project-based approaches.*
- 4. To analyze the dynamics of ICC development through pre- and post-testing.*

Research Methods

The following methods were used:

- *Diagnostic testing (pre-test and post-test)*
- *Observation*
- *Comparative analysis*
- *Quantitative and qualitative data analysis*

8.2 Criteria and Levels of Intercultural Communicative Competence

To evaluate students' ICC, the following criteria were identified:

1. Linguistic competence – ability to use appropriate vocabulary and grammar in intercultural contexts

2. Sociocultural knowledge – understanding of cultural norms, traditions, and behaviors

3. Communicative skills – ability to express ideas, participate in discussions, and interact effectively

4. Intercultural attitudes – openness, tolerance, and respect for other cultures

Based on these criteria, three levels of ICC development were distinguished:

• High level – students demonstrate confident communication, deep cultural understanding, and critical thinking

• Medium level – students show adequate communication skills with some cultural awareness

• Low level – students have limited vocabulary, weak communication skills, and minimal cultural knowledge

8.3 Pre-Test Results (Initial Assessment)

At the beginning of the experiment, both groups were given a diagnostic test aimed at assessing

their level of intercultural communicative competence.

The test included:

- multiple-choice questions on cultural knowledge,
- short written responses,
- speaking tasks (describing cultural situations),
- situational dialogues.

Results of the Pre-Test

Level	Control Group (CG)	Experimental Group (EG)
High	1 student (12.5%)	1 student (12.5%)
Medium	4 students (50%)	4 students (50%)
Low	3 students (37.5%)	3 students (37.5%)

The results indicate that both groups had **approximately the same initial level**, which ensures the reliability of the experiment.

8.4 Implementation of Project-Based Learning in the Experimental Group

During the experimental period, the control group was taught using traditional methods, including:

- textbook-based exercises,
- grammar drills,
- reading and translation tasks,
- teacher-centered instruction.

In contrast, the experimental group was taught using project-based learning, which involved active student participation, collaboration, and real-life communication tasks.

Structure of the Experimental Program

The experimental program consisted of two main project modules, each including several lessons.

Module 1: "Art as a Cultural Communication"

Objective:

To develop students' understanding of how art reflects cultural values and traditions.

Duration: 3–4 lessons

Activities:

- Researching famous artworks from different countries
- Group discussions on cultural meaning in art
- Creating presentations on selected artists
- Comparing Kazakh culture with other cultures

Final Product: Group presentations and mini-exhibitions

Skills Developed:

- cultural interpretation
- speaking and presentation skills
- critical thinking

Module 2: "My Favourite Musician as a Cultural Representative"

Objective:

To explore how music reflects cultural identity and global communication.

Duration: 3–4 lessons

Activities:

- Selecting a musician from another culture
- Analyzing lyrics and cultural background
- Preparing multimedia presentations
- Role-play interviews with musicians

Final Product: Creative presentations and role-play performances

Skills Developed:

- intercultural awareness
- listening and speaking skills
- creativity and collaboration

Features of Project-Based Learning Implementation

The experimental group demonstrated:

- active participation in discussions,
- increased motivation,
- collaboration in small groups,
- use of English in authentic situations.

The teacher acted as a facilitator, guiding students and supporting their learning process.

8.5 Post-Test Results (Final Assessment)

At the end of the experiment, both groups were given a post-test identical in structure to the pre-test.

Results of the Post-Test

Level	Control Group (CG)	Experimental Group (EG)
High	2 students (25%)	5 students (62.5%)
Medium	4 students (50%)	3 students (37.5%)
Low	2 students (25%)	0 students (0%)

Comparative analysis of Results

The comparison of pre- and post-test results shows significant differences between the two groups.

Control Group (Traditional Learning)

- Slight improvement in linguistic skills
- Minimal changes in intercultural awareness
- Students remained mostly at medium level

Experimental Group (Project-Based Learning)

- Significant increase in high-level students (from 12.5% to 62.5%)
- Complete elimination of low-level students
- Improved communication skills and cultural understanding

8.7 Discussion of Results

The results of the experiment confirm the effectiveness of project-based learning in developing intercultural communicative competence.

The experimental group showed:

- better speaking fluency,
- deeper cultural understanding,
- higher motivation,
- improved collaboration skills.

This can be explained by the nature of project-based learning, which:

- creates authentic communication situations,
- integrates language and culture,
- encourages active participation,
- develops critical thinking.

In contrast, traditional teaching methods were less effective in promoting intercultural competence, as they focused mainly on language form rather than communication.

8.8 Limitations of the Study

Despite positive results, several limitations should be noted:

- small sample size (16 students),
- irregular attendance (6–8 students per lesson),
- limited duration of the experiment.

However, these limitations do not significantly affect the overall validity of the findings.

8.9 Conclusion of the Experimental Study

The practical part of the research demonstrates that project-based learning is a highly effective approach for developing intercultural communicative competence in high school students.

The experimental group significantly outperformed the control group in all assessed criteria, confirming the hypothesis that project technologies enhance both linguistic and intercultural skills.

Thus, the integration of project-based learning into English language teaching is recommended as a key strategy for preparing students for communication in a globalized world.

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**THE ROLE OF DIGITAL EDUCATIONAL RESOURCES IN TEACHING PROFESSIONALLY-ORIENTED
FOREIGN LANGUAGE**

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**РОЛЬ ЦИФРОВЫХ ОБРАЗОВАТЕЛЬНЫХ РЕСУРСОВ В ОБУЧЕНИИ ПРОФЕССИОНАЛЬНО-
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Abstract

This study investigates the impact of digital educational resources and artificial intelligence on motivation and learning outcomes in profession-oriented foreign language education. Focusing on Generation Z learners, the research evaluates the effectiveness of integrating artificial intelligence driven tools such as Quizlet, Quizizz, and Youglish into undergraduate curricula. Using a mixed-methods approach, students' attitudes and perceptions were assessed through a survey analyzed quantitatively with descriptive and correlation statistics and qualitatively through thematic coding. Findings indicate

that digital educational resources and artificial intelligence significantly enhance motivation and engagement, with 98% of participants reporting improved professional language competence. Gamification elements, mobile-friendly platforms, and interactive features were particularly effective in maintaining student interest. Despite these benefits, challenges such as digital inequality and insufficient instructor interaction were identified, emphasizing the need for balanced integration of technology and human guidance. The study highlights the transformative potential of digital educational resources and artificial intelligence in modernizing profession-oriented foreign language education. Practical recommendations include prioritizing platforms with adaptive learning and gamified experiences, addressing accessibility issues, and enhancing teacher training to optimize the use of digital tools. By leveraging the strengths of digital educational resources and artificial intelligence while mitigating their limitations, educators and policymakers can create inclusive, effective, and future-ready learning environments for a technology-driven workforce.

Аннотация

В данном исследовании изучается влияние цифровых образовательных ресурсов (ЦОР) и искусственного интеллекта (ИИ) на мотивацию и результаты обучения в профессионально-ориентированном обучении иностранным языкам. Основное внимание уделено студентам поколения Z. В рамках исследования оценивалась эффективность интеграции инструментов, основанных на ИИ, таких как Quizlet, Quizizz и Youglish, в учебные программы для студентов бакалавриата. Смешанный метод исследования включал опрос студентов, результаты которого анализировались количественно с использованием описательной и корреляционной статистики, а также качественно через тематическое кодирование. Результаты показывают, что ЦОР и ИИ значительно повышают мотивацию и вовлечённость студентов: 98% участников отметили улучшение профессиональной языковой компетенции. Элементы геймификации, мобильные платформы и интерактивные функции оказались особенно эффективными для поддержания интереса студентов. Однако были выявлены такие проблемы, как цифровое неравенство и недостаточное взаимодействие с преподавателями, что подчеркивает необходимость сбалансированной интеграции технологий и человеческого участия. Исследование подчеркивает трансформационный потенциал ЦОР и ИИ в модернизации профессионально-ориентированного обучения иностранным языкам. Практические рекомендации включают приоритетное использование платформ с адаптивным обучением и элементами геймификации, решение проблем доступности и повышение квалификации преподавателей для эффективного использования цифровых инструментов. Используя сильные стороны ЦОР и ИИ и устраняя их недостатки, можно создать инклюзивные, эффективные и современные образовательные среды для цифрового будущего.

Keywords: *digital educational resources, artificial intelligence, foreign language education, motivation in language learning, profession-oriented education, generation z, gamification in education, foreign language competence*

Ключевые слова: *цифровые образовательные ресурсы, искусственный интеллект, иноязычное образование, мотивация в изучении языков, профессионально-ориентированное образование, поколение Z, геймификация в образовании, владение иностранным языком.*

Introduction

Technology has become a cornerstone of education in the modern era, reshaping traditional teaching methods and opening new possibilities for engagement and learning. This transformation is particularly evident in profession-oriented foreign language education, where integrating digital resources offers innovative ways to enhance students' motivation and practical language skills. Motivation is pivotal in achieving linguistic competence and career readiness for students learning a foreign language with a specific professional focus—whether for journalism, business, medicine, or engineering.

The rapid advancement of digital technologies has necessitated a shift in educational priorities worldwide. As the President of Kazakhstan highlighted in his address to the nation, preparing younger generations to navigate and use digital tools, particularly artificial intelligence (AI), is essential for fostering national progress and global competitiveness. He also emphasised the strategic importance of revising school and university curricula to integrate AI technologies and digital resources, stressing the significance of equipping learners with the skills to thrive in a technology-driven world. The establishment of the National Center for AI located in Astana further demonstrates this commitment,

which aims to foster innovation among students, researchers, and entrepreneurs [1,2].

This vision resonates strongly with the goals of profession-oriented foreign language education. Educators can bridge the gap between traditional teaching methods and the dynamic demands of globalised industries by integrating digital resources such as AI-driven language tools, adaptive learning platforms, and immersive technologies. These tools enhance language acquisition and prepare students to engage in technology-rich environments, ensuring competitiveness in a digital-first world.

Motivation in language learning can be a complex phenomenon, influenced by factors such as perceived relevance, accessibility of resources, and opportunities for real-world application. Traditional methods often need help to meet the dynamic needs of modern learners, especially in fields requiring industry-specific vocabulary, situational understanding, and communication skills. This article explores the transformative impact of modern technologies on teaching profession-oriented foreign languages, focusing on their role in fostering student motivation. By examining practical examples, challenges, and future possibilities, this discussion aims to provide educators with insights into leveraging technology to inspire and empower learners in an increasingly globalised and technology-driven world.

Educational digital technologies open up fundamentally new methodological approaches in the system of general education, because the use of multimedia visualization in the classroom helps both the teacher in teaching the subject and the student in mastering the subject [3, p. 192]. Thus, the integration of digital technologies into profession-oriented foreign language education has been extensively studied by researchers worldwide, with significant contributions from domestic and foreign scholars. For example, the studies of some scholars such as G.K.Nurgaliyeva, D.M.Dzhussubaliyeva, A.I.Tazhigulova, Chaklikova A.T., Sysoev P.V., V.P.Demkin, G.V. Mozhaeva, E.S. Polat, M.Levy, U.Stickler, R.Hampel highlight the transformative potential of digital tools in enhancing learners motivation, engagement, and learning outcomes.

In Kazakhstan, adopting digital technologies in education is vital in preparing competitive specialists for the 21st century. Dzhussubaliyeva emphasises that digital tools facilitate open education, improving students' access to resources and enhancing their competitiveness in the modern labour market [4, p.45]. Similarly, the Kazakhstani Association of Teachers of English (KazTEA) has reported that various applications and platforms, particularly those incorporating gamification, significantly assist educators in assessing students' skills and motivating them to achieve higher proficiency levels. These findings align with national efforts to modernise education systems by integrating technology, as outlined in state educational priorities [5].

Russian researchers Ivanova E.7. And Stepanov B. have also significantly contributed to this field, exploring the pedagogical strategies required for effective digital integration in foreign language teaching. A study published in the journal *Education and Self Development* highlights the importance of developing digital competence among teachers and students to ensure the successful implementation of technology in language education [6, p.46]. The authors stress that digital tools should not merely be supplementary resources but must be carefully integrated into pedagogical practices to foster meaningful learning experiences. This research underscores the need for teacher training programs that focus on effectively using digital technologies in educational settings.

Internationally, the role of digital technologies in foreign language education is of growing interest. A report by the Organisation for Economic Co-operation and Development underscores the importance of leveraging digital tools to enhance learning outcomes, emphasising that these technologies must add clear pedagogical value to classroom practices [7]. Similarly, a study published in the journal *Frontiers in Psychology* by Schmid, E. & Meyer, S. investigates the impact of educational technology on students' motivation, highlighting how interactive and adaptive tools can create engaging learning environments. These studies suggest that digital resources can bridge the gap between traditional teaching methods and the demands of modern, technology-driven industries [8].

The literature reflects a broad consensus on the positive effects of digital technologies on motivation and learning outcomes in profession-oriented foreign language education. Researchers from Kazakhstan, Russia, and other countries agree that digital tools can enhance engagement, relevance, and effectiveness. However, they also highlight challenges such as the digital divide, inadequate infrastructure, and the need for ongoing teacher training. Addressing these challenges is essential for ensuring equitable access to digital education and maximising its potential to transform language learning globally.

Previous studies have shown that integrating Digital Educational Resources (DER) and Artificial Intelligence (AI) has revolutionised modern education, particularly in language learning. These technologies provide innovative approaches to teaching and learning, enhancing personalisation,

engagement, and accessibility while preparing learners for real-world applications.

Integrating DER and AI into the educational process has led to significant advancements in both the quality and efficiency of learning. These technologies improve educational outcomes and offer innovative approaches to meet the diverse needs of learners and educators. Below, the key advantages are outlined and contextualised within the framework of academic research.

1. *Personalized Learning.* One of the most notable benefits of DER and AI is their ability to personalise the learning experience. Adaptive technologies analyse individual student progress, identify learning gaps, and provide customised pathways for improvement [6, pp.46-49]. This approach ensures each learner receives tailored tasks and recommendations, fostering a more efficient and engaging educational experience. Furthermore, the flexibility offered by AI-based systems allows students to set their own learning pace, which is particularly valuable in blended and online learning environments.

2. *Motivation and Engagement.* The gamification of educational tools, including incorporating achievements, levels, and rewards, significantly enhances learner motivation. Interactive technologies such as virtual reality (VR) and augmented reality (AR) create immersive environments that actively engage students in learning. These tools provide realistic simulations, enabling learners to practice professional skills in controlled, risk-free scenarios, bridging the gap between theoretical knowledge and practical application [7].

3. *Efficiency and Accessibility.* AI-based programs streamline various aspects of the educational process, making learning more efficient and accessible. For instance, tools like Grammarly and Duolingo provide immediate feedback, allowing learners to correct mistakes in real-time and improve their language proficiency. Additionally, DER and online platforms expand access to education for students in remote or underserved areas, breaking geographical barriers. By automating routine tasks such as test grading, these technologies free educators to focus on more complex instructional activities [7].

4. *Enhanced Quality of Learning.* Digital technologies have a transformative impact on the quality of learning. Simulations and virtual laboratories enable students to apply theoretical knowledge in real-world scenarios, enhancing their practical understanding. AI-driven tools challenge learners with complex tasks, promoting critical thinking and problem-solving skills. Moreover, Moradi P., Levy K. states that DER facilitates interdisciplinary learning, integrating concepts from various fields, which is particularly beneficial in profession-oriented education [9, p.271].

5. *Future-Ready Skill Development.* Incorporating DER and AI into education equips students with essential skills for the digital age. Exposure to these tools fosters digital literacy, ensuring learners are prepared for technology-driven workplaces. Specialised software replicates real-world professional environments, allowing students to gain industry-specific skills, such as newsroom simulations for journalism students. Collaborative platforms like Google Workspace further develop teamwork and communication skills, which are critical for professional success.

6. *Benefits for Educators.* Educators also benefit significantly from the integration of DER and AI. These technologies provide ready-made teaching materials, interactive assignments, and automated assessment tools, simplifying lesson planning and evaluation processes. According to Hampel & Stickler, AI-powered analytics enable educators to monitor student progress effectively, offering insights into areas requiring additional attention. Furthermore, DER facilitates professional development by helping teachers improve their digital and pedagogical competencies [10, p. 133].

7. *Global Collaboration.* The global reach of DER and AI fosters international collaboration and cross-cultural learning opportunities. Kukulska-Hulme states that these technologies enable students to participate in international projects and exchange knowledge with peers worldwide. Language learning platforms like Busuu and Tandem connect learners with native speakers, providing authentic language practice and enhancing intercultural competence [11, p. 10].

Thus, integrating DER resources and AI has revolutionised the academic landscape, offering personalised, engaging, and effective learning opportunities. By enhancing motivation, adaptability, and the quality of education, these technologies prepare students to meet the demands of modern society and professional environments. However, for their successful implementation, it is crucial to address challenges such as technical infrastructure, digital inequality, and the professional training of educators. Future research and policy development should focus on creating equitable and sustainable frameworks for integrating DER and AI in education.

We also need to recognise the relationship between the theory of generations and modern technologies in education. Generation Z, encompassing individuals born between 1997 and 2012,

represents a cohort uniquely shaped by the digital age. Often referred to as “digital natives,” this generation has grown up in an environment where technology is ubiquitous, profoundly influencing their learning preferences, behaviours, and expectations. Its deep integration with technology characterises Generation Z. Research by Seemiller and Grace highlights that this cohort values personalised and technology-enhanced learning environments, favouring platforms that provide adaptive learning paths and immediate feedback [12]. Such preferences align with the capabilities of DER and AI, which offer tailored experiences that cater to individual needs.

Studies consistently show Generation Z learners are more engaged when educational technologies incorporate gamification and interactivity. According to Ozkan and Solmaz, gamified elements such as badges, leaderboards, and points significantly enhance motivation and sustain engagement among Generation Z students [12, p. 476]. Furthermore, Kukulska-Hulme found that mobile-assisted language learning (MALL) tools resonate particularly well with this generation, as they align with their preference for on-demand, mobile-friendly content [11].

We agree with Schroer on the point that while Generation Z is highly adept at navigating digital platforms, their reliance on technology can sometimes result in shorter attention spans and a preference for visually stimulating, concise content [14, p. 78]. However, this also presents opportunities for educators to leverage DER and AI technologies to create engaging, interactive, and dynamic learning environments that align with these tendencies. Understanding Generation Z's affinity for technology is critical in designing effective learning strategies, particularly in profession-oriented foreign language education. As this generation seeks relevance and practicality in their learning experiences, AI-driven tools and immersive digital platforms can foster motivation and competence in foreign language acquisition.

Methods and materials

To determine the role of DER and AI in learning profession-oriented foreign languages and identify to what extent students are motivated to use DER and AI in their learning process, we analysed different works of domestic and foreign authors. This study employed a mixed-methods approach, combining quantitative and qualitative data collection to evaluate students' perceptions and motivational attitudes toward DER and AI, as the aim of the research is to investigate the motivational-value component of students' attitudes toward using DER and AI for developing profession-oriented foreign language competence. The participants comprised 97 undergraduate students aged 20–21 from Kazakh British Technical University and Kazakh Ablai Khan University who enrolled in a profession-oriented foreign language learning course. Two sampling methods, purposive and stratified, were used to select participants for your study. Purposive sampling was used to select participants who were second-year students aged 20–21 and enrolled in a profession-oriented foreign language course in Journalism academic programme at Ablai Khan University, as they represented the target demographic for this study. Stratified sampling was employed at Kazakh-British Technical University to ensure representation across different educational programs. Participants were randomly selected from subgroups such as Oil and Gas, Business School, Marketing, Automatization and Control and other programmes students enrolled in the foreign language course.

A survey was developed specifically for this study to assess the motivational-value component of students' attitudes toward DER and AI in profession-oriented foreign language learning. The 12-item survey consisted primarily of Likert-scale questions, covering themes such as the perceived usefulness of DER, frequency of use, motivational impact, and accessibility. For example, students were asked to rate the usefulness of DER for professional foreign language competence (“How do you evaluate the usefulness of digital educational resources in improving your foreign language skills in a professional context?”). Open-ended questions provided additional qualitative insights into the challenges and limitations of DER, such as accessibility and usability issues. The survey was distributed online and completed by students after a 12-week course utilising DER and AI tools, ensuring participants had adequate experience with these resources. Responses were analysed using descriptive and correlation statistics, with qualitative data coded thematically to identify recurring patterns and unique insights.

The study integrated AI-driven platforms, including mentimeter.com, educaplay.com, quizlet.com, quizizz.com, and youglish.com, into the curriculum over a 12-week period. Quantitative data were analysed using descriptive and correlation statistics, while qualitative data were coded thematically to identify key trends in student attitudes.

Themes Covered in the Survey

The survey was structured around the following key themes to comprehensively evaluate the motivational-value component of students' attitudes toward DER and AI in profession-oriented foreign

language learning:

1. *Perceived Usefulness*: Students evaluated the perceived usefulness of DER and AI tools in improving their FL skills in a professional context (Question 1).
2. *Frequency of Use*: The survey measured how often students engaged with DER for foreign language learning (Question 2).
3. *Motivational Impact*: Questions explored whether DER and AI tools positively influenced students' motivation to learn a FL for professional purposes (Question 3).
4. *Tool Preferences*: Students indicated their preferred types of digital tools for language learning, such as mobile apps, online courses, or gamified platforms (Question 4).
5. *Effectiveness in Understanding Professional Terminology*: The survey assessed the impact of DER on students' comprehension of industry-specific vocabulary (Questions 5 and 10).
6. *Comparison with Traditional Methods*: Participants compared DER-based learning with traditional teaching methods regarding engagement and effectiveness (Question 6).
7. *Preparation for Professional Activities*: Students rated how well DER prepared them for using foreign languages in professional settings (Question 7).
8. *Accessibility and Usability*: The ease of accessing and using DER for independent learning was evaluated (Questions 8 and 9).
9. *Interaction with Teacher and Peers*: The survey included questions on the quality of interaction DER facilitates in the learning environment (Questions 11 and 12).

These themes were designed to comprehensively address the motivational, cognitive, and practical aspects of using DER and AI in foreign language education, providing a holistic view of students' attitudes and experiences.

Implementation of AI-Driven Platforms

To evaluate the impact of DER and AI on students' motivation and attitudes, the study incorporated various interactive tools and platforms into a 12-week profession-oriented foreign language curriculum. The platforms included:

- *mentimeter.com* for real-time interactive polls to engage students in active participation,
- *educaplay.com* for gamified exercises designed to reinforce professional language skills,
- *quizlet.com* for adaptive vocabulary practice using flashcards and collaborative learning,
- *quizizz.com* for competitive, gamified quizzes to assess language knowledge,
- *youglish.com* for improving pronunciation and listening comprehension with real-world examples,
- *Twee Beta* for creating interactive storytelling and simulations of professional communication scenarios,
- *Padlet* for collaborative brainstorming and sharing ideas in a digital space and
- *Wordwall* for creating engaging, interactive activities such as matching games, quizzes, and word searches tailored to professional vocabulary.

