



*XXI international scientific conference
Madrid. Spain
11-12.11.2025*

MODERN SCIENCE: THEORETICAL AND PRACTICAL VIEW

*Proceedings of the XXI International
Scientific and Practical Conference
11-12 November 2025*

MADRID. SPAIN
2025

UDC 001.1
BBC 1

XXI International Scientific and Practical Conference «Modern science: theoretical and practical view», November 11-12, 2025, Madrid. Spain. 96 p.

ISBN 978-91-65424-46-3

DOI <https://doi.org/10.5281/zenodo.17709292>

Publisher: «SC. Scientific conferences»

Main organization: **artmedia²⁴**

Editor: Hans Muller

Layout: Ellen Schwimmer

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The sample of the citation for publication is Yusifov E.M., Niftaliyev V.R. CLUSTER AS A MODERN INSTRUMENT FOR INCREASING COMPETITIVENESS OF THE ECONOMY // XX International Scientific and Practical Conference «Modern science: theoretical and practical view», November 11-12, 2025, Madrid. Spain. Pp.8-11, URL: <https://sconferences.com>

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Content

Agricultural sciences

- Shainidze O., Beridze N., Lamparadze Sh., Lominadze Sh., Alasania N., Ebralidze L.* 3
MAIN PATHOGEN OF PEAR (PYRUS COMUNIS L.) AND THEIR CONTROL IN ADJARADJARA, GEORGIA

Economic sciences

- Alakbarov Rasul Safar oglu* 11
EFFICIENCY OF AN EXPORT-ORIENTED ECONOMY (IN THE NAKHCHIVAN MODEL)

Historical sciences

- Otar Nikoleishvili* 16
FROM THE HISTORY OF GEORGIAN STRUGGLE AGAINST RUSSIAN COLONIAL POLICY IN THE XIX CENTURY
Aghayeva Sevda Aydin 20
YEAR OF THE CONSTITUTION AND SOVEREIGNTY KONSTITUSIYA VƏ SUVERENLIK ILI

Jurisprudence

- Zhala Ganbarova* 26
THE IMPORTANCE OF THE COUNCIL OF EUROPE CONVENTION AGAINST TRAFFICKING IN HUMAN ORGANS

Medical sciences

- Dorina Ruci, Entela Shkodrani, Vasilika Gjika, Vilson Ruci, Krisli Serani* 31
SARCOPENIA IN RHEUMATOID ARTHRITIS
Emiljano Pjetri, Zojë Curri 32
NURSING CARE DURING BREASTFEEDING- LITERATURE REVIEW
Entela Shkodrani, Alert Xhaja, Dorina Ruci, Barbara Shkodrani 40
DERMOSCOPIIC CRITERIA OF CUTANEOUS METASTASES OF MALIGNANT MELANOMA – CASE REPORT

Pedagogical sciences

- Bauyrzhankyzy Zhaniya, Zhumash Zhanerke, Baines Sholpan Borantaikyzy* 41
THE USE OF LEXICAL GAMES IN ENGLISH LESSONS AT THE PRIMARY STAGE OF SECONDARY SCHOOL
Süleymanov M.T., Bayramova Ü.B. 44
THE CONDITIONS, PRINCIPLES, AND STAGES OF THE FORMATION OF THE SELF-ANALYSIS ACTIVITY OF SENIOR HIGH SCHOOL STUDENTS
Nassipkaliyeva Amilya Muratovna 47
APPLYING THE CONSTRUCTIVIST APPROACH IN TEACHING THE HISTORY OF KAZAKHSTAN: EXPERIENCE IN DEVELOPING AN INTERACTIVE MULTIMEDIA WEB RESOURCE
Sarbagys Aruzhan, Halit Yilmaz, Gulmira Bekenova 60
VIRTUAL LABORATORY - MODERN TECHNOLOGIES FOR DEVELOPING EXPERIMENTAL SKILLS IN SCHOOL CHILDREN

Philological sciences

- Leyla Vezirova* 73
PREPARATION AND PRESENTATION OF A PROJECT IN BUSINESS COMMUNICATION

Physical sciences

- Nataliya Dokukova, Pavel Konon* 76
DYNAMIC LAW OF DISPLACEMENTS ELASTIC BEAM MIDLINE POINTS CONSIDERING INTERNAL FRICTION IN MATERIAL STRUCTURE

Technical sciences

- Alzhanov Alisher* 81
THE ROLE AND IMPORTANCE OF STANDARDIZATION IN OPTIMIZING ENTERPRISE OPERATIONS
Amangeldy Farhad, Oksikbay Nurdaulet, Orazgaliev Duman, Kauymbaev Rakhimzhan 91
PROBLEMS AND TASKS IN THE FIELD OF STANDARDIZATION AT THE PRESENT STAGE
Kateryna Oleksiivna Sysak, Rubinskyi Mykhailo Mykhailovych 94
ENVIRONMENTAL PROTECTION OF THE TERRITORIES UNDER THE EXAMPLE OF PRYCARPATHIAN REGION

Agricultural sciences

MAIN PATHOGEN OF PEAR (*PYRUS COMUNIS L.*) AND THEIR CONTROL IN ADJARA, GEORGIA

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Abstract

During 2024 and 2025, research was carried out at the Plant Protection Laboratory of Batumi State University and in gardens apple the of Adjara, Georgia. The main objective of this study was to identify and determine the main pathogens of pear and their Control. Fungal cultures identification was based on macroscopic characteristics like colony morphology, colour, texture, shape and appearance were observed on potato dextrose agar (PDA) and microscopic characteristics like conidia shape, hyphen colour, concentric zone, and pigmentation. On the pear, 34 species of microbionts, including 4 view bacteria and 30 fungi were identified as a result of phytopathological and mycological studies conducted in different places of agrocenosis in Georgia. The results of studies have shown that among the detected mycobionts on apple the most dangerous and harmful species are: *Venturia inaequalis*, *Monilia fructigena*, *Gymnosporangium fuscum*, and *Erwinia amylovora*. These pathogenic microbionts species associated with pear fruits spoilage are of economical significance. Here we review some these diseases of pear and their management.

Keywords: Pear, Rust, Scab, Fruit rot, Fire blight, Disease cycle, Symptoms, Control

Introduction

Continental fruit growing, including pears are considered the most important economic fruit crops in the world. Pear is genetically quite diverse, with considerable variability in morphology and physiological adaptations (Knight 1963, Westwood 1982, Lombard and Westwood 1987, Bell et al. 1996). Unfortunately, several pathogens causing diseases in pear result in serious losses in terms of quality and quantity. Diseases of Pear occurs in including North and South America, Australia, New Zealand, South Africa, Japan, Israel, Georgia et al. (Spotts and Castagnoli, 2010). The pathogens can attack all known European pear varieties and cause serious disease in 'Anjou', 'Bosc', 'Bartlett', 'Comice', 'Winter Nelis', and 'Forelle'. Pear fruit is susceptible primarily early in the growing season, but pinpoint diseases may occur throughout the growing season (Gubler et al., 2007).

Pear disease is caused by the fungus *Venturia pirina* Aderhold, also known as *Venturia nashicola* Tanaka & Yamamoto—anamorph *Fusicladium pyrorum* (Lib.) Fuckel. On leaves and fruits, the disease appears as olive green to dark brown to black, velvety circular spots (lesions) that consist of sporulating mycelia growing under the epidermis. Although it causes tree damage, pear scab's main impact is Pear scab, a fungal disease closely related to apple scab, is neither as common nor as economically important

on pears as apple scab is on apples. Nevertheless, it can cause economic damage by marring the appearance the loss of fruit quality (Spotts and Castagnoli, 2010; Won et al., 2014). When very young fruits are attacked, they drop from the tree or become either misshapen or badly scabbed. Later infections may be more numerous, but the spots are generally smaller. As the lesions age on fruit, the velvety look disappears and infected areas become cracked and corky (Spotts and Castagnoli, 2010).

Pear blight is widespread on pears almost all over the world

The causal pathogen is *Erwinia amylovora*, a Gram-negative bacterium in the genus *Erwinia*, order *Enterobacterales*. Experiments in the early 1800s demonstrated that *E. amylovora* caused disease in plants, the first time that this could be shown. *E. amylovora* was found by Fritz Klement, a German scientist in 1910. It is generally accepted that this destructive crop bacterium initially originated in North America. Today, *E. amylovora* can currently be found in all the provinces of Canada, as well as in some parts of the United States of America, including Alabama, California, Colorado, Connecticut, Georgia, Illinois, Maine, Maryland, Massachusetts, Michigan, New York, North Carolina, Ohio, Oregon, Pennsylvania, Texas, Utah, Virginia, Washington, West Virginia and Wisconsin. In the Americas it also occurs in other countries including, but not limited to, Mexico and Bermuda. On the African continent, *E. amylovora* has been confirmed in Egypt (Beeret al., 1977; Boucheret al., 2021; Norelli et al., 2003; Thomson, 1986; Vrancken et al., 2013)

Among the registered pear diseases in Adjara (Shainidze, 2013) it is widespread *Venturia inaequalis*, *Monilia fructigena*, *Gymnosporangium fuscum*, *Erwinia amylovora* et al. Therefore, our attention will be focused on these diseases.

Materials and Methods

Collection of samples: Study was conducted from March 2023 to December 2024 in Laboratory Plant Protection Laboratory of Batumi State University, and field studies In subtropical and mountainous Adjara, Georgia.

Sampling location: The objects of research were various varieties of *Malus* plants, pathogenic bacteria and fungi inhabited on them in agrocenoses of the subtropical and mountainous Adjara, Georgia.. The materials were collected and analyzed (dissemination and development of diseases) by using the well-known methods (Foster et al., 2004). The symptoms such as rot, mummification, wilting, spotting, necrosis, mold, galls, canker, deformation, chlorosis, mosaic, etc., were recorded.

Isolation of fungi: For isolation of fungi from apple plants, the agar method was applied. Fungal pathogens responsible for disease were isolated from fruit. From the samples obtained, serial dilutions (1:10) were prepared in test tubes with 9 ml sterile water, adding 1 g of fruit samples until dilutions 10⁻⁵, 10⁻⁶ and 10⁻⁷, of which 50 µL and shaken at 200 rpm for 3 hours. Samples collected were seeded by duplicate through diffusion technique on Petri dishes of 90 mm diameter containing one of the following artificial Potato Dextrose Agar (PDA) and Czapeck's agar medium. After incubation (23°C for 6 days) the number for each fungi was calculated. All fungi were cultured using a single spore technique on PDA and Czapeck's medium. After incubation, fungi were identified by their macroscopic and microscopic characteristics

Identification of fungi: Fungal cultures identification was based on macroscopic characteristics like colony morphology, color, texture, shape and appearance were observed on potato dextrose agar (PDA) and microscopic characteristics like conidia shape, hyphae color, concentric zone, and pigmentation. Species identification was based on the morphological characteristics of single-spored isolates as described (Domsch, 1993; Navi et al., 1999; Watanabe, 2000). Collections of the fungi have been examined by standard light microscopy (Pereval, Carl Zeiss, Jena and Olympus, BX50, Hamburg, Germany). The SEM micrographs have been prepared by means of a JSM-35 (Japan) SEM microscope. The specimens examined are deposited at HAL, KW and TGM (Holmgren et al., 1990).

Data collected

Disease severity was recorded by using 0-5 visual diseases scoring scale stated by (Sharma, 1986).

Where; 0 = no symptoms (healthy), 1 = slight, less than 5% of leaves affected, 2 = moderate, 5-20% of leaves affected, some yellowing, little or no defoliation, 3 = extensive, 20-50% of leaves affected, significant defoliation, 4 = heavy, 50-80% of leaves affected, severe defoliation and 5 = extreme, 80-100% leaves affected, complete or near complete defoliation.

XIII Damage/severity of fruits were rated by 0-3 scale and average percentage respectively for each were; 0 = no symptom (healthy), 1 = slight (less than 5% of fruits affected), 2 = moderate (5-20% of fruits affected, some yellowing, little or no defoliation), 3 = extensive damage (20-50% of fruits affected) (Fetena and Lemma, 2014). Secondly, a semi-structured questionnaire was developed to collect data on apple tree management and awareness of farmers on occurrence of diseases and insect pests and their

control methods. Respondents were interviewed by trained enumerators with supervision of the research team.

$$\text{INTERNATIONDisease Severity (\%)} = \frac{\text{Area of Diseased Tissue}}{\text{Total Tissue Area}} \times 100$$

The severity grades were converted into percentage severity index (PSI).

$$\text{PSI} = \frac{\text{Sum of numerical ratings}}{\text{No. of plants scored} \times \text{maximum disease score on scale}} \times 100$$

The relative disease severity reduction on untreated and treated plots of the treatment combination was calculated as follows.

$$\text{Relative disease severity reduction (\%)} = \frac{\text{untreated} - \text{treated}}{\text{untreated}} \times 100$$

Data Analysis: Data were analyzed following a procedure appropriate to the design of the experiment as described by Gomez and Gomez (1984) and logistic model and, general linear model (GLM) of SAS version 9.2 (SAS, 2009). The treatment means were separated using the least significant difference (LSD) test at 5% probability level. Correlation and regression analysis was used to determine the relationships between growth, yield and yield related traits, and disease severity and AUDPC across the treatments. It was performed to determine the association of disease parameters with yield obtained from the different fungicide schedules.

Results

As a result of many years of research in Adjara thirty-four species of microbionts have been identified on pears (bacteria: Crown gall-*Agrobacterium tumefaciens*, Fire blight-*Erwinia amylovora*, *Pseudomonas blossom blast* and canker-*Pseudomonas syringae* pv. *Syringae*); fungi (*Alternaria fruit rot*-*Alternaria* spp., *Armillaria root rot* (shoestring root rot)-*Armillaria mellea*, Bitter rot-*Glomerella cingulate*=*Colletotrichum gloeosporioides* [anamorph], Black rot- leaf spot and canker-*Botryosphaeria obtuse*=*Sphaeropsis malorum* [anamorph], Black spot-*Alternaria alternata*, Blister canker-*Helminthosporium papulosum*, Blister disease-*Coniothecium chomatosporem*, Blue mold rot-*Penicillium expansum*, *Botrytis spur* and blossom blight-*Botrytis cinerea*=*Botryotinia fuckeliana* [teleomorph], Brown rot-*Monilinia fructicola*, *Cladosporium fruit rot*-*Cladosporium herbarum* = *Mycosphaerella tassiana* [teleomorph], *Diplodia canker*-*Botryosphaeria stevensii*, *Elsinoe leaf and fruit spot*-*Elsinoe piri*=*Sphaeloma pirinum* [anamorph], European canker-*Nectria galligena*, *Cylindrocarpum heteronemum* [anamorph], *Gibberella baccata*-*Fusarium lateritium* [anamorph], Gray mold rot-*Botrytis cinerea*, Late leaf spot-*Cercospora minima*, *Mucor fruit rot*- *Mucor piriformis*, *Mycosphaerella leaf spot*-*Mycosphaerella pyri*=*Septoria pyricola* [anamorph], *Nectria twig blight*-*Nectria cinnabarina*=*Tubercularia vulgaris* [anamorph], Pear scab - *Venturia pyrina* = *Fusicladium pyrorum* [anamorph], *Phyllosticta leaf spot*-*Phyllosticta* sp., *Phytophthora crown and root rot* -*Phytophthora cactorum*, Pink mold rot-*Trichothecium roseum*, Powdery mildew-*Podosphaera leucotricha*, *Pythium dieback*-*Pythium* spp., *Rhizopus rot*-*Rhizopus stolonifer*, Rust-*Gymnosporangium globosum*, Rust-pear trellis (European pear rust)-*Gymnosporangium fuscum*, *Valsa canker*-*Valsa ceratospe*) were identified as a result of phytopathological and mycological studies conducted in different places of agroecosis in Georgia.

Results of the studies showed that among the mycobionts found on pear, the most common, dangerous and harmful are 4 pathogens: *Venturia inaequalis* (32%), *Erwinia amylovora* (18%) *Monilia fructigena* (12%), *Gymnosporangium fuscum*, (11%) and the remaining 30 species make up 27% (Fig. 1).

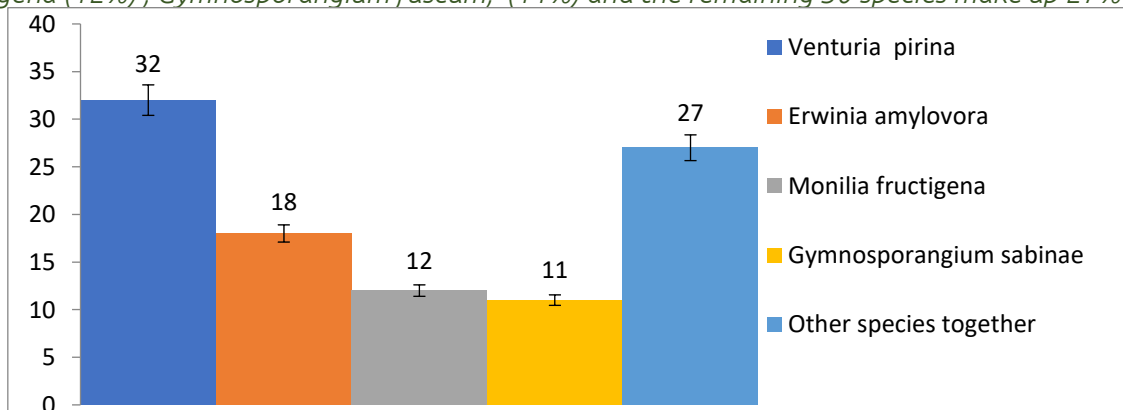


Figure 1. Spreads of the main pathogens of pear in Adjara, Georgia, %

Here we analyze only these 4 pathogens:

1. Pear scab

Pear scab is caused by the fungus *Venturia pirina* (Aderh.) (synonym, *V. pyrina*) is the most important *Venturiaceae*. It is closely related to the apple scab fungus, *V. inaequalis*, and has a very similar life cycle and mode of infection. It infects leaves, shoots, blossoms and fruit, and may result in major crop losses during particularly wet seasons.

Symptoms

Pear scab occurs on leaves, shoots, and fruits. Symptoms are very similar to apple scab. A major difference, however, is the frequent appearance of pear scab on twigs, where it can overwinter and sporulate to initiate new infections in the spring.

Lesions on leaves and petioles begin as round, brownish spots that eventually become velvety in appearance. Conidia, spores of the fungus, are produced within these lesions. Later in the season, small spots can be observed on the lower surface of the leaves. These are usually the result of late-spring or early summer infections. Leaf infection of pear is not as common as apple scab on apple leaves.

Scab lesions on fruit occur on the calyx end and eventually on the sides of the fruit. As these lesions enlarge, they become dark brown and form large black areas as they coalesce. Lesions on immature fruit are small, circular velvety spots. Darker, pinpoint spots develop as the fruit matures. Infected fruit often become irregular in shape (Fig. 1).

Disease Cycle

The fungus overwinters in leaves on the ground and also in infected twigs. Infection of pear foliage and fruit occurs under conditions similar to those required for infection of apple by the apple scab fungus. Ascospores are the major source of primary inoculum. Infection occurs in the spring around bud swell. Ascospores in the overwintered leaves are released as the result of rain and are carried by air currents to young leaves and fruit. Ascospores continue to mature over a 6- to 8-week period.

Conidia are the source of secondary inoculum and are produced in twig lesions. Many secondary cycles may occur over a growing season. The length of the wetting period and temperature required for infection depend on the number of hours of continuous wetness and the temperature during this wetting period. Scab lesions may develop in as few as 8 days after infection on young leaves and as many as 2 months on older leaves. Fruit are also more susceptible when young, however, mature fruit can be infected if the length of wetting period is sufficiently long.

Management of pear scab

Cultural controls

These practices include cleaning leaf litter from the base of previously-infected trees, as well as removing infected woody material from the canopy when performing annual pruning. Doing so will reduce the amount of primary inoculum in the spring and subsequently delay the establishment of the disease. Furthermore, regular pruning will improve air flow and light penetration in the canopy, which ultimately inhibits the development and spread of disease.

Chemical controls

Fungicides are typically applied early in the season, when ascospores are first released. Benzimidazole fungicides are among the most commonly-used classes of fungicide for managing pear scab in conventional orchards.

Biological Control

Several fungal antagonists have been isolated and identified as potential biocontrols. One of such antagonists is *Cladosporium cladosporioides* (strain H39). Antagonistic fungus has demonstrated significant bioactivity against pear scab. Applications of *C. cladosporioides* could reduce leaf scab incidence by 46-92%



Fig. 2. Symptoms of scab fungus infection of pear leaves and fruit

2. Fire blight

Fire blight, also written fireblight, is a contagious disease affecting pears, and some other members of the family Rosaceae. It is a serious concern to apple and pear producers. Under optimal conditions, it can destroy an entire orchard in a single growing season.

The causal pathogen is *Erwinia amylovora* a Gram-negative bacterium in the genus *Erwinia*, order Enterobacterales. It is a short rod with rounded ends and many peritrichous flagellae. Pears are the most susceptible, but apples, loquat, crabapples, quinces, hawthorn, cotoneaster, *Pyracantha*, raspberry and some other rosaceous plants are also vulnerable. The disease is believed to be indigenous to North America, from where it spread to most of the rest of the world.

Symptoms

Fire blight on a pear tree caused by *Erwinia amylovora*. Tissues affected by the symptoms of *Erwinia amylovora* include blossoms, leaves, fruits, shoots, and branches of pear, and many other rosaceous plants. All symptoms are above ground and are typically easy to recognize. Affected leaves often curl and turn black, hanging for a long time on the branches (Fig. 2). Symptoms on blossoms include water soaking of the floral receptacle, ovary, and peduncles. This results in a dull, gray-green appearance 1–2 weeks after petal fall, and eventually tissues will shrivel and turn black. The base of the blossom and young fruit show similar symptoms as infection spreads. Opaque white- or amber-colored droplets of bacterial ooze can be seen on the infected tissue in high humidity. Shoots show similar symptoms but these develop much more rapidly. A "Shepherd's Crook" can occur when the tip of the shoot wilts, and diseased shoot leaves typically have blackening along the mid-vein and before they die. When numerous, diseased shoots give the tree a blighted appearance. Infection of blossoms and shoots can spread to larger tree limbs. Branches will darken and become water soaked, eventually cracks will develop in bark. Wood under the bark will become streaked with black discoloration. Immature fruit forms water-soaked lesions and later turns black. Bacterial ooze can be found on these lesions (Fig. 2). Severe infections result in fruit turning entirely black and shrivelling.

Management

The only effective treatment for plants already infected is to prune off the affected branches and remove them from the area. Plants or trees should be inspected routinely for the appearance of new infections. The rest of the plant can be saved if the blighted wood is removed before the infection spreads to the roots.



Fig. 2. Curling of leaves of pears and whitish sticky mass on the fruit

3. Brown rot

Brown rot is one of the most destructive diseases of pear fruits. When environmental conditions favor this disease, crop loss can be devastating. Three species of *Monilinia* and the recently described anamorph, *Monilia polystroma*, formerly lumped into *M. fructigena*, cause brown rot in temperate regions in AdJara on members of the Rosaceae. *Monilinia fructicola* colonizes blossoms, twigs and fruit. Although brown rot damage is typically observed on fruit, the fungus may also infect blossoms, leaves, and shoots. Blighted blossoms turn brown and stick to shoots in a gummy matrix in which gray to tan fungal spore masses are produced.

Symptoms and Signs

Shoots infected by the brown rot fungus develop sunken, brown, elliptical cankers that may become gummy. Cankered areas are usually restricted to new shoots and typically occur as the disease advances from infected blossoms. Gray to tan fungal spore masses may be produced in cankered areas. If a shoot is girdled by a canker, the shoot will die and leaves will turn brown, but remain attached to the branch for a few weeks.

Symptoms on ripening pear may first appear as small, circular spots that enlarge or coalesce. On mature fruit, these lesions develop and enlarge rapidly. When environmental conditions favor disease development, ripe fruits may completely rot within two days. Tan to gray spore masses are often evident on rotting fruit (Fig. 3). Diseased fruits typically shrivel and turn brown to black, either dropping to the ground or remaining attached to the tree. These tough, shriveled fruits, termed mummies, are a major source of overwintering fungal inoculum, but the brown rot pathogen can also overwinter in cankers and infected fruit pedicels.

Causal Organism

The brown rot fungus survives the winter in mummified fruits (either on the ground or still on the tree) and in twig and branch cankers produced the preceding year. Both sources may produce spores that can infect blossoms and young shoots. At about blossom time, a mummified fruit that has fallen on the ground produces up to 20 or more small, tan, cup-like structures on slender stalks that are called apothecia. As an apothecium matures, it becomes thicker and the cup opens to a bowl-like disc 1/8 to 1/2 inch in diameter across the top. The inner surface of each bowl is lined with thousands of spore-containing sacs (asci). At this stage, the slightest disturbance of air movement will cause an apothecium to forcibly discharge millions of spores. These spores (ascospores) are carried by wind to the open or unopened blossoms and young shoots. If a film of water (either from dew or rain) is present for 5 hours or longer, the spores can germinate and penetrate the plant. Infected blossoms soon wilt and tan-gray tufts, composed of masses of another type of spore (conidia), develop on the outside of the flower shuck. If the infected blossom does not drop off, the fungus soon grows through the pedicel to the twig and forms a canker. Masses of conidia are soon produced on the newly cankered twig surface during moist periods throughout May and June. These summer spores are easily detached, and, like the ascospores, are mainly wind-borne. They are also splashed by rain or carried by insects to the growing fruit. Brown rot conidia can germinate and infect at temperatures of 32 to 90 degrees F. Wet weather and temperatures ranging from 60 to 70 degrees F are most favorable for disease development.

Following spring and summer rainy periods, mummified fruit still hanging in the tree become covered with masses of conidia that may result in blossom blight or fruit rot. Mummies hanging in the tree do not produce ascospores. Although the flesh of young fruit is very susceptible to brown rot infection, the fruit has such a tough skin that the germ tubes of the summer spores do not normally penetrate. For this reason, young uninjured fruits are fairly safe from infection. However, any type of injury to the fruit will provide entry points for brown rot spores. Insect and hail wounds, fruit cracking, limb rubs, twig punctures, and a variety of picking and packing injuries greatly increase the losses due to brown rot. Growers must realize that brown rot spores are practically everywhere during the fruit-ripening period.



Fig. 3. Brown rot producing spores on the surface of an infected pear fruit

Control

Sanitation is very important in controlling brown rot. All dropped and rotted fruit should be picked up and destroyed promptly. At the same time, remove all mummies from the trees. Prune out all cankers during the dormant season. Overripe or rotting fruit in the packing shed should be removed and destroy.

4. Pear rust—*Gymnosporangium libocedri*

The fungus infects pear, certain other Rosaceae plants, and incense cedar. Its other names include cedar broom rust, incense cedar rust, and Pacific coast pear rust.

Symptoms

Infected pear and other rose family plants develop discolored spots with dry, powdery or rough, reddish, yellowish, or orange spore masses (Tab. 4). Groups of tiny, cup-shaped, spore-forming bodies

appear as pustules on fruit, green stems, and leaves. On fruiting pears, infections occur primarily on the fruit.

Life cycle

Gymnosporangium libocedri alternates between incense cedar and apple, hawthorn, mountain ash, pear, quince, and serviceberry. Spores are produced on incense cedar in the spring and disperse in air to infect the young tissues of pear and the other rosaceous hosts. Wet weather favors rust disease, so infection and damage is more common on rosaceous hosts when it is rainy in the spring. The fungus grows in infected rosaceous hosts and produces airborne spores that infect cedar, usually in late summer or fall.

Control

Removed and destroy of infected fruit, leaves, and shoots as soon as symptoms appear. Fungicides applied in the spring can prevent or reduce rust disease.



Fig. 4. Symptoms of Pear rust—*Gymnosporangium libocedri*

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Economic sciences

EFFICIENCY OF AN EXPORT-ORIENTED ECONOMY (IN THE NAKHCHIVAN MODEL)

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Abstract

The article is devoted to the analysis of the current state of export-oriented industry in the Nakhchivan Autonomous Republic. The study examined the theoretical foundations of the concept of competitiveness and assessment criteria, as well as the possibilities of applying innovative regulatory models in the region.

The analyses show that the digitalization of the economy, strengthening human capital and the application of innovation-based development models are of particular importance for expanding export potential. These approaches serve not only to increase the product range, but also to improve quality, ensure production in accordance with international standards and diversify markets.

The results of the study show that innovation-oriented reforms and the application of digital technologies create conditions for increasing efficiency in the production areas of Nakhchivan, creating more flexible access to export markets. At the same time, education and vocational training programs aimed at the development of human capital act as one of the main factors ensuring the long-term economic sustainability of the region.

In general, an innovation-based development strategy, strengthening digitalization processes and improving human capital are considered to be decisive factors that can strengthen the competitive position of the Nakhchivan Autonomous Republic in international markets and ensure the economic independence of the region.

Keywords: Nakhchivan, export, innovation, competitiveness, industry, sustainable development

1. Introduction

The development of export-oriented industry is of strategic importance in terms of strengthening the positions of national economies in international markets and ensuring long-term economic sustainability. In the context of globalization, regional economic models, especially in regions with small and unique geopolitical positions - for example, in the Nakhchivan Autonomous Republic - increasing export potential is of particular relevance. In modern times, with the formation of innovation-based economies, the application of new regulatory models for the development of competitive industries has become a necessity. International experience shows that export-oriented industrial sectors gain a competitive advantage not only with their production capacity, but also with their high technological level, modern logistics and production processes in accordance with quality standards. (Porter, 1990; World Economic Forum, 2023).

2. Current status of export-oriented industry in Nakhchivan

The Nakhchivan Autonomous Republic, being one of the important economic and political regions of Azerbaijan, is a unique region that continues to develop in conditions of geographical blockade. In recent years, one of the main directions of the economic policy implemented in this region is the development of export-oriented industry. As a result of state support, stimulation of entrepreneurship and the creation of new production facilities, the economy of Nakhchivan continues to have an increasing export potential.

Currently, the main share in exports belongs to agro-industrial products, construction materials, light industry products and mineral waters. For example, Nakhchivan's "Badamli" mineral waters and salt products have been known in both domestic and foreign markets for many years. In addition, the activities of fruit and vegetable processing enterprises create conditions for the expansion of agricultural exports. In the field of construction materials, quarries and cement production enterprises also play a

significant role in the region's export structure.

According to official statistics, the volume of export operations in Nakhchivan has increased significantly over the past decade. According to the 2024 figures of the State Statistics Committee, the annual volume of exports from the region increased by 2.3 times compared to 2010, reaching 250 million US dollars. These indicators, at first glance, are a clear example of economic success. However, when looking at the structure of exports, it is observed that raw material-oriented products predominate, which may weaken competitiveness in the long term. Because raw material exports increase dependence on price fluctuations in global markets and do not create added value. (State Statistical Committee of the Republic of Azerbaijan, 2024).

In order to increase the export potential of Nakhchivan, it is necessary to expand the processing industry, stimulate innovation-based production, and apply new technologies. In particular, the establishment of new enterprises in areas such as agricultural product processing, food industry, textile, and pharmaceuticals can make the export structure more sustainable and competitive. Supporting small and medium-sized businesses in this direction is also an important factor.

International experience shows that export-oriented policy plays a special role in the economic development of small regions. The Baltic countries - Lithuania, Estonia, and Slovenia - have achieved high economic indicators with innovation-based export models, despite having a limited domestic market. Their experience proves that sustainable economic growth is possible when exports are based not only on raw materials, but also on high-value processing and technological sectors. In this regard, the promotion of innovative production and diversification of export-oriented sectors is also relevant for Nakhchivan.

Despite its geographical limitations, Nakhchivan's expansion of access to international markets is important for its future development. In particular, the prospect of opening the Zangezur corridor can provide new opportunities for the region's export potential. This will both reduce logistics costs and allow Nakhchivan products to reach wider markets. (World Economic Forum, 2023).

As a result, the development of export-oriented industry in the Nakhchivan Autonomous Republic is already showing its real results. However, the main task ahead is to gradually move away from raw material-oriented exports, expand innovation-based production, and strengthen the "Made in Nakhchivan" brand in international markets. If this goal is achieved, the region will both make a significant contribution to Azerbaijan's overall export potential and further strengthen its economic independence.

3. The concept of competitiveness and assessment criteria

Competitiveness is considered one of the most important concepts in economic science and policy. In a broad sense, this term refers to the ability of a country, region or enterprise to maintain a stable position in international markets and to offer its products and services on more favorable terms than its competitors. In other words, competitiveness is not only related to price, but also to quality, technology, innovation, production efficiency and access to markets. (Porter, 1990; World Economic Forum, 2023).

The famous economist Michael Porter, in his concept of "Competitive Advantage", explained this concept in more depth and distinguished four main factors for the sustainable economic development of regions and countries. These are:

- Production factors - human capital, natural resources, technology and infrastructure.
- Demand conditions - the level of demand and complexity of consumer tastes in the domestic market.
- Related and supporting industries - the presence of clusters and the strength of industrial chains.
- Enterprise strategy and competitive environment – management models of firms, intensity of competition in the market and regulatory policy of the state.

Together, these four elements form the model called "Porter's diamond" and create a theoretical basis for determining the competitiveness of economies. (Porter, 1990; World Economic Forum, 2023).

In modern times, various international organizations develop indices to assess the competitiveness of countries. One of the most widely used indicators is the Global Competitiveness Index published by the World Economic Forum (WEF). This index measures the level of economic development of countries and their resistance to market competition based on various criteria. Among them: (Porter, 1990; World Economic Forum, 2023).

- Infrastructure development (roads, logistics, energy supply and digital networks),
- Macroeconomic stability (inflation rate, budget balance, debt burden),
- Education and human capital (secondary and higher education level, vocational training),
- Innovation potential and technology adoption,

- *Market size and consumer behavior,*
- *Effectiveness of economic management and institutional environment.*

These indicators allow for a comparative assessment of the positions of countries in international markets. Competitiveness in the context of the Nakhchivan region (Porter, 1990; World Economic Forum, 2023).

Competitiveness in the context of the Nakhchivan region

Increasing competitiveness in regions with limited resources and markets, such as the Nakhchivan Autonomous Republic, is based more on innovation, efficient production technologies and export-oriented policies. In order to increase the region's export potential, it is important for enterprises to obtain international quality certificates (ISO, HACCP, etc.). This not only facilitates the access of products to foreign markets, but also strengthens consumer confidence. (Porter, 1990; World Economic Forum, 2023).

In addition, the development of human capital, strengthening of the modern vocational education system and digitalization of production are among the main factors that can ensure the regional competitive advantage of Nakhchivan. The prospect of opening the Zangezur corridor in the near future can also have a positive impact on the competitiveness of the region by increasing logistics and access to markets. The concept of competitiveness is not just an economic term, but also one of the main units of measurement of strategic development. Its assessment is based not only on market share and export indicators, but also on technological potential, human capital, state policy and innovation opportunities. In order to ensure competitiveness in regions with geographical limitations such as Nakhchivan, it is necessary to study international experience, strengthen local potential and develop an export-oriented economy. (Porter, 1990; World Economic Forum, 2023). (World Economic Forum, 2023).

4. Application of innovative regulatory models in Nakhchivan.

One of the main conditions for economic development in the modern era is that the state's regulatory mechanisms are flexible and innovative. The traditional administrative control model no longer provides effective results in the conditions of global competition. Therefore, the concept of an innovative regulatory model comes to the fore. In this model, the state acts not only as a controller, but also as a promoter and partner. That is, rather than tightening the business environment, the state acts as an institution that supports it, stimulates innovations and creates conditions for the dynamic development of the market.

The reforms implemented in the Nakhchivan Autonomous Republic in recent years also reflect this approach. The application of innovative regulatory models is especially noticeable within the framework of economic liberalization, promotion of entrepreneurship and export-oriented policy. (Ministry of Economy of the Nakhchivan Autonomous Republic, 2024).

Main areas of application Innovation funds and startup promotion.

Special funds are being created in the region to finance innovation activities and support startups. This mechanism is of great importance for the implementation of new ideas by small and medium-sized enterprises (SMEs). Soft loans and grants for startup projects allow diversifying the economic structure of the region.

Export promotion programs.

To facilitate access to foreign markets, the state applies concessions to exporters. For example, simplification of customs duties, support for certification of export products, and promotion of the "Made in Nakhchivan" brand increase the competitiveness of export-oriented manufacturers.

Application of digital technologies.

Digitalization in public administration, expansion of electronic services, and application of "e-government" platforms facilitate business activities. Electronic licensing, tax accounting, and e-invoice systems save time and resources of entrepreneurs, while also increasing transparency.

Modernization of agriculture and agrarian technologies.

The agricultural sector plays a leading role in the economy of Nakhchivan. With the regulatory support of the state, subsidies for farmers, agrotechnical services, and digital agricultural platforms are created. This creates conditions for both increased productivity and improved quality of export-oriented agricultural products.

E-commerce and electronic customs systems.

The application of electronic customs systems is of particular importance in terms of integration into global markets. The development of e-commerce facilitates the direct export of local producers to foreign markets. This reduces traditional logistics costs and expands the geography of exports.

Structural reforms and new economic opportunities

Within the framework of the reforms implemented in Nakhchivan in recent years, supporting small and medium-sized businesses and creating technoparks and industrial districts are of particular importance. Technoparks play the role of a concentration center of innovation activity, enabling the transfer of scientific research to practical production. Industrial districts, on the other hand, minimize infrastructure costs by facilitating the activities of manufacturing enterprises in one place.

In addition, expanding logistics capabilities is also an important component of the innovative regulatory model. Integration into international transport corridors, especially the prospective opening of the Zangezur corridor, will significantly increase Nakhchivan's access to regional and global markets. Simplification of customs procedures creates a more favorable business environment for exporters. As a result, innovative regulatory models applied in Nakhchivan serve to diversify the economy, increase export potential, and improve the business environment. When the state's promotional and partnering role is optimally balanced with market mechanisms, the region will not only satisfy domestic demand, but will also have a competitive position in international markets. This model can serve as a strategic basis for the sustainable economic development of Nakhchivan in the future. (Porter, 1990; World Economic Forum, 2023). (Ministry of Economy of the Nakhchivan Autonomous Republic, 2024). (World Economic Forum, 2023).

5. Recommendations and Conclusion

It is necessary to implement complex and phased measures for the development of export-oriented industry in Nakhchivan. The following main priorities are of particular importance in this direction:

Strengthening regional specialization and development of high value-added sectors – Expansion of production in areas consistent with the existing economic potential of Nakhchivan, especially the development of agricultural products processing, pharmaceuticals and construction materials industries will increase export opportunities.

Creation of technoparks and innovation centers – Application of new technologies, support for startups and integration of scientific research institutes with industry can increase the range and quality of export-oriented products.

Strengthening human capital, expanding education and training programs – Personnel training in accordance with the requirements of the modern labor market, advanced training and international exchange of experience will ensure the sustainability of the export industry.

Increasing digitalization and e-commerce opportunities – Creation of electronic platforms, digitalization of production processes and improvement of logistics services will facilitate access of products to wider markets.

Strengthening marketing and brand policy in foreign markets – Formation of the “Made in Nakhchivan” brand, active participation in international exhibitions and organization of export missions will serve to promote regional products.

Implementation of green economy principles and ensuring environmental sustainability – Application of alternative energy sources, environmentally friendly production processes and “green certification” will increase the international competitiveness of export products.

Overall conclusion

In conclusion, the application of innovative, environmentally sustainable and competitive approaches to the development of export-oriented industry in the Nakhchivan Autonomous Republic can significantly strengthen the region's position in international markets. In this direction, state support, the activity of the private sector and cooperation with foreign investors are of strategic importance. Thus, the implementation of complex measures has the potential to turn Nakhchivan into one of the export centers of the South Caucasus in the near future.

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Historical sciences

FROM THE HISTORY OF GEORGIAN STRUGGLE AGAINST RUSSIAN COLONIAL POLICY IN THE XIX CENTURY

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Abstract

The attitudes of Georgian patriots toward the colonial policies of the Russian Empire were closely aligned with the fundamental national principles that informed the Tergdaleulni movement (literally, "those who drank the waters of the Terek"). The primary objective of this intellectual and political current was the restoration and preservation of Georgian statehood as the ultimate national ideal.

Given the repressive political climate of the Russian Empire, Georgian patriots faced severe constraints on political and cultural expression. Censorship and state surveillance effectively suppressed any overt manifestations of anti-colonial sentiment or advocacy for the rights of subjugated nations.

The examined materials demonstrate that it was precisely through the persistent efforts of the Tergdaleulni and other leading figures of Georgian nationalism that the displacement of the Georgian language was prevented. Their activities not only safeguarded the linguistic and cultural integrity of the nation but also laid the essential foundations for the continued development of Georgian language and identity in subsequent periods.

Keywords: Georgia, History, Russian Empire, Politics

The attitude of Georgian patriots toward Russia's colonial policy is entirely consistent with the national principles that underlie the Tergdaleulni (literally, "those who drank the waters of the Terek") movement. Their highest national ideal has always been the restoration of Georgian statehood.

However, as realists, they did not view these phenomena from a romantic perspective and, given the existing situation, often even expressed a certain loyalty in relations with Russia. This explains, above all, the fact that the Protestant oppositional aspiration for national freedom and Russian colonialism, reflected in their views, is not marked by extreme radicalism. They try to limit their struggle against Russia's expansionist policies to specific facts and phenomena.

It should be noted that, given the complex situation that prevailed in the Russian Empire at the time, Georgian patriots were effectively unable to undertake any other actions. Censorship and other relevant authorities exercised strict control over all expressions of free thought, especially when it was directed against Russian colonialism and in defense of the national interests of oppressed peoples.

All of this naturally created a solid foundation for the assertion of the so-called two truths: a publicly expressed point of view, which could never be entirely sincere or unbiased, and an unofficially expressed desire of the heart, which was expressed primarily in oral conversations and various written records (diaries, personal letters, memoirs, etc.). Although documentary materials reflecting the second truth have survived in very small quantities, even with their help, the significant difference between these two truths is evident.

That this is indeed the case is confirmed by a fragment from a personal letter from Sergei Meskhi, the publisher and editor of the newspaper "Droeba," which offers an unequivocally negative assessment of Georgia's annexation to Russia: "After 1800, it will be impossible to write the history of our country properly and honestly. The censors will not allow it. The authorities will not permit the publication of a history that does not praise all their actions and decrees (in Georgia), that does not express the idea that Georgia, as a result of its annexation to Russia, has found a happy and blissful life; such a history, instead of benefiting, will only bring harm" (Meskhi, 1950: 143).

This fragment was from a personal letter from Sergei Meskhi to his fiancée, Ekaterina Melikishvili. He never expressed such an opinion—with such harshness and radicalism—in his publications, which is easy to understand. Because the letter was not intended for publication, the author was completely free

from any censorship restrictions and expressed his innermost thoughts openly. Naturally, great caution and circumspection were required in public speeches and publications, which led to opportunistic assessments.

One of the greatest misfortunes brought about by Georgia's annexation by Russia, according to the "Tergdaleulni," was that after it, Georgia found itself virtually completely cut off from the outside world. From that time on, "the Georgian people see no successes or accomplishments of any educated nation other than Russia, to emulate, to draw on their example; it is as if they are about to fall asleep, to freeze in place, like China" (Meskhi, 1963: 116).

Georgian public figures consider the greatest danger of Russian colonialism to be the consistent and purposeful struggle of the authorities and their loyal servants against the national identity of oppressed peoples. They fought and resisted Georgia's reactionary opponents as much as possible.

From this perspective, the polemical article "Some Questions," published in issue 14 of *Droeba*, is of particular interest. It sharply criticizes a letter from a St. Petersburg correspondent published in issues 25-26 of the newspaper *Tbilisi Moambe* (published from 1873 to 1880). Sergei Meskhi not only fundamentally opposed this question but even opposed its raising, which was the most important objective of the article. Specifically, Sergei Meskhi focuses on the St. Petersburg correspondent's question: "What would be more desirable and beneficial for the countries of the Caucasus—leaving them separate according to their status as nationalities and peoples, or bringing them all closer together, uniting them all into a single people?" (Meskhi, 1963:183). Sergei Meskhi considers this question and the answer given by the St. Petersburg author himself to be devoid of any scientific argumentation and directed against non-Russian peoples. Sergei Meskhi cannot hide his indignation at this point of view from the St. Petersburg correspondent, who characterizes the linguistic and cultural "backwardness" of the peoples of the Caucasus as follows: "Since the languages of the Caucasian peoples have not been developed, since they have not reached the stage where they can assimilate the fruits of science and civilization in general, since the development of individual languages is more complex and requires more time, it would therefore be better if all the peoples of the Caucasus adopted one language—Russian, through which they will more easily and quickly achieve their well-being" (Meskhi, 1963:183).

The anger of the participants in the "tergdaleulni" movement is further intensified by the fact that the editorial board of "Tbilisi Moambe," in response to the aforementioned letter, published an article outlining its own position, in which it essentially shared the reactionary viewpoint of the Black Hundreds Russian correspondent. Outraged by such judgments, Georgian public figures are trying to convincingly prove that the above considerations lack any scientific basis and that the struggle directed against peoples and languages is, in fact, a struggle against the laws of nature. According to him, "The language and literature of a people are the result of the nature and circumstances that have surrounded and influenced them for several centuries. Is it possible to change a people's language and character by advice? How can a reasonable person tell an entire nation, or several nations, that today you need French or German, forget your own language and literature, and study those languages? Is it possible to rid yourself of and forget what is inherent in a people, what they, so to speak, absorbed with their mother's milk?

...What happens if you desire something that is impossible, something that contradicts nature, something that violates all the laws of nature, the laws of human nature itself, the qualities of every human being! As if language, character, and literature were some kind of article of clothing or footwear that can be thrown away and replaced with a new one!"

However, the above position in no way signifies a struggle against the "acquisition" of a foreign language in general. On the contrary, according to Georgian figures, when a person sees that "acquisition of a language in life and science is essential for him," he studies that language without any compulsion. However, this circumstance will not prevent him from simultaneously "striving to develop and advance his own language, striving to prepare his native tongue so that with its help he can assimilate science and civilization" (Meskhi, 1963:185).

To support this, they cite examples from the history of England, France, and Germany, noting that if these countries had at one time refused to receive education through their own languages and had adopted Greek and Latin, the then-world-leading languages, then neither French, German, nor English would exist today. Despite the fact that many in Georgia and other subjugated countries of the empire fought against the colonial policies pursued by the Russian government and its allies, it nevertheless managed to recruit individuals among the conquered peoples who actively supported the practical implementation of its reactionary plans. One of these was G. Bagration-Mukhransky, who in 1872 published in Tbilisi in Russian the book "On the Essence of National Individuality and the Educational

Significance of Large National Units."

This book provoked enormous outrage among Georgian leaders, stemming from the reactionary ideas so fervently defended by the author.

Among Mukhransky's propositions, they are particularly outraged by the idea that "for complete human happiness and success, it is absolutely necessary for small peoples to lose their small nation, their language, customs, and unique way of life and join the larger people." According to Mukhransky's prediction, "someday, through the merging and unification of small and isolated peoples, several large nations will emerge, since over time the languages of the small peoples will be abolished."

As a result of this "brutal and ugly policy," devoid of any scientific basis or argumentation, the aggressive aspirations of the Russian colonialism of the time became clear, the victims of which were to be the non-Russian peoples living in the Russian Empire, including the Georgians. Mukhransky asserted that "since the languages of small nations cannot become the organ of all humanity, they must be abolished, and the small nations themselves, both for their own happiness and for the good of all humanity, must finally disappear from the face of the earth" (Meskhi, 1962:255).