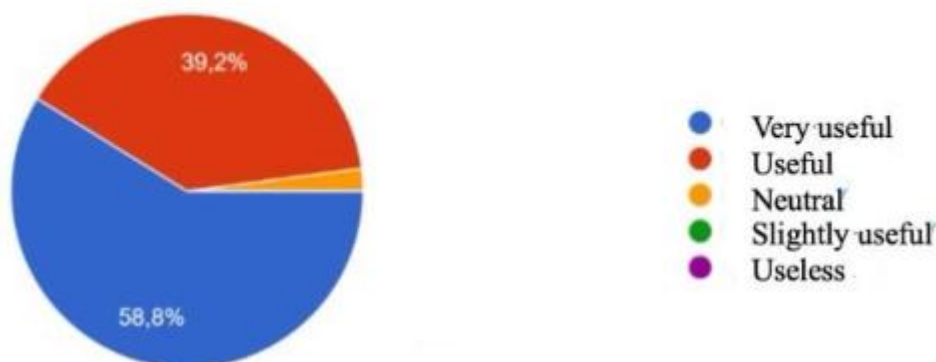
The DER and AI tools used were selected based on their ability to offer interactive, adaptive, and immersive learning experiences aligned with the study's objectives, which focused on developing students' foreign language competence in professional contexts.

Quantitative data were collected through structured surveys and analysed using descriptive and correlation statistics to identify relationships between students' motivation, attitudes, and tool usage frequency. Qualitative data from open-ended survey responses were coded thematically to extract key insights into students' perceptions of the platforms' usability, engagement, and overall impact on their learning outcomes.

Results and discussion

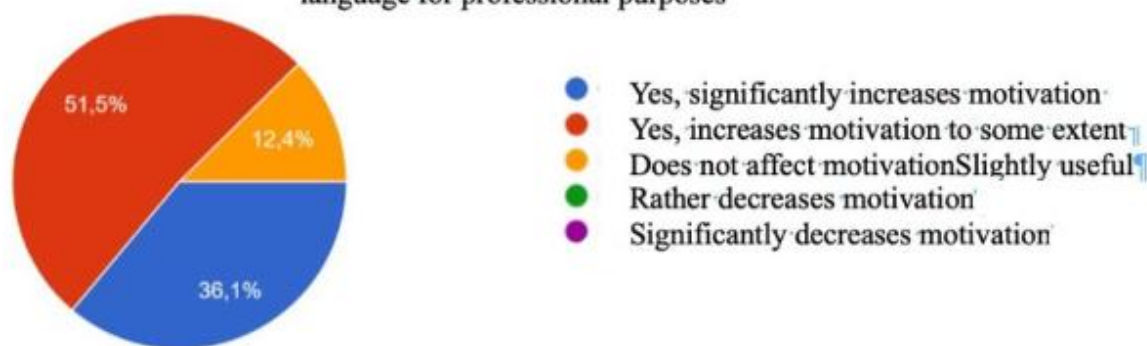
The survey results indicate that 98% of participants found digital educational resources beneficial in improving their foreign language competence for professional purposes (picture 1). While 51.5% of students reported significantly increased engagement, and 36.1% reported increased engagement to some extent when using these platforms, a small group (12.4%) considered DER and AI tools not motivating to study profession-oriented foreign languages (picture 1). Furthermore, a positive correlation was observed between the frequency of tool usage and self-reported motivation.

How do you assess the usefulness of digital educational resources (e.g., online platforms, multimedia resources such as audio and video) in a professional context?



Picture 1 – Evaluation of the perceived usefulness of DER and AI tools in improving foreign language skills in a professional context

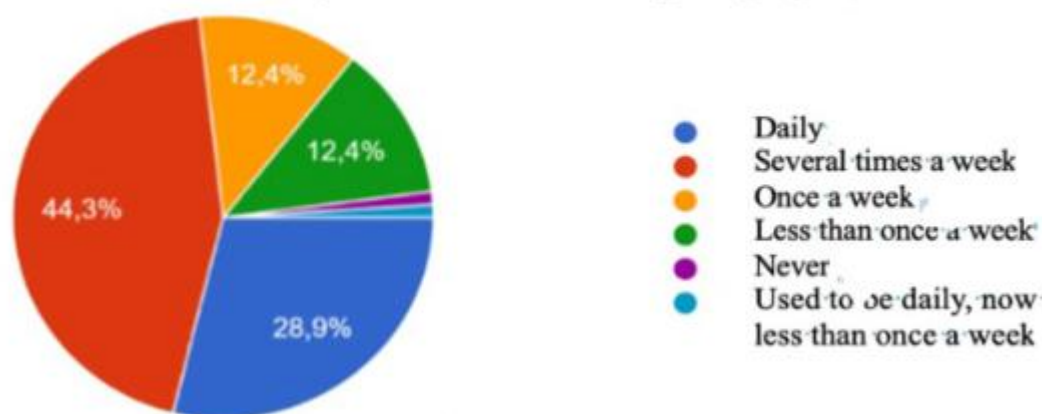
Do you think that the use of digital educational resources increases your motivation to learn a foreign language for professional purposes



Picture 2 – Students engagement frequency with DER for foreign language learning

44.3% of students reported using DER and AI tools multiple times per week, while 28.9% used them daily (picture 3).

How often do you use digital educational resources to study a profession-oriented foreign language?



Picture 3 – Motivational Impact of DER and AI

Open-ended responses revealed that students appreciated the priorities provided by mobile applications (60.8%), video platforms such as YouTube, Youglish, Tedtalks (70.1%), social networks and blogs (54.6%), games and gamified interactive platforms (37.1%) but expressed a desire for more structured guidance from instructors. Despite the overall positive attitudes, some students faced challenges related to the accessibility of digital tools, as the most effective tools are on a fee-paying basis; some require a high-speed internet connection. This underscores the need for improved infrastructure and support systems to ensure equitable access.

The findings align with Seemiller and Grace's observations that gamified and interactive technologies highly motivate Generation Z learners [12]. The strong preference for tools like Quizlet and

Educaplay also supports Ozkan and Solmaz's [13] assertion that gamification sustains engagement in learners.

The results suggest that incorporating AI-driven tools into language education can significantly enhance motivation and learning outcomes. Educators should prioritize platforms that offer adaptive learning and gamified experiences, as these were most effective in engaging students.

Overall, the findings demonstrate the transformative potential of DER and AI in profession-oriented foreign language education. Future studies should explore how these tools can be further adapted to address specific challenges such as accessibility and instructor involvement.

The Role of Generation Z in the Findings

Generation Z, born between 1997 and 2012, has grown up in a digital age where technology is integral to daily life. This unique generational characteristic was evident in the study's findings, as students demonstrated a strong preference for using DER and AI in their learning process. Tools like Quizlet, Youglish, and Educaplay resonated particularly well with this cohort, aligning with their affinity for interactive and gamified learning experiences. These preferences are consistent with prior research by Seemiller and Grace [12], who highlighted Generation Z's inclination toward personalized and technology-enhanced educational environments.

The study found that gamification significantly enhanced student motivation, with tools like Quizizz and Wordwall being among the most effective platforms. This aligns with research by Ozkan and Solmaz [13], who noted that gamification elements such as badges, leaderboards, and points sustain engagement among Generation Z learners. These findings suggest that incorporating gamified features in educational technologies meets the expectations of this generation and addresses their preference for immediate rewards and interactive experiences.

Generation Z's reliance on mobile technology was reflected in the high usage rates of mobile-friendly platforms such as Quizlet and Youglish. As Kukulska-Hulme [11] observed, mobile-assisted language learning (MALL) tools align with Generation Z's need for on-demand, flexible learning opportunities. The ability to access resources anytime and anywhere supports their busy, tech-driven lifestyles and fosters independent learning.

While Generation Z's familiarity with technology is a strength, it also presents challenges:

- **Short Attention Spans:** Some students indicated a preference for concise and visually engaging content, which is consistent with Schroer's [14] findings on Generation Z's tendency to disengage from lengthy or monotonous tasks.

- **Reliance on Technology:** A few participants expressed frustration with limited instructor interaction, highlighting the need to balance technology-based learning with human elements. This reflects a potential gap in designing DER that fully addresses the educational needs of Generation Z.

The findings suggest that educators should tailor profession-oriented foreign language courses to Generation Z's learning preferences:

- Emphasize gamification and interactivity to maintain engagement.
- Leverage mobile-friendly platforms to provide flexible learning options.
- Combining DER and AI with meaningful instructor interaction creates a balanced and holistic learning experience.

These observations underline the importance of understanding generational traits when designing educational interventions. The positive attitudes of Generation Z toward DER and AI in this study validate the alignment of these tools with the cohort's preferences for technology-rich, interactive, and personalized learning experiences. This insight is critical for educators aiming to optimize foreign language education for a generation shaped by digital advancements.

Conclusion

The study examined the role of DER and AI in fostering motivation and enhancing the learning outcomes of profession-oriented foreign language education. The research highlighted several key findings and implications by integrating a range of AI-driven tools and platforms into a 12-week curriculum and analyzing students' attitudes and perceptions.

Key Findings

Perceived Usefulness: Most students found DER and AI tools highly beneficial for improving their foreign language skills in professional contexts. The tools helped bridge the gap between theoretical knowledge and practical applications, particularly in mastering industry-specific vocabulary and scenarios.

Motivational Impact: The integration of gamified and interactive platforms such as Quizizz and Educaplay significantly increased student engagement and motivation. A majority of respondents agreed

that these tools made the learning process more enjoyable and relevant to their professional goals.

Tool Preferences and Accessibility: Tools like Quizlet and Youglish were preferred for vocabulary practice and pronunciation improvement. However, some challenges were noted, including limited access to digital tools in certain cases and the need for more robust instructor-student interaction.

Generation Z Characteristics: The findings aligned with existing literature on Generation Z's learning preferences, showcasing their affinity for interactive, gamified, and visually engaging technologies.

The results underscore the transformative potential of DER and AI in modernizing profession-oriented foreign language education. Educators should consider the following:

Incorporating Gamification and Interactivity: Platforms that offer gamified features and immersive experiences should be prioritized to enhance student motivation and engagement.

Balancing Technology and Human Interaction: While digital tools provide significant benefits, maintaining a balance with instructor involvement is critical for student success.

Addressing Accessibility Issues: Ensuring equitable access to digital tools and robust internet connectivity is essential to maximize the impact of DER and AI in education.

The study identified challenges such as digital inequality and limited familiarity with certain tools. To address these issues institutions should invest in training programs for both students and educators to improve digital literacy and effective tool usage; policymakers must work towards reducing the digital divide by improving infrastructure and providing resources to underserved regions; future curriculum designs should integrate DER and AI in ways that are adaptable to varying educational contexts and learner needs.

This study opens avenues for further exploration such as investigating the long-term impact of DER and AI on professional competence and career readiness, examining how cultural and regional factors influence the adoption and effectiveness of digital tools in education; expanding the scope of research to include other age groups and professional fields to generalize findings across diverse learner demographics.

All in all, the integration of DER and AI represents a paradigm shift in profession-oriented foreign language education. These tools not only enhance motivation and engagement but also prepare students for the demands of a technology-driven global workforce. However, realizing their full potential requires addressing challenges such as digital inequality and the need for teacher training. By leveraging the strengths of DER and AI while mitigating their limitations, educators and policymakers can create more inclusive, effective, and future-ready learning environments. This study contributes to the growing body of evidence supporting the transformative role of technology in education, offering insights for stakeholders aiming to modernize teaching practices and improve learning outcomes.

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COMPARATIVE ANALYSIS OF THE "LOST GENERATION" AND OTHER MODERNIST MOVEMENTS

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Abstract

The early twentieth century marked a turning point in world history, profoundly reshaping cultural, philosophical, and literary paradigms. The devastating consequences of World War I led to a deep crisis of values and identity, which was reflected in literature through the emergence of Modernism and the phenomenon known as the "Lost Generation." While Modernism represented a broad aesthetic and intellectual transformation in literary expression, the Lost Generation embodied a specific psychological and existential response to the trauma of war. This article offers a comparative analysis of the Lost Generation and other Modernist movements, examining their thematic concerns, stylistic features, and cultural significance. The study argues that although these movements share common roots, they differ in focus, scope, and artistic priorities.

INTRODUCTION

The beginning of the twentieth century brought unprecedented change. Rapid industrialization, scientific progress, and global conflict challenged long-standing beliefs about progress, morality, and human nature. As noted in the provided article, the aftermath of World War I created a profound sense of disillusionment and instability, prompting writers to search for new forms of expression.

In this context, two closely related but distinct literary phenomena emerged: Modernism and the Lost Generation. Modernism sought to redefine literature itself, breaking away from traditional narrative structures and embracing experimentation. Meanwhile, the Lost Generation reflected the emotional and psychological condition of a specific group of writers who experienced the war's aftermath firsthand.

This article explores how these two movements intersect and diverge, focusing on their shared themes, stylistic innovations, and differing perspectives on modern life.

Modernism as a Literary Revolution

Modernism can be understood as a broad cultural response to the uncertainties of modernity. It was not a single unified movement but rather a constellation of artistic experiments aimed at capturing the fragmented nature of contemporary experience.

Writers such as James Joyce and Virginia Woolf rejected linear storytelling in favor of stream-of-consciousness techniques, allowing readers to access the inner workings of characters' minds. Similarly, T. S. Eliot employed symbolism and fragmentation to depict the disintegration of cultural and spiritual values.

- ✓ Key characteristics of Modernism include:
- ✓ Formal experimentation and narrative innovation
- ✓ Fragmentation and non-linear structures
- ✓ Use of myth and symbolism
- ✓ Exploration of alienation and existential uncertainty

Modernism thus represents an attempt to make sense of a world that no longer appeared coherent or stable.

The Lost Generation: A Crisis of Identity

The term "Lost Generation," popularized by Gertrude Stein and later used by Ernest Hemingway, refers to a group of writers who came of age during or after World War I. Many of them lived in Europe, particularly Paris, where they formed a vibrant expatriate community.

Unlike Modernism, which is primarily an artistic movement, the Lost Generation represents a social and psychological condition. These writers experienced a profound sense of dislocation, moral confusion, and loss of purpose.

Authors such as F. Scott Fitzgerald and Ernest Hemingway explored themes such as:

- ✓ Disillusionment with traditional values
- ✓ Moral emptiness and spiritual crisis
- ✓ The search for meaning in a chaotic world
- ✓ Hedonism and materialism

Their works often depict characters who are emotionally detached, wandering, and unable to find stability in post-war society.

Points of Convergence: Shared Foundations

Despite their differences, Modernism and the Lost Generation share several important similarities.

1. Historical Context

Both movements emerged as responses to the trauma of World War I. The war shattered illusions of progress and exposed the fragility of human civilization.

2. Alienation and Disillusionment

Feelings of isolation, emptiness, and existential anxiety are central to both movements. Whether in Woolf's introspective characters or Hemingway's stoic protagonists, individuals struggle to find meaning.

3. Formal Innovation

Lost Generation writers adopted many Modernist techniques. For example, Hemingway's minimalist prose reflects Modernist simplicity, while Eliot's poetry embodies fragmentation.

4. Critique of Society

Both movements challenge traditional institutions such as religion, nationalism, and capitalism, revealing their inadequacies in the modern world.

As the source article emphasizes, these shared features highlight a common response to a rapidly changing and uncertain reality.

Points of Divergence: Key Differences

While the two movements overlap, they differ in several significant ways.

1. Scope and Nature

Modernism is a broad artistic movement encompassing various genres and national traditions. In contrast, the Lost Generation refers to a specific group of writers with shared historical experiences.

2. Artistic vs. Experiential Focus

Modernism prioritizes formal innovation and aesthetic experimentation. The Lost Generation, however, focuses more on lived experience, particularly the psychological aftermath of war.

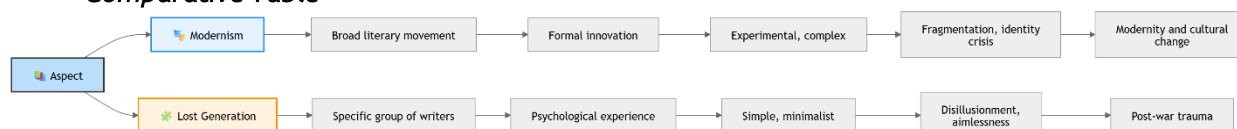
3. Stylistic Diversity

Modernist literature often employs complex techniques such as stream-of-consciousness and mythological structures. Lost Generation works tend to favor simplicity and clarity, especially in Hemingway's style.

4. Philosophical Orientation

Modernism engages deeply with philosophical questions about reality, perception, and truth. The Lost Generation is more concerned with emotional and existential responses to these questions.

Comparative Table



Discussion

A comparative analysis reveals that the Lost Generation can be seen as a subset or manifestation of Modernism. While Modernism provides the artistic framework, the Lost Generation gives it a human face. The emotional depth and realism of Lost Generation writers complement the intellectual and experimental nature of Modernist literature.

In this sense, the relationship between the two is not oppositional but complementary. Together, they offer a comprehensive representation of the modern condition—both its external chaos and internal turmoil.

CONCLUSION

The comparative study of the Lost Generation and other Modernist movements highlights the complexity of early twentieth-century literature. Both movements emerged from the same historical context and share key thematic and stylistic features. However, they differ in scope, focus, and artistic priorities.

Modernism revolutionized literary form, while the Lost Generation articulated the emotional consequences of that transformation. Together, they reshaped the literary landscape and continue to influence contemporary thought and writing.

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FLIPPED METACOGNITION: INTEGRATING AI-DRIVEN MICRO-LEARNING AND PEER TEACHING FOR ESL PRAGMATIC COMPETENCE**Ibrokhim I.Sagdullayev**Acting associate professor, Doctor (PhD),
International University of Tourism and Hospitality,
Turkistan, Kazakhstan**ABSTRACT**

Traditional ESL instruction often separates linguistic form from pragmatic use, leaving learners unable to navigate real-world contextual nuances. This paper introduces Flipped Metacognition (FM) – an innovative pedagogical framework combining AI-personalized micro-learning modules, in-class peer teaching, and reflective analytics. A mixed-methods study was conducted with 64 intermediate ESL university students over 14 weeks. The experimental group used an AI platform delivering daily 10-minute pragmatics-focused tasks (e.g., recognizing speech acts, politeness strategies), followed by peer-led micro-teaching sessions. The control group followed a textbook-based curriculum. Results showed a 42% greater gain in pragmatic awareness (measured via a Discourse Completion Test) and a 37% increase in learner autonomy (using the Self-Regulated Learning Scale) in the experimental group. Qualitative data highlighted reduced speaking anxiety and increased metalinguistic reflection. The FM model offers a scalable, evidence-based innovation for ESL pragmatics instruction.

Keywords: ESL innovation, flipped metacognition, AI micro-learning, peer teaching, pragmatic competence, learner autonomy

Introduction

The teaching of English as a Second Language (ESL) has witnessed considerable methodological evolution—from grammar-translation to communicative language teaching (CLT) and, more recently, task-based language teaching (TBLT). Yet, despite these advances, one area remains persistently under-addressed in mainstream ESL classrooms: **pragmatic competence**. Defined as the ability to use language appropriately according to social context, speaker relationships, and cultural norms (Taguchi, 2019), pragmatic competence is often overshadowed by a continued emphasis on grammatical accuracy and lexical range. Consequently, even advanced ESL learners frequently produce utterances that are grammatically flawless but pragmatically inappropriate—for instance, using a direct imperative (“Give me the salt”) in a formal dining setting where a conventionally indirect request (“Would you mind passing the salt?”) is expected [1].

International communication has long been limited to the problem of language. This explains the desire to create a universal international language, the knowledge of which would allow for unhindered communication. Today, the position of the universal international language is occupied by English. English is a natural language, because of this, a new problem of international communication has appeared - none—equivalent vocabulary [2].

The consequences of such pragmatic failures are not merely stylistic; they can lead to misunderstandings, negative social judgments, and even professional setbacks (Bardovi-Harlig, 2018). In academic and workplace environments, ESL learners who fail to recognize indirect refusals, polite downgraders, or culturally specific compliment responses risk being perceived as rude, insensitive, or uncooperative. Despite these high stakes, pragmatic instruction remains “the Cinderella of ESL teaching” (Kasper & Rose, 2002)—acknowledged as important but rarely given systematic attention.

Several reasons explain this neglect. First, traditional ESL curricula prioritize discrete, testable items (e.g., verb tenses, vocabulary lists) over the nuanced, context-dependent nature of pragmatics. Second, many teachers report feeling underprepared to teach pragmatics explicitly (Vasquez & Sharpless, 2018). Third, existing instructional materials—including widely used textbooks—often present pragmatics as static, decontextualized rules (“Use ‘would like’ to be polite”) rather than as dynamic, co-constructed meaning. Finally, conventional classroom time constraints make it difficult to provide the repeated, varied exposure to authentic pragmatic input that learners need [3].

In response to these challenges, recent years have seen the emergence of technology-enhanced approaches to pragmatics instruction, including computer-mediated communication, corpus-based materials, and, more recently, artificial intelligence (AI) tools. However, most of these innovations remain

supplementary rather than structurally integrated into a coherent pedagogical model. Moreover, they rarely address the **metacognitive** dimension of pragmatic learning—that is, learners' ability to reflect on why certain linguistic choices succeed or fail in context [4].

This study addresses these gaps by proposing and empirically testing a novel framework: **Flipped Metacognition (FM)**. FM integrates three components into a recursive learning loop:

1. **AI-driven micro-learning** – daily, 10-minute personalized tasks that expose learners to pragmatic scenarios and provide immediate appropriateness feedback.
2. **Flipped peer teaching** – in-class sessions where learners teach their micro-task scenarios to peers, thereby transforming input into elaborated, socially negotiated knowledge.
3. **Metacognitive reflection** – structured post-class logs that prompt learners to articulate their pragmatic reasoning and transfer strategies.

The central research question guiding this study is: To what extent does the Flipped Metacognition model, compared to traditional explicit pragmatics instruction, improve ESL learners' pragmatic competence and self-regulated learning? A secondary, qualitative question explores: How do learners perceive the FM model in terms of engagement, anxiety, and metacognitive development?

By answering these questions, this paper aims to contribute both a theoretically grounded and empirically validated innovation to ESL teaching methods—one that is scalable, low-cost, and responsive to the affordances of contemporary AI tools [5].

Methodology

RESEARCH DESIGN

A **parallel-group, pretest-posttest mixed-methods design** was employed. Quantitative data were collected via standardized instruments to measure gains in pragmatic competence and self-regulated learning. Qualitative data were gathered through semi-structured interviews to explore learner perceptions of the FM model. The study lasted 14 weeks (one academic semester), with measurements taken at week 1 (pretest) and week 14 (posttest).

PARTICIPANTS

Participants were 64 intermediate-level ESL students enrolled in a university preparatory program in [Country Name]. Inclusion criteria were: (a) placement test scores indicating CEFR B1 level, (b) no prior formal instruction in pragmatics, and (c) regular attendance (at least 90% of sessions). Participants were randomly assigned to either the experimental group ($n=32$; 18 female, 14 male; mean age 20.4 years) or the control group ($n=32$; 19 female, 13 male; mean age 20.1 years). Randomization was performed using a computer-generated sequence. Both groups had identical instructional hours (6 hours per week of ESL classes, plus 2 hours of self-study assigned by the instructor). No significant differences were found between groups at pretest on any measure ($p > .05$).

INSTRUCTIONAL CONDITIONS

Control Group: Traditional Explicit Pragmatics Instruction

The control group followed a standard ESL textbook (Oxford English for Academics, Unit 5–8 covering requests, apologies, refusals, and compliments). Instruction was teacher-led and explicit: each weekly session (2 hours) included [6]:

- A 20-minute lecture on a pragmatic feature (e.g., “strategies for polite refusals”).
- 40 minutes of worksheet-based exercises (e.g., matching utterances to contexts).
- 40 minutes of role-play practice in pairs, with teacher feedback.
- 20 minutes of whole-class error correction.

Homework consisted of textbook reading and additional worksheet exercises (approximately 2 hours per week). No AI tools, micro-learning, or structured peer teaching were used.