The indignation of Georgian patriots is further intensified by the fact that all of these "general theoretical" arguments were directed primarily against the Georgian people. In their view, Mukhransky's actions fundamentally contradict "the truth confirmed by science... With a single stroke of the pen, he wants to change the character, customs, and life of a people; he wants to take away their native language, which is most dear to humanity, and the removal of which is almost tantamount to the taking of life! He cannot understand that a people deprived of their native language is like a person who has been robbed of everything they considered dear and native, and who, because of this, can no longer accomplish anything remarkable in their life!" (Meskhi, 1962:256).

Georgian patriots also rightly criticize Mukhransky's view that the measure of a nation's culture and education is its size. They call this idea absurd and, in support of this, cite those peoples who, despite their small numbers, have created a culture far superior to that of numerous nations.

When discussing the negative aspects of Georgia's annexation by Russia, the leading representatives of the Tergdaleulni movement painfully emphasized that after this event, "the mention of our country almost completely disappeared in Europe" (Meskhi, 1964:328). They criticized with particular indignation and severity the cruelty and arbitrariness of Russian officials sent to Georgia. From this perspective, in their view, there were virtually no good or bad officials, and each of them consistently pursued policies directed against the national interests of the Georgian people. It was precisely this bitter truth that they came to understand after observing the life experiences of a number of high-ranking Russian officials who came to work in Georgia. True, at first many greeted them with great hopes, but very soon these hopes were dashed, since "at first this or that official seemed to live up to society's expectations, taking up his duties honestly and impartially. However, after a short time, this vaunted person, unfortunately, revealed the same shortcomings and the same character as the previous official (Meskhi, 1964: 329).

Among those high-ranking officials who led Georgian national figures to recognize this bitter truth, the well-known Yanovsky, then the trustee of the Caucasian educational district, aroused particular indignation with his reactionary activities. They note with pain in their hearts that very soon "the politician suppressed the educator in him," and they became disillusioned with him.

In support of this, Georgian patriots recall the imperial policy pursued by Yanovsky in opposition to education in the Georgian language. They perceive such actions by Yanovsky and his associates as subversive. activities directed against the national identity of the Georgian people, and with a clearly expressed sense of protest, remind the Russian high-ranking official of the fact that the Georgian people throughout their existence have "persistently and fearlessly fought to defend their land, faith, language and nationality" and that they will not deviate from this path in the future.

In his journalistic views, Sergei Meskhi, in his own way, repeated and, to some extent, even deepened the well-known motto of the outstanding Georgian writer and public figure Ilia Chavchavadze, which he recorded back in 1861 in his first polemical letter, which defines the national self-existence of the Georgian people: "Language, Fatherland, Faith." To this well-known triad, Sergei Meskhi added a fourth concept - "religion," formulating this motto as follows: "The desire of Georgians is the same as that of other peoples: to protect their native language, fatherland, religion, and faith" (Meskhi, 1964: 338). The materials examined confirm that it was only thanks to the tireless struggle of the participants of the Tergdaleulni movement and other remarkable Georgian national figures that it was possible not only to avoid the actual displacement of the native language from Georgia, but also to create all the preconditions for its functioning in the next stage of development.

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YEAR OF THE CONSTITUTION AND SOVEREIGNTY KONSTITUSIYA VƏ SUVERENLIK İLİ

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Abstract

"Constitution and Sovereignty Year" is an important initiative implemented in order to strengthen Azerbaijan's statehood traditions and expand legal education. The historical importance of the Constitution, its role in ensuring human rights, legal and political aspects of the concept of sovereignty are analysed in detail in the article. Also, within the framework of the declaration of this year in 2025, the work carried out in the direction of educational measures, legal reforms and promotion of national values is emphasised. The measures aim to further strengthen the country's development as a legal state and civil society. The article reflects the approaches of special importance for the protection of the principles of legal statehood of Azerbaijan and their transmission to future generations.

XÜLASƏ

"Konstitusiyaya və Suverenlik ili" Azərbaycanın dövlətçilik ənənələrinin möhkəmləndirilməsi və hüquqi maarifləndirmənin genişləndirilməsi məqsədilə həyata keçirilən mühüm təşəbbüsdür. Məqalədə Konstitusiyanın tarixi əhəmiyyəti, insan hüquqlarının təminatında rolu, suverenlik anlayışının hüquqi və siyasi aspektləri ətraflı təhlil edilir. Həmçinin, 2025-ci ildə bu ilin elan olunması çərçivəsində maarifləndirmə tədbirləri, hüquqi islahatlar və milli dəyərlərin təbliği istiqamətində görülən işlər vurğulanır. Tədbirlər ölkənin hüquqi dövlət və vətəndaş cəmiyyəti kimi inkişafını daha da gücləndirmək məqsədi daşıyır. Məqalə Azərbaycanın hüquqi dövlətçilik prinsiplərinin qorunması və gələcək nəsillərə ötürülməsi üçün xüsusi əhəmiyyət daşıyan yanaşmaları əks etdirir.

Keywords: Azerbaijan constitution, sovereignty, legal state, traditions of statehood, human rights, 2025 Constitution and Sovereignty Year, state independence, territorial integrity, legal education, democratic principles, Patriotic war, rights and freedoms, national legislation, public administration.

Açar sözlər: Azərbaycan konstitusiyası, suverenlik, hüquqi dövlət, dövlətçilik ənənələri, insan hüquqları, 2025 Konstitusiyaya və Suverenlik İli, dövlət müstəqilliyi, ərazi bütövlüyü, hüquqi maarifləndirmə, demokratik prinsiplər, Vətən müharibəsi, hüquq və azadlıqlar, milli qanunvericilik, dövlət idarəetməsi.

INTRODUCTION

There is nothing better than independence for the state and freedom for its citizens. The people of Azerbaijan, with a great and rich historical past, have gone through a long and struggle-filled path for free living and an independent state, and have written a heroic chronicle. Azerbaijan, which has a history of five thousand years of statehood, has been fighting for centuries against foreigners who were eyeing its land, threatening its freedom, and who were hostile to it. (1)

Each state's basic principles are reflected in its constitution and the concept of sovereignty. Declaring 2025 as the "Year of the Constitution and Sovereignty" in the Republic of Azerbaijan aims to strengthen the traditions of statehood and further develop public awareness in this area. The importance of the concepts of the Constitution and sovereignty, their role in Azerbaijan's history and the measures implemented within the framework of the "Year of the Constitution and Sovereignty" will be examined in this article.

Today, the Republic of Azerbaijan, guided by the national interests of our people, continues its independent policy more courageously and principledly in the conditions of new realities, and, based on the requirements of the Constitution and its sovereign rights, confidently moves towards the strategic goals ahead.

The Concept of the Constitution

The Constitution constitutes the legal and political basis of every state. It determines the form of

government of the country, the rights and freedoms of citizens, and the principles of operation of state bodies. The Constitution of the Republic of Azerbaijan was adopted on November 12, 1995 through a nationwide referendum. This historical document, as the first constitution of independent Azerbaijan, played an important role in the formation of a legal state.

The Constitution of Azerbaijan places special emphasis on the protection of human rights and freedoms. For example, its second section is dedicated to the fundamental rights and freedoms of the individual. It protects such fundamental values as the rule of law, personal inviolability, freedom of speech, and property rights.

At the same time, the Constitution also reflects the responsibility of state bodies to citizens. With the adoption of this document, the Azerbaijani state has taken an important step towards building a society based on democratic principles.

The concept of sovereignty

Sovereignty is one of the basic principles that expresses the independence of the state and its complete freedom in its internal affairs. The sovereignty of the Republic of Azerbaijan was confirmed by its act of independence. The "Constitutional Act on State Independence of the Republic of Azerbaijan", adopted on October 18, 1991, is of great importance in this regard.

The concept of sovereignty manifests itself in both legal and political terms. Legally, a sovereign state has the right to adopt its own laws and independently implement its internal policies. Politically, sovereignty ensures the right of a country to make independent decisions in international relations.

The strengthening of Azerbaijan's state sovereignty was accompanied by historical events. The

victory in the Patriotic War in 2020 not only ensured the territorial integrity of Azerbaijan but also further strengthened its sovereignty. This, in addition to being a source of national pride, confirmed the values of statehood based on the principles of international law.

Having an independent and sovereign state and building a developed society based on national and spiritual values, principles of solidarity, humanism, justice and the rule of law have been the greatest dream of the Azerbaijani people for centuries.

Despite external interference and deprivation at various stages of history, our people have preserved their national identity and fighting spirit, always remained faithful to their ideals, and restored state independence at the end of the 20th century. Although the Constitutional Act "On State

Independence of the Republic of Azerbaijan" adopted on October 18, 1991, provided for the preparation of a new Constitution, the ineffective activities of the authorities in 1991–1993 led to an acute crisis in all spheres of social life and the emergence of anarchy in the country, state governance mechanisms were not formed, and it was not possible to ensure the rule of law and the right of citizens to live freely and safely.

Only thanks to the great mission of salvation of the National Leader Heydar Aliyev, who returned to power at the request of the people in 1993, were the dangerous processes happening in our country halted, socio-political stability secured, and a reliable foundation laid for modern state-building. The first Constitution of the Republic of Azerbaijan, prepared under the direct leadership of the Great Leader and adopted on November 12, 1995, formed the basis for large-scale legislative and institutional reforms in our nation.

The Constitution has served as a vital legislative foundation for implementing lofty aims such as protecting the independence, sovereignty and territorial integrity of our state, establishing a legal and secular state, nation, ensuring a decent standard of living for our citizens, and fostering cooperation with countries worldwide in a friendly and peaceful environment. The preamble of the Constitution states that protecting Azerbaijan's independence, sovereignty and territorial integrity is among its primary objectives.



However, the fact that 20 per cent of our lands remained under occupation for nearly 30 years as a result of Armenia's aggression against Azerbaijan did not allow the sovereign rights of the Republic of Azerbaijan to be applied in those territories. Putting an end to Armenia's occupation policy and restoring the territorial integrity and sovereignty of our country have become one of the main goals of the national idea of the Azerbaijani people, and all the resources of our society have been directed to solving this fateful task. As a result of the historic victory in the Patriotic War that began on September 27, 2020 in response to Armenia's provocations and the successful anti-terrorist operation carried out on September 19–20, 2023, the territorial integrity and sovereignty of our country have been fully restored, and the legal force of the Constitution of Azerbaijan has been established in all territories where the occupation has been eliminated. In accordance with Decree № 294 of the President of the Republic of Azerbaijan dated September 19, 2024, September 20 was declared the Day of State Sovereignty in the Republic of Azerbaijan. (1)



Taking into account the full restoration of our territorial integrity and sovereignty, as one of the intentions declared by our Constitution, and the 30th anniversary of the adoption of our Constitution in 2025 and the 5th anniversary of our victory in the Patriotic War, President of the Republic of Azerbaijan Ilham Aliyev declared 2025 the "Year of the Constitution and Sovereignty" in the Republic of Azerbaijan.

The declaration of 2025 as the "Year of Constitution and Sovereignty" in our country by President Ilham Aliyev's Decree dated December 28, 2024 plays an indispensable role in the study of the history of our statehood, as well as in the great importance of new national ideological priorities in the post-war period, in the taking of a worthy place for powerful Azerbaijan among the countries of the world, and in the irrevocability and eternality of our independence, in terms of further highlighting both the historical importance and essence of many principles. (4)

Azerbaijan took important steps to regain its independence in the early 1990s, following the collapse of the Soviet Union. At the same time, the Azerbaijani people's desire for sovereignty and the will for independence were rooted in traditions stemming from the Azerbaijan Democratic Republic, established in 1918 and lasting only two years. After the collapse of the republic, which was part of the Soviet Union for nearly 70 years, the Azerbaijani people always kept their dreams of independence alive in their hearts.

With the Constitutional Act on State Independence of the Republic of Azerbaijan adopted on October 18, 1991, Azerbaijan officially restored its independent state status.

The Fundamental Law, one of the most important events in the history of our state's independence, was developed as a result of the hard work of the Great Leader Heydar Aliyev. The Constitution of the Republic of Azerbaijan, adopted by a nationwide referendum on November 12, 1995, broadly enshrines the ideas and values that determine the main directions of development of modern society in our country. Thus, the Constitution reflects the democratic formation of state authorities, respect for human personality and dignity, the existence of effective mechanisms for the protection of human rights, ensuring pluralism in the political system, commitment to universal values, and other values. Taking into account the exceptional importance of the country's Basic Law in the history of national statehood, in accordance with the Decree dated November 1, 1996, signed by the Great Leader Heydar Aliyev, November 12 is celebrated as Constitution Day in our country every year.

The Great Leader's advice to each of us is: "Every person must abide by the Constitution and laws, duly fulfil their duties to the state and society arising from it, and closely participate in the process of building a democratic, legal, secular state in our country"; "Our goal is to protect and enrich the spirituality of our people. Our Constitution is the Constitution of the people. It is the Constitution of every citizen!" (4)

The Constitution of the Republic of Azerbaijan, as the highest legal document of the state, is the basis of the country's legal system. The history of the Constitution includes several important stages:

1. Azerbaijan Democratic Republic (1918-1920):

The Azerbaijan Democratic Republic was declared an independent state on May 28, 1918. The republic's first constitution was adopted on May 1, 1920, but it was not implemented for a long time due to the ADR's short tenure.

2. Soviet Period (1920-1991):

In April 1920, with the accession of Azerbaijan to the Soviet Union, the constitution of the Azerbaijan Soviet Socialist Republic was implemented. This constitution, along with the Soviet Union, defined the legal foundations of the Azerbaijan SSR.

The Soviet-era constitution of Azerbaijan consisted, in general, of documents that promoted socialist ideology, aligned with the laws of the Soviet Union.

3. Independence Period (since 1991):

After Azerbaijan declared its independence in 1991, the country decided to adopt a new constitution.

November 12, 1995: The Republic of Azerbaijan adopted its first independent Constitution after gaining independence. This document defined the country's state structure, legal system, rights and freedoms of citizens, and the state's domestic and foreign policy.

The Constitution reflects Azerbaijan's independence, democratic state-building, the rule of law, and the foundations of a legal state.

4. Amendments to the Constitution:

The first amendments to the Constitution were made on August 24, 2002. These amendments, in particular, regulated the holding of elections and the division of power.

In 2009, after several more amendments and additions were made to the Constitution, this document was updated in line with the country's development.

On July 18, 2016, the President of the Republic of Azerbaijan signed an order on the draft Referendum Act of the Republic of Azerbaijan "On Amendments to the Constitution of the Republic of Azerbaijan." According to the draft, 29 amendments were proposed to 42 articles of the Constitution of the Republic of Azerbaijan. (3)

5. Current Situation:

The Constitution of the Republic of Azerbaijan, in terms of legal foundations, serves to establish a modern state of law and it is impossible for any law to contradict this constitution. The Constitution ensures the country's domestic and foreign policy, economic development, and the rights and freedoms of citizens.

The Constitution of the Republic of Azerbaijan, as the most important document in the country's legal system, directs the activities of all state management structures and plays a key role in the development of Azerbaijani society.

History

Azerbaijan established the first parliamentary, democratic, secular state in the Muslim East in 1918-1920, but this independence, which our people achieved through great struggles and wars, did not last long, it lasted only 23 months. Although this is a very short time in history, it has been forever engraved in the blood memory of our people in terms of its importance. During this short period of its existence, the Azerbaijan Democratic Republic provided all its citizens with constitutional rights and tried to establish relations with all countries based on utility, regardless of their internal structure.

Great leader Heydar Aliyev emphasised that despite the Azerbaijan Democratic Republic only lasting 23 months in tense and complex socio-political conditions, it will remain in the memory of generations as one of the brightest pages in our people's history. He stated that we inherit a rare legacy: "Every Azerbaijani citizen should strive to be worthy of this heritage and approach the past, present and future of our country, which has a great historical past, culture and high spirituality, with a deep sense of responsibility."

The steps taken by the republic in the areas of democratic, legal, secular state-building, economy, culture, education, healthcare, etc. were not left unfinished, and our state, which restored its independence at the end of the 20th century, has kept alive and developed the traditions of succession. The independence we regained in 1991 was the fruit of the national awakening and love of freedom created in the minds of our people by the glorious history they lived at the beginning of the last century. On August 30 of that year, the Declaration of Independence of Azerbaijan was adopted, and on October 18, the Constitutional Act on the State Independence of the Republic of Azerbaijan was adopted. Thus, Azerbaijan declared its existence to the world again as an independent, democratic and secular state.

Our state independence was recognized and accepted by the world community. Although Azerbaijan has achieved unprecedented development and progress in all areas during this period, the achievements and successes achieved have not come easily. Every person knows well that a prosperous life, comfortable living, and an increase in well-being go through difficulties. Living a prosperous life, like independence and freedom, is also achieved at the cost of sacrifices and with difficulty. In the first years of our independence, our people literally experienced difficult, trying days. In any case, the conflict that

Armenia started with its land claim to Azerbaijan in 1988 had made the situation in our country extremely difficult. Our compatriots who were deported from their ancestral lands in Armenia had taken refuge in Azerbaijan.

There was a war on our lands, the number of tent camps was increasing day by day. Garabakh, as well as the surrounding territories, were occupied by Armenian invaders. The authority of the Azerbaijani state in the mountainous part of Garabakh was non-existent. On the one hand, we had to overcome the real threat to our independence, and on the other hand, we had to fulfill our duty to the homeland, such as getting rid of Armenian aggression, defending our lands, preserving the territorial integrity of our country, and liberating our occupied lands. Our people had to show their strength and power. At a time when our statehood was facing the threat of destruction, the then incompetent and indecisive leaders of our republic could not cope with such important and fateful tasks. That is why a significant part of our lands was lost, chaos and anarchy prevailed in the country, the threat of civil war arose, fratricidal massacres began, the foundations of law were seriously weakened, crime reached an unprecedented level, and our statehood and independence were in danger. The then government officials, who were incapable of governing the country, were so bewildered that they didn't even know what to do. (2)



The national leader of the Azerbaijani people Heydar Aliyev said: "History has repeatedly proven that the protection of independence, which is the invaluable national wealth of the people, is a much more difficult and complex task than its acquisition." The existence of Azerbaijan as an independent country, the preservation and strengthening of statehood and the establishment of democratic principles, the successful and rapid implementation of the process of building a democratic, legal, secular state are precisely connected with the name of the great leader Heydar Aliyev. The return of the outstanding statesman, world-famous politician, and genius Heydar Aliyev from Moscow to Azerbaijan, and his leadership first of the Nakhchivan Autonomous Republic, and soon after the country as a whole, created conditions for the purposeful management, advancement, and development of state-building and socio-political processes.

Several important measures taken by the great leader Heydar Aliyev in this direction during the period of state independence have become historical events in the life of our country. One of these events was the decree of Heydar Aliyev, dated December 16, 1991, when he was the Chairman of the Supreme Assembly of the Nakhchivan Autonomous Republic, on the celebration of December 31 of each year as the Day of Solidarity of World Azerbaijanis. For the first time in the history of Azerbaijani statehood, this decree introduced the concept of "World Azerbaijanis" into big politics. Currently, the Day of Solidarity of World Azerbaijanis is celebrated on December 31 every year both nationally and at the state level in foreign countries and serves to further strengthen the unity and ties of world Azerbaijanis.

Thanks to the strong political will and great foresight of the outstanding statesman Heydar Aliyev, the "Contract of the Century", signed on September 20, 1994, forms the basis of the oil strategy that occupies an important place in the economy of the independent Azerbaijani state. Projects such as the Baku-Tbilisi-Jeyhan oil pipeline, the Baku-Tbilisi-Erzurum gas pipeline, "Shah Deniz-2", TANAP and TAP, which are of international importance, are important and successful results of the "Contract of the Century". At the same time, the policy of developing the non-oil sector at the expense of oil revenues is being successfully implemented in our country. Currently, the purposeful state policy carried out in this direction gives a serious impetus to the development of the agricultural sector, tourism, transport sector, and service sectors. The place and role of the private sector in the economy of the Republic of Azerbaijan continues to grow. A diversified multi-profile economic model is driving the country's economy forward.

Behind the wheel of our state is our esteemed President Ilham Aliyev, a worthy disciple of our national leader Heydar Aliyev, a follower of the political course he created, and a guarantor of our independence. With Mr. Ilham Aliyev, who firmly stated that he would be the president of every Azerbaijani and has proven this once again with his practical work and large-scale activities over the past period, our people will achieve new successes and achievements, and will move forward in the direction of protecting our independence, developing and strengthening our statehood.

Conclusion

"Year of Constitution and Sovereignty" creates new opportunities not only for state structures but also for civil society. The measures implemented this year will contribute to the further development of Azerbaijan as a stable legal state and a thriving civil society. This initiative aims to enhance legal

knowledge and foster a national consciousness among all citizens.

Understanding the role played by the Constitution and the principles of sovereignty in the life of every citizen requires a responsible approach to the future of our country. These values are the basis of national solidarity and development. The work done within the framework of the "Year of Constitution and Sovereignty" is of great importance to instil the importance of a legal society in future generations.

The historic Victory achieved in the 44-day Patriotic War means strengthening the values of sovereignty not only militarily, but also legally and politically. Our people, under the leadership of the President, the Victorious Supreme Commander-in-Chief Ilham Aliyev, are experiencing the proud triumph of the liberation of our ancestral lands from occupation, the full restoration of territorial integrity, state sovereignty and the legal force of the Constitution of the Republic of Azerbaijan in all territories of the country. In the post-war period, reconstruction works in Garabakh and East Zangezur, the return of internally displaced persons to their native lands and economic integration projects have been a real embodiment of the concept of a sovereign state. (4)

The establishment of the territorial integrity and sovereignty of our country by President Ilham Aliyev with his historic military and political victories resulted in the establishment of the legal force of the Constitution in all our territories, especially in Garabakh and Eastern Zangazur: "This configuration created by the victorious leader also creates an opportunity for our country to be independent in the conditions of new realities. continue his policy with more principles.

President Ilham Aliyev's declaration of 2025 as the "Year of Constitution and Sovereignty" aims to further strengthen Azerbaijan's statehood traditions and emphasize its commitment to ensuring the rights and freedoms of the people. This decision is also a historic step in terms of promoting our national sovereignty and legal values. As in the past, the large-scale reforms to be implemented during the year will pave the way for the Azerbaijani people to move forward on the path of building a legal state. (4)

As a result, under the leadership of Mr Ilham Aliyev, Azerbaijan is confidently moving towards the strategic goals ahead based on the requirements of the Constitution and its sovereign rights, and we believe that the successes observed in 2024 will continue at a higher pace in 2025."

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Jurisprudence

THE IMPORTANCE OF THE COUNCIL OF EUROPE CONVENTION AGAINST TRAFFICKING IN HUMAN ORGANS

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In the global era, the trafficking of human organs primarily arises in situations where states face difficulties in meeting the transplantation needs of their own citizens. Organ shortages, deepening social inequalities exacerbated by economic crises, and the emergence of illegal organ markets have led to a rise in transplantation tourism in recent years.

As a global problem, the trafficking of human organs severely violates fundamental freedoms, human rights, and human dignity. At the same time, it poses a direct threat to public health, as well as to the inviolability, freedom, and life of individuals. Therefore, effective measures are essential to protect the most vulnerable groups. This crime, often associated with the activities of organized criminal networks, exploits the vulnerability of donors living in poverty and socio-economically disadvantaged regions, as well as the desperation of individuals in need of donor organs. This process undermines public trust in existing transplantation systems and, as a result, fails to eliminate its root cause — the shortage of organs.

Although it is difficult to accurately determine the scale of this criminal activity, the growing number of cases of trafficking in human organs has become a matter of serious concern for the international community. Despite the various responses of individual states to this phenomenon, the establishment of a solid legal framework—particularly at the international level—was essential. The absence of a unified international legal instrument defining this activity as a criminal offence facilitated cross-border cooperation among criminal networks. Consequently, the trafficking of human organs became part of a broader pattern of violence and threats directed against human rights, democracy, and the rule of law. As these values constitute the core principles of the Council of Europe, the effective resolution of the problem could only be ensured through coordinated and joint global efforts.