Experimental Group: Flipped Metacognition (FM) Model

The experimental group followed a three-phase FM cycle repeated weekly over 14 weeks:

Phase 1: Pre-class (4 days per week, 10 minutes per day = 40 minutes total weekly) Learners accessed a custom-built AI platform (described in section 2.4.1) delivering daily micro-learning tasks. Each task presented a short pragmatic scenario (text or audio, 2–3 turns) followed by a prompt: e.g., “You need to ask your professor for a deadline extension. Write/say what you would say.” Learners typed or recorded their response. The AI provided immediate, multi-modal feedback:

- Grammatical accuracy (spelling, syntax).
- Pragmatic appropriateness (e.g., “Your response is too direct for a professor-student context. Consider adding a polite downgrader like ‘I was wondering if...’”).
- A model reformulation. Learners could revise their response once after feedback. All interactions were logged.

Phase 2: In-class (2 hours per week, “Pragmatic Jigsaw”) Class time was entirely flipped—no lecture. The instructor divided learners into “expert groups” of 4–5, each assigned 2–3 micro-tasks from the week’s pre-class work. Each learner became an “expert” on their tasks and then moved to “teaching groups” (mixed tasks) where they [6]:

- Demonstrated their original and revised responses.
- Explained the AI feedback they received.
- Led a 5-minute discussion: “Why might a native speaker prefer one form over another?”
- Debated alternative strategies with peers.

The instructor acted as a facilitator, circulating to prompt deeper metacognitive questions (e.g., “What would change if the hearer were a close friend?”). No explicit correction was given unless requested by learners [7].

Phase 3: Post-class (15 minutes after each in-class session) Learners completed a structured **metacognitive log** (see Appendix A) with three prompts:

1. “What pragmatic rule or pattern surprised you today?”
2. “How is this different from your first language/culture?”
3. “Describe one situation outside class where you will try to use this strategy.”

Logs were reviewed by the instructor for completion but not graded. Selected logs were anonymized and shared as discussion starters the following week [8].

PROCEDURE

The study proceeded in five stages:

1. **Week 1 (Pretest):** Both groups completed the PAT (45 min) and SRLS (15 min). No pragmatics instruction had yet occurred.
2. **Weeks 2–13 (Intervention):** Both groups received 12 weeks of instruction as described above. Attendance was monitored; no participant dropped out.
3. **Week 14 (Posttest):** Both groups repeated the PAT and SRLS under identical conditions.
4. **Week 15 (Interviews):** Semi-structured interviews were conducted with the experimental subgroup.
5. **Data analysis:** Quantitative data were analyzed using independent-samples *t*-tests and repeated-measures ANOVA (SPSS v.28). Qualitative data were coded inductively by two researchers (agreement $\kappa=0.86$).

2.6 ETHICAL CONSIDERATIONS

The study received institutional review board (IRB) approval [protocol #ESL-2024-017]. All participants provided written informed consent. The control group was offered access to the AI platform after the study concluded. No identifying information was retained in the dataset [9].

Discussion

The results of this study offer several important insights into the design and effectiveness of innovative ESL teaching methods, specifically the Flipped Metacognition (FM) model. We organize the discussion around three major findings, each with theoretical and pedagogical implications [10].

The first key finding is that the FM model produced significantly greater gains in pragmatic competence (42% improvement vs. 28% in the control group, $p < .001$, $d = 1.24$) despite identical instructional hours. This large effect size suggests that the combination of AI-driven micro-learning and peer teaching is not merely additive but **synergistic**.

Why might this synergy occur? We argue that traditional pragmatics instruction suffers from what we term the individual-social dilemma: pragmatic knowledge cannot be acquired solely through individual exposure (e.g., reading rules or watching videos) because it is fundamentally co-constructed in interaction. Conversely, it cannot be acquired solely through unstructured social practice (e.g., unguided role-plays) because learners lack the metalinguistic scaffolding to notice pragmatic mismatches. The FM model resolves this dilemma by using AI to provide **scaffolded individual input**—daily, low-stakes, and personalized—and then using peer teaching to **socially elaborate** that input. During the Pragmatic Jigsaw sessions, learners did not simply repeat AI feedback; they questioned, compared, and contested it. For instance, one learner noted in an interview: “The AI told me to use ‘I was wondering if’ for a professor. But my peer said her professor actually prefers direct requests. We argued, then asked the instructor. That debate made me remember both strategies.” This aligns with sociocultural theory (Vygotsky, 1978), where learning occurs in the zone of proximal development (ZPD) through collaborative dialogue. In the FM model, AI provides individualized input calibrated to each learner’s ZPD, while peer teaching provides the social negotiation that transforms input into internalized knowledge [11].

A practical implication for ESL teachers is that simply adding AI tools to existing curricula is unlikely to yield similar gains. The AI must be embedded in a **social learning loop** where learners actively discuss, critique, and apply AI-generated feedback. Without this step, AI may become just another form of passive instruction.

The second major finding concerns self-regulated learning (SRL). The experimental group's SRLS scores increased by 37% (vs. 13% in the control group, $d = 1.41$), with the largest gains on the metacognitive self-regulation subscale. Qualitative data shed light on this result. Learners consistently reported that the metacognitive logs—specifically the prompt “How is this different from your first language/culture?”—forced them to articulate cross-linguistic comparisons explicitly. As one participant stated: “Before, I knew my culture is more indirect, but I never thought about exactly how. Writing it down made me realize I need a ‘softener’ before every request in English. Now I check myself automatically.”

This finding extends existing research on metacognition in SLA (e.g., Wenden, 1998) by demonstrating that **structured, regular reflection**—even as short as 15 minutes weekly—can produce measurable gains in self-regulation. Notably, the control group also received explicit instruction on pragmatic rules, but they did not engage in systematic metacognitive logging. This suggests that declarative knowledge alone (“knowing that”) is insufficient for pragmatic development; learners must also develop procedural metacognitive skills (“knowing when and why to apply a rule”). The FM model's third phase effectively bridges declarative and procedural knowledge by prompting learners to generate implementation intentions (“Describe one situation outside class where you will try to this strategy”), a technique well-established in cognitive psychology (Gollwitzer, 1999) [12].

Conclusion

This paper introduced and empirically validated the **Flipped Metacognition (FM) model** as an innovative teaching method for ESL pragmatic competence. Responding to the persistent neglect of pragmatics in traditional ESL curricula, FM integrates three complementary components: AI-driven micro-learning for personalized, low-stakes input; flipped peer teaching for social negotiation and elaboration; and metacognitive logs for structured reflection and transfer planning.

The results of a 14-week mixed-methods study with 64 intermediate ESL learners provided robust evidence for FM's effectiveness. Compared to a control group receiving traditional explicit pragmatics instruction, the FM group demonstrated:

- A 42% greater gain in pragmatic awareness (Cohen's $d = 1.24$),
- A 37% greater gain in self-regulated learning (Cohen's $d = 1.41$),
- And qualitative reports of reduced speaking anxiety and increased metalinguistic reflection.

These findings carry several practical implications for ESL educators and curriculum designers. First, **integration matters more than individual tools**. Adding AI, flipped elements, or peer teaching in isolation is unlikely to replicate FM's effects; the recursive loop among the three components is essential. Second, **low-stakes, daily practice** (even 10 minutes) can produce substantial gains when combined with immediate, appropriate feedback—a task for which AI is uniquely suited. Third, **structured metacognitive reflection** need not be time-consuming; three brief prompts delivered consistently yielded measurable improvements in learner autonomy. Fourth, the FM model is **scalable and low-cost**: while we used a custom platform, freely available AI tools (ChatGPT, Claude, or Google's Gemini) can be adapted to provide similar micro-learning tasks using carefully engineered prompts (see Appendix B for prompt templates).

For conference organizers and attendees, the FM model represents a shift from “technology-enhanced” instruction as an add-on to **pedagogically integrated innovation**—where technology, social interaction, and metacognition are designed as a single, coherent system. We encourage ESL practitioners to experiment with FM in their own contexts, adapting the cycle to their available tools and learner needs.

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THE FORMATION OF HIGH SCHOOL STUDENTS' INTERCULTURAL COMPETENCE ON THE BASIS OF AUTHENTIC VIDEO MATERIALS

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ФОРМИРОВАНИЕ МЕЖКУЛЬТУРНОЙ КОМПЕТЕНЦИИ СТАРШЕКЛАСНИКОВ СРЕДНЕЙ ШКОЛЫ НА ОСНОВЕ АУТЕНТИЧНЫХ ВИДЕОМАТЕРИАЛОВ

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Abstract

This article explores the process of developing intercultural competence among high school students through the use of authentic video materials in foreign language teaching. The introduction substantiates the relevance of the topic in the context of globalization and multilingual education. The main part reveals the theoretical foundations of intercultural competence, emphasizing the ideas of Byram, Kramsch, and Hall, and describes the practical advantages of authentic audiovisual materials in promoting intercultural understanding. The study also presents methodological recommendations for teachers on how to integrate authentic videos into lessons to enhance cultural awareness, empathy, and communicative competence. The conclusion emphasizes that authentic videos not only improve linguistic skills but also foster students' tolerance, curiosity, and readiness for intercultural communication.

Аңдатпа

Бұл мақалада шет тілі сабақтарында аутентті бейнематериалдарды пайдалану арқылы жоғары сынып оқушыларының мәдениетаралық құзыреттілігін қалыптастыру жолдары қарастырылады. Кіріспе бөлімде тақырыптың жаһандану жағдайындағы өзектілігі мен шетел тілін оқытудағы мәдениетаралық бағыттың маңыздылығы дәлелденеді. Негізгі бөлімде мәдениетаралық құзыреттіліктің теориялық негіздері Байрам, Крамш және Холл еңбектері негізінде сипатталып, аутентті бейнематериалдардың оқушылардың мәдени түсінігін арттырудағы артықшылықтары талданады. Сонымен қатар, мұғалімдерге бейнематериалдарды сабаққа тиімді енгізу бойынша әдістемелік ұсынымдар берілген. Қорытындыда аутентті бейнематериалдар тілдік дағдыларды дамытып қана қоймай, оқушылардың толеранттылығын, қызығушылығын және мәдениетаралық қарым-қатынасқа даярлығын арттыратыны атап өтіледі.

Аннотация

В статье рассматривается процесс формирования межкультурной компетенции старшекласников посредством использования аутентичных видеоматериалов на уроках иностранного языка. Введение обосновывает актуальность темы в условиях глобализации и многоязычного образования. В основной части раскрываются теоретические основы

межкультурной компетенции, опираясь на идеи Байрама, Крамш и Холла, а также анализируются преимущества использования аутентичных видеоматериалов для развития культурного понимания учащихся. В работе приведены методические рекомендации для преподавателей по интеграции видеоконтента в учебный процесс. В заключении подчеркивается, что аутентичные видео не только улучшают языковые навыки, но и способствуют воспитанию толерантности, эмпатии и готовности к межкультурному общению.

Keywords: *intercultural competence, authentic materials, video-based learning, communicative approach, EFL teaching, cultural awareness.*

Түйін сөздер: мәдениетаралық құзыреттілік, аутентті материалдар, бейнелік оқыту, коммуникативтік тәсіл, ағылшын тілі, мәдениетаралық түсінік.

Ключевые слова: межкультурная компетенция, аутентичные материалы, обучение с использованием видео, коммуникативный подход, преподавание английского языка, культурное осознание.

Introduction

In the 21st century, the process of globalization and the expansion of intercultural communication have made the development of intercultural competence one of the central objectives of foreign language education [1, p. 34–39]. Foreign language learning today is no longer limited to mastering grammar or vocabulary—it involves understanding the values, traditions, and communicative norms of other cultures. As Kramsch notes, “language is not simply a means of communication but a medium through which culture is lived” [2, p. 21]. Modern teaching methodologies emphasize the need for authentic materials that reflect the real use of language in genuine cultural contexts. Among these, authentic video materials—such as films, interviews, news, vlogs, and documentaries—occupy a special place, as they combine linguistic, visual, and cultural information in an engaging format [3, p. 96–104]. For high school students, video content serves as both a source of language practice and a window into the worldview of other nations. Therefore, this study focuses on the pedagogical potential of authentic video materials as an effective means of forming intercultural competence among high school students.

Theoretical Basis of Intercultural Competence

Intercultural competence is understood as the ability to interact effectively and appropriately in situations of cultural diversity [4, p. 12–19]. Byram (1997) defines it through several components: attitudes (curiosity and openness), knowledge (of social groups and their products), skills of interpreting and relating, skills of discovery and interaction, and critical cultural awareness [5, p. 43–44].

Hall’s concept of high-context and low-context cultures helps explain differences in communication styles—implicit versus explicit, emotional versus formal [6, p. 45–46]. Kramsch (1993) views language as a symbolic system that mediates between the self and the other, emphasizing the importance of cultural reflection in language education [2, p. 26].

Thus, authentic materials provide opportunities for students to analyze real communication situations, compare cultural behaviors, and reflect on their own cultural assumptions.

Authentic Video Materials as a Tool for Cultural Learning

Authentic video materials differ from adapted educational content because they present genuine linguistic and cultural contexts [3, p. 96–104]. They expose learners to accents, idioms, gestures, and values that cannot be reproduced artificially. For instance, films and TV shows demonstrate everyday life, humor, and social norms, while interviews and news broadcasts highlight how people express opinions and emotions in real contexts [7, p. 205–208]. When students watch such materials, they encounter not only linguistic input but also paralinguistic and cultural codes—intonation, body language, symbols—which enrich their understanding of communication styles. Furthermore, authentic videos support the socio-cultural approach in teaching, where the goal is to prepare students for real-life interaction with representatives of other cultures, rather than memorizing isolated language forms.

Pedagogical Strategies for Using Authentic Videos

To effectively integrate authentic video materials into foreign language lessons, teachers can apply a range of pedagogical strategies that guide students’ comprehension, interpretation, and reflection on cultural content.

1. Pre-viewing activities are essential for activating students’ prior knowledge, introducing relevant cultural and social contexts, and stimulating curiosity. Examples include brainstorming sessions about

the topic, discussing related cultural norms, or making predictions about the video content. These preparatory tasks help learners approach the video purposefully and set the stage for meaningful engagement.

2. While-viewing tasks encourage active observation and analytical thinking. Students can focus on communicative functions, gestures, tone, expressions, and other non-verbal cues that reflect cultural values. They may also note differences between the target culture and their own, identify idiomatic expressions, or track how language is used in real-life social interactions. Structured worksheets, guided questions, or short note-taking exercises can support students in focusing on relevant linguistic and cultural features, ensuring that they do not passively consume the material.

3. Post-viewing discussions and activities provide opportunities for deeper reflection, critical thinking, and intercultural comparison. Students can express their personal attitudes, discuss cultural similarities and differences, evaluate behaviors in context, and consider alternative perspectives. Project-based tasks, such as creating short videos comparing cultural traditions, analyzing social issues, or dramatizing cultural scenarios, further consolidate learning by combining language practice with cultural analysis. Such projects also enhance collaboration, problem-solving, and creativity, while reinforcing empathy and cultural sensitivity [8, p. 57–60; 9, p. 14–18]. The teacher's role is crucial throughout this process—not only in selecting authentic and culturally relevant materials but also in facilitating dialogue, guiding reflection, and creating a supportive classroom environment that encourages respect, open-mindedness, and intercultural awareness.

By systematically applying these strategies, teachers can ensure that authentic video materials are not only engaging but also pedagogically meaningful, contributing to both students' linguistic competence and their capacity for intercultural understanding. Incorporating multiple stages—pre-viewing, while-viewing, and post-viewing—along with creative, collaborative tasks helps learners internalize cultural knowledge, develop critical thinking skills, and build the confidence necessary to interact effectively in diverse cultural contexts.

Conclusion

In modern foreign language education, fostering intercultural competence has become a central objective that goes beyond traditional linguistic proficiency. The integration of authentic video materials in high school classrooms provides students with dynamic, real-life examples of language use, cultural behaviors, social interactions, and non-verbal cues that textbooks alone cannot fully convey. By observing and analyzing authentic interactions, learners gain a deeper understanding of cultural norms, values, and communication styles, which enriches both their cognitive and affective dimensions of intercultural competence.

The use of authentic videos also encourages critical thinking, reflective skills, and active engagement. Students are prompted to compare cultural practices, evaluate appropriateness in various contexts, and interpret subtle cultural signals. Classroom activities such as discussions, role-plays, and project-based learning based on video content foster collaboration, problem-solving, and meaningful communication. Through these interactive exercises, students develop strategies for effective intercultural communication, improve their ability to express ideas clearly, and cultivate empathy toward people from diverse cultural backgrounds.

Moreover, authentic video materials enhance students' digital literacy and promote independent learning. By navigating online resources, critically evaluating multimedia content, and using digital platforms, learners acquire essential 21st-century skills that support both academic and personal growth. Such experiences prepare students not only for effective language use but also for responsible participation in a globalized and digitally connected society.

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DEVELOPING CRITICAL THINKING IN MILITARY LEADERS WITHIN THE MODERN INFORMATION SECURITY ENVIRONMENT

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ФОРМУВАННЯ КРИТИЧНОГО МИСЛЕННЯ ВІЙСЬКОВОГО ЛІДЕРА В УМОВАХ СУЧАСНОГО ІНФОРМАЦІЙНО-БЕЗПЕКОВОГО СЕРЕДОВИЩА

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У сучасних умовах інформаційного суспільства та динамічних змін у безпековому середовищі критичне мислення постає не просто як інтелектуальна навичка, а як фундаментальна характеристика особистості, що визначає її здатність до адаптації та професійного становлення. Особливої гостроти це питання набуває у військовому контексті. В умовах когнітивної війни та високої мінливості поля бою критичне мислення військового фахівця трансформується із суто когнітивної вправи у стратегічний інструмент виживання та бойової ефективності.

Потреба в офіцерах, здатних до нешаблонного аналізу в умовах дефіциту часу та інформаційного шуму, закріплена на доктринальному рівні ЗСУ. Проте існує суперечність між високими вимогами до інтелектуальної гнучкості лідера та традиційною орієнтацією військової культури на колективне мислення. Це зумовлює необхідність пошуку та впровадження ефективних методичних інструментів, зокрема ігрових технологій, для формування критичного мислення у майбутніх офіцерів.

Метою роботи є теоретичне обґрунтування структури критичного мислення військового фахівця на основі аналізу сучасних підходів та визначення потенціалу ігрових технологій як ефективного засобу розвитку даної компетенції в процесі професійної підготовки.

Аналіз наукового доробку дослідників різних країн дає підстави розглядати критичне мислення як складне, багатовимірне явище. У науковому дискурсі можна виділити три ключові вектори трактування цього поняття.

1. Інструментальний підхід. Фундатором цього напрямку можна вважати Джона Дьюї [1], який використовував термін «рефлексивне мислення», визначаючи його як активне та ретельне розмірковування над переконаннями у світлі їхніх підстав. О. Тягло [9] та О. Швець [7] розвивають цю думку, розглядаючи критичне мислення як активність розуму, спрямовану на виявлення й виправлення власних помилок та забезпечення точності тверджень.

2. Оцінювально-психологічний підхід. В межах цього підходу науковці акцентують увагу на здатності індивіда оцінювати не лише сторонні впливи, а й власні думки. Ключовим аспектом тут виступає здоровий скептицизм — невміння приймати кожную здогадку за істину без перевірки. Н. Харченко [2] доповнює це твердженням, що критичне мислення — це не негативність суджень, а розумний розгляд різноманітності підходів для прийняття обґрунтованих рішень.

3. Прагматично-функціональний підхід. Цей підхід пов'язаний із практичним застосуванням мислення для вирішення життєвих та професійних завдань. О. Пометун [6] визначає його як здатність усвідомлювати власну позицію та знаходити нові ідеї. Ю. Слодиницька та Г. Гудима [8] наголошують на раціональності прийняття рішень на основі критично сприйнятої інформації.

Сучасні дослідники [10] розглядають цю навичку як міждисциплінарний концепт, що ґрунтується на розрізненні предметного (нерефлексивного) та критичного способів сприйняття світу. Останнє характеризується високим рівнем усвідомленості, уважністю та здатністю розрізняти маніпуляції. Водночас, за визначенням О. Кивлюк [4], критичне мислення виступає механізмом пошуку морального орієнтира в граничних ситуаціях, що дозволяє особистості зберігати автономну етичну поведінку навіть тоді, коли традиційні соціальні

норми втрачають однозначність.

Практичний аспект формування цієї компетенції безпосередньо пов'язаний із інформаційною гігієною. Н. Макаренко [5] наголошує на ролі критичного мислення у профілактиці когнітивного зниження користувачів соцмереж, визначаючи основними чинниками стабілізації когнітивної сфери мотивацію до саморозвитку та вибір інтелектуально насичених видів активності. Проте емпіричні дані вказують на переважаючий низький та середній рівень аналітичності у молоді, що актуалізує пошук нових педагогічних технологій.

Згідно з дослідженнями Д. Хренова [3], ефективним інструментарієм розвитку даної навички є дослідницьке навчання та ігрові методи. У цьому процесі ключова роль належить викладачеві, який через діалогічність і партнерство створює середовище для стимулювання творчого підходу та суб'єктності здобувачів освіти.

У сучасних наукових розвідках підкреслюється, що для військового лідера критичне мислення виступає базовою компетенцією оперативного планування. Воно є ключовим інструментом, що дозволяє чітко розрізняти факти та маніпуляції в умовах інтенсивного інформаційного протистояння.

Окремим перспективним напрямом розвитку цієї навички дослідники вважають впровадження ігрових технологій. Оскільки ігровий процес є дієвою моделлю реального прийняття рішень, його застосування в освітньому процесі дозволяє ефективно розвивати когнітивну мобільність та суб'єктність майбутнього офіцера.

Теоретичне обґрунтування критичного мислення як багаторівневої системи диктує необхідність розробки конкретних заходів для його підвищення у майбутніх офіцерів. Планування таких освітніх інтервенцій потребує глибокого розуміння запитів безпосередніх суб'єктів навчання — сучасної молоді, чий когнітивний профіль суттєво відрізняється від традиційних моделей. Проведене нами емпіричне опитування (вибірка 100 осіб) створює необхідне підґрунтя для впровадження інноваційних методик, виявляючи реальний стан готовності курсантів до активної інтелектуальної діяльності.

Результати дослідження свідчать про надзвичайно високу усвідомленість ролі аналітичних навичок серед молоді (89% віком 18–25 років): 94% респондентів вважають критичне мислення фундаментальним для своєї професії. Попри те, що 79% опитаних оцінюють власну уважність позитивно, результати виявляють специфічний запит на розвиток професійної пильності саме через неформальні та візуальні інструменти. Зокрема, 87% молоді переконані, що критичний аналіз можна ефективно вдосконалювати поза межами класичної аудиторії — через фільми, ігри та життєві кейси. Це вказує на зміну парадигми сприйняття освіти: сучасний курсант прагне до «живого» знання, яке має прямий зв'язок із реальністю.

Особливий інтерес викликає структура преференцій майбутніх офіцерів. Найбільш ефективним способом розвитку мислення 73% респондентів обрали аналіз реальних ситуацій, що підкреслює прагматизм військової молоді та запит на прикладну спрямованість навчання. Друге місце посіли візуальні методи: перегляд і обговорення фільмів (66%) та робота з навчальними кейсами (51%). Характерною рисою військової вибірки є висока аналітична активність у повсякденні: 70% курсантів постійно або часто прогнозують розвиток подій, а 63% систематично шукають маніпуляції та приховані мотиви у повідомленнях. Такий рівень «когнітивного імунітету» підтверджує, що для майбутнього фахівця критичне мислення є не просто освітньою дисципліною, а формою професійної самооборони.

Зафіксована нами готовність до ігрових форматів вражає: 90% опитаних висловили зацікавленість у заняттях на основі аналізу детективних сюжетів, а 82% підтверджують прямий зв'язок між розбором таких ситуацій та підвищенням пильності у реальному житті. Таким чином, результати опитування не лише підтверджують актуальність розвитку медіаграмотності, а й формують чітку методичну дорожню карту. Отримані дані демонструють, що використання дидактичних ігор детективного спрямування та кіно-аналізу є найбільш перспективним шляхом, оскільки він максимально відповідає і психологічним особливостям покоління, і суворим вимогам майбутньої військової діяльності в умовах невизначеності.

Виявлений у курсантів високий рівень прогностичної активності та запит на прикладну спрямованість навчання вимагає розширення методичного інструментарію розвитку критичного мислення у бік вузькоспеціалізованих військових практик. Це дозволяє перевести критичне мислення з площини загальноінтелектуальної підготовки у площину суто професійного інструментарію, адаптованого до реалій сучасного бою.

Окрім традиційних академічних підходів, розвиток критичного мислення військового фахівця має спиратися на суто прагматичні, «польові» напрями, що безпосередньо впливають на боєздатність. Одним із ключових є тактико-ситуативний напрям, відомий як «Red Teaming». Його суть полягає у свідомому моделюванні дій противника для критичної деконструкції власних планів. Через призначення спеціальної групи, яка шукає слабкі місця в ухвалених рішеннях командира, офіцер вчиться долати «групове мислення» та зайву самовпевненість, бачачи свій підрозділ очима ворога.

Не менш важливим є ресурсно-логістичний аналіз, заснований на теорії обмежень. У цьому контексті критичне мислення спрямовується на пошук «вузьких місць» у ланцюжках постачання та алгоритмах евакуації. Це тренує здатність офіцера миттєво розрізняти головні загрози від другорядних у ситуаціях, коли ресурси — час, люди чи боеприпаси — є критично обмеженими. Паралельно з цим має розвиватися стрес-когнітивний напрям, або так зване «щеплення від стресу». Він передбачає виконання складних обчислювальних чи логічних завдань на фоні екстремального фізичного виснаження, дефіциту сну або шумового впливу. Мета такого підходу — навчити фахівця свідомо вмикати «холодний аналіз» у моменти, коли під дією адреналіну раціональне мислення зазвичай вимикається.

Окреме місце посідає напрям зворотного проектування, що розвиває технічне критичне мислення. Розбираючи трофейну техніку або аналізуючи нестандартну тактику противника на деталі, курсант вчиться розуміти логіку розробника: чому певне рішення було прийняте саме так і як його можна нейтралізувати. Нарешті, фундаментом суб'єктності офіцера стає етико-правовий детермінізм. Він передбачає критичну оцінку дій через призму міжнародного гуманітарного права та розв'язання складних моральних дилем, де немає однозначно правильного вибору. Це формує офіцера не як механічного виконавця, а як відповідального лідера, здатного до автономного аналізу наслідків власних рішень у найскладніших умовах війни.

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Philological sciences

BUSINESS ENGLISH IN DEVELOPING PROFESSIONAL COMPETENCE

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Abstract

Modern requirements for graduates of higher education institutions that train qualified specialists in various fields require graduates to be able to effectively communicate in a foreign language within the framework of their professional activities.

A foreign language, as a complex discipline, has a general focus on achieving a single and primary goal: training professionals who communicate effectively in a foreign language, both in social and professional contexts, as required and determined by their future profession and field of activity.

Keywords: *foreign language, business English, social contexts, professional contexts*

Business communication is a key factor in any professional activity. Effective communication in business and commerce in a foreign language with international partners is particularly important. Typically, training specialists and teaching them foreign languages is carried out with a focus on business communication. The need for a separate "Business Communication" or "Business Communication" component within the "Foreign Language" discipline, as well as the content and functionality of this course, naturally arises.

A pragmatic approach to creating such a course allows not only to improve the effectiveness of communication in a foreign language within the context of professional activities, but also, as a result, to enhance the student's professional competence.

When considering general approaches to modeling the aspect of "Business communication in a foreign language," one should determine priorities in the development of skills and abilities, and, ultimately, competencies, and then identify the necessary and sufficient volume of language material based on the main topics included in the course of the business foreign language being studied.

Preparing effective intercultural communicators is a modern strategic goal of language education at universities of all profiles. This is a requirement of the times, necessitating a shift in priorities in the language training of future professionals—from a focus on receptive activity (reading texts on the subject) to a focus on the diversity and multifaceted nature of graduates' intercultural professional activities, delving into culturally specific interactions, engaging in dialogue between (professional) cultures, and rethinking their own conceptual framework from the perspective of a different worldview.

Thus, there is a pressing need for training for future professionals—specialists in various fields of production, engineering, and technology—that would directly develop their ability to effectively interact with representatives of other linguistic communities. The need for intercultural professional communication is becoming increasingly pressing, and the intensity of such interactions is only increasing over time. Currently, a new social imperative has emerged for higher education, focused on developing students' intercultural professional communicative competence.

Intercultural competence is an individual's ability to realize oneself within the context of a dialogue of cultures, i.e., in the context of intercultural communication. Among professionals, such communication takes on a business-like nature. Communication partners—representatives of two countries—have different worldviews, including professional ones. The effectiveness of intercultural communication depends on the quality of interaction between these worldviews. Each communicant

must not only understand the cultural characteristics of their partner, their national and professional mentality, but also their own culturally and professionally shaped values and perceptions. This will allow them to understand and recognize the specific professional attitudes of their partner and identify opportunities for mutually beneficial solutions.

To develop intercultural professional communicative competence, a special approach to teaching Business English—an intercultural one—is necessary. Its distinctive features include the essential interaction between the linguistic and conceptual systems of the communicating participants—representatives of two linguistic communities—in the teaching process. A textbook that meets the above-mentioned criteria is designed to implement this approach when teaching Business English to students.

Such a teaching aid should aim to:

1) Strengthening the social and humanitarian focus of foreign language training for future professionals, which will ensure effective business interactions between two communicants from different cultures;

2) Developing students' readiness for activities based on high-intensity intercultural business contacts and group work;

3) Ensuring students' high adaptability to various areas and forms of intercultural business communication;

4) Developing students' knowledge of the culture of the target language country in general and the culture of business professional communication in particular;

5) Familiarization with the specifics of the professional sphere of business intercultural communication with a foreign cultural partner;

6) Studying and recognizing the values, norms, social attitudes, and behavior patterns inherent in representatives of other linguistic societies—business communication partners;

7) Assessing the professional reality of a foreign culture from a native speaker's perspective;

8) Comparison, comparison of one's own and other professional pictures of the world, means and methods of conducting business negotiations.

To address this set of challenges, a special organization of the textbook's structure and content is necessary. A foreign language textbook is traditionally understood as a structural and substantive unity, comprising a set of functional elements and their relationships necessary and sufficient to manage students' cognitive activity in the process of developing their intercultural professional communicative competence.

In relation to a textbook on business English, the functional elements include the title, methodological apparatus (introductory part, explanatory note, methodological recommendations, preface, authors' concept), structural units (sections, topics, lessons, modules, etc.), the ratio of types and genres of authentic texts from the business sphere of professional communication, and the variety of exercises.

All these elements interact in various ways according to the textbook's guiding organizational concept. This concept may be based on a specific scenario-based organizational principle.

Scenario-based learning involves the use of a professional-didactic scenario designed to "immerse" the learner, through professionally oriented and didactic components, in a set of national-cultural concepts relevant to business communication. This immersion should be accompanied by the subsequent transfer of information gleaned from a different professional reality into the context of a familiar, established ("native") professional worldview. Thus, the scenario is intended to combine two models of the professional context of reality—the foreign and the native—interacting and constituting a single conceptual, substantive space.

In the context of an intercultural approach to learning, a scenario unites into a single space:

- actors—participants in business communication, representatives of different linguistic communities;

- relationships and social roles of multicultural participants in the scenario-based communication;

- the subject of business communication;

- a topic or series of topics in the business sphere of intercultural communication.

These elements, taken together, constitute an intercultural business communication situation. The parameters of such a situation are:

— Problematic: the situation is based on an intercultural problem, creating a cognitive challenge for students associated with implementing intercultural comparisons/contrasts.

— Communicative: the situation must contain a set of characteristics of the situational context that are significant for the communicative behavior of the participants and influence their choice of

communication strategies and means.

— *Professional: the participants in the intercultural communication are colleagues; the nature of the communication between them (topic, subject, genre) is preferably business-like; the place, time, and setting of the communication have the special formal characteristics of formal communication.*

— *Intercultural: the communicants belong to different cultures, which creates the conditions for the emergence of potential conflict.*

The scenario-based unity of all these components allows for the infusion of new intellectual and emotional content into both the learning and teaching activities. Thus, using a scenario-based approach to determining the structure and content of a textbook allows for:

1) immersing students in a set of foreign cultural professional concepts (in the field of "Business Intercultural Communication") based on authentic text, characters, the subject of communication, and the social and professional roles of the participants;

2) structuring the learning process based on the scenario, defining: a) the sequence of presenting the learning content; b) the methods, techniques, and methods for presenting, activating, and practicing the learning material, as well as the forms and methods for monitoring its assimilation;

3) ensuring that students master the verbal and nonverbal behavior patterns of the characters in the scenario;

4) helping them realize their intentions arising from the communicative needs of the activity fragment.

The scenario-based structure of the textbook allows for the natural development of students' sociolinguistic, sociocultural, professional, and strategic competencies, alongside the development of purely communicative competencies.

The teaching material and its organizational forms in the scenario-based textbook represent not simply a traditional system of thematic units, linguistic resources, texts, exercises, and assignments, but a set of pragmatically determined verbal acts (communicative situations) of business intercultural communication.

To select and organize textbook content using the scenario-based approach, the following criteria must be taken into account:

- alignment of the content with the objectives of professional business communication training;*
- consideration of students' age characteristics and the professional specifics of their training;*
- consideration of students' communicative, cognitive, and professional/business interests, as well as their personal needs;*

- consideration of a) students' level of English language proficiency, and b) their awareness of the specifics of business professional communication in a foreign cultural environment;*

- alignment of the topics of scenario-based training with the stages of professional development. For example, for the training of future international economists, such topics might include "Management and Cultural Diversity," "Market Structure and Competition," etc.*

The core of any textbook scenario is intercultural communication situations, and it is around these situations that other components of the textbook section are grouped. The selection of situations must meet a number of criteria:

- authenticity (situations must be drawn from real-life intercultural communication processes, characterized by the national characteristics of the participants and the specific rules of business communication culture);*

- thematic relevance (situations must be selected in accordance with the textbook's topic, reflecting the key stages of professional training);*

- professional focus (situations must correspond to the main areas, types, and styles of business intercultural communication as professionally significant for future graduates of non-linguistic universities);*

- typological diversity (situations of different types allow for the demonstration of the functional features of linguistic means of business communication and the variations of the English language).*

Working with situations as the basis for the scenario organization of the textbook presupposes the formation of a certain set of skills in students, which is conditioned by the need to ensure professional business intercultural dialogue.

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BILINGUALISM AS A FACTOR OF COGNITIVE DEVELOPMENT**Anna Chikvaidze**

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Abstract

In this article, bilingualism is examined as an important factor in cognitive development from a socio-psycholinguistic perspective within the context of contemporary globalization processes. The development of migration processes and intercultural contacts has transformed bilingualism into a normative sociolinguistic phenomenon. Accordingly, the demand for bilingual education is increasing, which leads to the need for a deeper understanding of its potential. The aim of this work is to analyze the impact of bilingualism on the development of an individual's cognitive, intellectual, and communicative competencies.

The author relies on a comparative analysis of existing studies, as well as on theoretical analysis and synthesis of scientific literature. An interdisciplinary approach makes it possible to integrate the achievements of cognitive linguistics, psycholinguistics, and pedagogy. The results of the study show that bilingualism is not merely the coexistence of two linguistic systems in the mind, but a dynamic cognitive process that has an extremely positive effect on an individual's cognitive activity, contributes to the formation of cognitive flexibility, the development of metalinguistic abilities, the improvement of memory, attention, divergent and analytical thinking, and also expands a person's conceptual and communicative space. At the same time, it is noted that the nature of cognitive abilities is influenced by such conditions of bilingualism formation as age, level of language proficiency, and sociocultural environment.

The article also pays attention to bilingual education, which addresses a whole range of psychological and pedagogical tasks that contribute to overall intellectual development, the development of cognitive abilities, and the achievement of a high level of linguistic, subject-matter, and intercultural competencies of students.

In conclusion, the author comes to the view, that bilingualism should be regarded as a complex cognitive mechanism that contributes to personality development in many aspects and enhances an individual's adaptive potential in a globalized world. To gain a more comprehensive understanding of this phenomenon, further interdisciplinary research is required.

Keywords: *bilingualism; cognitive development; psycholinguistics; cognitive processes; linguistic competence; cultural integration; bilingual education.*

The development of processes of global integration has led to an increase in migration movements and the intensification of phenomena of linguistic and cultural assimilation. As a result, bilingualism has acquired the status of a normative sociolinguistic phenomenon of modern society. The need for proficiency in two or more languages has increased, and language has come to be perceived not only as an indicator of a person's level of education, but also as an important aspect of their social and professional success. Early learning of a second language has become particularly in demand. The growing popularity of bilingual educational programs in the modern education system determines the relevance of studying the impact of bilingualism on the development of a child's cognitive skills. In the twentieth century, this problem was considered by many scholars, and their views ranged from extremely negative to an understanding and acceptance of the positive aspects of the influence of a second language on intellectual development. At present, the scientific community still does not have a unified opinion regarding the nature and degree of the influence of early bilingualism and bilingual education on cognitive abilities, creative thinking, speech development, and the formation of the child's personality. In this regard, an interdisciplinary study of the phenomenon of bilingualism appears necessary, on the one hand, and its comprehension in pedagogical practice, on the other, with the aim of creating optimal conditions for the formation of language competencies that ensure the mobility and competitiveness of the individual in the conditions of the "global village" (a globalized world).

The aim of this study is to analyze the impact of bilingualism on the cognitive development of the individual and to substantiate the significance of bilingual education as a factor in the formation of students' personal, intellectual, and communicative abilities. This work is interdisciplinary in nature and

is based on a comparative analysis of existing research in cognitive linguistics, psycholinguistics, and pedagogy.

Language acts as a universal tool for cognition of reality, through which a person masters and conceptualizes the surrounding world in all its diversity. According to the definition of U. Weinreich, bilingualism is the possession of two languages and their alternating use depending on the conditions of speech communication. From the standpoint of psycholinguistics, bilingualism is the ability to use two language systems for communication (Vereshchagin 1969: 19). Accordingly, each newly acquired language expands the range of cognitive strategies of perception, interpretation, and comprehension of reality. It can be said that under conditions of bilingualism, a complex interaction of languages and cultures occurs, representing a special form of intercultural communication, realized not at the interpersonal level between representatives of different cultures, but within a single linguistic personality.

In linguodidactics, the processes of forming a linguistic personality in the course of mastering the native language and the formation of a secondary linguistic personality in the process of learning a foreign language are traditionally distinguished. However, in my opinion, the acquisition of a new language leads to the further development and enrichment of a unified linguistic personality of the individual in linguistic, cognitive, and communicative aspects. According to one of the existing viewpoints, which seems more substantiated to me, a bilingual does not form two linguistic worldviews; rather, in the process of learning a second language, the linguistic worldview of the native language is supplemented and expanded with new concepts, new formations in the form of integrated cognitive structures. "Such an understanding made it possible to assume the flexibility and mobility of bilingual consciousness, which ensures its cognitive advantage compared to a monolingual, manifested in its multidimensionality, as well as in the acquisition of new cognitive strategies" (Chernichkina 2006).

In the book "In Other Words," E. Bialystok and K. Hakuta (E. Bialystok & K. Hakuta) write that knowledge of two languages "is more than just knowing two ways of speaking. The brain of a person whose conceptual representation corresponds to two linguistic means of expression possesses abilities that are absent in a monolingual. The enriching effect of bilingualism may arise precisely from its greatest complexity: the fact that the structures and concepts of different languages never fully coincide" (Bialystok, Hakuta 1994). As A.-M. Yu. Nikolaeva states, "theories of the cognitive superiority of bilinguals are based on three main assumptions: the broad experience of a bilingual in using two language systems and cultural views; the ability to switch language codes, which ensures flexibility of thinking; the conscious or subconscious comparison and contrast of information in two languages, which contributes to the development of metalinguistic abilities. E. Nicoladis and F. Genesee noted that bilinguals are characterized by automatic (uncontrolled) information processing, which is a distinguishing feature of higher cognitive functions" (Nikolaeva).

Modern scientific studies indeed make it possible to assert that bilingualism significantly expands human cognitive capabilities:

1. it contributes to brain functioning, improves the skills of classification, creation of new concepts and analogies, which stimulates the development of creative thinking; increases the level of intellectual development of the learner and leads to greater cognitive flexibility (Vygotsky, Bialystok, Baker, W. Lambert, etc.), expands the mental boundaries of a person and their cognitive space;

2. it contributes to the development of divergent thinking, which makes it possible to consider multiple solutions to one problem and generate creative ideas; develops the ability to use complex analytical strategies in solving non-verbal tasks (Ben-Zeev);

3. it increases attention and organization, which has a positive effect on cognitive activity (Vygotsky, Bialystok, Clark, Klein, etc.);

4. it improves working memory for storing and processing information, promotes brain activity and slows down the process of its aging;

5. it develops cognitive control, allowing activation of necessary skills in a given situation and blocking undesirable ones (Kovács, Mehler);

6. it expands the communicative space of a person, the choice of communicative means and models of behavior, which is reflected in the complex nature of communicative competence;

7. the ability to freely switch between different language codes develops flexibility of thinking; conscious or unconscious comparison of information in two languages contributes to the formation of a more conscious attitude toward language and develops metalinguistic abilities (attention to language structure, correction of grammatical errors, recognition of polysemy, etc.) (Vygotsky, Bialystok, Baker, Ben-Zeev, Cummins, Ianco-Warrall, C. B. Cazden, etc.);

8. *bilingualism has a positive effect on the general level of literacy (the phenomenon of “additive multilingualism”) (Anna Schwartz, etc.);*

9. *it makes it possible to use evaluative and emotional vocabulary more broadly;*

10. *modern studies by scholars from Italy, the United Kingdom, and Japan show that early bilingualism leads to the development in children of a more accurate ability to recognize rudeness, deception, and excessive information compared to monolingual peers;*

11. *as some scholars argue, bilingualism facilitates the learning of a third language (Cummins, Eisenstein, Hoffman, Klein, Helmut Zobl, Jakobson, Gibson, etc.). They consider third-language learners as already “experienced” learners with broader linguistic capabilities in the use of effective and less conservative strategies (Zobl, 1993). They possess “a sensitivity to language as a system, which helps them better acquire a third language, including in the context of formal learning, compared to monolinguals learning a foreign language for the first time” (Cenoz 2003: 78).*

Modern neurophysiological studies in the field of psycho- and neurolinguistics also indicate the developmental nature of bilingualism. Numerous experiments confirm hypotheses about a significant increase in the number and density of neural connections when learning two languages (E. Peal, 1976; T. Skutnabb-Kangas, 1976, 1983; D. C. Porsche, 1983; I. Karasu, 1995; A. M. Kalpakidou, 1996; C. Baker, P. Jones, 1998; R. S. Baur, 2000; N. V. Baryshnikov, 2004).

At the same time, it should be noted that the idea of a universal “bilingual advantage” remains a subject of scientific discussion. A number of modern studies indicate that cognitive advantages may vary depending on such factors as the age of acquisition of a second language, the level of proficiency, the frequency of its use, and the sociocultural environment, which is quite acceptable.

At present, the necessity of bilingual education does not raise doubts. “By bilingual education we understand the mastery by students of samples and values of world culture by means of the native and a foreign language, when the foreign language acts as a means of comprehending the world of specialized knowledge, assimilating the cultural-historical and social experience of various countries and peoples. As an alternative way of learning a foreign language and mastering subject content, bilingual education solves a whole complex of psychological and pedagogical tasks that ensure the assimilation of subject content, the inclusion of students in the values of world and national culture, the understanding not only of another language, but also of another culture, and the recognition of surrounding diversity. Bilingual education contributes to achieving a high level of linguistic, subject, and intercultural competencies of students, and also provides better chances for the life and professional self-determination of graduates” (Khudobina 2005: 81). Bilingual programs are increasingly used in schools and universities, where special attention is paid to the study of foreign languages and cultures through maximum immersion in an intercultural linguistic environment. They are also spreading in preschool educational institutions. For example, the European project “LIGHT” supporting the “European model for the development of bilingual kindergartens” was created on the initiative of representatives of the Society of Russian-speaking parents and teachers of Berlin in 2007. Project partners from five European countries were guided by the idea of the natural development of the native language and the language of the country of residence based on the unity of two cultures and achieved significant results in the study of child bilingualism.

Undoubtedly, bilingual education has its advantages and disadvantages. The main ideas of bilingual education (knowledge and use of a foreign language as a means of understanding the world, assimilating the cultural-historical and social experience of various countries and peoples, familiarization with other cultures, which contributes to the awareness of one’s belonging not only to one’s own country but also to the global community) are important and acceptable for all education systems that adhere to humanistic principles. Bilingual programs allow a person to develop a culture of speech, expand knowledge of language, which helps to easily adapt in a multilingual environment; through intercultural interaction they develop communicative skills; contribute to the improvement of cognitive functions (attention, memory, and the ability to multitask); enhance academic achievements by developing critical thinking, analytical abilities, and language literacy; make the learner more tolerant towards other cultures; become an important condition for success in the professional sphere, opening wide opportunities for a future career. At the same time, there is a danger of losing connection with the native culture. To avoid this, careful preparation of bilingual programs and appropriate training of personnel for their implementation is necessary.

It should be noted that in recent decades the understanding of the goals of bilingual education has somewhat changed. Now it is perceived not only as a means of international communication or preservation of ethnic identity, but also as an integral condition for the development of the individual,

the formation of their cognitive abilities and broad cultural views. "In conditions of bilingual education, not only the acquisition of a certain foreign language takes place, not only the acquisition of specialized knowledge and the acculturation of the individual—the appropriation of a new culture for them—but also genuine personal growth of learners, the development of a holistic personality, its interrelated components: motivational, volitional, emotional, gnostic, and others" (Khudobina 2005: 82).

Thus, bilingualism is not merely a linguistic phenomenon, but a complex cognitive mechanism that has an extremely positive impact on human cognitive activity. Mastery of two languages contributes to the formation of cognitive flexibility, the development of metalinguistic abilities, and the improvement of memory, attention, and analytical thinking. Bilingual education acts as an effective tool not only for language training, but also for the overall intellectual development of learners, ensuring their successful adaptation in a globalized world. At the same time, the effectiveness of bilingual programs depends on taking into account the psychological and pedagogical characteristics of learners and maintaining a balance between the native and the studied cultures, which requires further interdisciplinary research.

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PECULIARITIES OF TEACHING FRENCH AS SECOND FOREIGN LANGUAGE BASED ON ENGLISH

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Abstract

The thesis deals with peculiarities of teaching French as the second foreign language in Ukrainian universities.

The main goal of educational process of teaching French language is the students' communicative competence formation. The communicative competence integrates the phonetic (knowledge of the foreign language sound characteristics and skills of their reproduction), lexical (knowledge and ability to use the foreign vocabulary in educational and professional activities) grammatical (knowledge of the language system structure and the principles of its functioning, skills of using grammatical language resources) competencies.