The Council of Europe Convention against Trafficking in Human Organs represents a historic milestone in the fight against the illicit trade in human organs, particularly in terms of enhancing the effectiveness of international action. This article presents the Convention and its most significant features, assessing the extent to which this legal instrument contributes to the establishment of a “zero-tolerance zone” against organ trafficking.

It should be noted that the issue of trafficking in human organs had already been present on the international agenda prior to the adoption of the Convention. Various international organizations had addressed this problem from different perspectives—bioethics, organ transplantation, and criminal law (particularly in the context of human trafficking)—and had launched important initiatives to combat organ trafficking.

a) Article 21 of the Convention on Human Rights and Biomedicine (Oviedo Convention) — formally known as the Convention for the Protection of Human Rights and Dignity of the Human Being with regard to the Application of Biology and Medicine — prohibits any act aimed at making financial gain from the human body or its parts.[2] This principle is reaffirmed in Article 21 of the Additional Protocol to the Convention[1], and further strengthened in Article 22 through the explicit prohibition of organ and tissue trafficking. Article 26 of the same Protocol calls upon the Parties to ensure the application of appropriate sanctions in cases of violation of this prohibition.

In addition to the Oviedo Convention, other legal instruments adopted by the Committee of Ministers of the Council of Europe regulate primarily organizational and technical matters. These documents emphasize that the removal of organs from living donors may only take place where the donor's freedom and safety, as well as the protective conditions necessary for a successful transplantation, are ensured. In this context, Recommendation Rec(2004)7 concerning organ trafficking (4) is of particular importance. It explicitly states that organ trafficking is illegal and calls upon member states to ensure the existence of effective legal mechanisms[5] prohibiting this activity.

b) At the level of the European Union: Although the primary objective is to ensure the safety and quality of organs, the EU Directive 2010/45/EU on standards of quality and safety of human organs intended for transplantation [3] indirectly contributes to the fight against organ trafficking. It does so

through the establishment of competent authorities, the accreditation of transplantation centers, and the implementation of systems for organ procurement and traceability. These measures, while primarily focused on medical standards, strengthen transparency and oversight, thereby reducing the risk of illicit practices in organ transplantation.

c) Within the framework of the United Nations: The World Health Organization (WHO) Guiding Principles on Human Cell, Tissue and Organ Transplantation aim to establish an ethical and legal framework for the procurement and transplantation of human cells, tissues, and organs for therapeutic purposes [8]. In addition to this international legal framework, other significant initiatives undertaken by international bodies should also be noted.

The Istanbul Declaration of 2008 [6] defined the concepts of “organ trafficking” and “transplant tourism,” emphasizing their prohibition. However, it should be underlined that this declaration emerged as the outcome of a summit organized by The Transplantation Society and the International Society of Nephrology, and thus reflected the initiative of certain expert circles rather than the official position of the international community.

However, the existing legal instruments did not comprehensively address either the trafficking of human organs or other situations in which the donor consented to the removal of organs. The gaps present in the international legal framework prompted the Council of Europe to consider the necessity of developing a distinct legal instrument specifically addressing this issue.

Prior to this initiative, the Council of Europe and the United Nations (UN) jointly prepared a document entitled “Joint Study on Trafficking in Organs, Tissues and Cells and Trafficking in Human Beings for the Purpose of the Removal of Organs” [7], which put forward the following key recommendations:

- Clearly distinguish between two different phenomena: on the one hand, the trafficking in human organs, and on the other, trafficking in human beings for the purpose of organ removal;
- Support the principle of non-commercialization of the human body;
- Emphasize the need for an internationally agreed definition of organ trafficking;
- Develop an international legal instrument aimed at preventing such trafficking, protecting and assisting victims, and ensuring the punishment of offenders.

As a result of these recommendations, the Committee of Ministers of the Council of Europe, under the authority of the European Committee on Crime Problems (CDPC), mandated the Committee of Experts on Trafficking in Human Organs, Tissues and Cells to prepare a draft criminal-law convention against trafficking in human organs and, if necessary, a corresponding additional protocol. Within less than a year, the Committee members completed the draft text. The document was finalized and approved by the CDPC in 2012 and subsequently adopted by the Committee of Ministers of the Council of Europe on 9 July 2014.

The Convention was opened for signature on 25 March 2015 in Santiago de Compostela, Spain—hence it has become known as the “Santiago de Compostela Convention.”

During the drafting process of the Convention, the following international and regional instruments were taken as its primary legal and conceptual basis:

- The Convention on Human Rights and Biomedicine and its Additional Protocol concerning Transplantation of Organs and Tissues of Human Origin;
- The Council of Europe Convention on Action against Trafficking in Human Beings;
- The World Health Organization’s Guiding Principles on Human Cell, Tissue and Organ Transplantation;
- The 2009 Joint Study by the Council of Europe and the United Nations.

As a result, the Council of Europe Convention against Trafficking in Human Organs was designed to recognize all forms of organ trafficking as distinct criminal offences, aiming both to prevent such crimes and to strengthen international cooperation. The Convention was opened for signature on 25 March 2015 by member states, the European Union, non-member states with observer status, and other interested countries.

For the Convention to enter into force, at least five ratifications—three of which had to be from Council of Europe member states—were required. This condition was fulfilled on 1 March 2018. In total, 28 states have signed the Convention, and 15 of them have ratified it. Azerbaijan signed the Convention on 30 October 2023, but has not yet completed the ratification process.

The primary purpose of the Convention is to prevent and combat trafficking in human organs, to address the global threats arising in this field, and to ensure effective international cooperation among the Parties. It aims to safeguard human dignity, the right to life, and the protection of public health. The

Convention establishes new legal obligations to prevent organ trafficking and to define criminal liability in this sphere.

The main objectives of the Convention are as follows:

- *To criminalize acts related to the trafficking of human organs;*
- *To protect the rights of victims;*
- *To promote cooperation at both national and international levels.*

Under the Convention, State Parties are obliged to criminalize the following acts:

a) The illicit removal of human organs (Article 4.1)

Within the scope of this article, the following acts are considered criminal offences:

- *The removal of organs from living or deceased donors without their free, informed, and specific consent (Article 4.1.a);*
- *The removal of organs from a deceased donor without authorization in accordance with domestic law (Article 4.1.a);*
 - *Cases in which financial gain or any comparable advantage is obtained or offered:*
 - *For the removal of an organ from a living donor or a third party (Article 4.1.b);*
 - *By offering such gain or advantage to a third party in exchange for the removal of organs from a deceased donor (Article 4.1.c).*

According to the Convention, the removal of organs from a living or deceased person is considered unlawful if valid consent is not obtained and/or if financial gain or any other advantage is offered. The concept of "consent" derives from Article 5 of the Oviedo Convention and should be interpreted in conjunction with Article 19.2 of the same Convention. Under these provisions, consent must be specific, informed, and given freely, and it must be documented in writing or formally certified before a competent authority.

Moreover, Article 13 of the Additional Protocol to the Oviedo Convention further develops these requirements, providing additional safeguards to protect the rights of donors and to prevent exploitation. Within the framework of the Convention, the removal of organs from certain categories of individuals is subject to special restrictions, which are regulated either through complete prohibitions or varying levels of legal safeguards:

- *Persons unable to give consent: The Convention explicitly prohibits the removal of organs from individuals who are not legally capable of giving consent. This provision aims to protect the rights of donors and prevent cases of exploitation.*
- *Persons with restricted liberty: Article 4 applies fully to individuals with restricted liberty, whether living or deceased donors. This ensures that the same legal protections are maintained regardless of the donor's circumstances, safeguarding against risks related to consent and potential exploitation.*

b) Use of Illegally Obtained Organs (Article 5). Article 5 applies to the implantation or other use of human organs that have been illegally removed under the circumstances described in Article 4.1, whether for transplantation purposes or for other purposes, such as research activities. This provision ensures that legal liability extends throughout the entire chain of the offense, recognizing not only the illegal removal itself but also the subsequent use of these organs as a criminal act.

c) Solicitation, Recruitment, and Unlawful Benefits (Article 7). Article 7 criminalizes the activities of intermediaries or facilitators who connect donors, recipients, and medical personnel. This is a key mechanism aimed at preventing the illegal circulation of human organs and the encouragement of such activities. Specifically, the illegal recruitment or solicitation of organ donors or recipients, carried out to obtain financial gain or other advantages—whether for the recruiter's own benefit or that of a third party—is considered a criminal offense.

According to Article 21.3 of the Convention, any advertisement regarding the availability of or demand for human organs is prohibited if it is intended to offer financial gain or other advantages. However, this prohibition does not apply to donor recruitment or awareness activities permitted under domestic law.

Additionally, active and passive bribery by healthcare professionals, public officials, or private sector employees in connection with the illegal removal or implantation of organs is explicitly recognized as a criminal offense under the Convention.

d) Subsequent Acts Related to the Illegal Removal of Human Organs (Article 8). Under Article 8, a range of subsequent operations involving illegally removed human organs are also considered criminal offenses. Specifically, preparation, preservation, storage, transport, transfer, receipt, import, and export of such organs, if intentionally carried out in connection with the acts described in

Article 4.1, and where applicable Article 4.4, are criminalized. The phrase “where applicable” refers to situations in which a Party has criminalized the acts listed in Article 4.4, making it necessary to include these subsequent operations within the scope of Article 8. This approach ensures that the entire chain of illegal organ trafficking, not only the act of removal but also subsequent circulation, is covered, thereby upholding the principle of comprehensive criminal liability.

e) Assistance, Encouragement, and Attempt (Article 9). Article 9 of the Santiago de Compostela Convention stipulates that anyone who assists, encourages, or attempts to commit crimes related to illegal organ trafficking must also be held criminally responsible. This provision covers both direct and indirect contributions to the criminal activity, reinforcing the preventive character of the Convention’s criminal law framework.

Aggravating Circumstances. The Convention identifies specific circumstances that can aggravate the offense:

- The crime results in the victim’s death or serious physical/psychological harm;
- The crime is committed abusing a professional position;
- The crime is committed within the framework of an organized group;
- The offender has previous convictions for similar crimes;
- The crime targets children or other vulnerable groups.

Preventive Measures and International Cooperation (Articles 21 and 22). States are required to adopt measures to prevent the circulation of illegal organs, including:

- Establishing a transparent and fair transplantation system;
- Ensuring equal access to services;
- Organizing data collection, analysis, and exchange;
- Implementing training programs for competent authorities;
- Promoting public awareness;
- Prohibiting commercial advertising of human organs.

Within the framework of international cooperation, States must establish mechanisms for data exchange and accountability, reporting incidents of organ trafficking through national contact points.

Implementation and Oversight. The Convention is implemented through the Committee of the Parties, composed of State representatives. The Committee monitors the application of the Convention, facilitates exchange of experience between States, and operates based on a multisectoral and multidisciplinary approach, supported by expertise from relevant Council of Europe bodies. Plenary sessions of the Committee, which include representatives from National Contact Points (NETTA) and other organizations, serve as a platform for sharing best practices, discussing awareness and monitoring mechanisms, and promoting cooperation among States.

At the most recent plenary session of the Santiago de Compostela Committee, the potential of artificial intelligence (AI) and machine learning technologies for detecting content related to organ trafficking was highlighted. Based on recent research, these systems have demonstrated up to 92% accuracy in identifying relevant material. In addition, the application of agent-based models was discussed as a potential tool to support preventive measures in the digital age.

As highlighted above, human organ trafficking in the contemporary era represents a multifaceted problem encompassing not only criminal-legal but also ethical, medical, and socio-economic dimensions. This type of crime directly targets human dignity, bodily integrity, and the right to life. Persistent global organ shortages, socio-economic inequalities, and disparities in healthcare systems make complete eradication of this problem particularly challenging.

The Council of Europe Convention on Action against Trafficking in Human Organs represents a landmark international instrument with a systematic legal framework to address this phenomenon. The Convention criminalizes illegal removal and use of human organs, as well as acts of facilitation and inducement, thus covering the entire chain of legal responsibility. Beyond punitive measures, the instrument also emphasizes victim protection, preventive mechanisms, and enhanced interstate cooperation.

The international standards established by the Santiago de Compostela Convention provide States with a framework to align national legislation and implement a zero-tolerance policy against human organ trafficking. The Committee of the Parties, established for the implementation of the Convention, serves as the principal monitoring and accountability mechanism, ensuring transparency and exchange of best practices among States. At the same time, the application of emerging technologies such as AI and machine learning offers promising opportunities for detecting and preventing organ trafficking-related content in the digital era. Such approaches could complement legal and institutional

mechanisms, facilitating the establishment of more effective preventive controls and early-warning systems.

In conclusion, the fight against human organ trafficking requires not only strengthened legal accountability but also the promotion of social justice, equitable access to medical services, and international solidarity. The Council of Europe Convention represents a crucial legal instrument in this regard and makes a significant contribution to global efforts to safeguard human dignity.

Keywords: *trafficking in human organs, Santiago de Compostela Convention, legal mechanisms, international cooperation, Oviedo Convention, criminal liability*

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Medical sciences

SARCOPENIA IN RHEUMATOID ARTHRITIS

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Background: Sarcopenia is defined as an age-related disease characterized by decreasing muscle mass and strength or performance. Sarcopenia predisposes to increased mortality, particularly in the elderly, due to falls, fractures, and prolonged immobilization. Although the definition of sarcopenia was originally intended for the elderly, in recent years younger patients with autoimmune diseases such as Rheumatoid arthritis (RA) have been recognized with sarcopenia. Due to the chronic inflammation caused by RA, patients have reduced physical activity, immobility, stiffness, and joint destruction and all of that lead to the loss of muscle mass, muscle strength, disability and significantly lowering the patients' quality of life.

Objective: To evaluate the presence of sarcopenia in patients with rheumatoid arthritis (RA).

Method: We conducted a study including 100 patients with RA and 100 gender-matched healthy individuals. The study aims to investigate sarcopenia prevalence in patients with rheumatoid arthritis (RA) and to detect factors associated with low muscle mass and strength. Sarcopenia was assessed using performing tests such as handgrip strength, short physical performance battery and also by determining skeletal mass index using dual photon X-ray absorptiometry (DXA).

Results: The participants comprised of 65 females and 35 males. The frequency of sarcopenia was 40% in the RA group and 8% in the control group. The prevalence was significantly different between juvenile idiopathic arthritis (JIA), spondyloarthritis (SpA), and rheumatoid arthritis (RA) groups. Results of handgrip and gait speed tests were lower in the RA group than in the healthy control group ($P = .002$ and $P < .001$, respectively). Disease activity scores were higher in patients with sarcopenia than in patients without sarcopenia. A statistically significant association was found between handgrip test results and age, gender, and disease activity.

Conclusions: Patients with rheumatoid arthritis have not only bone tissue, but also skeletal muscle tissue disorders, resulting in a significant deterioration of functional capacity and quality of life. Longer disease duration and higher disease activity may provoke the development of sarcopenia due to chronic inflammation in patients with RA. Therefore, physicians should take into account the preservative and preventive methods against sarcopenia by encouraging patients about exercise along with controlling disease activity.

Keywords: sarcopenia, rheumatoid arthritis, handgrip strength, skeletal mass index, prevention

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NURSING CARE DURING BREASTFEEDING- LITERATURE REVIEW

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Abstract

Introduction: Breastfeeding is globally recognized as the optimal form of infant nutrition, promoting long-term health benefits for both mother and child. Despite World Health Organization recommendations for exclusive breastfeeding during the first six months, global adherence remains below target due to limited professional support and psychosocial or institutional barriers. Nurses play a pivotal role in promoting breastfeeding through education, counseling, and continuous postpartum support.

Methods: A narrative literature review was conducted across PubMed, SCOPUS, ScienceDirect, Elsevier, and Google Scholar databases. Only peer-reviewed studies published between 2020 and 2025 were included. Twenty studies meeting predefined inclusion criteria were analyzed thematically across domains of nursing-led education, maternal mental health, family and workplace engagement, and telemedicine-based interventions.

Results: Four thematic patterns emerged: (a) structured nursing education and lactation counseling significantly enhanced exclusive breastfeeding and maternal confidence; (b) integrating mental health care into lactation support improved maternal wellbeing and breastfeeding persistence; (c) family, partner, and workplace involvement increased breastfeeding sustainability; and (d) digital and telehealth models expanded equitable postpartum support.

Conclusions: Effective breastfeeding promotion depends on an integrated framework of nursing, psychosocial, and institutional support. Strengthening nursing leadership, embedding mental health and partner-inclusive strategies, and leveraging digital innovations can enhance breastfeeding outcomes and advance global maternal-child health.

Keywords: Breast feeding, Lactation, Mother, Nursing Care

1. Introduction

Breastfeeding is globally recognized as the optimal form of infant nutrition, conferring substantial health benefits for both mother and child. The World Health Organization (WHO) recommends exclusive breastfeeding for the first six months of life, yet global rates remain suboptimal due to multifaceted challenges ranging from limited professional guidance to sociocultural and psychological barriers (Government of Belize, 2007). Nurses play a pivotal role in addressing these gaps through education, counseling, and ongoing postpartum support, which are essential for improving breastfeeding initiation, duration, and exclusivity.

Recent studies highlight that breastfeeding outcomes are influenced by multiple interacting factors, including maternal mental health, family and partner support, workplace policies, and access to healthcare resources (Abageda et al., 2025; Alao et al., 2023; Chrzan-Dętkoś et al., 2021; Daniels et al., 2024). Nursing-led interventions whether delivered face-to-face, through structured education, or via telehealth have demonstrated measurable improvements in lactation outcomes and maternal self-efficacy (Di et al., 2024; Ramadan et al., 2025; Yulianti, 2024).

This review synthesizes evidence from twenty peer-reviewed studies published between 2020 and 2025 that examined how nursing interventions, mental health integration, and partner involvement contribute to improved breastfeeding outcomes. By identifying key determinants and intervention models, this synthesis aims to inform future nursing practice and health policy initiatives.

2. Aim and Objectives**Aim:**

To analyze and summarize current evidence on nursing interventions and support strategies that enhance breastfeeding initiation, exclusivity, and duration.

Objectives:

- To identify the most effective nursing interventions promoting breastfeeding success.

- To examine the influence of maternal mental health and psychosocial support on breastfeeding outcomes.
- To explore the impact of partner involvement, workplace support, and digital technologies on breastfeeding maintenance.
- Highlight implications for clinical practice, health policy, and future research.

3. Methodology

As a first step in conducting this narrative literature review, relevant research studies were identified and retrieved from a range of reputable academic databases including PubMed, ScienceDirect, SCOPUS, Elsevier, and Google Scholar.

Only peer-reviewed journal articles were included to ensure reliability, methodological rigor, and scientific validity of the findings.

To maintain contemporary relevance, the search was limited to studies published between 2020 and 2025. The search strategy used combinations of keywords and Medical Subject Headings (MeSH) such as "nursing support," "breastfeeding education," "lactation counseling," "maternal mental health," "partner involvement," "workplace breastfeeding policies," and "telemedicine breastfeeding interventions." Reference lists of included articles were also screened to identify additional eligible sources.

The selection criteria included studies that examined nursing interventions and support strategies aimed at improving breastfeeding outcomes specifically breastfeeding initiation, exclusivity, and duration as well as factors such as maternal self-efficacy, mental health, partner or workplace involvement, and the use of telehealth or digital platforms. Studies were required to:

- Involve pregnant or postpartum women within breastfeeding support programs delivered by nurses or allied health professionals;
- Be published in English; and
- Provide original empirical data (quantitative, qualitative, or mixed-method).

Studies were excluded if they were non-empirical (e.g., commentaries, reviews, or editorials) or if they focused on topics unrelated to nursing or breastfeeding support.

A total of 295 records were initially identified through the database search. After removing duplicates, 257 studies remained for title and abstract screening. Following exclusion of irrelevant articles, 87 full-text papers were assessed for eligibility, and finally 20 studies met all inclusion criteria and were retained for detailed synthesis (See **Figure 1.**).

The method of data analysis involved thematic content analysis of each included study to identify common patterns, concepts, and outcomes related to nursing support and breastfeeding care. Each study was reviewed in terms of its purpose, methodology, population, intervention characteristics, key results, and conclusions.

Findings were grouped into four thematic categories:

- Nursing and educational interventions to promote breastfeeding efficacy and exclusivity;
- Maternal mental health and psychosocial support;
- Partner, family, and workplace engagement; and
- Telemedicine and innovative nursing care models.

This thematic synthesis allowed for an integrated interpretation of evidence across different study designs and geographic contexts, highlighting recurring challenges and successful strategies in nursing-led breastfeeding support.

The following table provides a detailed summary of the 20 included studies, listing the authors, publication year, research design, main findings, and corresponding DOI (see **Table 1.**). These studies collectively illustrate the critical role of nursing interventions in enhancing breastfeeding outcomes and maternal well-being across diverse healthcare systems.

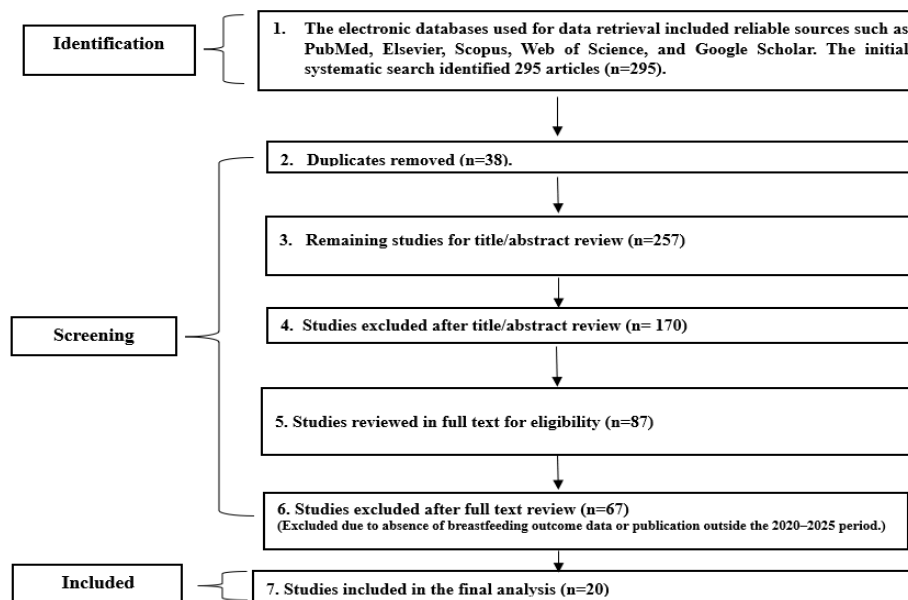


Figure 1. The process of identifying studies via databases

4. Results

4.1. Nursing and Educational Interventions

Nursing education and structured lactation counseling consistently improved breastfeeding outcomes (Di et al., 2024; Nassar et al., 2022; Yulianti, 2024).

Targeted breastfeeding education significantly reduced breast pain, improved lactation, and enhanced maternal–infant bonding (Di et al., 2024). Mothers who received structured lactation education maintained higher exclusive breastfeeding rates at one and three months postpartum (Yulianti, 2024). Proactive postpartum outreach and follow-up counseling increased breastfeeding rates at six and twelve months (Nassar et al., 2022).

At the institutional level, optimal nurse staffing and supportive work environments were associated with higher exclusive breastfeeding rates (Mason et al., 2024). Implementation of the ci-BPC program, which integrated prenatal, hospital, and postpartum components, effectively increased breastfeeding duration at a sustainable cost (Keenan-Devlin et al., 2024). These findings confirm that continuous, evidence-based nursing education and postnatal follow-up are essential for sustaining breastfeeding success (Di et al., 2024; Keenan-Devlin et al., 2024; Mason et al., 2024; Nassar et al., 2022; Yulianti, 2024).