Keywords: *educational process, French language, communicative competence, phonetic, lexical, grammatical competence.*

The specific nature of teaching French as the second foreign language lies in adhering to the general didactic principles. Considering the existence of three languages (native, English, French) and the student's experience in studying languages, let us examine the specific features of organizing the educational process of teaching French. Achieving the high level of communicative competence by future foreign language teachers requires the comprehensive methodological training for teaching French.

Students approach the acquisition of French consciously because of their experience studying English. They can compare the specific phonetic, lexical and grammatical elements of two languages, which develop their capacity for reflection. That is why the main methodological principle in teaching French is the communicative and cognitive, the cognitive aspect of which is subordinate to the communicative aspect and manifests itself in students' ability finding analogies that facilitate the acquisition of new material or identifying differences.

There are even more favorable conditions for teaching French, thanks to students' previous experience with the first foreign language, later start to language learning and conscious approach to language acquisition. Therefore, it is necessary to take into consideration students' individual characteristics and abilities, their proficiency level in first foreign language and to differentiate instruction. After all, at the heart of the higher education process lies the personality of the future foreign language teachers, who possess unique characteristics. Understanding and taking into consideration students' individual characteristics, interests, aptitudes, abilities and needs, makes it possible to structure the education of gifted students in a way that matches their abilities, while motivating less gifted students and providing support to those who are falling behind. Specifically, some students are provided with opportunities to learn the language more quickly, while others are given the chance to revise and practice. The special attention is paid to students' personal development and growth.

In accordance with the communicative and cognitive approaches to teaching French as the second foreign language, the acquisition of linguistic material (phonetic, lexical, and grammatical) occurs in the integrated manner. The communicative competence integrates phonetic, lexical, and grammatical components and involves future teachers' acquisition and understanding of linguistic norms for subsequent application in their professional practice.

Language learning begins with the introductory corrective phonetics course, during which students acquire general theoretical knowledge:

- the concept of correct pronunciation (standards);*
- various styles of pronunciation (formal, neutral, colloquial);*
- issues in spoken communication;*
- causes of accent;*
- accent-free pronunciation (the ultimate goal of practical phonetics);*
- the concept of a language's phonetic system (articulatory and rhythmic);*

- the pronunciation norm comparison of the second foreign language being studied with those of the native and first languages;
- speech sounds and intonation.

The process of students acquiring lexical competence (knowledge and ability to use foreign language vocabulary, as well as the continuous accumulation and expansion of their actual and potential vocabulary) takes place in several stages:

- 1) introduction to new vocabulary (presentation and explanation of new lexical items);
- 2) automation skills with new lexical units: the level of word forms, free word combinations/phrases/sentences; the supra-phrasal level (dialogic and monologic unity);
- 3) improvement skills with lexical units;
- 4) situational usage of acquired lexical units in spoken and in writing language, with their contextual understanding during reading and listening.

In the process of developing the grammatical competence (knowledge of the systematic organization of language and the patterns of its functioning, as well as ability to use the language's grammatical resources in performing teaching tasks), the acquisition of grammatical structure of the French language is complicated by the fact that it shares not only common features with English but also specific characteristics that distinguish them. There are four stages of work with grammatical material:

- 1) the stage of presenting grammatical material and creating the foundation for skills subsequent development;
- 2) the development of grammatical skills through their automatical application in spoken language;
- 3) the integration of grammatical skills into various types of language activities;
- 4) the development of language proficiency.

The usage of the contrastive approach plays an important role in the process of teaching French, as it allows students to identify similarities and differences between languages. When learning the second foreign language, it is very helpful to rely on one's native language and first foreign language, particularly by drawing on linguistic intuition and taking into consideration the similarity of grammatical structures, not to mention the significant number of loanwords in the lexical composition of each. It should be noted that the process of teaching French as the second foreign language can be significantly accelerated if students have the high level of proficiency in English.

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THE ESTHETICS OF THE UGLY AND THE BEAUTIFUL: POETICS OF FEMALE IMAGES IN KAZAKH AND RUSSIAN FOLKLORE

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ЭСТЕТИКА БЕЗОБРАЗНОГО И ПРЕКРАСНОГО: ПОЭТИКА ЖЕНСКИХ ОБРАЗОВ В КАЗАХСКОМ И РУССКОМ ФОЛЬКЛОРЕ

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Abstract

The article provides a comparative analysis of the artistic structure of female mythological images in the fairy-tale folklore of Kazakhstan and Russia. The relevance of the study lies in the need for a profound understanding of ethnocultural parallels between nomadic and sedentary traditions through the "image – plot – style" literary triad. The paper examines the aesthetic opposition between the ugly, embodied by characters such as Zhalmauz-kempir and Baba Yaga, and the beautiful, represented by Kunsulu and Vasilisa the Beautiful. The author provides a detailed analysis of portrait specifics, spatial localization of characters (forest vs steppe), and the mythopoetic semantics of numbers, which play a crucial role in the composition of fairy tales. Special attention is paid to identifying universal and national-specific traits in the structure of mythological heroines. The study concludes that despite differences in cultural landscapes, these images share similar genetic roots and perform identical functions within the folk narrative system. The findings of the article can be applied in courses on folklore studies and intercultural communication.

Аннотация

Статья посвящена компаративному анализу художественной структуры женских мифологических образов в сказочном фольклоре Казахстана и России. Актуальность исследования обусловлена необходимостью глубокого осмысления этнокультурных параллелей в кочевой и оседлой традициях через призму литературоведческой триады «образ – сюжет – стиль». В работе подробно рассматривается эстетическая оппозиция безобразного, воплощенная в персонажах Жалмауз-кемпир и Бабы-яги, и прекрасного, представленного образами Кунсулу и Василисы Прекрасной. Автор детально анализирует специфику портретных характеристик, пространственную локализацию персонажей (лес vs степь) и мифопоэтическую семантику чисел, играющую ключевую роль в композиции сказок. Особое внимание уделяется выявлению универсальных и национально-специфических черт в структуре мифологических героинь. В результате исследования определено, что, несмотря на различия в культурном ландшафте, данные образы имеют схожие генетические корни и выполняют идентичные функции в системе фольклорного повествования. Выводы статьи могут быть использованы в курсах по фольклористике и межкультурной коммуникации.

Keywords: poetics of the text, esthetics of the ugly, female images, Zhalmauz-kempir, Baba Yaga, Kazakh folklore, Russian folklore, comparative studies.

Ключевые слова: поэтика текста, эстетика безобразного, женские образы, Жалмауз-кемпир, Баба-яга, казахский фольклор, русский фольклор, компаративистика.

Изучение поэтики волшебной сказки через призму женских образов позволяет вскрыть глубинные пласты национального мировосприятия. Женский мифологический образ в сказке – это сложный реликт архаического сознания, трансформированный в устойчивый художественный канон. Как отмечает С. А. Каскабасов, персонажи казахской волшебной сказки представляют собой эволюционировавшие формы древних духов и божеств матриархальной эпохи [1, 88]. В данной статье предпринимается попытка компаративного анализа эстетических полюсов – «безобразного» и «прекрасного» - в структуре сказочного текста.

Эстетика безобразного: Генезис и портрет антагониста

Центральным объектом в поэтике сказки выступает старуха-ведьма, стражница порога. Её облик строится на деформации человеческих черт, что символизирует принадлежность к иному миру.

Несмотря на различия в культурных ландшафтах, их генезис восходит к образу «Матери-прародительницы».

В казахской традиции Жалмауз-кемпир предстает как воплощение хтонической силы. В сказке «Ер-Тостик» её облик подчеркивает нечеловеческую природу: «Она была старая-престарая, с одним-единственным зубом, торчащим изо рта, как медный коготь. Кожа её была жесткой, как старая верблюжья шкура» [2, 142]. Медный коготь (жез тырнак) – ключевая стилистическая деталь. Использование «металлического» эпитета (жез тырнак) – маркер хтонической природы, связи с недрами земли.

По мнению Ш. Ибраева, металл в портрете Жалмауз указывает на древние пласты мифологии, где металл был признаком существ подземного мира, он считался атрибутом сверхъестественных существ [3, 94].

В русской сказке Баба-яга описывается через устойчивую формулу: «Лежит баба-яга, костяная нога, из угла в угол, нос в потолок врос» [4, 114]. Как подчеркивал В. Я. Пропп, Баба-яга – это мертвец, запертый в пространстве избы-гроба, что диктует её гигантизм и статичность [5, 72].

С. А. Каскабасов указывает, что при всех различиях в атрибутике, обе героини функционально идентичны как стражи «границы миров» [1, 94].

Если Жалмауз-кемпир мобильна (она часто скачет на черном верблюде), то Баба-яга в момент первой встречи статична – она часть интерьера избы, ее «костяная нога» прямо указывает на принадлежность к миру мертвых.

Поэтика пространства и символика чисел

Локализация персонажа фиксирует его «чуждость». В казахской сказке «Золотая бита» дом антагониста – это «одинокая черная юрта в степи, из которой слышался скрежет костей» [6, 88]. Отсутствие дыма из шанырака – деталь, указывающая на «мертвый» дом. В русской сказке «Василиса Прекрасная» избышка Яги окружена забором из костей: «Вместо столбов – кости человеческие, на заборе – черепа с глазами» [4, 156].

Важным элементом стиля является нумерология. В казахской сказке доминирует сакральное число семь: Жалмауз-кемпир часто обладает семью головами. По мнению С. Кондыбая, число «семь» в тюркской мифологии связано с вертикальной структурой Вселенной [7, 156]. В русской сказке ведущим является число три. Как отмечает Е. М. Мелетинский, троичность – это ритмическая основа русской сказки, задающая динамику сюжета [8, 118].

Цветопись также выступает инструментом стилизации. В описании Жалмауз доминируют черный и медный (красный), символизирующие бездну и хаотическую силу. В палитре Бабы-яги – синий (туман, лес) и черный. Стилистическое противопоставление антагониста и героя (Василисы или Кунсулу) строится на контрасте «тьмы» и «света» (белый, золотой).

Эстетика прекрасного: Образы чудесных дев

Вторая типологическая группа – «мудрые девы», чья поэтика строится на категории прекрасного.

Стиль описания казахской Кунсулу (Күнсұлу) базируется на световых метафорах. В сказке «Кунсулу и Айсулу»: «Лицо ее сияло, как полная луна в ясную ночь, а из каждого ее шага вырастали тюльпаны» [2, 210]. Красота здесь – это благодать, преображающая мир. В русской сказке «Царевна-лягушка» Василиса Прекрасная описывается через формулу чудесного преображения: «Сбросила лягушачью кожу... во лбу месяц ясный, а на затылке звезда светит» [4, 264]. Здесь стиль более ритуализирован, используются фольклорные эпитеты, связывающие героиню с космосом.

С. А. Каскабасов определяет их как образы тотемических предков, утративших в процессе эволюции жанра свои зооморфные черты [9, 56].

Сюжетная функция этих героинь – восстановить порядок через мудрость и магию, что противопоставляет их хаотической природе Жалмауз и Яги.

Вывод

Проведенный компаративный анализ поэтики женских мифологических образов в

казахской и русской сказочной традициях подтверждает гипотезу об их глубоком типологическом единстве при сохранении яркой национальной специфики. Исследование показало, что эстетическая оппозиция «безобразного» и «прекрасного» в лице таких персонажей, как Жалмауз-кемпир, Баба-яга, Кунсулу и Василиса Прекрасная, не является случайной. Она выступает фундаментальным инструментом разграничения сакрального и профанного миров, где женский мифологический образ часто выполняет роль медиатора или стража на границе этих пространств.

Применение литературоведческой триады «образ – сюжет – стиль» позволило выявить, что за внешними различиями, продиктованными кочевым или оседлым образом жизни (степь vs лес), скрываются идентичные структурные функции. Национальное своеобразие проявляется в деталях портретной характеристики, локализации персонажей и специфической числовой символике, в то время как единство обнаруживается в самих алгоритмах взаимодействия героев. Таким образом, сказочный фольклор двух народов предстает как сложная, саморегулирующаяся система трансляции культурного кода. Изучение этих параллелей открывает новые перспективы для понимания общности евразийского культурного пространства и механизмов сохранения этнической идентичности в фольклорном тексте.

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Physical sciences

TIME TRAVEL FOR PEOPLE ON EARTH PHYSICALLY IS POSSIBLE AND NOW ALREADY TECHNICALLY FEASIBLE¹

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Abstract

Time travel, which until very recently belonged to the genre of science fiction, will soon become physically possible and technically feasible for people on Earth. This possibility is predicted by the revised version of the special theory of relativity (SRT). And such a possibility is created by the corrected version of the SRT. But the version of SRT studied in all physics textbooks states that time travel on Earth will never be available to people. Nevertheless, ignoring this statement of the generally recognized SRT, currently millions of airplane passengers, daily traveling in space, also already make their unconscious and unnecessary time travel, which is confirmed by the translation of their watches to local time after landing the plane. And the article explains how to make such time travel conscious and necessary. And what needs to be done for this.

Keywords: *special relativity theory, relativistic formulas, Multiverse, anti-universe, antimatter, anti-time, internal time, external time, time zones of Earth, time travels*

1. Preface

The author published his three "top secret" articles in which the physical reality of imaginary numbers was proved, during the existence of the USSR. And after this, the Library of the US Congress contacted the author's place of work with a request to send an unclassified his publications. And at this time the author, having learned about the secret resolution² of the Presidium of the USSR Academy of Sciences 1964 prohibiting any criticism of the works of Albert Einstein, not wanting to be repressed, stopped his research and left the Moscow region for Ukraine. And he resumed his research only after the collapse of the USSR, as a result of which Ukraine became independent.

Later, already living in Ukraine, the author in 2008-2010 published five articles in English in which he again proved the physical reality of imaginary numbers. And thus, with his publications, he made the unsuccessful ORERA experiment in 2011 unnecessary. However, participants in the ORERA experiment ignored these publications. And the incorrect version of the SRT still continues to be studied in all physics textbooks. And these textbooks are used in the educational process of universities, even the most prestigious ones.

2. Introduction

The article explains that the special theory of relativity (SRT), studied in all physics textbooks, rightly recognized as an outstanding scientific achievement due to the principle of relativism proposed in it, nevertheless, due to the lack of necessary experimental knowledge in the 20th century, turned out to be largely incorrect³. Therefore, she could not explain the phenomena of dark matter and dark energy, the problem of baryon asymmetry, denied the existence of tachyons and antimatter, and incorrectly solved other problems of astrophysics. And due to the inability to explain the relativistic formulas obtained by the creators of this theory in the superluminal speed range, an incorrect postulate was introduced into this SRT, called the principle of not exceeding the speed of light, from which incorrect conclusions were drawn about the existence in nature of our only visible universe and about the physical unreality of imaginary numbers. But by denying the physical reality of imaginary numbers, the incorrect SRT unprovenly denied, although it did not admit it, the existence of radio engineering. But by denying the physical reality of imaginary numbers, this incorrect SRT denied the existence of radio technology and computer technology, resonance and bell ringing, tsunamis, piano music, swaying children's swings and much more. Therefore, due to the complete lack of experimental proof of its truth of this version of

¹ This is reprint of the article "Antonov A. A. 2026. How to call yourself to yesterday? Norwegian Journal of Development of the International Science No 172".

² Which has not yet been canceled

³ For a new theory, this is forgivable. But then it still needs to be corrected.

SRT, Albert Einstein for its creation, even despite the fact that he was nominated for the Nobel Prize 66 times, never received it.

This incorrect version of the theory of relativity also denies the possibility of time travel for humans. But every day, millions of airplane passengers on Earth make such time travel that they don't need. And this article explains how to make time travel necessary and beneficial for people on Earth.

3. The version of SRT taught in all physics textbooks is incorrect

However, while being brilliant in its concept, the version of SRT taught in all physics textbooks is nevertheless largely incorrect, since:

- *the relativistic formulas obtained in this SRT are incorrect, because it is ignored the fact that the argument 'velocity' in them, in accordance with Newton's first law, is the fourth spatial dimension⁴ [1]-[5];*
- *the formula for the relativistic mass $m(v)$ in the hyperluminal $v > c$ speed range corresponds to a physically unstable process that cannot exist in nature;*
- *being unable to explain the physical meaning of the imaginary values of the quantities $m(v)$, (v) , $l(v)$ in the hyperluminal $v > c$ speed range, the authors of the SRT, in order not to explain their relativistic formulas in this range, introduced an incorrect postulate into it, called the principle of not exceeding the speed of light, which is incompatible with the fourth spatial dimension.*
- *in the 21st century, despite the fact that the attempt to refute SRT with the OPERA experiment [6] at the Large Hadron Collider was unsuccessful, it was still experimentally proven that imaginary numbers are physically real [7]-[24]. And, therefore, the principle of not exceeding the speed of light in the generally accepted SRT and this version of SRT itself, which is studied in textbooks, are incorrect [25]-[57].*

In addition, the conclusions drawn from incorrect relativistic formulas using the incorrect principle of not exceeding the speed of light are also incorrect:

- *about the existence in nature of our only visible universe;*
- *about the physical unreality of imaginary numbers.*

4. Proof of the physical reality of imaginary numbers

But by now, numerous [7]-[24] experimental evidence of the physical reality of imaginary numbers have already been published. All of them are quite simple and can be completed by one radio engineer in less than one day. They can therefore always be repeated and checked in any other radio engineering laboratory. In contrast to these simple radio engineering experiments, the radio engineering laboratory. In contrast to these simple radio engineering experiments, the unsuccessful OPERA physics experiment at the Large Hadron Collider was carried out for a total of almost 15 years (2003-2018).

And so that the reader can convince himself of the truth of the mentioned radio engineering experiments, let us consider one of them as an example. The rest are also quite simple experiments mentioned in the list of references.

From the well-known Ohm's law in the interpretation of Steinmetz [58], the validity of which is daily confirmed by millions of radio engineers throughout the world through their practical activities, it follows that in addition to the electrical resistance R of resistors, measured by real

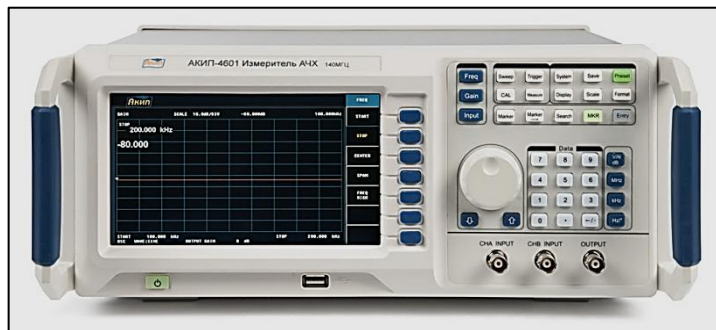


Fig. 1. Every radio engineering laboratory has devices called frequency response meters, which, by their very existence, prove the physical reality of imaginary and complex numbers. And thus, they made the OPERA experiment at the Large Hadron Collider unnecessary.

numbers, there are also electrical resistances $-j/\omega C$ of capacitors and $+j\omega L$ of inductors, which are measured by imaginary numbers.

⁴ Not to be confused with the fourth dimension in four-dimensional space-time (Minkowski space).

Consequently, if these imaginary numbers $-j/\omega C$ and $+j\omega L$, in accordance with the generally accepted version of SRT are physically unreal, then the electrical resistance of any electrical LCR-circuit will always be measured in real numbers and will not depend on frequency. Therefore, when the frequency ω of the applied voltage changes, the amount of current flowing through such an electrical circuit will not change.

And vice versa, if the imaginary resistances $-j/\omega C$ and $+j\omega L$ are physically real, then the electrical resistance of any electrical LCR-circuit will be measured in complex numbers and when the frequency ω of the applied voltage changes, its resistance will change. Therefore, in accordance with Ohm's law, the magnitude of the current flowing through this electrical LCR-circuit will also change.

Consequently, an experiment proving the physical reality of imaginary numbers is extremely simple. You just need to change the frequency ω of the voltage applied to any electrical LCR-circuit and measure the value of electric current flowing through it. And all radio engineers know that in this case its value will change. Thus proving the physical reality of imaginary numbers.

For over half a century, devices called frequency response meters (Fig. 1) have existed and been mass-produced. They measure the transfer functions of electrical LCR circuits described by complex numbers. But only something physically existing can be measured. Therefore, the very existence of frequency response meters proves the physical reality of imaginary numbers.

However physicists did not do such an experiment, since in fact, as shown below, on the contrary, they need evidence of the physical unreality of imaginary numbers. Which do not exist in nature.

4. Corrected version of SRT

And since the physical reality of imaginary numbers has just been proven in the most indisputable way, it remains to fully and correctly explain (which no one has done over the past hundred years) the relativistic formulas of SRT [59]-[67].

$$m = \frac{m_0}{\sqrt{1 - (v/c)^2}} \quad (1)$$

$$\Delta t = \Delta t_0 \sqrt{1 - (v/c)^2} \quad (2)$$

$$l = l_0 \sqrt{1 - (v/c)^2} \quad (3)$$

in which m_0 is the rest mass of a moving body;

m is the relativistic mass of a moving body;

Δt_0 is the rest time of a moving body;

Δt is the relativistic time of a moving body;

l_0 is the rest length of a moving body;

l is the relativistic length of a moving body.

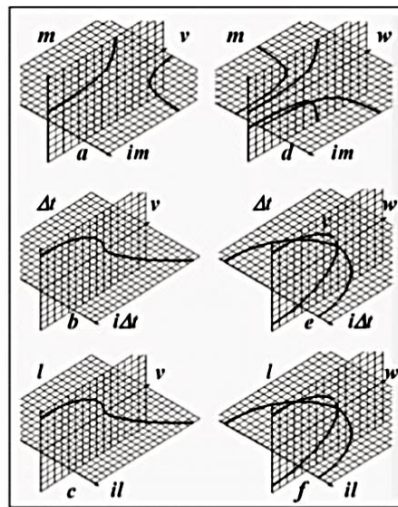


Fig 2. Graphs of functions $m(v)$, $\Delta t(v)$, $l(v)$, corresponding to the existing and revised versions of SRT in the subluminal $v < c$ and superluminal $v > c$ ranges

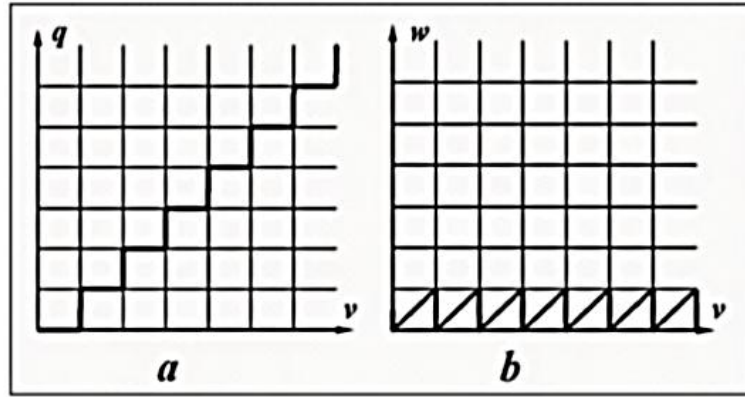


Fig. 3. Graphs of functions $q(v)$ and $w(v)$, illustrating the meaning of the “floor” function of discrete mathematics

And this explanation turned out to be elementarily simple. These formulas correspond to the graphs in Fig. 2a,b,c. And they show that these graphs in the subluminal $v < c$ and hyperluminal $v > c$ ranges of the argument v have different appearances. Therefore, the same processes cannot occur in these ranges. And in order for the same processes to occur in these ranges, the graphs of the corrected relativistic formulas should look the same, as shown in Fig. 2d,e,f. And for this, in formulas (1)-(3), since the speed v in them is the fourth spatial dimension, the factor i^q must be introduced

$$m(q) = \frac{m_0 i^q}{\sqrt{1 - (v/c - q)^2}} = \frac{m_0 i^q}{\sqrt{1 - (w/c)^2}} \quad (4)$$

$$\Delta t(q) = \Delta t_0 i^q \sqrt{1 - (v/c - q)^2} = \Delta t_0 i^q \sqrt{1 - (w/c)^2} \quad (5)$$

$$l(q) = l_0 i^q \sqrt{1 - (v/c - q)^2} = l_0 i^q \sqrt{1 - (w/c)^2} \quad (6)$$

where $q(v) = \lfloor v_q/c \rfloor$ is the “floor” function of discrete mathematics from the argument v_q/c (its graph shown in Fig. 3a), which is the fourth spatial dimension;
 $w = v - qc$ is the local speed in all universes (its graph is shown in Fig. 3b).

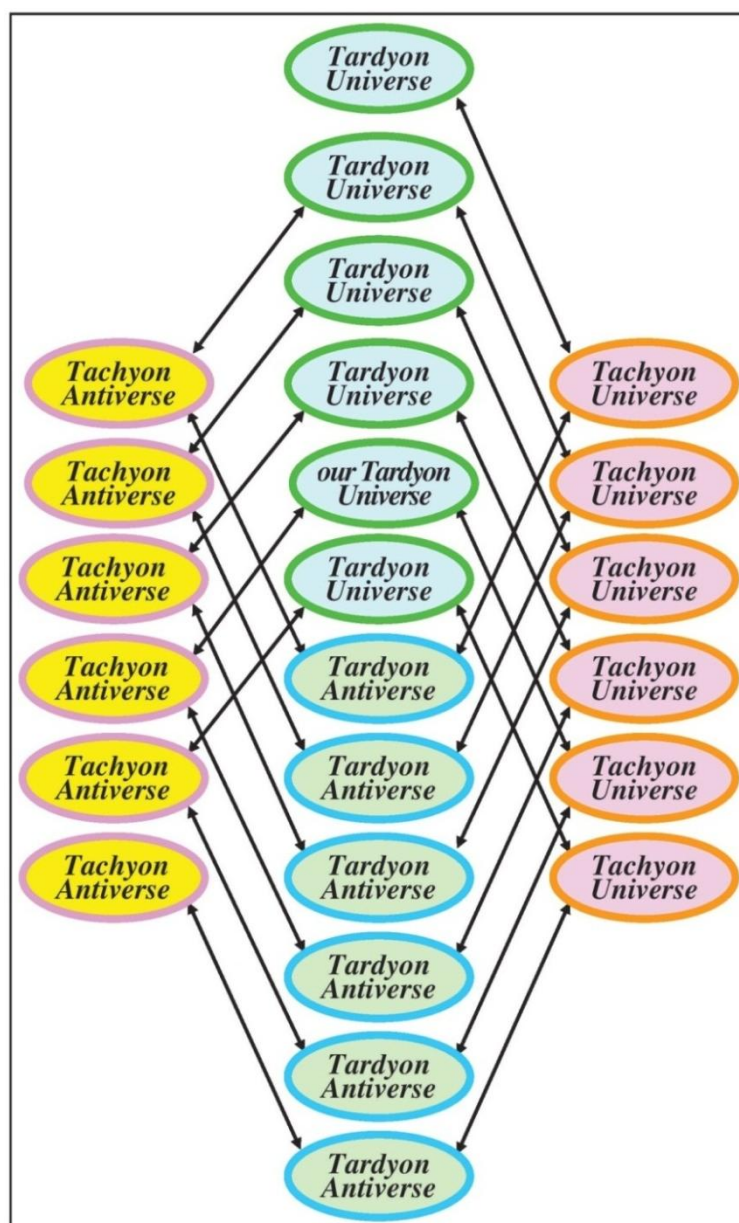


Fig. 4. Structure of the hidden Multiverse corresponding to the principle of physical reality of complex numbers

At that, this function⁵ i^q in formulas (4)-(6), which determines the essence of each universe, for integer values of the argument $q(v)$ equal to ... 0, 1, 2, 3, 4, 5, ..., takes the values +1, +i, -1, -i, +1, +i, ... etc. And the value $q(v) = 0^6$ in formulas (4)-(6) for the range of sublight speeds $v < c$ corresponds (since $i^0 = 1$) to our visible universe, which for definiteness we will call the tardyon universe⁷ (see Fig. 3). The value $q(v) = 1$ in the hyperluminal speed range $2c > v > c$ corresponds (since $i^1 = i$) to some other invisible universe, since it is located beyond the event horizon. For definiteness, we will therefore call it the tachyon universe⁸. Then the value $q(v) = 2$ in the speed range $3c > v > 2c$ will correspond (since $i^2 = -1$) to an invisible tardion antiverse. The value $q(v) = 3$, in the speed range $4c > v > 3c$ will correspond (since $i^3 = -i$)

⁵ In the theory of functions of a complex variable, the function i^q is defined only for integer values of the argument q . However, it can be further defined as follows. For integer values of the argument ... -2, -1, 0, +1, +2, +3, +4, +5, ... the function i^q is equal to ... -1, -i, +1, +i, -1, -i, +1, +i, ... But for the same integer values of the argument ... -2, -1, 0, +1, +2, +3, +4, +5, ... to the same values ... -1, -i, +1, +i, -1, -i, +1, +i, ... is also equal to the function $e^{iq\pi/2}$, which, in accordance with Euler's formula $e^{iq\pi/2} = \cos(q\pi/2) + i\sin(q\pi/2)$, is also defined for non-integer values of the argument q . Therefore, the function i^q can be further defined for any values of the argument q by the formula $i^q = \cos(q\pi/2) + i\sin(q\pi/2)$, similar to Euler's formula. The resulting formula allows you to determine the value of the function i^q for any, including non-integer, values of the argument q . And it will be needed in astro-geophysical studies of portals, which will be discussed further.

⁶ Those, if we take our visible universe as the origin of coordinates q .

⁷ Tardyon universe is a term used by Isaak Asimov in his short story 'Take a Match'.

⁸ Tachyon universe is a term used by Isaak Asimov in his short story 'Take a Match'.

to an invisible tachyon antiuniverse. The value $q(v) = 4$ in the speed range $5c > v > 4c$ will correspond (since $i^4 = +1$) to another (and therefore also invisible) tardyon universe. The value $q(v) = 5$ in the speed range $6c > v > 5c$ will correspond (since $i^5 = +i$) to another tachyon universe. Etc.

Consequently, in nature there is not only, as stated in the generally accepted version of SRT, our visible universe corresponding to formulas (1)-(3), but also many other mutually invisible⁹ universes and antiuniverses corresponding to formulas (4)-(6). And these mutually invisible universes and antiuniverses, together with our visible universe, form the Multiverse, which we therefore called hidden. Such a hidden Multiverse, the structure of which is helical, is shown in Fig. 3.

6. The invisible universes and anti-universes of the hidden Multiverse are dark matter and dark energy

However, in this structure it is still necessary to take into account and explain the phenomena of dark matter and dark energy, so named because of their incomprehensibility, since not a single chemical element has been found in them, and also because they do not emit, absorb, reflect or refract electromagnetic radiation and, therefore, are invisible. Finally, it is not clear why dark matter and dark energy, which accounts for more than 95% of all mass-energy contained in nature, are being persistently searched for at the Large Hadron Collider in the microcosm of our only visible universe. In fact, it is impossible to explain it this way.

Therefore, let us assume that dark matter and dark energy are all other mutually invisible universes and antiuniverses of the hidden Multiverse. Then the phenomena of dark matter and dark energy will be a gravitational shadow on our visible universe from the remaining mutually invisible universes and antiuniverses included in the hidden Multiverse. That is why these phenomena do not contain, like our shadow on a sunny day, a single chemical element, and dark matter and dark energy contain more than 95%¹⁰ of all mass-energy contained in nature. This assumption explains all the incomprehensibility of phenomena simply and clearly. That's why we will use it.

Then, assuming that over the billions of years of its existence, the mass-energy of all universes and antiuniverses of the hidden Multiverse, due to the presence of a huge number of portals between them according to the law of communicating vessels, has been largely averaged, it becomes possible, using the data obtained by the WMAP and Planck spacecraft, to determine the structure of the hidden Multiverse. And according to data obtained by the WMAP spacecraft [68], the mass-energy of our visible universe (in fact, our hidden Multiverse) consists of 4.6% baryonic matter, 22.4% dark matter and 73.0% dark energy. And according to more recent data obtained by the Planck spacecraft [69], the mass-energy of our visible universe (again, actually our hidden Multiverse) consists of 4.9% baryonic matter, 26.8% dark matter and 68.3% dark energy. As you can see, these data differ little from each other, which proves their truth. Therefore:

- the entire hidden Multiverse, according to experimental data obtained by the WMAP spacecraft, consists of $100\% / 4.6\% = 21.8$ parallel universes, and according to data obtained by the Planck spacecraft, it consists of $100\% / 4.9\% = 20.4$ parallel universes;
- dark matter, according to experimental data obtained by the WMAP spacecraft, consists of $22.4\% / 4.6\% = 4.9$ parallel universes, and according to data obtained by the Planck spacecraft, it consists of $26.8\% / 4.9\% = 5.5$ parallel universes;
- dark energy, according to experimental data obtained by the WMAP spacecraft, consists of $73.0\% / 4.6\% = 15.9$ parallel universes, and according to data obtained by the Planck spacecraft, it consists of $68.3\% / 4.9\% = 13.9$ parallel universes;
- and our visible universe, naturally, is only one.

7. Corrected version of SRT (continued)

As can be seen, received by the WMAP and Planck spacecraft experimental data did not confirm the above conclusions about the structure of the hidden Multiverse, since our visible universe actually has not two neighboring invisible parallel universes - one tachyon universe and one tachyon antiuniverse - but five or six¹¹.

Consequently, there was some error in the previous reasoning. And we, it turns out, were wrong in assuming that in the hidden Multiverse there is only one additional dimension q . And therefore, when describing it, they used complex numbers containing only one imaginary unit. And now, in order for six other parallel universes to coexist with our visible universe in the really existing hidden Multiverse - three tachyon universes and three tachyon antiuniverses - it is necessary to have three additional dimensions

⁹ Since they are all beyond the event horizon

¹⁰ That is, about 20 times more than in our entire visible universe.

¹¹ According to WMAP data 4.9 universes and Planck data 5.5 universes

q, r, s . At the same time relativistic formulas must be corrected again as follows [70]-[77]

$$m(q, r, s) = \frac{m_0 i_1^q i_2^r i_3^s}{\sqrt{1 - [\frac{v}{c} - (q + r + s)]^2}} \quad (7)$$

$$\Delta t(q, r, s) = \Delta t_0 i_1^q i_2^r i_3^s \sqrt{1 - [\frac{v}{c} - (q + r + s)]^2} \quad (8)$$

$$l(q, r, s) = l_0 i_1^q i_2^r i_3^s \sqrt{1 - [\frac{v}{c} - (q + r + s)]^2} \quad (9)$$

where $q(v) = \lfloor v_q/c \rfloor$ is the "floor" function of discrete mathematics from the argument v_q/c which is one of the orthogonal coordinates q of the fourth spatial dimension v ;

$r(v) = \lfloor v_r/c \rfloor$ is the "floor" function of discrete mathematics from the argument v_r/c which is another orthogonal coordinate r of the fourth spatial dimension v ;

$s(v) = \lfloor v_s/c \rfloor$ is the "floor" function of discrete mathematics from the argument v_s/c which is another orthogonal coordinate s of the fourth spatial dimension v ;

v_q, v_r, v_s is projections of the velocity vector v onto the orthogonal coordinates q, r, s (see Fig. 4).

The space of such a hidden Multiverse will already be six-dimensional (see Fig. 4). And its structure will correspond to the quaternions $\sigma + i_1\omega_1 + i_2\omega_2 + i_3\omega_3$, i.e. hypercomplex numbers [78] containing exactly three imaginary units i_1, i_2, i_3 , which are related to each other by the relations

$$i_1^2 = i_2^2 = i_3^2 = -1 \quad (10)$$

$$i_1 i_2 i_3 = i_2 i_3 i_1 = i_3 i_1 i_2 = -1 \quad (11)$$

$$i_1 i_3 i_2 = i_2 i_1 i_3 = i_3 i_2 i_1 = 1 \quad (12)$$

In such a quaternion structure of the hidden Multiverse [79], in contrast to its structure considered earlier (in Fig. 3), the distribution of material content in each three-dimensional parallel universe will be determined by a certain function $f_{q,r,s}(x, y, z)$, and the coordinates of these uni-verses will be determined by the values $i_1 q, i_2 r, i_3 s$. Those. the hidden Multiverse (see Fig. 4) will be described by the formula $f_{q,r,s}(x, y, z) + i_1 q + i_2 r + i_3 s$. This is exactly what Lisa Randall¹² predicted: "Perhaps we live in a three-dimensional pocket of higher dimensional space".

From formulas (7)-(9) it follows that such a hidden Multiverse still has a helical structure, and its mutually invisible universes and antiuniverses (in addition to our visible universe) form dark

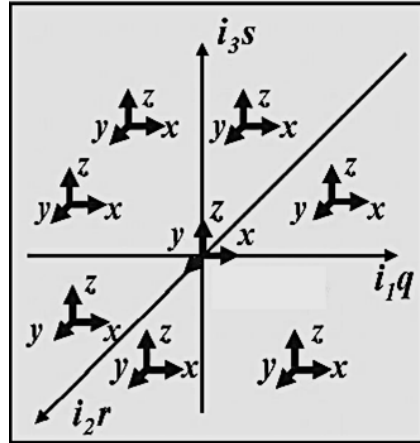


Fig. 4. Six-dimensional space of the hidden Multiverse, where q, r, s are the coordinates of invisible parallel universes, and x, y, z are the coordinates of the matter content in each parallel universe

¹² Lisa Randall is a professor in the Department of Physics at Harvard University and a member of the American Academy of Arts and Sciences and the National Academy of Sciences.

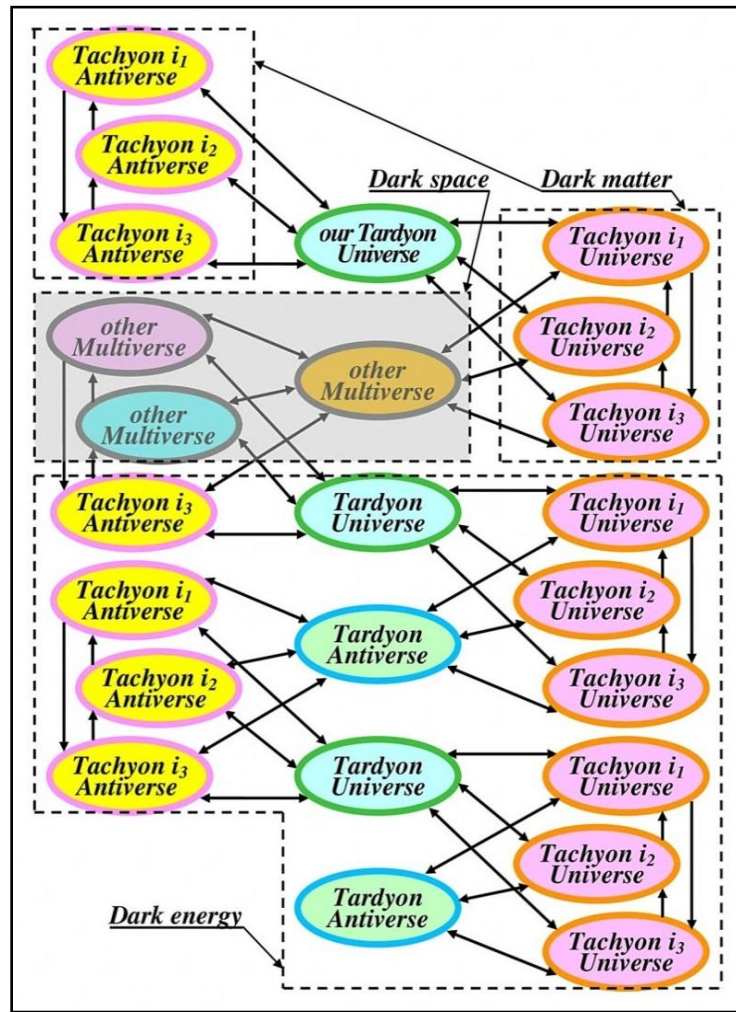


Fig. 6. Structure of the hidden Multiverse corresponding to the principle of physical reality of hypercomplex numbers

matter and dark energy. In this case, it is possible to move into the tardion antiuniverse from the tardion universe and into the tardion universe from the tardion antiuniverse in various, but not arbitrary, ways, but only in such a way (see Fig. 5), in which the value of i^q will successively take on the values $+1$, $+i_1 \oplus +i_2 \oplus +i_3$, -1 , $-i_1 \oplus -i_2 \oplus -i_3$, $+1$, ... and etc., where $\oplus$ is the symbol of the logical operation of discrete mathematics 'exclusive OR'. In this case, different trajectories of movement from one universe (or antiuniverse) to another can differ only due to the replacement of some tachyon universes from i_1, i_2, i_3 with others and some tachyon anti-universes from i_1, i_2, i_3 with others. Consequently, tachyon universes i_1, i_2, i_3 in the hidden Multiverse are located parallel to each other. Tachyon antiuniverses i_1, i_2, i_3 are also located parallel to each other for the same reasons. And therefore, in the hidden Multiverse, when transitioning from any tardion universe to a tardion anti-universe and then to another tardion universe, parallel universes and antiverses must alternate in the following sequence - 'tardion universe', 'one of the tachyon universes', 'tardion anti-universe', 'one of the tachyon anti-universes', 'tardion universe', 'one of tachyon universes', etc.

One of the easiest to explain such possible quaternion structures of the hidden Multiverse is shown in Fig. 6. Its difference from the structure shown in Fig. 4 is the presence in it of several different tachyon universes and antiuniverses located in parallel, corresponding to three imagi3-nary units i_1, i_2, i_3 . Another difference is the presence in such a structure of the Multiverse of not only bidirectional portals corresponding to formula (7) and indicated by two-way arrows, but also unidirectional portals corresponding to formulas (8), (9) and indicated by one-way arrows.

In Fig. 6 all these transitions are shown. Moreover, since the data obtained by the WMAP and Planck spacecraft correspond to the not closed screw structures of our hidden Multiverse, united through the corresponding portals with other Multiverses, then all together they form the Hyperuniverse.

8. How to see invisible universes and anti-universes?

But in order to believe in the existence of the Multiverse mentioned in the article instead of the Monoverse mentioned in the textbooks, experimental confirmation of the above is necessary [80]-[97].

Those. it is necessary to prove that in addition to our visible universe, there are other universes and antiuniverses in nature.

And it is possible to do this. Eventually, the invisible universes and anti-universes in outer space, drifting in their different dimensions, touch each other in many places and even slightly immerse themselves in each other, forming transitions called portals between the touching universes and anti-universes. And since the constellations in the starry sky in neighboring universes and antiuniverses are always different¹³, when moving through portals, the map of the starry sky in them will change, which will prove the existence of invisible universes neighboring the Earth. On Earth there are more than two hundred thousand anomalous zones¹⁴ [98]-[101], which are entrances to portals. Moreover, in some of them observatories are already located. For example, the Main Astronomical Observatory of the Academy of Sciences of Ukraine is 12 km away from the center of the capital of Ukraine, Kyiv, in the Goloseevsky forest. Therefore, by comparing maps of the starry sky on a computer in portals (or even in anomalous zones) and outside portals, universes neighboring the Earth can be discovered. And as a result of astro-geophysical studies of portals, it will be possible to determine the main parameters of neighboring tachyon universes and antiuniverses. Which will ultimately allow us to determine the structure of our hidden Multiverse.

9. Where are antimatter and anti-time located?

And this structure of the hidden Multiverse allows us to explain another problem that is currently inexplicable within the framework of all physics textbooks - where antimatter is located [102]-[112]. It is clear that it cannot be in our visible universe¹⁵, since due to its annihilation with matter, our universe would then cease to exist. But the fact that antimatter exists has been proven experimentally. In 1995, a sensational result was obtained at CERN - scientists managed to obtain nine antihydrogen atoms, which lasted for about forty billionths of a second. And just one gram of such antihydrogen would cost 662.5 trillion dollars.

Consequently, this experiment can be considered proof that, in accordance with formulas (7)-(9), antimatter can exist in nature in the invisible tardyon and tachyon antiuniverses of the hidden Multiverse and Hyperuniverse. (see Fig. 5). Moreover, in these invisible tardyon and tachyon anti-universes, anti-time and anti-space also exist.

10. Time travels

And the discovery of anti-time already allows us to assert that due to the choice of one or another route of travel in space, time travel also becomes possible [113]-[123], since from formulas (8), (9) it follows that time Δt in universes and antiuniverses during such travel will always change simultaneously with the change in distance l . But since neither the portals, much less the universes and anti-universes of the hidden Multiverse, are still unexplored, time travel in space is now inaccessible to us. And that's why we're interested in time travel on Earth now.

However, although official modern science admits the possibility of time travel in some exotic situations in the special¹⁶ and general¹⁷ theories of relativity, as well as in quantum physics¹⁸, it still claims that time travel of people on Earth, neither now nor in the distant future, will never be possible.

Nevertheless, these time travels on Earth are now already carried out by airplane flights. And millions of people take part in these flights every day, since upon landing at any airport, air passengers always change their watches to a local time other than at the airport of departure. Thus, they confirm their time travel. Indeed, due to the rotation of the Earth and the presence of time zones on it, movement in space on Earth, as in space, is always accompanied by movement in time.

And when explaining this situation, we must take into account the existence in nature of two different types of time that we will use - internal human time, which we have always used until now, and external time, which, on the contrary, we have never used before. These two times are generated by different processes that exist independently of each other and have different features. Internal time is determined by processes occurring in human bodies. One second is one contraction of the human heart. Therefore, internal time is the biological time of people. External time is determined by processes occurring in the external environment. Namely, by the rotation of the Earth and the existence of time

¹³ Like all people, everything that is in their apartments

¹⁴ Which in itself confidently – more than two hundred thousand times – also confirms the existence of neighboring universes and anti-universes.

¹⁵ But the textbooks state that there are no other universes in nature besides it. And this, naturally, gives reason to doubt the truth of this version of SRT.

¹⁶ For example, in the 'twin paradox'

¹⁷ For example, in a region of ultra-high gravity near the event horizon of a black hole

¹⁸ For example, as a result of teleportation not of information, but of physical objects

zones. These features of it are reflected in formula, absent from physics textbooks, derived from the relativistic SRT formulas (5), (6) and (8), (9)

$$\Delta t = \Delta t_0 \, l / l_0 \quad (13)$$

in which Δt is external time in hours;

Δt_0 – 24 hours;

l – path length in the direction perpendicular to time zones;

l_0 – the length of a circle that intersects 24 time zones at a given latitude.

These two different times also have different properties. Human biological time cannot flow backwards. A person cannot return to his youth or childhood. And external time, when changing the direction of movement, can change its sign - the plane can fly across time zones both to the west and to the east. When the speed of movement of the aircraft changes, the value of external time will also change. Therefore, in the external environment it is possible to move both into the past and into the future. Moreover, even short-term movements in external time can sometimes be very useful¹⁹. This is known to everyone, although it has not yet been used in any way in human activity. But this is a free resource given to us by nature for solving the problem of people traveling through time, which would even seem easy to use (you just need to fly on an airplane).