4.2. Maternal Mental Health and Psychosocial Support

Several studies emphasized the link between maternal mental health and breastfeeding outcomes (Alao et al., 2023; Chrzan-Dętkoś et al., 2021; Dagla et al., 2025; DeCoste et al., 2024). Women seeking lactation support exhibited more psychological distress but improved markedly after consultations, reporting increased self-efficacy and reduced depressive symptoms (Chrzan-Dętkoś et al., 2021). Themes of mental health support and care recognition were identified as crucial in lactation consultations, suggesting the integration of mental-health screening into perinatal care (DeCoste et al., 2024). Among Nigerian mothers, 24% experienced mental disorders inversely related to breastfeeding support quality (Alao et al., 2023). Anxiety and depression were also found to significantly reduce breastfeeding duration among women with high-risk pregnancies (Dagla et al., 2025). Collectively, these findings highlight that strengthening emotional support within nursing interventions enhances both maternal wellbeing and breastfeeding persistence (Alao et al., 2023; Chrzan-Dętkoś et al., 2021; Dagla et al., 2025; DeCoste et al., 2024).

4.3. Partner, Family, and Workplace Support

Social and contextual factors play a decisive role in sustaining breastfeeding. Male partner participation in breastfeeding education increased the likelihood of optimal breastfeeding by 38% (Abageda et al., 2025). Workplace breastfeeding models were viewed as feasible but were often constrained by space limitations and low organizational commitment, emphasizing the need for institutional advocacy (Daniels et al., 2024). Supportive workplace policies and child-friendly spaces improved exclusive breastfeeding rates and confidence among healthcare workers (Gilder et al., 2024). Family-centered nursing support was also found to strengthen mothers' practical skills and emotional reassurance (Alao et al., 2023). These findings underscore that empowering fathers, families, and

employers is vital for sustainable breastfeeding promotion (Abageda et al., 2025; Alao et al., 2023; Daniels et al., 2024; Gilder et al., 2024).

4.4. Digital and Innovative Models

Technological solutions are reshaping postpartum care. Nurse-led telemedicine achieved breastfeeding initiation and satisfaction rates comparable to in-person care, confirming telehealth as an equitable and effective alternative (Ramadan et al., 2025). The PeriWell virtual intervention enhanced emotional regulation and breastfeeding confidence through a twelve-week online program (Busch et al., 2025; Moss & Busch, 2025). Global breastfeeding research has also shown an increasing focus on collaboration, innovation, and inclusivity (Ozen Cinar, 2025). These findings indicate that integrating telehealth into nursing practice can extend the reach of lactation support, particularly for mothers facing geographic or logistical barriers (Busch et al., 2025; Moss & Busch, 2025; Ozen Cinar, 2025; Ramadan et al., 2025).

4.5. Health-System and Policy Perspectives

Systemic and policy dimensions also influence breastfeeding practices. Clear communication and respectful postpartum care were found to enhance satisfaction across Italian hospitals, although nearly one-fifth of mothers reported insufficient post-discharge information (Davanzo et al., 2025). Pandemic-related visitation restrictions unexpectedly benefited mother–infant bonding and breastfeeding within maternity wards (Kersting et al., 2024). Overweight mothers were identified as facing unique barriers to breastfeeding, highlighting the need for tailored and cost-effective counseling interventions (Aldana-Parra et al., 2020). These findings suggest that institutional continuity of care, effective communication, and adaptive health policies are essential complements to nursing education in promoting optimal breastfeeding outcomes (Aldana-Parra et al., 2020; Davanzo et al., 2025; Kersting et al., 2024).

5. Conclusion

This review demonstrates that breastfeeding success depends on a multidimensional network of nursing, psychological, familial, and institutional supports. Evidence consistently shows that structured nursing education, family and partner involvement, and attention to maternal mental health significantly enhance breastfeeding outcomes. Telemedicine and workplace interventions further expand access, equity, and sustainability in postpartum care.

To maximize impact, nursing leadership should prioritize comprehensive, culturally sensitive, and technologically enabled breastfeeding programs integrated across prenatal, intrapartum, and postnatal stages. Future research should employ longitudinal and multicenter designs to evaluate scalability and cost-effectiveness. Strengthening the nursing workforce and embedding mental-health and partner-inclusive approaches will remain key strategies for promoting global breastfeeding success.

Table 1. Article selected for review

No	Authors (Year)	Methods	Results	Conclusions	DOI
1	(Paredes Garcés et al., 2023)	Mixed methods	The study identified lack of information and emotional support as major breastfeeding challenges and found a positive correlation between proper newborn latch and increased breast milk production.	The study highlights nursing training and lactation support as key to improving breastfeeding care in hospitals.	https://doi.org/10.51798/sijis.v4i4.715
2	(Di et al., 2024)	Randomized controlled trial (RCT) method	The intervention group showed reduced breast pain, improved lactation, higher self-efficacy, better maternal-infant interaction, and fewer complications than the control group.	Breastfeeding health education with nursing intervention effectively relieves breast pain and enhances lactation outcomes postpartum.	doi: 10.12998/wjcc.v12.i2.2.5059
3	(Mason et al., 2024)	Systematic review	Eight studies showed that better nurse staffing and supportive work environments were linked to higher breastfeeding support and exclusive breast milk feeding rates.	Improving nurse staffing and work environments can enhance breastfeeding outcomes and should be prioritized in practice and future research.	DOI: 10.1097/JPN.0000000000000859

4	(Keenan-Devlin et al., 2024)	Program implementation research design	The ci-BPC program increased breastfeeding intensity and duration through comprehensive prenatal, hospital, and postpartum support at a cost of \$297–386 per patient.	A multidisciplinary, evidence-based approach created a sustainable breastfeeding peer counseling program that effectively improved breastfeeding outcomes.	https://doi.org/10.1038/s41372-024-01995-3
5	(Chrzan-Dętkoś et al., 2021)	Observational study	Women seeking lactation support had more mental health difficulties, but after consultations showed higher breastfeeding self-efficacy and reduced psychological symptoms.	Strengthening breastfeeding confidence through lactation consultations can improve maternal mental health and breastfeeding outcomes.	https://doi.org/10.1016/j.midw.2020.102905
6	(DeCoste et al., 2024)	Qualitative descriptive study	Three themes emerged: supporting maternal mental health, providing care, and recognizing mothers' need for support.	Lactation consultant visits offer key opportunities for maternal mental health screening and care, emphasizing the need for collaborative, integrated perinatal support.	https://doi.org/10.1016/j.midw.2024.104145
7	(Alao et al., 2023)	Cross-sectional study	Among 895 Nigerian mothers, 24% had common mental disorders, which were inversely associated with breastfeeding support quality, particularly family-centered care and practical guidance.	Strengthening family-centered care and breastfeeding support skills among healthcare workers is essential to improve maternal mental health and breastfeeding outcomes.	https://doi.org/10.21203/rs.3.rs-2566447/v1
8	(Daniels et al., 2024)	Mixed-method research study	Participants positively perceived the breastfeeding workplace model as practical and feasible, though challenges like limited commitment and space availability were noted.	Advocacy for supportive workplace environments is essential, as the model offers a useful framework for initiating and enhancing breastfeeding support globally and locally.	https://doi.org/10.1186/s13006-024-00638-9
9	(Yulianti, 2024)	Quasi-experimental study	Mothers who received structured lactation education showed significantly higher exclusive breastfeeding rates at 1 and 3 months postpartum, with improved confidence and techniques.	Lactation education effectively enhances exclusive breastfeeding success, emphasizing the need for comprehensive educational and support-based interventions for postpartum mothers.	https://doi.org/10.35335/ners.v3i1.380
10	(Moss & Busch, 2025)	Theoretical and conceptual development method	The PeriWell Intervention, a 12-week perinatal virtual program, was developed to enhance emotional regulation and breastfeeding self-efficacy.	By integrating the Positive Direction and Tri-Core Breastfeeding Models, the PeriWell Intervention provides a comprehensive framework supporting emotional well-being and breastfeeding confidence during the perinatal period.	DOI: 10.1891/CL-2024-0011
11	(Busch et al., 2025)	Longitudinal quality improvement (QI) study	The PeriWell approach significantly increased prenatal breastfeeding confidence and self-efficacy, highlighting the value of specialized interventions for maternal support.	Integrating tailored virtual peripartum and breastfeeding support effectively enhances maternal and infant outcomes, emphasizing the need for innovative, empowering care in recovery settings.	DOI:10.1891/CL-2024-0012
12	(Nassar et al., 2022)	Quality improvement retrospective chart review study	Breastfeeding rates significantly increased at 6 and 12 months after implementing post-birth outreach and lactation support.	Early proactive follow-up and lactation counseling effectively enhance long-term breastfeeding outcomes.	DOI:10.1891/CL.2021-0002
13	(Gilder et al., 2024)	Mixed-methods	Supportive workplace policies, child-friendly spaces, and goal setting significantly increased exclusive breastfeeding rates and confidence among healthcare workers.	Enhancing workplace protections and facilities for breastfeeding staff improves both employee breastfeeding outcomes and the quality of breastfeeding support provided to patients.	https://doi.org/10.1186/s13006-024-00613-4

14	(Aldana-Parra et al., 2020)	Two-arm randomized controlled trial (RCT) design	Overweight mothers face multiple barriers to breastfeeding, highlighting the need for tailored interventions to improve initiation and duration rates.	Developing and implementing cost-effective, evidence-based breastfeeding counseling programs for overweight women is essential to enhance breastfeeding outcomes and inform public health policy.	https://doi.org/10.1186/s13006-019-0249-2
15	(Ramadan et al., 2025)	Parallel-group, non-inferiority randomized controlled trial.	Telemedicine breastfeeding support achieved initiation and outcome rates comparable to in-person care, with higher satisfaction and accessibility among participants.	Nurse-led telemedicine is an effective, equitable alternative to in-person breastfeeding support, sustaining maternal confidence and outcomes over time.	https://doi.org/10.1186/s12884-025-08236-1
16	(Ozen Cinar, 2025)	Descriptive analysis	Bibliometric analysis revealed that breastfeeding research was highly collaborative, with key themes centered on breastfeeding, lactation, support, and exclusivity, and the United States leading in publication output and international collaboration.	Breastfeeding remains a central and enduring focus in nursing research over the past decade.	https://doi.org/10.1016/j.pedn.2024.10.036
17	(Dagla et al., 2025)	Cohort study	Maternal anxiety and depression were found to significantly reduce breastfeeding duration and exclusivity, especially among women with high-risk pregnancies.	Early identification and integration of mental health support into perinatal care can improve breastfeeding outcomes and maternal-infant well-being, highlighting the need for further longitudinal research on broader social and healthcare influences.	https://doi.org/10.3390/psychiatryint6040123
18	(Davanzo et al., 2025)	Cross-sectional study	Most mothers positively evaluated postpartum care and breastfeeding support across 26 Italian hospitals, praising clear communication, emotional assistance, and respect for the mother-baby relationship, though 19.9% noted insufficient post-discharge information.	Postpartum and breastfeeding support were generally effective, but improved guidance on available resources after discharge is needed to strengthen continuity of care.	DOI: 10.20944/prerprints202501.2038.v1
19	(Kersting et al., 2024)	Cross-sectional study	Most hospital staff and mothers viewed pandemic-related visiting restrictions positively, with over 80% of staff favoring their continuation and many mothers maintaining similar limits at home.	Visiting restrictions, though introduced out of necessity, may offer unexpected benefits for mother-infant bonding and breastfeeding support in maternity care settings.	https://doi.org/10.1186/s13006-024-00664-7
20	(Abageda et al., 2025)	Cluster randomized controlled trial (RCT) design	Male partner participation in breastfeeding education increased the likelihood of optimal breastfeeding by 38%.	Engaging fathers in breastfeeding education effectively promotes optimal breastfeeding and should be integrated into maternal health programs.	https://doi.org/10.1111/mcn.13764

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DERMOSCOPIC CRITERIA OF CUTANEOUS METASTASES OF MALIGNANT MELANOMA – CASE REPORT

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Introduction: Melanoma is a malignant neoplasm with a high metastatic potential; however, the route and pattern of its dissemination are often unpredictable. The most common sites of melanocytic metastases include the skin, subcutaneous tissue, and lymph nodes, followed by internal organs. The differential diagnosis of cutaneous metastases from other malignant cutaneous lesions may be challenging for dermatologists and is particularly important for the early and accurate diagnosis as well as monitoring of disease progression. Dermoscopy serves as a powerful diagnostic tool in this context. The dermoscopic criteria of metastatic melanocytic lesions are generally divided into: a) Nevus blue-like criteria b) Globular nevus-like criteria c) Non-globular nevus-like criteria d) Angioma-like criteria e) Vascular criteria f) Non-specific criteria.

Case Report: We report the case of a 50-year-old female patient, referred by the rheumatologist due to persistent pain in the right knee, accompanied by the appearance of an irregular brown lesion with central bluish areas and asymmetric borders on the right lower limb. After dermoscopic examination, the case was referred to Oncology for surgical excision with a suspected diagnosis of Acral Melanoma. Histopathology and immunohistochemistry confirmed the diagnosis of Malignant Acral Melanoma, Stage IV. Approximately four months after surgical excision, a small bluish, shiny, soft nodule appeared at the excision site. Dermoscopy revealed typical features of a melanocytic metastasis, resembling a blue nevus-like pattern. The lesion was excised, and the patient was re-evaluated for oncologic management. Histopathologic report: Melanomatous recurrence. Molecular analysis: BRAF mutation testing performed by RT-PCR (Easy BRAF kit) revealed the presence of the V600 mutation in exon 15 of the BRAF gene. Despite treatment, during a six-month follow-up period, 30–40 small metastatic nodules developed around the excision site.

Conclusion: Although in this case the diagnosis of metastatic melanocytic lesions was straightforward due to the patient's medical history, dermatologists must remain vigilant during dermoscopic examination of de novo cutaneous lesions. Atypical features and the lack of resemblance to typical dermoscopic criteria of benign lesions should raise suspicion for a possible underlying malignant process or cutaneous metastasis.

Keywords: malignant melanoma, cutaneous metastasis, dermoscopy, immunohistochemistry, biopsy

Pedagogical sciences

THE USE OF LEXICAL GAMES IN ENGLISH LESSONS AT THE PRIMARY STAGE OF SECONDARY SCHOOL

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Abstract

The development of vocabulary is one of the central tasks in the process of teaching English at the primary stage of secondary school. Lexical games, being an effective pedagogical tool, play an important role in enhancing pupils' motivation, interest, and ability to retain new words. This article explores the theoretical foundations and practical implementation of lexical games in English lessons for young learners aged 10–11. The theoretical section outlines the role of vocabulary in language acquisition and the importance of communicative and activity-based approaches in modern pedagogy. It also discusses the psychological and linguistic features of young learners that make games particularly effective for vocabulary learning.

In the practical section, various lexical games used in English classrooms are presented, including "Word Bingo," "Memory Chain," "Guess the Word," and "Word Association." These activities help pupils activate new vocabulary, improve pronunciation, and develop contextual understanding. Classroom observations and small-scale applications demonstrated that the inclusion of lexical games significantly increases learners' engagement and retention rates. The combination of competition, collaboration, and creativity contributes to the internal motivation of pupils and reduces anxiety associated with language learning.

The study concludes that lexical games are not simply entertainment but a purposeful didactic instrument that supports vocabulary acquisition, communication, and critical thinking. Their systematic integration into lesson plans fosters a positive classroom atmosphere, encourages participation, and builds a solid foundation for further language development. The article combines theoretical analysis with practical experience, offering recommendations for teachers on how to effectively select, adapt, and conduct lexical games according to the learners' age and proficiency level.

Keywords: *lexical games, vocabulary acquisition, young learners, communicative approach, motivation, English teaching, primary school, active learning, language development, methodology*

Introduction

Teaching English to young learners requires the use of interactive, engaging, and child-centered techniques. One of the most effective ways to make vocabulary learning enjoyable and memorable is through the use of lexical games. Games turn the classroom into a dynamic space where children can learn by doing, interacting, and experimenting with language. At the primary stage of secondary school, pupils are naturally curious, energetic, and motivated by play, which makes lexical games particularly suitable for this age group.

This article aims to examine the theoretical basis of using lexical games in English lessons and to describe practical methods for their implementation in the classroom. The authors combine pedagogical theory with personal teaching experience to demonstrate the educational potential of lexical games.

Theoretical Background

Lexical competence forms the foundation of communicative competence. Without sufficient vocabulary, learners cannot express themselves effectively, regardless of grammatical accuracy. According to Nation (2001), vocabulary knowledge includes both breadth (number of words known) and depth (how well those words are understood and used).

Modern teaching methodologies, such as the communicative approach and task-based learning, emphasize the importance of active engagement in meaningful communication. For young learners,

games provide this natural context for communication and learning. Vygotsky's sociocultural theory (1978) also supports the idea that children learn through social interaction, and games create a safe, motivating environment for such interaction.

Psychologically, children at this age learn best through play, movement, and imagination. Lexical games appeal to these natural learning preferences, turning abstract vocabulary into concrete, memorable experiences.

Practical Application of Lexical Games

In practical classroom settings, lexical games can be used at different stages of the lesson — for introducing, practicing, or revising vocabulary. The following examples illustrate effective strategies:

- **"Word Bingo"** – pupils mark words on a bingo card as they are called out; the first to complete a line wins. This reinforces listening comprehension and word recognition.
- **"Memory Chain"** – each pupil repeats the previous words and adds a new one, enhancing recall and pronunciation.
- **"Guess the Word"** – one pupil describes a word without naming it, and others guess; this develops descriptive skills and contextual understanding.
- **"Word Association"** – learners respond quickly with related words, helping to build lexical networks.

These games were applied in English lessons with pupils aged 10–11. Observations showed that learners were more active, motivated, and willing to participate in speaking tasks after such activities. The games also helped in differentiating instruction for mixed-ability groups, as they encouraged cooperation and peer learning.

Findings and Discussion

The integration of lexical games into English lessons has multiple pedagogical benefits. Firstly, it enhances vocabulary retention through repetition in varied contexts. Secondly, it fosters positive emotions, which are essential for long-term memory and motivation. Thirdly, games promote learner autonomy — pupils begin to monitor their own progress while engaging in play.

Teachers reported that pupils became more confident in using new vocabulary spontaneously. The classroom atmosphere became more collaborative and communicative. However, it is important to balance the entertainment aspect with educational goals: games should always serve a clear linguistic purpose.

The results of classroom applications align with previous research emphasizing that playful learning environments support both cognitive and affective aspects of language acquisition.

Conclusion

Lexical games represent a powerful pedagogical technique for vocabulary teaching at the primary stage of secondary school. They combine enjoyment with learning, allowing pupils to acquire and use new words naturally and effectively. By integrating games systematically into lesson plans, teachers can enhance learners' motivation, engagement, and linguistic competence.

The combination of theory and practice in this article confirms that lexical games are not only supplementary tools but an essential part of modern English teaching methodology. Future research could further explore how digital or interactive online games can expand these benefits in blended learning environments.

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THE CONDITIONS, PRINCIPLES, AND STAGES OF THE FORMATION OF THE SELF-ANALYSIS ACTIVITY OF SENIOR HIGH SCHOOL STUDENTS

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Abstract

Throughout the development of society, there has been and will continue to be a need for scientific achievements and optimal educational methods. People involved in this field have always been concerned with searching for new methods and tools. Self-education has always been positively received by society, so its conditions, principles, and stages should constantly be improved by keeping them in the spotlight. In the developing world, the importance of self-education in an era of changing and abundant information is one of the modern realities of education.

Keywords: self-education, extracurricular activities, interests, goals, inclinations, motivations, innovations, analyses.

Throughout history, education has played a crucial role in enhancing people's living conditions and well-being. Therefore, scientists in this field are constantly working on new projects and concepts. The growing societal demand, the creation of new production areas, and the increasing relevance of artificial intelligence in recent times encourage people to continuously expand their knowledge in this field.

Innovations in all fields have increased the demand for new educational approaches. Today, self-development ultimately serves self-realization in education, and this process must continue. Self-education is the path to achieving the aforementioned. For self-education to be successful, it is important to understand its conditions, principles, and stages.

Regarding the conditions of self-education:

1. Self-education is a type of cognitive activity carried out during and outside of the learning process.
2. In addition to instilling independence, cognitive activity, and a creative attitude toward work, self-education also fosters qualities such as cultural behavior, communication skills, and patience.
3. One condition for preparing senior students for self-education is taking individual characteristics into account.
4. Students engaged in self-education must possess a variety of skills.
5. Active self-education is possible only under conditions of serious motivation. [1. p. 74]

The aforementioned conditions demonstrate that classical pedagogical theories, including issues relevant to modern pedagogy, will never fade into the background.

G.N. Serikov demonstrated the psychological and pedagogical characteristics of students' readiness for self-education as follows:

- Personality-oriented values that determine their worldview and their place in life and society.
- Their attitude toward socially useful work, learning, and self-education.
- their attitude toward the role of the collective and experienced consultants in their activities, as well as their sociability with others;
- The level of development of the emotional-volitional apparatus up to the realization of the possibilities of voluntary, consistent self-education. [4. p. 541]

Self-education provides students with the ability to learn independently, think critically, and draw conclusions. In this sense, self-education is based on the following principles:

1. The principle of democratic cooperation between teachers, students, and parents implies creating opportunities for students to fulfill their healthy interests, instilling patriotism, educating students in the spirit of patriotism, instilling a love of labor, and fostering self-education and self-discipline habits. This principle also involves carefully addressing individual characteristics and interests.

2. Taking into account the difficulties of the self-education process. Implementing this principle involves determining the degree of difficulty, removing obstacles, and considering the relationship and sequence of the materials being studied.

3. The principles of theoretical knowledge, determining concepts and relationships, and establishing intra- and interdisciplinary connections are as important as developing habits.

4. Students must understand what they have learned. This principle aims to develop reflection and students' self-awareness as learners. This principle may be relevant to the development of self-regulatory reflection. [5. p. 4-8]

These principles are based on the general principles accepted in pedagogy. Thus, these principles imply developing active awareness of students' inclinations and interests, as well as the ability to think freely and independently. Students should also be able to express their ideas, develop creative, logical, and critical thinking skills, ask questions, listen, draw conclusions, and make generalizations.

The success of self-study depends on students' cognitions and activities.

- realization of personality-oriented principles, in which students can choose work according to their interests;

- achievement of the necessary intellectual development, realistic approach to problems, planning to solve problems.

- Senior students independently search for and integrate information, applying previously acquired knowledge in practice. Students' creative and intellectual abilities, independence, and responsibility develop, as well as their planning and decision-making skills. [2. p. 78]

Essentially, self-education is directed according to the student's needs and interests. It provides students with intellectual development to solve problems and benefit from the information they receive according to real learning opportunities.

Taking individual characteristics into account when preparing students for self-education is only natural. First of all, this involves selecting special methods that correspond to their developmental patterns and individual psychological characteristics, such as functional asymmetry of the hemispheres, gender, and age. Additionally, gender characteristics are important for learners. Girls tend to cooperate. Boys are characterized by creative and research activities, solving spatial tasks, orientation to practical information, and competition. [6. p. 56]

Self-education is a complex, multifaceted learning process that occurs in several stages:

1. Determining the motivation to learn. For training to be effective, the student must be motivated to learn. Although the concept of self-education includes the presence of a motive, it is not the main condition for effectively organizing the training process. It is important for the student to have an internal desire to realize his dreams, affirm himself as a person, achieve success on his chosen path, and gain knowledge. At the same time, it is important to protect their morals and instill a sense of self-respect. A student with these qualities will not be overwhelmed by unnecessary information from websites. He knows his abilities and what he wants to study.

2. Information and Source Search: All activities in this area aim to obtain information. A student engaged in self-education selects the necessary sources in their field of interest and determines their quality and results.

3. Drawing up a plan for self-education. When writing a plan, the student predicts what he will achieve in advance. Having a clear plan enables one to implement the learning process and its goals, determine the stages for achieving them, correctly divide the learning process, and make it comfortable and efficient. [3. p. 79]

Studies show that a large proportion of students achieve their goals. However, this task is relatively easy if the path to achieving the goal is planned and gradual. First, the student confirms the topic that interests him in accordance with the plan. Then, he learns the related information. The student learns to use effective materials to remember the information.