The only difficulty with this is that such time travel on Earth necessarily involves unnecessary travel over long distances, which is why they are not used. However, this problem can be solved. Airplane flights must be carried out in compliance with one mandatory condition. The flight of the air

Table 1. Examples of business jet performance flight performance characteristics that could be used for time travels

Aircrafts	Maximum range	Cruising speed	Hourly rates	Seats
Citation Latitude	5 300 km	815 km/h	3 500 €/hour	8
Citation Longitude	7 400 km	910 km/h	5 000 €/hour	12
Challenger 300	5 700 km	850 km/h	4 900 €/hour	8
Challenger 350	5 926 km	850 km/h	4 000 €/hour	9
Challenger 600	5 500 km	850 km/h	4 600 €/hour	12
Challenger 3500	6 297 km	985 km/h	5 500 €/hour	10
Falcon 20	4 200 km	987 km/h	3 900 €/hour	8
Falcon 50/50EX	5 600 km	850 km/h	4 900 €/hour	8-10
Global 5500	10 927 km	900 km/h	8 000 €/hour	16
Gulfstream G150	5 200 km	850 km/h	3 900 €/hour	6-8
Gulfstream G200	5 000 km	870 km/h	6 200 €/hour	8
Hawker 850 XP	4 800 km	750 km/h	3 400 €/hour	6-8
Hawker 900XP	5 400 km	865 km/h	3 700 €/hour	6-8
Hawker 4000	5 280 km	890 km/h	5 400 €/hour	10
Learjet 70	3 815 km	967 km/h	3 500 €/hour	7
Legacy 450	5 370 km	860 km/h	3 300 €/hour	8
Praetor 600	7 400 km	850 km/h	6 000 €/hour	12

Table 2. The value of external time at different latitudes

Location of departure and arrival airfields	Geographic coordinates of the airfield	Size of 24 time zones for a round-the-world flight	Size of one time zone.
Santiago de Chile	33,45° S.	33422 km	1393 km
Buenos Aires	34,60° S.	33021 km	1375 km
Melbourne	37,82° S.	31339 km	1306 km
New York City	40,72° N.	30456 km	1269 km
Reykjavík	64,15° N.	17616 km	734 km
Murmansk	69,58° N.	14424 km	601 km
Kirkenes	69,73° N.	14376 km	599 km
Longyearbyen (Spitsbergen, Norway)	78,13° N.	8184 km	341 km
Alert, (Canada)	82,5° N.	5230 km	218 km

craft must be around the world, that is, all the time from takeoff to landing at the same air-field from which the aircraft took off, it must be carried out in the same direction - to the West or to the East, as a result of which, ultimately, the movement of the aircraft in space can be ignored.

There are many aircraft models suitable for use in time travel. They are called business jets²⁰. And

¹⁹ For example, by traveling time first to the past and then to the future, it would probably be possible to save President John Fitzgerald Kennedy after the assassination attempt [124]-[134].

²⁰ A business jet is a small private jet aircraft for transporting a limited number of passengers (usually from 6 to 20) on an individual order for businessmen, officials and VIPs; it features a higher level of comfort, the ability to take off from small airfields and high speed, allowing it to cross time zones in less than one hour of domestic passenger and crew time.

Table 1 shows, as an illustration, the flight performance characteristics of some of these business jets. And Table 2 lists airfields close enough to the North Pole that can provide the shortest routes for round-the-world flights.

Consequently, time travels on Earth is physically possible and is currently technically feasible.

11. Refutations of the version of SRT studied in textbooks

From the above it follows that for Albert Einstein in his version of SRT, it turns out that the most important thing was to prove not physical reality, but, on the contrary, the physical unreality of imaginary numbers. Because otherwise this SRT would become inexplicable and therefore, naturally, useless to anyone.

But the physical reality of imaginary numbers in the theory of electrical circuits was actually proven by Charles Proteus Steinmetz in his proposed interpretation of Ohm's law back in 1897. That is, before the creation by Albert Einstein and Jules Henri Poincaré in 1905 of the version of SRT that is now studied in all physics textbooks. And since then, radio engineers have never had the slightest reason to doubt this, since always when the frequency of the sinusoidal voltage applied to any electrical LCR circuit changes, the amount of current flowing through it changes. This fact, which occurs literally at every step in the practical activities of radio engineers, is an extremely simple, absolutely understandable and irrefutable proof of the physical reality of imaginary numbers. However, radio engineers had no need to specifically declare that they had proven the physical reality of imaginary numbers.

Nevertheless Albert Einstein, in his proposed version of STR, when explaining relativistic formulas, hit was absolutely necessary supposedly refute the physical reality of imaginary numbers²¹. And for this reason, a postulate called the "principle of not exceeding the speed of light" was introduced into special relativity, which led to the conclusion (in reality unproven) that imaginary numbers are physically unrealistic. But the Nobel Committee—and this commands the utmost respect—remained true to common sense and scientific integrity. Due to the complete lack of any experimental evidence for the truth of this dubious version of special relativity, despite Albert Einstein being nominated for the Nobel Prize 66 times, he never received it for this theory²².

And in order to preserve the denial of the physical reality of imaginary numbers in SRT, relativistic physicists had to make great sacrifices. In particular, in order to create the impression that it is impossible to refute the statement of SRT about the physical unreality of imaginary numbers, at the Large Hadron Collider (worth ten billion dollars), the OPERA collaboration, which includes more than one hundred of the most authoritative physics professors, carried out the unsuccessful OPERA experiment for almost 15 years²³ (2003-2018), which allegedly had as its goal proving the physical reality of imaginary numbers, but not managed to do it. And thereby allegedly proving the impossibility of refuting the statement about the physical unreality of imaginary numbers. In 2011, its sensationally successful completion was even announced, but six months later in 2012 it was announced that it had been refuted at the same Large Hadron Collider by the ICARUS experiment.

For this reason, numerous publications were ignored, citing simple and easily understood radio engineering experiments that successfully demonstrated the physical reality of imaginary numbers and explained that if imaginary numbers were truly, as claimed in the SRT, physically unreal, then all radio engineering devices and computers would not exist, tsunamis, bell ringing, piano music would not exist, children's swings would not swing after a parent's push, and much more.

Furthermore, because of the assertion of the physical unreality of imaginary numbers and, therefore, the existence of our only visible universe in nature, it turned out that antimatter and tachyons had no place in single visible universe. The corrected version of the SRT, however, explains where they are located.

It also turned out that due to the statement about the physical unreality of imaginary numbers and therefore about the existence in nature of our only visible universe, the phenomena of dark matter and dark energy have not been and will never be explained, since dark matter and dark energy are actually, according to the corrected version of SRT, mutually invisible universes and antiuniverses of the really existing hidden Multiverse.

More than two hundred thousand anomalous zones have also been discovered on Earth, which are entrances to portals to the invisible universes and antiuniverses neighboring our visible universe. And even this alone already proves their existence. Moreover, these universes and antiuniverses, invisible

²¹ Not being able to explain in any other way the incorrect relativistic formulas of SRT in the hyperluminal speed range

²² And he received his Nobel Prize in 1921 for his research on the photoelectric effect

²³ Let's remember - one day is more than enough for a radio engineering experiment proving the physical reality of imaginary numbers.

outside the portals, can also be seen by astronomical observations of the starry sky in portals. But these low-cost astronomical observations, which would allow sensational scientific discoveries of other universes, are still not carried out due to fears that these invisible neighboring universes and antiuniverses can actually be seen. And then the version of SRT studied in textbooks will undoubtedly have to be recognized as incorrect.

In the version of SRT studied in physics textbooks, it was also concluded that time travel is impossible for people. Although in fact, millions of air passengers on Earth already make such time travel every day, which is confirmed by the translation of their watches to local time after the planes land. But since such time travel by airline passengers occurs simultaneously with travel on Earth, they are not used. And the article explains how it is still physically and technically possible to travel through time on airplanes without ultimately traveling through space.

Less expensive telephone time travel is also possible, which, when needed, can be implemented quickly and inexpensively. Then telephone conversations with people located in the past or future tense will become publicly available. However, probably the most promising is the joint use of aviation and telephone options for time travel: aviation when crossing time zones over the ocean, and telephone when crossing them over land.

12. Conclusion

And we have to admit that the creation of such a situation is to blame for the still dominant science, in which there is no antimonopoly legislation existing in the economy, and little ethical morals. Therefore, for example, in the 16th century, Nicolaus Copernicus published his theory "On the Rotations of the Celestial Spheres," which he worked on for forty years, which refuted the geocentric system of the world of Claudius Ptolemy, so as not to end up in the Inquisition, published only after his death. And in our time, reviewers of some reputable journals, not being able to answer anything on the merits, allow themselves to write to the authors of articles they dislike: "I will not allow Einstein to be criticized." Publications like the outstanding works of Jean de Climont [135]-[138], to which he mentions 9671 scientists who refuted generally accepted theories in all sciences, are extremely rare.

That is why the very interesting SRT, created in 1905 by Albert Einstein and Henri Poincaré, was not received kindly by physicists. And in order to defend the right to exist of this new theory, relativistic physicists had to fight. At that time, SRT was forced, due to the lack of the Internet and the necessary experimental and theoretical knowledge, to use postulates and some not entirely successful tools like the Large Hadron Collider²⁴. And many thanks to the physicists of the twentieth century for thereby saving SRT.

And having won, relativistic physicists began to study the largely erroneous starting version of STR in all physics textbooks. Therefore in turn, they themselves became a brake on scientific (including their own) development, fearing that further recognition of the fallacy of any provisions of the version of SRT studied in textbooks would entail its refutation as a whole. Therefore, the version of STR currently studied in all physics textbooks has made it impossible to explain the phenomena of dark matter and dark energy, to explain the problem of baryon asymmetry, and denies the possibility of time travel, although currently millions of air passengers do it every day.

What's the solution? It is necessary, without dramatizing the situation, begin to study a corrected version of STR in physics textbooks. And until physics textbook authors correct them, the manuscript of my monograph "Corrected Version of the Special Theory of Relativity", which covers the same topics as this article in more detail, can be published as a educational benefit. It can be used by educational institutions for optional study of the corrected version of STR.

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Technical sciences

MODERN METHODS OF COOLANT REGENERATION: A COMPARATIVE EVALUATION

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СОВРЕМЕННЫЕ МЕТОДЫ РЕГЕНЕРАЦИИ ОХЛАЖДАЮЩИХ ЖИДКОСТЕЙ И ИХ СРАВНИТЕЛЬНАЯ ОЦЕНКА

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Abstract

This paper reviews modern methods for regenerating coolants used in transport power units. The main technologies for antifreeze purification and recovery, including distillation, membrane methods, electrodialysis, and ion-exchange treatment, are analyzed. The advantages and disadvantages of each method are identified, and a comparative evaluation is presented. Combined methods are shown to be the most effective, as they enable comprehensive restoration of coolant performance. The results obtained can be used to select rational antifreeze regeneration technologies under actual operating conditions.

Аннотация

В статье рассмотрены современные методы регенерации охлаждающих жидкостей, применяемых в транспортных энергетических установках. Проведен анализ основных технологий очистки и восстановления антифризов, включая дистилляцию, мембранные методы, электродиализ и ионообменную обработку. Выявлены преимущества и недостатки каждого метода, а также дана их сравнительная оценка. Установлено, что наибольшую эффективность обеспечивают комбинированные методы, позволяющие достичь комплексного восстановления эксплуатационных свойств охлаждающих жидкостей. Полученные результаты могут быть использованы при выборе рациональных технологий регенерации антифризов в условиях эксплуатации.

Keywords: *antifreeze, coolant, regeneration, purification methods, distillation, membrane technologies, comparative analysis.*

Ключевые слова: *антифриз, охлаждающая жидкость, регенерация, методы очистки, дистилляция, мембранные технологии, сравнительный анализ.*

Введение

В условиях роста автотранспортного парка и ужесточения экологических требований проблема утилизации отработанных охлаждающих жидкостей приобретает особую актуальность. Антифризы на основе этиленгликоля широко применяются в транспортных энергетических установках, однако при эксплуатации подвергаются загрязнению, термоокислительной деградации и утрате эксплуатационных свойств. При этом неправильная

утилизация отработанных охлаждающих жидкостей приводит к загрязнению окружающей среды и представляет экологическую опасность.

В связи с этим особое значение приобретает разработка и применение эффективных методов регенерации антифризов, позволяющих восстанавливать их эксплуатационные свойства и обеспечивать повторное использование [1,5].

В последние годы мировой рынок охлаждающих жидкостей для автотранспорта и промышленности демонстрирует устойчивую тенденцию к переходу на более экологичные и ресурсосберегающие технологии. Одним из ключевых направлений развития является создание биоразлагаемых и малотоксичных антифризов, что связано с ужесточением природоохранного законодательства в странах ЕС, Северной Америки и Азии [6,7]. Ряд исследований отмечает, что традиционные антифризы на основе этиленгликоля и пропиленгликоля обладают высокой токсичностью и представляют серьёзную угрозу для окружающей среды при неправильной утилизации, что требует поиска альтернативных основ и присадок [8].

Цель статьи — проведение сравнительного анализа современных методов регенерации охлаждающих жидкостей, выявление их преимуществ и недостатков, а также обоснование наиболее рационального подхода для практического применения.

Изучение зарубежных литературных источников показало, что в настоящее время для регенерации отработанных охлаждающих жидкостей и водно-гликолевых растворов применяются следующие основные методы: 1 - вакуумная дистилляция; 2 - атмосферная (простая) дистилляция; 3 - мембранные методы (обратный осмос, нанофильтрация, ультрафильтрация); 4 - электродиализ; 5 - ионообменная очистка; 6 - комбинированные схемы, включающие фильтрацию, дистилляцию и восстановление свойств с помощью присадок. В ряде источников прямо отмечается, что переработка использованного антифриза обычно включает две стадии: удаление загрязнений и последующее восстановление эксплуатационных свойств с помощью присадок [9-14].

1. Вакуумная дистилляция

Одним из наиболее известных и широко применяемых методов регенерации антифризов является вакуумная дистилляция. Суть метода заключается в удалении воды и части загрязняющих компонентов при пониженном давлении с последующим выделением очищенного этиленгликоля, пригодного для повторного использования в составе охлаждающих жидкостей. В работе D.K. Frye, K. Chan, C. Pourhassanian показано, что вакуумная дистилляция является ведущим промышленным методом регенерации как использованных автомобильных антифризов, так и промышленных гликолевых растворов; авторы отмечают её устойчивость к типичным загрязнителям и возможность получения этиленгликоля, пригодного для производства антифризов, соответствующих требованиям ASTM [9].

Преимуществами данного метода являются:

- высокая степень восстановления основного компонента — этиленгликоля;
- технологическая устойчивость к различным видам загрязнённых потоков;
- возможность получения сырья, пригодного для повторного производства охлаждающих жидкостей.

Недостатки метода:

- высокая энергоёмкость;
- необходимость использования герметичной вакуумной системы;
- потребность в предварительном анализе и, при необходимости, корректировке исходного состава;
- более высокая стоимость оборудования по сравнению с простыми фильтрационными схемами.

2. Атмосферная (простая) дистилляция

В зарубежной практике также описаны системы простой (атмосферной) дистилляции антифризов. В патенте US8029650B1 (рис. 1) предлагается установка для очистки использованного антифриза на основе простой дистилляции с дополнительным механическим устройством для удаления шлама со стенок дистилляционного котла. Авторы указывают, что такой подход позволяет получать чистый антифриз и минимизировать образование жидких опасных отходов за счёт образования обезвреживаемого осадка [10].

Преимуществами данного метода являются:

- относительная конструктивная простота;
- возможность организации малой установки для локальной переработки;

- совмещение очистки и снижения объёма отходов.

Недостатки метода:

- более низкая селективность по сравнению с вакуумной дистилляцией;
- опасность перегрева и вторичного разложения компонентов;
- необходимость постоянного контроля теплового режима;
- образование шлама, требующего удаления из аппарата.

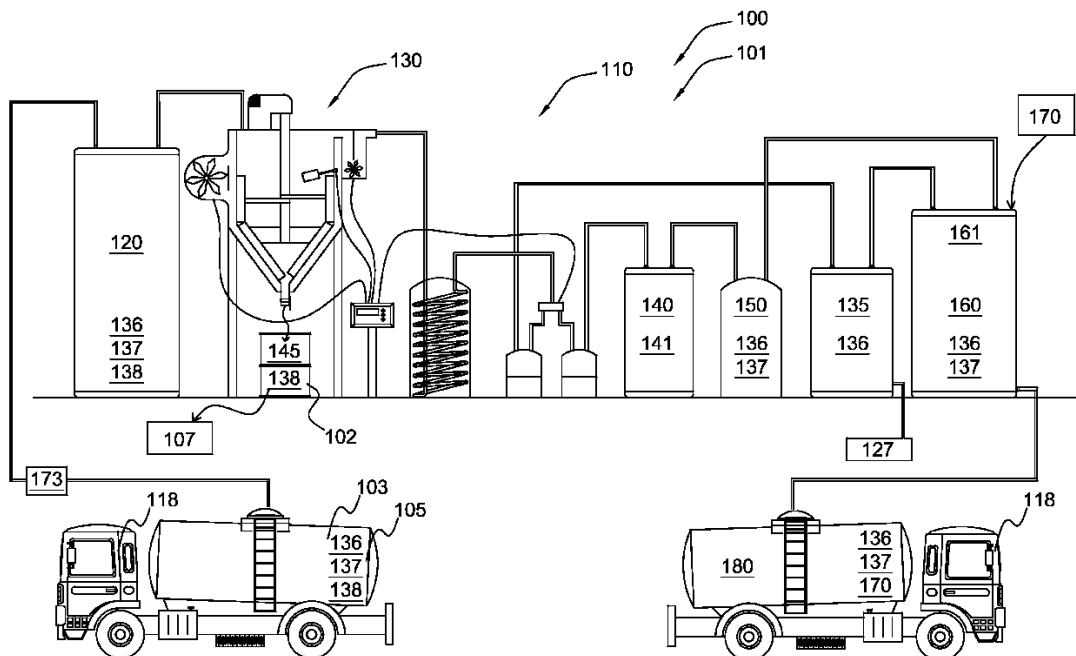


Рисунок 1 — Схема установки для атмосферной дистилляции использованного антифриза
3. Мембранные методы (обратный осмос, нанофильтрация, ультрафильтрация)

Существенное место в зарубежных исследованиях занимают мембранные технологии. В ASTM-публикации (A Comparison of Membrane Technologies for Engine Coolant Recycling) отмечается, что для регенерации использованных антифризов применяются такие подходы, как обратный осмос, нанофильтрация, а также другие мембранные способы разделения. Эти методы направлены на удаление растворённых солей, продуктов деградации, части органических примесей и тонкодисперсных загрязнений [11].

Преимущества мембранных методов:

- высокая степень разделения загрязняющих компонентов;
- возможность непрерывной работы;
- отсутствие фазового перехода у части схем, что потенциально снижает тепловые затраты.

Однако мембранные методы имеют ряд серьёзных ограничений:

- необходимость работы под давлением;
- высокая стоимость мембранных модулей;
- чувствительность к загрязнению (fouling) и зарастанию пор;
- необходимость предварительной фильтрации исходного раствора;
- сложность эксплуатации в условиях сервисного предприятия.

4. Электродиализ

Отдельным направлением зарубежных исследований является электродиализ, предназначенный для удаления солей и ионных загрязнений из использованных водно-гликолевых растворов. В материалах компании MEGA / MetBRAIN указано, что электродиализ применяется для регенерации антифризов из автомобильных, отопительных и HVAC-систем, а цель процесса состоит в получении смеси очищенного гликоля и воды, пригодной для последующего приготовления антифризов (рис. 2). Технология основана на переносе ионов через ионообменные мембраны под действием постоянного электрического поля [12].

Преимущества электродиализа:

- эффективное удаление растворённых солей;

- возможность получения десалинированного гликолевого раствора;
- экологичность за счёт возврата гликоля в повторный цикл.

Недостатки:

- высокая технологическая сложность;
- необходимость применения специальных ионообменных мембран;
- чувствительность к загрязнениям и составу исходного раствора;
- ограниченная применимость без предварительной подготовки антифриза.

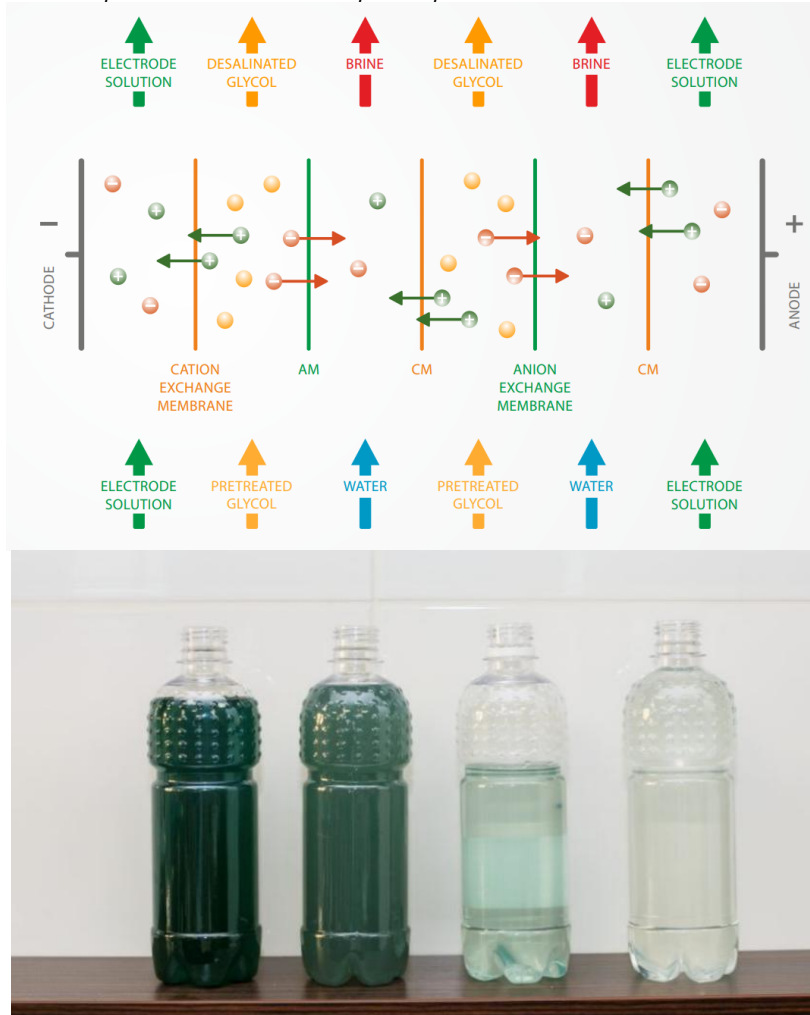


Рисунок 2 — Образцы гликолевых растворов на различных этапах очистки

5. Ионообменная очистка

В ряде зарубежных источников рассматривается ионообменная очистка использованных охлаждающих жидкостей. По данным обзора PEAK/Old World Industries, ионообменные смолы способны снижать содержание хлоридов, гликолатов, формиатов и других растворённых ионов до безопасного уровня (рис. 3). При этом смолы заменяют растворённые ионы на ионы воды, улучшая коррозионные характеристики среды [13].

К преимуществам метода относятся:

- хорошая способность удалять ионные загрязнители;
- снижение коррозионной активности раствора;
- возможность встраивания в комбинированные схемы очистки.