Self-education reaches its highest level when this form of education becomes part of one's life. To achieve this, it is important to adhere to the aforementioned conditions, principles, and stages.

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APPLYING THE CONSTRUCTIVIST APPROACH IN TEACHING THE HISTORY OF KAZAKHSTAN: EXPERIENCE IN DEVELOPING AN INTERACTIVE MULTIMEDIA WEB RESOURCE

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ҚАЗАҚСТАН ТАРИХЫН ОҚЫТУДА КОНСТРУКТИВИСТІК ТӘСІЛДІ ҚОЛДАНУ: ИНТЕРАКТИВТІ МУЛЬТИМЕДИЯЛЫҚ ВЕБ-РЕСУРСТЫ ӘЗІРЛЕУ ТӘЖІРИБЕСІ

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Abstract

This study examines the application of a constructivist approach in teaching the History of Kazakhstan and the experience of developing an interactive multimedia web resource to enhance the learning process. The relevance of the research is determined by the need to modernize historical education in the context of digital transformation and to organize learning as a learner-centered and experience-based process. The main purpose is to design a structural and content model of an interactive multimedia web resource based on constructivist principles and to evaluate its effectiveness in the teaching of the History of Kazakhstan.

The research employed a mixed-method design combining qualitative and quantitative approaches. The materials included the content of History of Kazakhstan courses in schools and higher education institutions, as well as empirical data obtained from teachers and students. Data were collected through surveys, interviews, classroom observations, and comparative experiments, and were processed using SPSS and NVivo software.

The findings demonstrated that the use of interactive multimedia web resources increased students' learning motivation by 34.3% and improved their ability to understand and interpret historical sources by 21.2%. Cognitive engagement and research skills also showed significant growth. Additionally, 79.4% of teachers reported that multimedia technologies enhanced lesson effectiveness and student participation.

The study concludes that the integration of constructivist pedagogy and multimedia technologies provides an effective methodological model for teaching the History of Kazakhstan. This approach fosters historical awareness, promotes critical thinking, and develops learners' research competencies.

Аңдатпа

Бұл зерттеу Қазақстан тарихын оқытуда конструктивистік тәсілді қолдану мүмкіндіктерін және оқу үдерісін тиімді ету мақсатында интерактивті мультимедиялық веб-ресурс әзірлеу тәжірибесін қарастырады. Зерттеудің өзектілігі цифрлық трансформация жағдайында тарихи білім беруді жаңғырту қажеттілігімен, сондай-ақ оқытуды білім алушыға бағытталған және тәжірибеге негізделген үдеріс ретінде ұйымдастыру талабымен айқындалады. Зерттеудің негізгі мақсаты конструктивистік қағидаларға сүйенген интерактивті мультимедиялық веб-ресурстың құрылымдық-мазмұндық моделін әзірлеу және оның Қазақстан тарихын оқытудағы тиімділігін бағалау.

Зерттеу барысында сапалық және сандық әдістерді үйлестіретін аралас әдіснама қолданылды. Материалдар мектептер мен жоғары оқу орындарындағы Қазақстан тарихы курстарының мазмұнын, сондай-ақ мұғалімдер мен білім алушылардан алынған эмпирикалық деректерді қамтыды. Деректер сауалнама, сұхбат, сабақ бақылауы және салыстырмалы эксперименттер арқылы жиналып, SPSS пен NVivo бағдарламалары арқылы өңделді.

Нәтижелер интерактивті мультимедиялық веб-ресурстарды қолдану студенттердің оқу мотивациясын 34,3%-ға арттырғанын, тарихи дереккөздерді түсіну және интерпретациялау қабілеттерін 21,2%-ға жақсартқанын көрсетті. Танымдық белсенділік пен зерттеу дағдыларының да едәуір өскені анықталды. Сонымен қатар мұғалімдердің 79,4%-ы мультимедиялық технологиялар сабақтың тиімділігін және білім

алушылардың қатысуын айтарлықтай күшейткенін атап өтті.

Зерттеу қорытындысы конструктивистік педагогика мен мультимедиалық технологияларды біріктіру Қазақстан тарихын оқытуға арналған тиімді әдістемелік үлгі қалыптастыратынын көрсетеді. Бұл тәсіл тарихи сананы дамытуға, сыни ойлау қабілетін жетілдіруге және білім алушылардың зерттеушілік құзыреттіліктерін қалыптастыруға ықпал етеді.

Keywords: *constructivist approach, History of Kazakhstan, multimedia web resource, interactive learning, historical education, digital pedagogy.*

Түйін сөздер: конструктивистік тәсіл, Қазақстан тарихы, мультимедиалық веб-ресурс, интерактивті оқу, тарихи білім беру, цифрлық педагогика.

Кіріспе.

Қазіргі кезеңде білім беру жүйесі терең трансформация үдерісін бастан өткеріп отыр. Ғылым мен технологияның дамуы, ақпараттық кеңістіктің кеңеюі және оқыту формаларының цифрлануы оқу процесінің мазмұны мен әдістемесін түбегейлі жаңартуды талап етеді [1]. Осы контексте тарих пәні де қоғамның әлеуметтік-мәдени дамуы мен ұлттық бірегейлікті қалыптастыруда маңызды рөл атқарып, жаңа педагогикалық парадигмалармен ұштасуы қажет. Қазақстан тарихын оқытуда конструктивистік тәсілді қолдану осы міндеттерді іске асырудың тиімді жолдарының бірі. Конструктивизм оқытуды тұлғаға бағдарланған, тәжірибеге негізделген және бірлескен танымдық әрекет ретінде қарастырады. Мұнда білім алушы тарихи ақпаратты дайын күйінде қабылдамай, өз танымдық белсенділігі арқылы тарихи деректер мен құбылыстарды талдап, түсінік пен мағынаны өзі қалыптастырады [2].

Қазіргі педагогикалық ғылымда конструктивистік тәсілдің негізгі қағидалары оқу материалының өмірлік тәжірибемен байланысы, белсенді танымдық әрекет, рефлексия және оқу нәтижесінің тұлғалық мәні болып саналады. Бұл тәсіл білім алушылардың танымдық дербестігін, сын тұрғысынан ойлауын және тарихи фактілерге сыни көзқарасын дамытуға бағытталған [3]. Тарихты оқытуда конструктивизм тәсілін қолдану оқушылардың тек хронологиялық білім алуын емес, тарихи процестердің себеп-салдарлық байланысын түсінуін, әлеуметтік-мәдени құндылықтарды салыстыруын және өз ұстанымын дәлелдеуді көздейді.

Цифрлық қоғам жағдайында тарихи білім беру жүйесі ақпараттық-коммуникациялық технологиялармен (АКТ) тығыз байланыста дамуда. Интерактивті мультимедиялық веб-ресурстарды пайдалану оқыту сапасын арттырудың, оқушының танымдық белсенділігін ынталандырудың және тарихи материалды көрнекі әрі мағыналы жеткізудің маңызды тетігі [4]. Мұндай ресурстар деректерді визуалды және интерактивті форматта ұсынуға, күрделі тарихи ұғымдар мен құбылыстарды кеңістіктік, хронологиялық және мәдени контексте бейнелеуге мүмкіндік береді.

Зерттеулер көрсеткендей, заманауи педагогикалық технологиялар мен конструктивистік ұстанымдарды үйлестіру оқу процесінің тиімділігін арттырады [5]. Жоғары оқу орындарында тарихты оқытудың тәрбиелік және танымдық әлеуетін күшейту студенттің азаматтық және тарихи санасын қалыптастыруда шешуші рөл атқарады. Жаңартылған білім беру бағдарламалары аясында тарих пәнін оқыту зерттеушілік дағдыларды дамытуға және пәнаралық байланыстарды күшейтуге бағытталуы тиіс. Сонымен қатар өлкетану мен мәдени-тарихи туризмнің мүмкіндіктерін пайдалану ұлттық құндылықтарға негізделген тәжірибелік оқытудың тиімділігін арттырады. Осындай тәсілдердің барлығы тарихи білім беруді жаңғыртудың негізгі бағыты ретінде конструктивистік ұстанымдарды теориялық және практикалық тұрғыда іске асырудың маңызын дәлелдейді [6,7].

Зерттеу нысаны Қазақстан тарихын оқыту үдерісі, ал пәні конструктивистік тәсіл негізінде интерактивті мультимедиялық веб-ресурсты әзірлеу және оны оқу процесінде қолдану шарттары мен әдістемесі.

Зерттеудің мақсаты Қазақстан тарихы пәнін оқытуда конструктивистік тәсілді іске асыруға бағытталған интерактивті мультимедиялық веб-ресурстың құрылымдық-мазмұндық моделін әзірлеу және оның оқу үдерісіндегі тиімділігін айқындау.

Осы мақсатқа жету үшін төмендегідей міндеттер қойылады:

1. Конструктивистік тәсілдің теориялық негіздерін және оның тарихи білім берудегі қолданылу ерекшеліктерін талдау;

2. Интерактивті мультимедиялық веб-ресурстардың білім беру кеңістігіндегі мүмкіндіктерін анықтау;

3. Қазақстан тарихын оқытуға арналған веб-ресурстың құрылымдық және мазмұндық моделін жобалау;

4. Ұсынылған модельді тәжірибелік-эксперименттік негізде сынақтан өткізіп, оның тиімділігін бағалау.

Зерттеу тақырыбының өзектілігі білім беру жүйесінің цифрлық трансформациясы жағдайында Қазақстан тарихын оқытудың сапасын арттыру қажеттігімен айқындалады. Бүгінгі таңда оқушылардың ақпаратты талдау, дәлелдеу және тарихи фактілерді сыни тұрғыдан пайымдау қабілеттерін дамыту басты міндетке айналды. Интерактивті веб-ресурстар бұл үдерісті жаңаша ұйымдастыруға, оқу материалының мазмұнын кеңейтіп, білім алушыны белсенді әрекетке тартуға мүмкіндік береді.

Осылайша, конструктивистік тәсіл мен мультимедиялық технологияларды біріктіру Қазақстан тарихы пәнін оқытудың заманауи моделін қалыптастырып, оқыту процесін ғылыми тұрғыда жаңғыртуға және тарихи білімнің сапасын арттыруға ықпал етеді. Бұл зерттеу отандық педагогикада цифрлық оқыту мәдениетін дамытуға, сонымен қатар тарихи білімнің мазмұнын интерактивті форматта жаңаша ұсынуға бағытталған маңызды ғылыми қадам болып табылады [8].

Әдеби шолу

Конструктивизм және тарихи білім берудің теориялық негіздері

Зерттеу нәтижелері университеттік деңгейде Қазақстан тарихын оқыту үдерісіне конструктивистік ұстанымдарды енгізудің ғылыми-әдістемелік және практикалық негіздерін жан-жақты айқындады. Бұл бағытта білім беру процесі тек қана ақпарат берудің емес, сонымен қатар тұлғаның азаматтық, мәдени және дүниетанымдық қалыптасуын қамтамасыз ететін тәрбиелік және танымдық әлеуеті жоғары интеграцияланған жүйе ретінде қарастырылды. Конструктивистік тәсіл тарихи білімді дайын күйінде меңгертуге емес, студенттің өз бетімен іздену, дәлелдеу және сыни тұрғыдан талдау арқылы жаңа білім құрастыруына басымдық беруді көздейді. Осы тұрғыда студенттердің тарихи деректермен өзара әрекетке түсуі олардың зерттеушілік қабілетін, тарихи ойлау мәдениетін және азаматтық жауапкершілігін дамытуда шешуші рөл атқаратыны анықталды [9].

Әдіснамалық тұрғыда тарихи-салыстырмалы және жүйелік тәсілдерді үйлестіре қолдану конструктивистік тұғырдың ғылыми дәлдігін күшейтті. Бұл тәсіл тарихты оқытудың мазмұнын тек хронологиялық фактілер тізбегі ретінде емес, тарихи оқиғалардың өзара себеп-салдарлық байланыстарын, әлеуметтік-мәдени контекстін және адамдық факторды түсіндіретін тұтас жүйе ретінде қарастыруға мүмкіндік берді. Мұндай көзқарас студенттердің тарихи процестерді логикалық және сыни тұрғыдан пайымдауына, оқиғаларды талдау мен салыстыру дағдыларын дамытуына септігін тигізетіні тәжірибе жүзінде дәлелденді [9].

Зерттеу нәтижелері орта білім беру деңгейінде де тарих пәнін оқытудың мазмұны мен әдістемесін жаңартылған білім беру парадигмасына сәйкес жетілдіру қажеттігін көрсетті. Тарих сабақтары енді фактілерді механикалық түрде жаттауға емес, тарихи деректерді талдау, олардың шынайылығын бағалау, әртүрлі дереккөздерді салыстыру және оқиғаларды көпәспектiлi тұрғыдан пайымдау сияқты когнитивтік дағдыларды қалыптастыруға бағытталуы тиіс. Бұл тәсіл оқушыларды тарихи білімді сыни тұрғыдан қабылдауға, дәлелді пікір айтуға және өткеннен сабақ ала отырып қазіргі шындыққа баға беруге үйретеді.

Осылайша, конструктивизмнің негізгі қағидалары белсенді танымдық әрекет, өзіндік рефлексия, мағыналық байланыстар орнату және білімді жеке тәжірибемен ұштастыру заманауи тарих сабағында тиімді жүзеге асырылатыны анықталды. Мұндай әдістемелік бағыт білім алушылардың тарихи санасын тереңдетіп, олардың ұлттық және жалпыадамзаттық құндылықтарға негізделген дүниетанымын қалыптастыруға мүмкіндік береді [10].

Өлкетану және мәдени-тарихи туризмнің рөлі

Зерттеулерде тарихи білім мазмұнын жергіліктендіру және оқушылардың аймақтық мәдени мұраға қызығушылығын арттырудың тиімді жолы ретінде өлкетану мен мәдени-тарихи туризмді кіріктірудің педагогикалық негіздері айқындалған. Мұндай тәсіл білім алушылардың туған өлке тарихын зерделеу арқылы ұлттық құндылықтарды терең түсінуіне, тарихи сана мен азаматтық жауапкершіліктің қалыптасуына ықпал етеді. Сонымен қатар аймақтық тарихи деректер мен мәдени нысандарды оқу процесіне енгізу оқытудың тәжірибеге

бағытталуын қамтамасыз етіп, тарихи білімнің өмірмен байланысын күшейтеді [11, 12]. Зерттеу авторларының пайымдауынша, оқушылардың туған жерінің тарихын тануы олардың танымдық және азаматтық уәжін арттырып, тарихи сананы жандандырады. Мұндай тәсіл білімді өмірлік тәжірибемен ұштастырып, оқу процесін мағыналық және эмоциялық тұрғыдан байытады. Бұл конструктивистік теорияның «білім тәжірибеге сүйенген әрекет нәтижесі» қағидасына нақты мысал.

Сонымен қатар зерттеуде мәдени-тарихи туризм мен өлкетанудың тарих сабағындағы интеграциясы пәнаралық тәсілді жүзеге асыруға мүмкіндік беретіні, ал бұл өз кезегінде оқушылардың зерттеушілік, коммуникативтік және жобалық дағдыларын дамытуға септігін тигізетіні көрсетілген.

Цифрлық және мультимедиялық технологиялардың маңызы

2021 жылғы республикалық ғылыми конференция материалдарында интерактивті мультимедиялық веб-ресурстарды білім беру процесіне енгізу мәселелері жан-жақты қарастырылған. Зерттеулерде тарихты оқытуда ақпараттық-коммуникациялық технологиялардың (АКТ) әлеуетін тиімді пайдалану заманауи білім берудің басты міндеттерінің бірі екені атап өтілді. Авторлар атап өткендей, жаңа цифрлық ортада мұғалімнің рөлі дәстүрлі ақпарат жеткізушіден оқу процесін ұйымдастырушы, бағыттаушы және фасилитатор рөліне өзгереді, ал оқушының рөлі пассивті тыңдаушыдан белсенді ізденуші мен зерттеушіге айналады [13, 14].

Мұндай парадигмалық өзгеріс білім алушылардың оқу процесіне қатысу деңгейін арттырып қана қоймай, олардың дербес ойлау, ақпаратты талдау және тарихи оқиғалар арасындағы себеп-салдарлық байланыстарды анықтау қабілеттерін дамытады. Цифрлық құралдар виртуалды музейлер, QR-код жүйелері, тарихи интерактивті карталар, 3D модельдер мен мультимедиялық реконструкциялар оқушылардың тарихи деректерді визуалды және интерактивті форматта қабылдауына мүмкіндік береді. Бұл тәсіл оқушылардың тарихи материалға деген эмоционалды және танымдық қызығушылығын арттырып, оқу процесін белсенді тәжірибеге негізделген танымдық іс-әрекетке айналдырады.

Сонымен қатар, осындай құралдар тарихи оқиғаларды уақыт пен кеңістік аясында көрнекі түрде көрсету арқылы сыни және салыстырмалы ойлауды дамытады. Мысалы, тарихи карталар мен уақыт сызықтары оқушыларға оқиғалардың динамикасын, өзгерістердің логикасын түсінуге көмектеседі, ал виртуалды музейлер мәдени мұраны цифрлық форматта зерттеу мүмкіндігін ұсынады. Мұның барлығы конструктивизмнің басты қағидасына «оқушы білімді дайын күйде алмай, оқу процесі арқылы өз тәжірибесін құрады» деген тұжырымға толық сәйкес келеді [15].

Осылайша, интерактивті мультимедиялық веб-ресурстарды пайдалану тарих пәнін оқытудың әдіснамалық және технологиялық жаңғыруына ықпал етіп, оқушылардың тарихи ойлау, деректерді талдау және өзіндік қорытынды жасау дағдыларын дамытудың тиімді құралы ретінде танылды.

Құзыреттілік пен зерттеушілік мәдениетті қалыптастыру

Барлық талданған еңбектерде тарихты оқытудың түпкі нәтижесі ретінде білім алушылардың пәндік құзыреттілігін, зерттеушілік мәдениетін және сыни ойлау қабілетін дамыту басым бағыт ретінде қарастырылады [16]. Зерттеушілердің пікірінше, тарихи білімнің сапасы тек деректер мен фактілерді есте сақтаумен өлшенбейді; ол ең алдымен оқушының тарихи пайымдау жасау, себеп-салдарлық байланыстарды анықтау, әртүрлі көзқарастарды салыстыру және дәлелге негізделген тұжырым қалыптастыру дағдыларымен айқындалады. Мұндай қабілеттердің дамуы тарихи сананы тереңдетіп қана қоймай, тұлғаның әлеуметтік белсенділігі мен азаматтық жауапкершілігін қалыптастыруға да ықпал етеді.

Зерттеулер нәтижелері көрсеткендей, мәдени-тарихи мазмұнға, дереккөздерге және практикалық тәжірибеге негізделген сабақтар оқушылардың рефлексиялық ойлауын, талдау және интерпретациялау машығын едәуір арттырады. Тарихи мәтіндермен және түпнұсқа дереккөздермен жұмыс істеу барысында білім алушылар тек ақпарат қабылдаушы рөлінде емес, деректердің мағынасын өз бетінше ашушы, салыстырушы және бағалаушы субъект ретінде әрекет етеді. Осы арқылы тарихи білім механикалық есте сақтаудан мағыналы таным мен дербес талдау деңгейіне көтеріледі [17, 18].

2021 жылғы республикалық ғылыми конференция материалдарында да осы бағыттағы нақты тәжірибелік қадамдар талқыланды. Онда тарих сабақтарында интерактивті мультимедиялық веб-ресурстарды пайдалану арқылы зерттеушілік дағдыларды

қалыптастыруға бағытталған жобалар, дебаттар, виртуалды зертханалар мен цифрлық симуляциялар енгізіліп жатқаны атап өтілді. Мұндай құралдар оқушыларға тарихи құбылыстарды модельдеу, дереккөздермен тәжірибелік жұмыс жасау және тарихи гипотезаларды тексеру мүмкіндігін береді. Бұл үрдіс конструктивтік тәсілдің білім беру практикасына нақты және тиімді түрде енгенін көрсетеді [19].

Жалпы алғанда, қазіргі тарихи білім берудің эволюциясы ақпаратты жаттау парадигмасынан зерттеушілік-рефлексиялық модельге көшуімен сипатталады. Бұл модель оқушыны белсенді таным субъектісі ретінде қалыптастырып, оның жеке тәжірибесіне сүйенген мағыналы оқу әрекетін қамтамасыз етеді, ал бұл өз кезегінде тарихи ойлаудың жоғары деңгейін дамытуға негіз қалайды.

Материалдар мен әдістер

Бұл зерттеу сапалық және қолданбалы сипаттағы педагогикалық-әдістемелік зерттеу болып табылады. Негізгі әдіснамалық негіз ретінде конструктивистік педагогика қағидалары білім алушының оқу процесіндегі белсенді рөлі, әлеуметтік өзара әрекет арқылы мағыналы білім құрастыру, рефлексия және тәжірибе арқылы үйрену принциптері алынды. Зерттеу жұмысы Қазақстан тарихын оқыту үдерісін жаңартылған білім беру парадигмасы тұрғысынан қарастырып, оны заманауи цифрлық технологиялармен үйлестірудің тиімді жолдарын анықтауға бағытталды. Негізгі назар интерактивті мультимедиялық веб-ресурстарды конструктивистік тәсіл контекстінде педагогикалық тұрғыда жобалау мен олардың оқу процесіне ықпалын талдауға аударылды.

Зерттеу 2023-2025 жылдар аралығында үш кезеңде жүргізілді. Бірінші кезеңде теориялық-әдіснамалық дайындық жұмыстары атқарылды: конструктивизмнің философиялық және педагогикалық негіздері талданып, отандық және шетелдік зерттеулер салыстырмалы түрде қарастырылды. Бұл мақсатта ғылыми мақалалар, диссертациялық зерттеулер, оқу бағдарламалары мен әдістемелік құралдарға контент-талдау жүргізілді (5). Теориялық талдау нәтижесінде конструктивистік тәсілдің Қазақстан тарихын оқытудағы қолданыс аясын айқындайтын ұғымдық-әдістемелік модель әзірленді. Осы кезеңде зерттеу нысаны мен пәні, негізгі мақсат пен міндеттер нақтыланды.

Екінші кезеңде эмпирикалық деректер жинау жүзеге асырылды. Зерттеу жұмысы педагогикалық жоғары оқу орындары мен жалпы білім беретін мектептер базасында жүргізіліп, қатысушылар контингентін тарих пәнінің оқытушылары, педагогикалық мамандықтағы студенттер және мектеп мұғалімдері құрады. Барлығы 146 қатысушы зерттеу процесіне ерікті түрде тартылды: оның ішінде 32 жоғары оқу орнының оқытушысы, 68 студент және 46 жалпы орта мектеп мұғалімі. Бұл іріктеме Қазақстанның әр аймағындағы оқу орындарын қамтыды және әртүрлі кәсіби деңгейдегі педагогтардың тәжірибесін салыстыруға мүмкіндік берді. Қатысушылардың жасы 19 бен 54 жас аралығында болды, ал тәжірибе деңгейі 1 жылдан 25 жылға дейінгі аралықты қамтыды.

Эмпирикалық материалды жинау үшін деректерді жинаудың аралас әдістері қолданылды: сауалнама, жартылай құрылымданған сұхбат, бақылау және сабақ талдау. Сауалнамада мұғалімдердің конструктивистік тәсіл элементтерін қолдану жиілігі, мультимедиялық және веб-технологияларды пайдалану тәжірибесі, сондай-ақ оларды қолданудағы қиындықтар мен артықшылықтарға қатысты көзқарастары анықталды. Сұхбат әдісі арқылы мұғалімдердің педагогикалық ұстанымдары, веб-ресурстарды оқу процесіне енгізу шарттары мен жеке тәжірибелік шешімдері тереңірек зерттелді. Сабақтарға қатысу және бейнеталдау әдістері арқылы оқыту процесінің құрылымы мен студенттердің танымдық белсенділік деңгейі бағаланды.