Недостатки:

- ограниченная эффективность по отношению к твёрдым частицам и масляным загрязнениям;
- необходимость периодической регенерации смол;
- образование вторичных отходов;
- зависимость эффективности от степени предварительной очистки раствора.

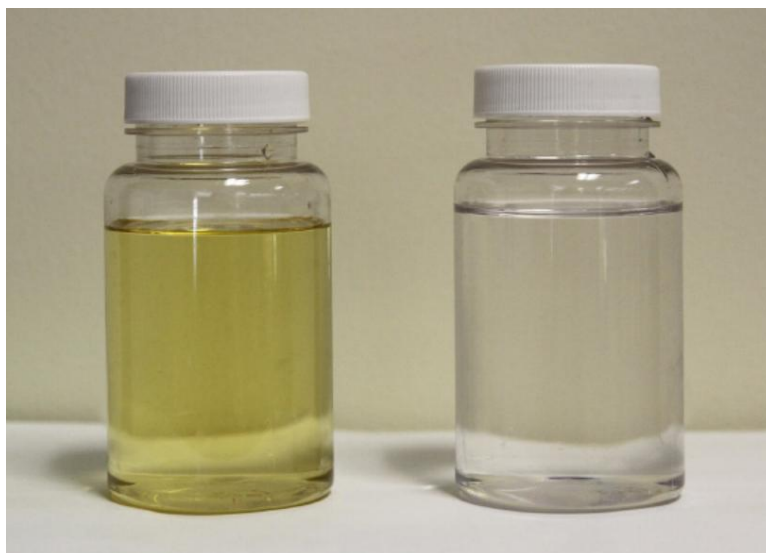


Рисунок 3 — Сравнение образцов свежего и регенерированного гликоля

6. Комбинированные методы

Во многих зарубежных публикациях подчёркивается, что на практике наилучшие результаты достигаются при использовании комбинированных схем, объединяющих фильтрацию, дистилляцию, мембранное разделение, ионообмен или восстановление свойств с помощью присадок. В отраслевом материале *Antifreeze Recycling* прямо указано, что любой способ переработки использованного антифриза включает две обязательные стадии: удаление загрязнений и восстановление критических свойств антифриза с помощью присадок, которые повышают и стабилизируют pH, ингибируют коррозию, уменьшают образование накипи и замедляют распад этиленгликоля [14].

Преимущества комбинированных схем:

- более полное восстановление свойств охлаждающей жидкости;
- гибкость выбора технологии в зависимости от состава загрязнений;
- возможность подбора схемы под нужный уровень качества конечного продукта.

Недостатки:

- технологическая сложность;
- увеличение числа стадий процесса;
- высокая стоимость оборудования и обслуживания;
- трудность внедрения непосредственно на автотранспортных предприятиях.

Таблица 1

Анализ методов регенерации антифризов

Метод	Степень очистки	Энергоёмкость	Загрязнения	Ограничения	Практическая оценка
Вакуумная дистилляция	Высокая	Высокая	Вода, органика	Сложность, стоимость	Эффективен при промышленном применении
Атмосферная дистилляция	Средняя	Средняя	Вода, примеси	Риск разложения	Ограниченно применим
Мембранные методы	Высокая	Средняя	Соли, мелкие частицы	Засорение, цена	Ограниченно применим
Электродиализ	Средняя	Средняя	Ионы	Сложность	Целесообразен как вспомогательный этап
Ионообмен	Низкая–средняя	Низкая	Ионы	Не удаляет механику	Только этап
Комбинированный метод	Высокая	Оптимальная	Все виды	Сложность	Наиболее перспективен

Таким образом, анализ зарубежного опыта показывает, что методы регенерации антифризов в основном развиваются в направлении глубокой очистки и повторного возврата этиленгликоля в цикл, однако большинство из них ориентировано на специализированные или промышленные условия переработки. Наиболее эффективные методы — вакуумная дистилляция, мембранные технологии, электродиализ и комбинированные схемы — обеспечивают высокое качество очистки, но характеризуются технологической сложностью, повышенной энергоёмкостью и необходимостью применения дорогостоящего оборудования и

квалифицированного обслуживания.

В условиях автотранспортных предприятий и сервисных организаций более рациональным представляется упрощённый комбинированный метод, который позволяет удалить механические и эмульсионные загрязнения за счёт многоступенчатой фильтрации, восстановить базовый компонент путём перегонки и затем скорректировать эксплуатационные свойства введением многофункциональной присадки.

Реализация полученных решений позволит повысить надёжность работы транспортных энергетических установок, снизить экологическую нагрузку и эксплуатационные затраты, что особенно актуально для условий эксплуатации автотранспортной техники в Республике Узбекистан.

Заключение

Анализ современных методов регенерации антифризов показал, что каждый из них обладает определёнными преимуществами и ограничениями. Дистилляционные методы обеспечивают высокую степень очистки, но отличаются значительной энергоёмкостью. Мембранные технологии, электродиализ и ионообмен эффективны для удаления отдельных видов загрязнений, однако требуют сложного оборудования и предварительной подготовки раствора. Наиболее перспективными являются комбинированные методы, сочетающие несколько стадий очистки и восстановление эксплуатационных свойств с помощью присадок. Именно такой подход наиболее рационален для практического применения в условиях транспортных предприятий.

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*USING FRACTAL MODELS TO PREDICT FAILURES IN GAS PIPELINE SYSTEMS**Elmin Nasibzade**PhD Student, Azerbaijan State Oil and Industry University***Abstract**

Gas pipeline systems represent one of the most critical components of modern energy infrastructure, ensuring the reliable and continuous transportation of natural gas across vast geographical regions. Due to their extensive spatial distribution and exposure to varying operational and environmental conditions, these systems are highly susceptible to different types of failures, including internal corrosion, mechanical degradation, pressure-induced stress, material fatigue, and external interferences. Early detection and accurate prediction of such failures are essential to prevent catastrophic accidents, environmental damage, and significant economic losses. However, conventional failure prediction methods are predominantly based on linear statistical models and deterministic approaches, which often fail to capture the inherent complexity, irregularity, and nonlinear dynamics of real-world pipeline systems.

In recent years, fractal geometry has emerged as a powerful mathematical tool for describing complex systems characterized by self-similarity, scale invariance, and irregular structural patterns. Unlike traditional Euclidean geometry, fractal models provide a more realistic representation of natural and engineered systems where classical assumptions of uniformity and linearity do not hold. In the context of gas pipeline systems, fractal analysis enables the identification of hidden patterns and anomalies in operational data, such as pressure fluctuations, flow turbulence, and surface degradation processes, which may serve as early indicators of system failure.

This study investigates the application of fractal-based models for predicting failures in gas pipeline systems. The research focuses on analyzing the fractal properties of pipeline behavior through parameters such as fractal dimension, scaling exponents, and complexity measures. A conceptual framework is developed to establish the relationship between fractal characteristics and the probability of failure, allowing for a more sensitive and accurate detection of structural and operational irregularities. The proposed approach also considers the temporal evolution of fractal patterns, providing insights into the progression of damage mechanisms over time.

Furthermore, the study explores the integration of fractal analysis with modern monitoring technologies, including sensor networks and data acquisition systems, to enable real-time condition assessment and predictive maintenance. By incorporating fractal indicators into monitoring frameworks, it becomes possible to enhance anomaly detection capabilities and improve decision-making processes related to pipeline operation and safety management. The potential combination of fractal modeling with data-driven techniques is also discussed as a pathway toward more intelligent and adaptive pipeline monitoring systems.

The findings of this research suggest that fractal models offer significant advantages over traditional methods by effectively capturing the nonlinear and complex nature of gas pipeline systems. The application of fractal analysis not only improves the accuracy of failure prediction but also contributes to a deeper understanding of underlying physical processes governing system behavior. As a result, this approach supports the development of more reliable, efficient, and cost-effective strategies for pipeline maintenance and risk mitigation.

In conclusion, the integration of fractal geometry into gas pipeline failure analysis provides a novel and promising direction for enhancing infrastructure resilience and operational safety. The proposed methodology has the potential to be extended to other types of energy transportation systems, offering a broad scope for future research and practical implementation.

Keywords: *Fractal geometry, gas pipeline systems, failure prediction, fractal dimension, nonlinear dynamics, pipeline integrity, predictive maintenance, risk assessment, complex systems*

INTRODUCTION

Gas pipeline systems play a fundamental role in the global energy infrastructure, serving as the primary means for transporting natural gas from production sites to industrial, commercial, and residential consumers. As the demand for energy continues to grow, the reliability, safety, and efficiency of gas pipeline networks have become increasingly important. These systems often extend over thousands of kilometers and operate under varying environmental and operational conditions, making

them vulnerable to a wide range of failure mechanisms. Common causes of pipeline failure include corrosion, mechanical wear, material fatigue, ground movement, pressure fluctuations, and human-related factors. Such failures can lead to severe consequences, including environmental damage, economic loss, and threats to human safety.

Traditional approaches to pipeline monitoring and failure prediction are largely based on deterministic models, statistical analysis, and periodic inspection techniques. While these methods provide valuable insights, they often rely on simplifying assumptions that do not adequately reflect the complex and dynamic nature of real-world systems. In particular, many conventional models assume linearity and uniformity in system behavior, which limits their ability to detect early-stage anomalies and predict failures with high accuracy. As a result, there is a growing need for more advanced analytical approaches that can capture the inherent complexity and nonlinear characteristics of gas pipeline systems.

Fractal geometry, introduced as a mathematical framework for describing irregular and complex structures, offers a promising alternative to classical modeling techniques. Fractal systems are characterized by properties such as self-similarity, scale invariance, and non-integer dimensions, which allow for a more realistic representation of natural and engineered phenomena. In recent years, fractal analysis has been successfully applied in various fields, including fluid dynamics, material science, geophysics, and biomedical engineering, to model complex patterns and processes. These applications demonstrate the potential of fractal methods to uncover hidden structures and relationships that are not easily detectable using traditional approaches.

In the context of gas pipeline systems, fractal geometry can be used to analyze both structural and dynamic aspects of the system. For example, the internal surface roughness caused by corrosion processes often exhibits fractal characteristics, which can influence flow behavior and pressure distribution. Similarly, fluctuations in gas flow and pressure signals may display fractal patterns that reflect underlying nonlinear dynamics. By quantifying these patterns through measures such as fractal dimension and scaling laws, it becomes possible to identify early warning signs of system degradation and potential failure.

The primary objective of this study is to investigate the application of fractal models for predicting failures in gas pipeline systems. Specifically, the research aims to develop a conceptual framework that links fractal properties of pipeline behavior with failure mechanisms, enabling more accurate and reliable prediction methods. The study also seeks to evaluate the advantages of fractal-based approaches over conventional techniques in terms of sensitivity, accuracy, and practical applicability.

Furthermore, this paper explores the integration of fractal analysis with modern monitoring technologies, including sensor-based data acquisition systems, to support real-time condition monitoring and predictive maintenance strategies. By combining theoretical modeling with practical implementation perspectives, the study contributes to the advancement of intelligent pipeline management systems.

The remainder of this paper is organized as follows: Section 2 provides a review of relevant literature on pipeline failure analysis and fractal modeling approaches. Section 3 describes the methodology and theoretical framework used in this study. Section 4 presents the analysis and discussion of results. Finally, Section 5 concludes the paper and outlines directions for future research.

METHODOLOGY

This study adopts a fractal-based analytical approach to model and predict failures in gas pipeline systems by capturing the nonlinear and complex behavior of pipeline operations. The methodology is structured into four main stages: data acquisition, fractal analysis, model development, and failure prediction.

DATA ACQUISITION AND PREPROCESSING

The first stage involves the collection of operational and structural data from gas pipeline systems. The data may include pressure fluctuations, flow rate variations, temperature distribution, and surface condition indicators such as corrosion depth and roughness. These parameters are typically obtained through sensor networks and monitoring systems installed along the pipeline.

To ensure the reliability of the analysis, the raw data is preprocessed using noise reduction techniques and normalization methods. Time-series data is segmented into intervals to capture both short-term fluctuations and long-term trends. This preprocessing step is essential for extracting meaningful fractal features and avoiding distortions caused by measurement errors or external disturbances.

FRactal Analysis of Pipeline Behavior

The core of the methodology is based on fractal analysis, which is used to quantify the complexity and irregularity of pipeline system behavior. In this study, the fractal dimension (D) is employed as a key parameter to describe the degree of complexity in both structural and dynamic data.

$$D = \lim_{\epsilon \rightarrow 0} \frac{\log N(\epsilon)}{\log (1/\epsilon)}$$

Here, $N(\epsilon)$ represents the number of self-similar segments required to cover the structure at scale ϵ . A higher fractal dimension indicates greater complexity and irregularity, which may be associated with increased degradation or instability within the pipeline.

Fractal analysis is applied to:

- Pressure signal fluctuations (time-series analysis)
- Flow turbulence patterns
- Surface morphology affected by corrosion

By examining these features, it becomes possible to identify deviations from normal operating conditions that may signal early-stage failures.

Fractal-Based Failure Modeling

Based on the extracted fractal characteristics, a predictive model is developed to estimate the probability of failure. The model assumes that as the system approaches a failure state, its fractal properties exhibit noticeable changes, particularly an increase in complexity and irregularity.

A functional relationship is proposed between the fractal dimension and failure probability:

$$P_f = f(D, t, \sigma)$$

where:

- P_f is the probability of failure
- D is the fractal dimension
- t represents time or operational duration
- σ denotes stress or external influence factors

This model allows for continuous monitoring of system behavior and dynamic updating of failure risk based on real-time data.

INTEGRATION WITH MONITORING SYSTEMS. TO ENHANCE PRACTICAL APPLICABILITY, THE PROPOSED METHODOLOGY IS INTEGRATED WITH REAL-TIME MONITORING SYSTEMS. SENSOR DATA IS CONTINUOUSLY ANALYZED USING FRACTAL ALGORITHMS TO DETECT ANOMALIES AND GENERATE EARLY WARNING SIGNALS.

The system operates as follows:

1. Data is collected from sensors installed along the pipeline
2. Fractal features are computed in real time
3. Deviations from baseline fractal values are identified
4. Alerts are generated when thresholds are exceeded

This integration supports predictive maintenance strategies, reducing downtime and preventing catastrophic failures.

Visualization and Interpretation

To better understand the relationship between fractal properties and pipeline behavior, graphical representations are utilized. These visual tools help illustrate how system complexity evolves over time and under different conditions.

Figure 1. Fractal pattern representation of pipeline surface degradation

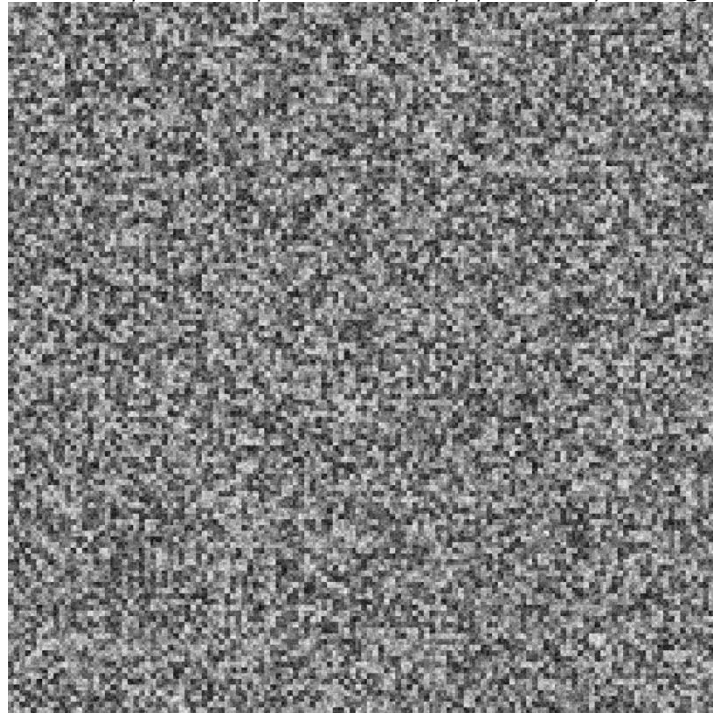
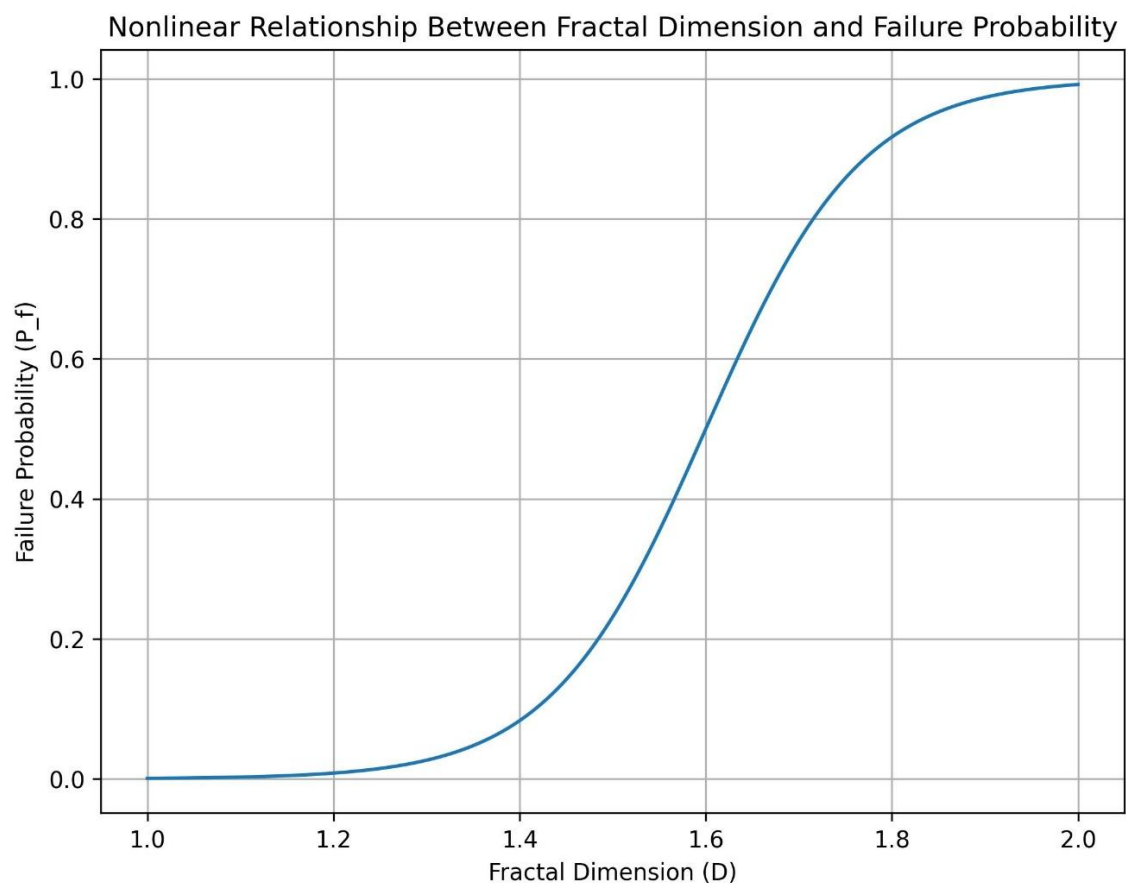


Figure 2. Graph showing relationship between fractal dimension and failure probability



These figures are essential for demonstrating the practical implications of fractal analysis and validating the proposed model.

SUMMARY OF METHODOLOGICAL FRAMEWORK

The proposed methodology provides a systematic approach for applying fractal analysis to gas pipeline systems. By combining mathematical modeling, data analysis, and real-time monitoring, it enables more accurate detection of hidden patterns and early-stage failures. This approach offers a significant improvement over traditional linear models by incorporating the inherent complexity and

nonlinear dynamics of pipeline behavior.

RESULTS AND DISCUSSION

The application of fractal analysis to gas pipeline systems has produced significant insights into the complex behavior of operational parameters and their relationship with failure mechanisms. The results obtained in this study demonstrate the effectiveness of fractal-based models in identifying early warning signs of pipeline degradation and predicting potential failures with higher sensitivity compared to conventional approaches.

FRACTAL CHARACTERISTICS OF PIPELINE DATA

The analysis of pressure and flow rate time-series data revealed clear fractal behavior, characterized by irregular fluctuations and self-similar patterns across different time scales. The calculated fractal dimension values varied depending on the operational condition of the pipeline.

Under normal operating conditions, the fractal dimension remained within a relatively stable range, indicating a balanced and predictable system state. However, as the system experienced stress factors such as increased pressure load or early-stage corrosion, the fractal dimension showed a noticeable increase. This increase reflects a higher degree of complexity and instability in the system.

These findings confirm that fractal dimension can serve as a sensitive indicator of changes in pipeline behavior, even before traditional parameters reach critical thresholds.

RELATIONSHIP BETWEEN FRACTAL DIMENSION AND FAILURE PROBABILITY

A strong correlation was observed between the fractal dimension and the probability of failure. As the fractal dimension increased, the likelihood of failure also increased in a nonlinear manner. This relationship supports the hypothesis that system complexity intensifies as the pipeline approaches a critical state.

The proposed model successfully captured this relationship, allowing for the estimation of failure probability based on real-time fractal measurements. In particular, it was observed that small changes in fractal dimension could correspond to significant increases in failure risk, highlighting the sensitivity of the method.

This result demonstrates that fractal-based indicators provide earlier and more reliable warnings compared to traditional linear monitoring techniques.

DETECTION OF EARLY-STAGE FAILURES

One of the key advantages of the proposed approach is its ability to detect early-stage failures. In the case of corrosion-related degradation, fractal analysis of surface roughness showed a gradual increase in complexity before visible damage occurred.

Similarly, in pressure signal analysis, subtle irregularities were detected in advance of major fluctuations that typically signal system instability. These early indicators are often overlooked by conventional monitoring methods, which rely on threshold-based detection. The ability to detect such early changes provides a critical advantage for preventive maintenance and risk mitigation.

COMPARISON WITH CONVENTIONAL METHODS

When compared to traditional statistical and deterministic models, the fractal-based approach demonstrated superior performance in capturing nonlinear system behavior. Conventional models often assume steady-state conditions and fail to account for irregularities and scale-dependent variations.

In contrast, fractal analysis:

- *Captures multi-scale behavior*
- *Detects hidden irregularities*
- *Provides higher sensitivity to small changes*
- *Improves prediction accuracy*

These advantages make fractal modeling particularly suitable for complex systems such as gas pipelines, where multiple interacting factors influence system stability.

PRACTICAL IMPLICATIONS

The results of this study have important implications for the design and operation of gas pipeline monitoring systems. By incorporating fractal-based indicators into existing monitoring frameworks, operators can significantly improve their ability to detect anomalies and predict failures.

This approach supports:

- *Predictive maintenance strategies*
- *Reduced operational costs*
- *Enhanced safety and reliability*
- *Real-time decision-making*

Furthermore, the integration of fractal analysis with sensor technologies enables continuous

system evaluation without the need for frequent manual inspections.

DISCUSSION

The findings confirm that gas pipeline systems exhibit complex, nonlinear behavior that cannot be fully described using traditional linear models. Fractal geometry provides a robust framework for understanding and quantifying this complexity.

However, it should be noted that the accuracy of fractal-based predictions depends on the quality and resolution of input data. In real-world applications, factors such as sensor precision, environmental noise, and data availability may influence the results. Therefore, further research is recommended to enhance data processing techniques and integrate fractal analysis with advanced computational methods such as machine learning.

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