Интерактивті мультимедиялық веб-ресурс әзірлеу кезеңінде педагогикалық дизайн мен жобалау әдістері қолданылды. Ресурс құрылымы төрт модульден тұрды: (1) тарихи деректер және мәтіндік контент; (2) визуалды-мультимедиялық блок (интерактивті карталар, 3D модельдер, уақыт сызықтары, бейнефрагменттер, фотоматериалдар); (3) зерттеу және талдау аймағы (тапсырмалар, рефлексиялық эссе, пікірталас модулі); (4) бағалау және кері байланыс жүйесі. Веб-ресурс контенті отандық және халықаралық ашық білім беру платформаларынан алынған деректерге негізделді («Қазақстан тарихы» порталы, e-history.kz, UNESCO digital archives, Europeana Collections). Барлық материалдар дидактикалық өңдеуден өткізіліп, оқу мақсаттары мен тарихи кезеңдерге сәйкестендірілді.

Эмпирикалық зерттеу барысында веб-ресурс екі түрлі форматта апробацияланды: дәстүрлі сабақ (бақылау тобы) және интерактивті сабақ (тәжірибелік топ). Бақылау тобы

дәстүрлі әдістерді пайдаланып оқыды, ал тәжірибелік топ интерактивті мультимедиялық веб-ресурс арқылы жұмыс істеді. Екі топ та бірдей тақырыптар мен оқу мақсаттарын орындады. Бұл салыстырмалы тәсіл интерактивті цифрлық орта қолданылған жағдайда оқыту тиімділігінің арту деңгейін өлшеуге мүмкіндік берді.

Деректерді өңдеу мен талдау сапалық және сандық әдістердің үйлесімінде жүргізілді. Сандық деректер SPSS бағдарламасы арқылы статистикалық талдаудан өтті: орташа арифметикалық көрсеткіш, стандарттық ауытқу, корреляциялық байланыс және пайыздық таралымдар есептелді. Мұғалімдер мен студенттердің жауаптары мен бағалау нәтижелері топтар арасындағы айырмашылықты анықтау мақсатында салыстырылды. Сапалық деректер мазмұндық талдау және индуктивті категориялау әдістері бойынша кодталды. Сұхбат пен бақылау нәтижелерінен алынған деректер үш негізгі индикатор бойынша жіктелді: танымдық белсенділік деңгейі, тарихи пайымдау сапасы және ынтымақтастық әрекет дәрежесі.

Бақылау барысында алынған бейнеталдау материалдары мен рефлексиялық эсселер NVivo бағдарламасы арқылы талданып, конструктивистік ортадағы танымдық әрекеттің негізгі сипаттары айқындалды. Мұғалімдердің тәжірибесін салыстырмалы талдау педагогикалық модельдің практикалық жарамдылығын анықтауға мүмкіндік берді. Сонымен қатар, эксперимент нәтижелерін интерпретациялау барысында студенттердің оқу мотивациясының артуы, тарихи деректерді интерпретациялау дәлдігінің жоғарылауы және өздігінен іздену әрекетінің жиіленуі анықталды.

Зерттеу барысында этикалық нормалар қатаң сақталды. Барлық қатысушылардан ақпараттандырылған келісім алынды, деректердің құпиялығы қамтамасыз етілді, зерттеу нәтижелері тек ғылыми мақсатта пайдаланылды.

Жалпы алғанда, зерттеу әдістемесі теориялық және эмпирикалық деректерді үйлестіріп, Қазақстан тарихын оқытуда конструктивистік тәсіл мен интерактивті мультимедиялық веб-ресурстарды біріктірудің тиімділігін дәлелдеуге бағытталды. Жиналған материалдар тарихи білім беру үдерісін цифрлық және мағыналық тұрғыдан жаңғыртудың педагогикалық шарттарын айқындауға, сондай-ақ осы бағыттағы әдістемелік модельдің ғылыми негізін қалыптастыруға мүмкіндік берді.

Нәтижелер

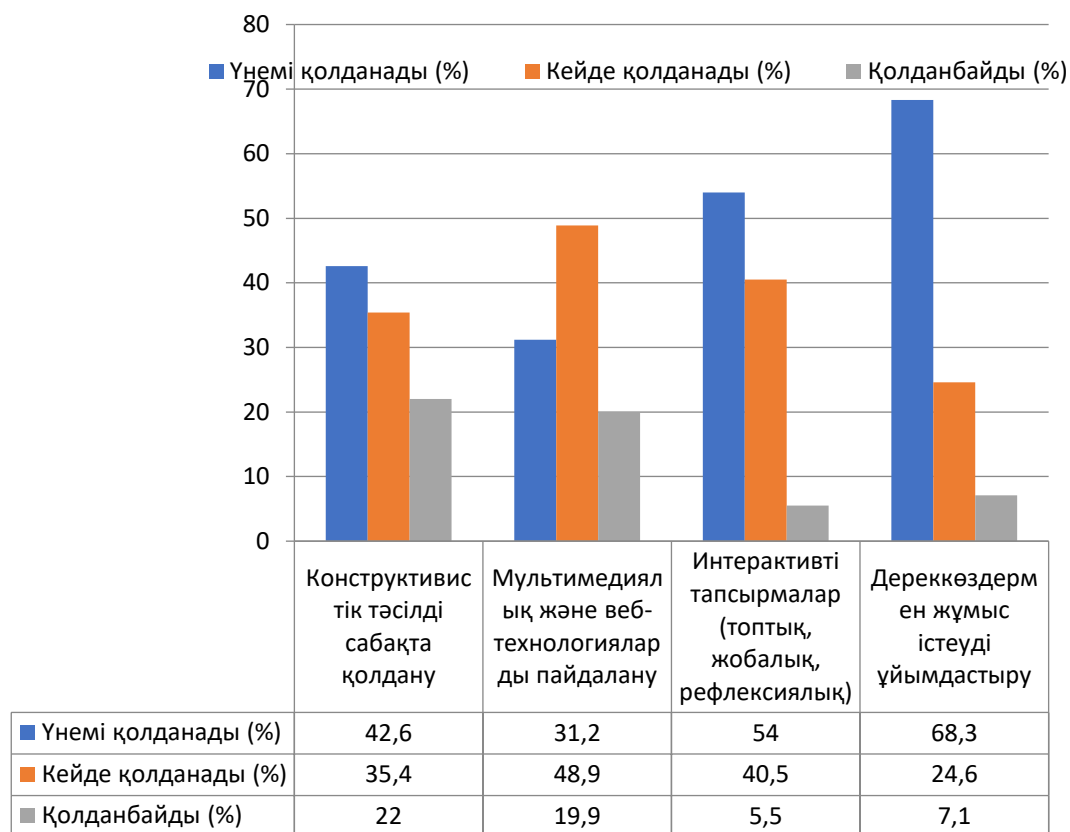
Зерттеу нәтижелері Қазақстан тарихын оқытуда конструктивистік тәсілді іске асыру мен интерактивті мультимедиялық веб-ресурстарды қолданудың оқу үдерісінің сапасына ықпалын жан-жақты сипаттайды. Алынған деректер педагогтардың кәсіби ұстанымдарын, студенттер мен оқушылардың оқу белсенділігі мен уәжін, сондай-ақ тарихи деректермен жұмыс істеу қабілетінің даму динамикасын көрсетеді.

Зерттеу үш кезеңде жүргізілгендіктен, нәтижелер де үш блок бойынша ұсынылады: (1) мұғалімдердің тәжірибелік және әдістемелік дайындығы; (2) студенттер мен оқушылардың оқу жетістіктері; (3) интерактивті веб-ресурстарды қолдану тиімділігіне қатысты сандық және сапалық көрсеткіштер.

Сауалнама нәтижелері тарих пәні мұғалімдерінің көпшілігі конструктивистік әдістемені оң қабылдайтынын көрсетті. Респонденттердің 87,5%-ы бұл тәсіл оқушылардың танымдық белсенділігін арттыратынын айтқанымен, тек 42,6%-ы оны тұрақты және жүйелі қолданатынын хабарлады. Сонымен қатар 35,4%-ы конструктивистік әдістерді тек кей жағдайларда қолданатынын, ал 22,0%-ы бұл тәсілді толық меңгермегенін мойындады.

Мұғалімдердің интерактивті мультимедиялық құралдарды пайдалану жиілігі де зерттелді. 31,2% мұғалім сабақтарында веб-ресурстарды тұрақты қолданатынын, 48,9% кейде қолданатынын, ал 19,9% техникалық шектеулерге байланысты сирек пайдаланатынын атап өтті (Сурет 1).

Сурет 1. Мұғалімдердің конструктивистік тәсіл мен мультимедиялық технологияларды қолдану тәжірибесі (n = 46)



Сурет 1. Мұғалімдердің басым бөлігі интерактивті әдістердің тиімділігін мойындағанымен, қолдану жиілігі инфрақұрылым мен әдістемелік дайындыққа тәуелді екенін көрсетті.

Оқушылар мен студенттердің оқу мотивациясы мен танымдық белсенділігі

Тәжірибелік сабақтар барысында дәстүрлі және интерактивті форматтағы оқыту әдістерінің тиімділігі салыстырмалы түрде талданды. Екі топта да оқу мазмұны мен мақсаттары бірдей сақталғанымен, қолданылған әдістемелік тәсілдер мен оқу ортасы айтарлықтай ерекшеленді. Бақылау тобында сабақтар дәстүрлі түсіндірмелі-иллюстративтік әдістер арқылы өткізілсе, тәжірибелік топта интерактивті мультимедиялық веб-ресурстар пайдаланылды. Мұндай орта студенттер мен оқушыларға тарихи деректермен тікелей өзара әрекет етуге, карталар мен уақыт сызықтарын талдау арқылы себеп-салдарлық байланыстарды өз бетінше анықтауға мүмкіндік берді.

Оқу мотивациясы мен танымдық белсенділік көрсеткіштері сандық және сапалық тұрғыда салыстырылды. Интерактивті ортада білім алушылардың сабаққа қызығушылығы, ынтықсы мен қатысу деңгейі дәстүрлі форматқа қарағанда айтарлықтай жоғары болды. Төмендегі мәліметтер осы айырмашылықты нақты көрсетеді (Кесте 1).

Кесте 1. Оқу мотивациясы мен белсенділіктің салыстырмалы көрсеткіштері (n = 146)

Көрсеткіштер	Бақылау тобы (дәстүрлі әдіс)	Тәжірибелік тобы (веб-ресурстармен)	Айырмашылық (%)
Оқу мотивациясы индексі (5 балдық шкала)	3,2	4,3	+34,3
Танымдық белсенділік деңгейі (%)	58,0	83,4	+25,4
Сабақтағы топтық жұмысқа қатысу жиілігі (%)	52,6	79,8	+27,2
Пікірталасқа қатысу белсенділігі (%)	47,3	74,9	+27,6
Рефлексия сапасы (жазбаша талдау, 5 балдық)	3,1	4,4	+41,9

Кесте 1. Интерактивті веб-ресурстарды қолданған жағдайда оқу мотивациясы мен белсенділік барлық көрсеткіштер бойынша айтарлықтай артқан.

Аналитикалық өңдеу нәтижелері көрсеткендей, тәжірибелік топта оқу мотивациясы орта есеппен 1,1 балға (34,3%) жоғарылады. Бұл көрсеткіш оқушылардың оқу процесіне белсенді қатысуына және сабақ материалын эмоционалды қабылдауына тікелей байланысты болды. Танымдық белсенділік деңгейі 25,4%-ға өсіп, интерактивті ортаның зерттеу және талдау әрекеттерін ынталандыратынын дәлелдеді. Топтық жұмыс пен пікірталасқа қатысу көрсеткіштерінің тиісінше 27,2% және 27,6%-ға жоғарылауы интерактивті форматтың кооперативті оқытуды күшейтіп, бірлескен ойлау дағдыларын дамытатынын көрсетті.

Рефлексия сапасының 3,1-ден 4,4 балға дейін артуы (+41,9%) студенттердің өз оқу әрекетіне талдау жасап, жеке пікір қалыптастыру қабілетінің нығайғанын білдіреді. Бұл

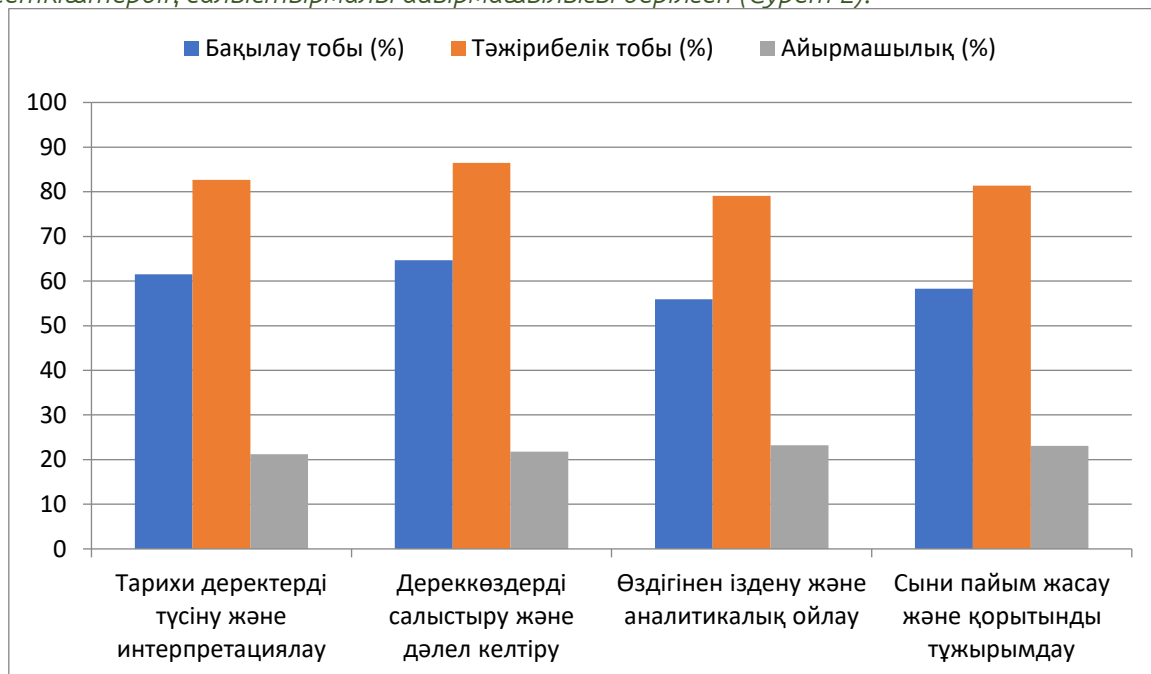
көрсеткіш конструктивистік тәсілдің басты қағидаларының бірі өзіндік рефлексия мен мағыналы тәжірибеге негізделген үйренудің нақты нәтижесін сипаттайды.

Тарихи деректермен жұмыс және зерттеушілік дағдылар

Зерттеу нәтижелері интерактивті мультимедиялық веб-ресурстарды қолдану студенттердің тарихи деректермен жұмыс істеу сапасын едәуір арттырғанын көрсетті. Оқушылар мен студенттер тарихи мәтіндер мен құжаттардағы деректерді талдау, салыстыру және интерпретациялау барысында анағұрлым белсенді әрі дәл әрекет ете бастады. Егер дәстүрлі әдіспен оқытылған топта қатысушылардың небәрі 61,5%-ы дерек мазмұнын дұрыс түсіндірсе, интерактивті веб-ортада бұл көрсеткіш 82,7%-ға дейін артты. Бұл айырмашылық 21,2 пайыздық тармақты құрап, веб-негізді оқыту форматының тарихи материалды ұғыну мен мағыналық байланыстарды орнатудағы тиімділігін дәлелдейді.

Сондай-ақ өздігінен іздену және талдау қабілеті бойынша айқын оң динамика байқалды: тәжірибелік топта бұл көрсеткіш 79,1%-ға жетіп, бақылау тобындағы 55,9%-дан 23,2%-ға жоғары болды. Мұндай нәтиже интерактивті орта студенттерді ақпаратты дайын күйінде қабылдаудан гөрі, оны өз бетінше іздеу, салыстыру және интерпретация жасау арқылы меңгеруге бағыттайтынын көрсетті.

Бұл айырмашылықтар тарихи деректерді меңгеру сапасының өсуімен қатар, танымдық дербестіктің, сыни талдау мен дәлелге негізделген ойлау дағдыларының қалыптасқанын дәлелдейді. Төмендегі суретте дәстүрлі және интерактивті форматтағы топтар арасындағы көрсеткіштердің салыстырмалы айырмашылығы берілген (Сурет 2).



Сурет 2. Тарихи деректермен жұмыс дағдыларының салыстырмалы нәтижелері
Сапалық деректер мен корреляциялық байланыстар

Сұхбат және бақылау материалдарын талдау интерактивті мультимедиялық ортаның оқыту процесін құрылымдық және мотивациялық тұрғыда өзгертетінін көрсетті. Мұғалімдердің 79,4%-ы веб-платформаларды қолдану оқушылардың белсенділігін арттыратынын айтса, студенттердің 84,7%-ы интерактивті тапсырмалар мен мультимедиялық материалдар сабаққа деген қызығушылықты күшейтетінін растады.

Статистикалық талдау нәтижесінде оқу мотивациясы мен танымдық белсенділік арасында жоғары оң корреляция ($r = 0,78$, $p < 0,01$) анықталды. Сондай-ақ дерекпен жұмыс істеу дағдылары мен рефлексия деңгейі арасындағы байланыс коэффициенті $r = 0,72$ ($p < 0,01$) деңгейінде болды, бұл екі фактордың өзара тәуелділігін дәлелдейді (Кесте 2).

Кесте 2. Негізгі көрсеткіштер арасындағы корреляциялық байланыстар (Pearson r)

Көрсеткіштер жұбы	Корреляция коэффициенті (r)	Маңыздылық деңгейі (p)
Оқу мотивациясы танымдық белсенділік	0,78	< 0,01
Дерекпен жұмыс істеу рефлексия деңгейі	0,72	< 0,01
Сыни пайым тарихи интерпретация дәлдігі	0,69	< 0,05
Топтық жұмысқа қатысу оқу мотивациясы	0,63	< 0,05

Кесте 2. Позитивті корреляциялық байланыстар конструктивистік тәсілдің кешенді

әсерін көрсетеді.

Мұғалімдердің пікірлері және қолдану тиімділігі

Мұғалімдердің рефлексиялық есептері мен сапалық сұхбаттары интерактивті мультимедиялық веб-ресурстарды қолдану сабақ құрылымына, мазмұнына және педагогикалық өзара әрекет сипатына елеулі өзгеріс енгізетінін көрсетті. Мұғалімдердің пікірінше, мұндай құралдар оқу процесін дәстүрлі ақпарат беру моделінен белсенді және зерттеушілік бағыттағы сабақ форматына көшіреді. Цифрлық визуализация, интерактивті карталар мен виртуалды экскурсиялар тарихи материалды көрнекі әрі өмірмен байланысты күйде ұсынуға мүмкіндік береді.

Педагогтардың бағалауына сәйкес, интерактивті карталармен және уақыт сызықтарымен жұмыс (73%) оқу материалын құрылымдауға және кеңістіктік-уақыттық байланыстарды түсіндіруге ең тиімді әдіс болып танылды. Цифрлық дереккөздерге QR-код арқылы өту (68%) тарихи құжаттарға тікелей қол жеткізуді жеңілдетсе, виртуалды экскурсиялар (54%) мен музей сабақтары оқушылардың эмоциялық қабылдауын күшейтті. Топтық жобалық жұмыстар (62%) бірлескен зерттеу мен пікір алмасуға жағдай жасап, конструктивтік оқыту қағидаларының іске асуын қамтамасыз етті. Ал цифрлық тесттер мен рефлексиялық тапсырмалар (59,5%) білім алушылардың өз оқу әрекетіне баға беру қабілетін дамытты.

Кесте 3. Мұғалімдердің интерактивті технологиялар тиімділігі туралы бағалауы

Қолданылған әдіс немесе құрал	Тиімді деп бағалаған мұғалімдер үлесі (%)
Интерактивті карталар және уақыт сызықтары	73,0
Виртуалды экскурсиялар мен музей сабақтары	54,0
QR-код арқылы цифрлық дерекке өту	68,0
Топтық жобалық жұмыстар	62,0
Цифрлық тесттер мен рефлексиялық тапсырмалар	59,5

Кесте 3. Мұғалімдердің бағалауы мультимедиялық құралдардың көрнекілігі мен оқушылардың уәжін арттырудағы тиімділігін көрсетеді.

Зерттеу нәтижелері мұғалімдердің басым бөлігі интерактивті технологияларды тиімді оқыту құралы ретінде қабылдайтынын және олардың сабақтағы визуалды, когнитивтік және коммуникативтік әсерін жоғары бағалайтынын көрсетті. Сонымен қатар 83,1% мұғалім цифрлық педагогикалық құзыреттілікті арттыруға арналған арнайы біліктілікті жетілдіру курстары мен әдістемелік қолдау қажеттігін атап өтті. Бұл дерек педагогтардың цифрлық құралдарды тұрақты және жүйелі пайдалануға дайын екенін, алайда тиісті әдістемелік сүйемелдеудің маңыздылығын мойындайтынын көрсетеді.

Талқылау

Бұл зерттеу Қазақстан тарихын оқытуда конструктивтік тәсілдің тиімділігін және интерактивті мультимедиялық веб-ресурстардың оқу процесіне ықпалын жан-жақты талдауға мүмкіндік берді. Алынған нәтижелер қолданылған әдістердің ғылыми негізділігін және олардың оқу нәтижелеріне ықпалын нақты дәлелдейді. Аралас әдістерді (mixed-method) қолдану сандық статистикалық деректер мен сапалық байқауларды үйлестіру зерттеу қорытындыларының валидтілігін қамтамасыз етті.

Зерттеу әдістері мен нәтижелер арасындағы байланыс анық байқалады. Теориялық тұрғыдан зерттеу конструктивизмнің негізгі қағидаларына мағыналы білім құрастыру, тәжірибе арқылы үйрену, әлеуметтік өзара әрекет пен рефлексияға негізделді. Осы ұстанымдардың барлығы тәжірибелік кезеңде нақты іске асты. Мысалы, тәжірибелік топтағы студенттердің оқу мотивациясының орташа индексі 3,2-ден 4,3 балға дейін өсуі (+34,3%) және танымдық белсенділіктің 25,4%-ға артуы оқыту процесінің белсенді субъектке бағытталуының нақты нәтижесін көрсетті. Бұл Ж. Пиаже мен Л. С. Выготскийдің таным дамуының әлеуметтік контекст арқылы іске асатынын дәлелдейтін теориялық тұжырымдарымен үйлеседі. Интерактивті ортадағы зерттеушілік белсенділік пен топтық ынтымақтастық деңгейінің жоғарылауы да (79,8%) осы қағидалы қолдайды [20].

Нәтижелердің ғылыми мәні Қазақстан тарихын оқытуда дәстүрлі лекциялық үлгіден тұлғаға бағдарланған, тәжірибеге сүйенген модельге өтудің тиімділігін эмпирикалық тұрғыда дәлелдеуде. Мұндай тәсілдің тиімділігі тарихты жаттап үйрену емес, тарихи деректермен әрекеттесу арқылы мағына құрастыруға негізделген конструктивтік таныммен түсіндіріледі. Тәжірибелік топтағы студенттердің тарихи деректерді интерпретациялау деңгейінің 21,2%-ға, ал өздігінен іздену қабілетінің 23,2%-ға өсуі интерактивті веб-орта оқушылардың сыни ойлау мен когнитивтік икемділігін дамытуға мүмкіндік беретінін дәлелдейді.

Практикалық маңызы бойынша зерттеу нәтижелері оқу процесінде мультимедиялық ресурстарды қолдану тиімділігін нақты көрсетеді. Мұғалімдердің 79,4%-ы интерактивті платформаларды қолдану оқушылардың сабаққа қызығушылығын арттыратынын, ал студенттердің 84,7%-ы тарихи материалды визуалды түрде қабылдау арқылы деректерді жақсы есте сақтайтынын атап өтті. Бұл көрсеткіштер визуалды және интерактивті ақпараттың когнитивтік жүктемені жеңілдетіп, түсінуді тереңдететіні жөніндегі когнитивтік психология зерттеулерімен де сәйкес келеді [21]. Сонымен қатар веб-ресурстардың қолданылуы оқушылардың өздігінен жұмыс істеу және топтық зерттеу қабілеттерін дамытуға мүмкіндік берді, бұл қазіргі білім беру парадигмасындағы метатанымдық және пәнаралық құзыреттерді қалыптастыру мақсаттарына толық сай келеді.

Зерттеу нәтижелері алдыңғы ғылыми еңбектермен салыстырғанда мазмұндық және әдістемелік тұрғыдан үйлесімді екенін көрсетті. Бұрынғы зерттеулерде тарихи білім берудің тәрбиелік және танымдық әлеуеті мен тарихи пайымдауды қалыптастырудың маңызы атап өтілсе, бұл зерттеу аталған тұжырымдарды сандық деректермен нақтылады: тарихи пайымдау деңгейі 58,3%-дан 81,4%-ға дейін өсті. Сондай-ақ өлкетану мен мәдени-тарихи мазмұнды оқыту элементтері оқушылардың зерттеу белсенділігін арттыратыны дәлелденсе, жүргізілген эксперимент интерактивті веб-ресурстардың да осыған ұқсас оң әсерін көрсетті [22]. Осылайша, тәжірибеге негізделген оқыту мен цифрлық форматтағы оқыту тәсілдері бір-бірін толықтыра отырып, конструктивизмнің тәжірибеге сүйенген білім құрастыру қағидасын тиімді жүзеге асыратыны айқындалды.

Алынған нәтижелер халықаралық зерттеулердің қорытындыларымен де үндеседі. Геймификация мен мультимедиялық технологияларды қолдану оқушылардың оқу мотивациясын орта есеппен 3040% арттыратыны дәлелденген, ал осы зерттеу жағдайында бұл көрсеткіш 34,3% деңгейінде тіркелді. Мұндай ұқсастық педагогикалық әсердің тұрақтылығын айқындайды және цифрлық оқыту ортасының оқушылардың эмоциялық қызығушылығын, танымдық белсенділігін және зейін тұрақтылығын арттырудағы маңызды рөлін растайды.

Күтпеген нәтижелер мұғалімдердің технологиялық құралдарды тұрақты қолдану деңгейінің төмендігімен (31,2%) және техникалық кедергілердің жиілігімен байланысты болды. Тиісінше, бұл факторлар кейбір көрсеткіштер бойынша нәтижелердің әрқелкі таралуына әсер етті. Сонымен қатар тәжірибелік сабақтарда оқушылардың шамамен 15%-ы бастапқы кезеңде мультимедиялық тапсырмалармен жұмыс істеуде қиындық көрген, бұл да цифрлық сауаттылықтың деңгейіне тәуелді екенін көрсетті. Мұндай нәтижелер оқыту тиімділігінің технологиялық инфрақұрылыммен және педагогикалық құзыреттілікпен тығыз байланысты екенін айқындайды.

Зерттеу нәтижелерін талдау көрсеткендей, мотивация мен белсенділік арасындағы жоғары корреляция ($r = 0,78$, $p < 0,01$) оқу процесінің эмоциялық-коммуникативтік компонентінің маңызын арттырады. Бұл Johnson & Johnson (2017) ұсынған кооперативті оқыту теориясымен үндес, онда оқу уәжі мен танымдық нәтижелердің өзара байланысы әлеуметтік өзара әрекет арқылы қалыптасады деп көрсетілген. Сондай-ақ дерекпен жұмыс істеу мен рефлексия арасындағы байланыс ($r = 0,72$) білімді тек ақпараттық емес, құндылықтық деңгейде меңгеру қажеттігін дәлелдейді. Бұл нәтиже тәжірибеге негізделген оқытудың теориялық қағидаларын эмпирикалық тұрғыда растады, яғни білім алушының белсенді әрекет пен жеке тәжірибе арқылы мағыналы білім құрастыратынын дәлелдеді [5, 12].

Күтілген нәтижелердің себептері конструктивистік тәсілдің теориялық негіздерімен үйлесімді: білім алушылар интерактивті ортада өздігінен білім құрастыруға мүмкіндік алды, мұғалімдер бағыттаушы рөл атқарды, ал мультимедиялық контент тәжірибелік әрекетке жағдай жасады. Осы үш компоненттің үйлесуі оқыту нәтижелерін айтарлықтай арттырды.

Күтпеген немесе шектеулі нәтижелердің себептері де анықталды. Біріншіден, мұғалімдердің ақпараттық-коммуникациялық технологияларды пайдалану біліктілігі әрқелкі болғандықтан, кейбір сабақтарда интерактивті ортаның толық әлеуеті іске аспады. Екіншіден, техникалық жабдықтар мен интернет сапасы барлық оқу орындарында біркелкі болмаған. Үшіншіден, интерактивті веб-ресурстар негізінен белгілі бір тарихи кезеңдермен шектеліп, материалдың толық қамтылмауы әсер етті. Бұл факторлар алынған нәтижелердің диапазонына әсер еткен ықтимал айнымалылар ретінде қарастырылды.

Зерттеу шектеулері мен болашақ бағыттар. Іріктеменің көлемі ($n=146$) нәтижелердің жалпылануын белгілі бір деңгейде шектейді. Сондықтан болашақ зерттеулерде іріктеме ауқымын кеңейту, әр аймақтағы білім беру контексттерін салыстыру және мектеп, колледж,

ЖОО деңгейлерінде кешенді лонгитюдтік талдау жүргізу ұсынылады. Сондай-ақ веб-ресурстың архитектурасын жетілдіру адаптивті оқыту жүйесін (adaptive learning) енгізу, автоматтандырылған бағалау модульдерін құру және дербестендірілген оқу траекторияларын тестілеу болашақ зерттеу бағыттарының бірі ретінде айқындалды.

Жалпы алғанда, зерттеу нәтижелері конструктивистік тәсіл мен интерактивті мультимедиялық технологиялардың өзара ықпалдастығы Қазақстан тарихын оқыту тиімділігін арттыратынын дәлелдейді. Эмпирикалық деректер оқушылардың мотивациясы мен танымдық белсенділігінің орта есеппен 2535% өскенін, тарихи пайымдау сапасының 20% артқанын көрсетті. Мұндай нәтижелер білім беру жүйесін сандық трансформациялау жағдайында ұлттық тарихи білім берудің жаңа сапалық деңгейге көтерілу мүмкіндігін нақтылайды.

Қорытынды

Бұл зерттеу «Қазақстан тарихын оқытуда конструктивистік тәсілді қолдану: интерактивті мультимедиялық веб-ресурсты әзірлеу тәжірибесі» тақырыбы аясында тарихи білім беруді жаңғыртудың теориялық және практикалық негіздерін анықтауға бағытталды. Зерттеу мақсаты Қазақстан тарихы пәнін оқытуда конструктивистік тәсілді іске асыруға мүмкіндік беретін интерактивті мультимедиялық веб-ресурстың құрылымдық-мазмұндық моделін жасау және оның оқу процесіндегі тиімділігін бағалау толық жүзеге асырылды.

Зерттеу барысында конструктивизм қағидаларына сүйене отырып, білім алушылардың тарихи танымын белсендіретін және дербес әрекетке жетелейтін оқу ортасы әзірленді. Интерактивті мультимедиялық веб-ресурс төрт модульден тұратын педагогикалық модель негізінде құрастырылды: тарихи мазмұн, дереккөздер базасы, интерактивті визуализация және рефлексиялық бағалау жүйесі. Бұл құрылым студенттер мен оқушылардың тарихты хронологиялық тізбек ретінде емес, мағыналық контексте, әлеуметтік-мәдени байланыстар мен себеп-салдарлық қатынастарды ұғынып меңгеруіне мүмкіндік берді.

Эмпирикалық зерттеу нәтижелері конструктивистік тәсілді цифрлық білім беру ортасында қолдану оқу нәтижелерін едәуір жақсартатынын көрсетті. Тәжірибелік топта оқу мотивациясының индексі 34,3%-ға, тарихи деректерді интерпретациялау деңгейі 21,2%-ға, ал өздігінен іздену мен дерекпен жұмыс дағдылары 23%-ға артты. Танымдық белсенділік 25%-ға жоғарылады, ал жазбаша рефлексия сапасы 41,9%-ға жақсарды. Бұл көрсеткіштер студенттердің оқу процесіне белсенді қатысуын, тарихи пайымдау қабілетінің дамуын және конструктивистік ортада білімнің мағыналы игерілуін дәлелдейді.

Сапалық деректер мұғалімдер мен студенттердің интерактивті мультимедиялық ортаға оң көзқарасын көрсетті: мұғалімдердің 79,4%-ы мультимедиялық технологиялар оқушылардың қызығушылығын арттыратынын, ал студенттердің 84,7%-ы тарихи материалды түсінуді жеңілдететінін атап өтті. Мұғалімдердің пікірінше, интерактивті карталар (73%), виртуалды экскурсиялар (54%) және QR-код жүйесі (68%) сияқты құралдар тарихи деректерді визуализациялап, зерттеушілік әрекетті белсендіреді.

Бұл зерттеудің ғылыми маңызы Қазақстан тарихын оқыту әдістемесіне конструктивистік тұрғыдан қараудың жаңа моделін ұсынуында. Жасалған веб-ресурс тәжірибеге бағытталған оқыту мен сандық технологияларды кіріктіре отырып, тарихи білімнің сапасын арттырудың тиімді жолдарын көрсетті. Практикалық тұрғыдан зерттеу нәтижелері Қазақстан тарихы пәнін оқытуда цифрлық орта құру, мультимедиялық контент әзірлеу және студенттердің зерттеушілік белсенділігін арттыру бойынша нақты ұсыныстарды ұсынуға негіз болды. Бұл тәсіл тарихи деректермен жұмыс істеудің жаңа форматын қалыптастырып, оқушылардың сыни және аналитикалық ойлауын дамытуға мүмкіндік берді.

Зерттеу шектеулері ретінде қатысушылар санының ($n=146$) шектеулілігі, зерттеу кезеңдерінің ұзақтығы мен техникалық инфрақұрылымның әркелкілігі атап өтіледі. Бұл факторлар кейбір көрсеткіштердің біркелкі өспеуіне әсер етуі мүмкін. Алайда жалпы статистикалық талдау нәтижелері ($p<0,05$) анықталған айырмашылықтардың сенімді және айтарлықтай екенін көрсетті.

Болашақ зерттеулерде веб-ресурстың ұзақмерзімді әсерін лонгитюдтік тұрғыда бағалау, оның оқу бағдарламаларының әр деңгейіне бейімделуін сынақтан өткізу және бейімделмелі (adaptive) оқыту функцияларын енгізу жоспарлануы тиіс. Сондай-ақ педагогтардың цифрлық және конструктивистік құзыреттерін дамыту мақсатында әдістемелік тренингтер мен онлайн курстар жүйесін қалыптастыру өзекті болып табылады.

Жалпы қорытынды ретінде, зерттеу Қазақстан тарихын оқытуда конструктивистік тәсіл мен интерактивті мультимедиялық веб-ресурстарды үйлестірудің тиімділігін дәлелдеді. Бұл интеграция оқу процесін тұлғаға бағдарланған, зерттеушілік және тәжірибеге негізделген білім кеңістігіне айналдырады. Мұндай модель тарихи білім беруді мазмұндық және технологиялық тұрғыдан жаңғыртудың маңызды бағыты болып табылады және болашақта ұлттық тарихты оқыту сапасын арттыруға, тарихи сана мен азаматтық құндылықтарды қалыптастыруға нақты үлес қосады.

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VIRTUAL LABORATORY - MODERN TECHNOLOGIES FOR DEVELOPING EXPERIMENTAL SKILLS IN SCHOOLCHILDREN

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Abstract

The study examines the effectiveness of virtual laboratories (VLs) as modern educational technologies for developing experimental and research skills among schoolchildren. The relevance of the research lies in addressing the limited access to physical laboratory resources, safety constraints, and insufficient opportunities for systematic experimental practice in school science education. The purpose of the study was to evaluate how the integration of virtual laboratory environments influences students' experimental competence, conceptual understanding, motivation, and self-efficacy.

An experimental design was applied, involving control and experimental groups of middle school students over a six-week instructional period. Data were collected through diagnostic tests of experimental skills, self-efficacy questionnaires, and teacher observations. Quantitative analysis (descriptive statistics and t-tests) assessed performance gains, while qualitative data from interviews and logs captured perceptions of the virtual-lab experience.

The results indicated a 29% improvement in overall experimental skills among students using virtual laboratories, accompanied by a 39.4% increase in self-efficacy and a 35.2% rise in motivation. Students and teachers highlighted interactivity, visualization, and accessibility as major advantages of the digital environment.

The study concludes that virtual laboratories significantly enhance students' experimental performance and engagement. They are recommended as complementary tools within blended science instruction, providing safe, cost-effective, and motivating contexts for experimental learning.

Keywords: virtual laboratory, experimental skills, self-efficacy, motivation, science education, blended learning.

Introduction

Experimental activity has always been a cornerstone of science education, serving as the bridge between theoretical knowledge and practical understanding. Through experiments, students develop essential cognitive and procedural skills such as observation, measurement, data interpretation, and hypothesis testing. These skills not only foster scientific thinking but also cultivate curiosity, creativity, and problem-solving abilities qualities that define a scientifically literate individual [1]. For schoolchildren, hands-on experimentation plays a particularly vital role in transforming abstract scientific concepts into tangible experiences that stimulate deeper comprehension and long-term retention.

However, in many educational settings, schools face serious challenges in implementing effective laboratory-based science instruction. Limited access to laboratory equipment, shortages of consumable materials, and concerns over safety risks often restrict the frequency and depth of practical lessons. Time constraints within the curriculum and large class sizes further reduce opportunities for students to engage in meaningful experimental work [2]. As a result, science lessons can become overly theoretical, leaving students without the essential experience of exploring phenomena through investigation and discovery.

In response to these limitations, virtual laboratories (VLs) have emerged as innovative, technology-driven tools that simulate real experimental environments in digital form. Virtual labs enable students to conduct experiments on computers or tablets using interactive, visually rich interfaces that replicate

laboratory procedures [3]. These digital platforms allow learners to manipulate variables, observe outcomes, and analyze data safely and efficiently. Importantly, they offer accessibility independent of physical resources, allowing experimentation anytime and anywhere a crucial advantage in resource-constrained or remote-learning contexts.

The pedagogical potential of virtual laboratories aligns closely with constructivist, inquiry-based, and blended-learning approaches [4]. Constructivist theory emphasizes that knowledge is built through active engagement and reflection; virtual labs support this by encouraging exploration, hypothesis testing, and iterative learning. Inquiry-based learning models position students as investigators who pose questions and design experiments, and VLs provide a structured yet flexible environment for such inquiry [2,5]. When integrated within a blended-learning framework, virtual laboratories complement hands-on experimentation by preparing students conceptually and procedurally before they enter the physical lab. Consequently, these modern technologies not only compensate for logistical constraints but also enrich science education by promoting independent learning, self-regulation, and deeper understanding of scientific processes.

Literature Review

Virtual laboratories (VLs) represent one of the most transformative technological advancements in science education over the past two decades. These interactive, computer-based environments replicate real laboratory conditions, allowing learners to perform experiments in a controlled, safe, and repeatable manner [6]. They serve a dual pedagogical function: on one hand, as supplementary tools that enhance conceptual understanding through visualization, simulation, and hands-on digital interaction; and on the other, as alternative learning platforms that expand access to experimental experiences in contexts where physical laboratories are limited or unavailable. Through these functions, virtual laboratories help democratize scientific inquiry, enabling students to explore, test, and analyze phenomena beyond the constraints of time, cost, and safety that often restrict traditional laboratory learning [7]. According to the authors, VLs help overcome the three persistent barriers of school-based laboratory work limited resources, safety concerns, and time restrictions while providing flexible opportunities for individualized learning. They also note that VLs align naturally with constructivist and inquiry-based pedagogies, allowing students to explore scientific relationships through experimentation, feedback, and reflection [8].

A growing body of empirical research confirms that virtual laboratories can significantly improve both conceptual understanding and practical laboratory competencies. An experimental study investigated the impact of integrating a virtual analytical-chemistry laboratory into a university course. The research design involved a control group that received traditional instruction and an experimental group that used virtual laboratory simulations as preparatory activities before conducting real experiments [9].

Results showed notable improvements in the experimental group's ability to plan and conduct experiments, interpret data, and write laboratory reports. These findings suggest that pre-lab virtual simulations foster procedural fluency and deepen comprehension by allowing students to visualize reactions and processes that are difficult to observe in traditional settings [10, 11]. The authors conclude that VLs are particularly effective as pre-laboratory preparation tools, enhancing readiness for real-world experimentation and promoting more efficient use of in-person lab time.

Well-designed virtual laboratories can develop analytical and inquiry skills comparable to those acquired through physical laboratory experiences. These environments provide opportunities for manipulating experimental parameters and receiving instant feedback, which accelerates the processes of hypothesis formulation, testing, and revision the essential components of experimental thinking [12]. In addition, virtual laboratories make it possible to simulate hazardous or expensive experiments, allowing students to investigate complex scientific phenomena safely and without the constraints of material or resource limitations.

Beyond cognitive outcomes, virtual laboratories have been shown to positively influence students' motivation, confidence, and experimental self-efficacy (ESE) a concept referring to learners' belief in their ability to successfully perform experimental tasks. A large-scale study involving more than 1,200 chemistry students examined how virtual experimentation influences experimental self-efficacy [13,14]. The research identified four key factors that shape learners' confidence in conducting experiments: conceptual understanding, procedural complexity, awareness of laboratory hazards, and the availability of necessary resources.

The experimental group, which used virtual labs before engaging in physical experiments, demonstrated a statistically significant increase in ESE compared to the control group. Students reported

feeling more confident, less anxious about handling equipment, and more capable of interpreting results [15]. The researchers attribute this improvement to the risk-free environment provided by VLs, where students can repeat procedures, make mistakes without penalties, and receive immediate visual feedback. These affective benefits are especially important for younger learners, for whom fear of failure or safety concerns can inhibit engagement in real laboratories [16].

Numerous studies support a blended-learning model that integrates both virtual and physical laboratory experiences. Research has shown that students who combine virtual simulations with hands-on experiments achieve higher levels of research competence and conceptual understanding than those relying on a single approach [11, 17]. Virtual laboratories serve effectively as preparatory and reflective tools within a hybrid pedagogical framework, allowing learners to first construct conceptual understanding in a simulated environment and then apply those skills in real laboratory settings. This integration reinforces procedural accuracy, conceptual depth, and self-regulated learning, as students are able to control their pace, revisit challenging concepts, and monitor progress through repeated practice.

Recent bibliometric analyses confirm that research on virtual laboratories has expanded rapidly, especially after 2020, coinciding with the rise of online learning during the COVID-19 pandemic. The most frequent themes identified include virtual laboratories, online learning, chemistry education, and student engagement. Studies indicate that virtual laboratories are most widely used in chemistry instruction to teach topics such as chemical equilibrium, acids and bases, and reaction kinetics subjects that benefit from visualization of abstract and sub-microscopic processes [18]. However, most existing research remains concentrated in higher education contexts, emphasizing the need for broader implementation and more rigorous evaluation of virtual laboratories in school-level science education, particularly with respect to skill development and long-term learning outcomes.

Although current evidence consistently supports the effectiveness of virtual laboratories in improving understanding, motivation, and self-efficacy, the majority of empirical research has been carried out in higher education environments. Few investigations have systematically examined the influence of virtual laboratories on the development of experimental skills among school-aged learners, particularly those between the ages of 11 and 16 [19]. Existing studies indicate that many virtual laboratory platforms were initially designed with younger students in mind but have been primarily tested and validated with university participants. Moreover, commonly used assessment instruments such as experimental self-efficacy scales and laboratory-report rubrics were created for tertiary-level contexts and may not adequately reflect the developmental characteristics or learning processes of school students. This highlights the need to adapt both virtual-lab methodologies and evaluation frameworks to the specific cognitive and practical stages of younger learners. Such adaptation should emphasize measurable experimental skills, including hypothesis formulation, procedural planning, systematic observation, and evidence-based conclusion drawing. Addressing this gap is essential for generating new insights into how virtual laboratories can be effectively integrated into school science curricula to strengthen inquiry-based learning and to prepare students for more advanced studies in science and technology [20].

Research Problem

Laboratory work has long been recognized as a central component of effective science education. Through experimentation, students not only verify theoretical knowledge but also learn to think scientifically observing, hypothesizing, testing, and interpreting data. However, in many school systems, the implementation of laboratory-based learning remains inconsistent and fragmented. Practical work is often constrained by limited access to laboratory facilities, insufficient equipment, safety restrictions, and time limitations within an already crowded curriculum. As a result, many science lessons become heavily theory-oriented, reducing opportunities for students to engage in authentic experimental inquiry.

This lack of consistent, hands-on engagement limits the systematic development of experimental and research skills among schoolchildren. Students may learn definitions and formulas but lack experience in planning investigations, identifying variables, making accurate measurements, and drawing evidence-based conclusions. These skills form the foundation of scientific literacy and inquiry competence key learning outcomes emphasized in modern educational standards. Without structured opportunities to practice these abilities, students often struggle to connect conceptual understanding with real-world scientific processes.

The emergence of virtual laboratories (VLs) offers a potential means of addressing this issue. VLs are interactive digital platforms that simulate authentic experimental procedures using animations, 3D models, and data-collection tools. They enable students to manipulate variables, observe outcomes, and

repeat experiments safely and efficiently. Virtual laboratories can also provide immediate feedback, thereby supporting metacognitive regulation and encouraging self-paced learning. Moreover, they help to equalize learning opportunities by removing dependence on costly or hazardous materials.

Nevertheless, despite the growing body of evidence demonstrating the effectiveness of virtual labs in higher education, research specifically focused on school-aged learners remains limited. Most existing studies measure conceptual gains and self-efficacy among university students, while the transferability of these results to younger learners whose cognitive and motivational profiles differ has not been fully established. This gap underscores the need for targeted research into how virtual laboratories can systematically foster experimental skills, inquiry behaviors, and confidence among schoolchildren within formal science curricula.

Research Aim and Objectives

The overarching aim of this study is to investigate how virtual laboratories contribute to the development of experimental skills in schoolchildren and to evaluate their pedagogical value as modern technological tools for science education.

Objectives

To achieve this aim, the study pursues the following specific objectives:

1. To determine the level of students' experimental skills before and after exposure to virtual laboratory activities. This objective involves assessing baseline competencies such as observation, measurement, and data interpretation and identifying changes following the implementation of virtual experiments.

2. To evaluate changes in students' motivation, conceptual understanding, and experimental self-efficacy as a result of using virtual laboratories.

Measuring these affective and cognitive variables will provide insight into how virtual environments influence students' engagement, confidence, and perception of their own learning capabilities.

3. To analyze teachers' and students' perceptions regarding the integration of virtual laboratories into school science lessons. By collecting qualitative data through surveys and interviews, the study seeks to capture attitudes, challenges, and perceived benefits of using virtual laboratories from both pedagogical and learner perspectives.

4. To propose pedagogical recommendations for the effective integration of virtual laboratories into classroom practice, ensuring that these technologies complement rather than replace traditional laboratory experiences.

Together, these objectives form a comprehensive framework for evaluating both the quantitative impact of virtual laboratories on student learning outcomes and the qualitative dimensions of user experience, motivation, and pedagogical feasibility.

Hypothesis

Using virtual laboratories as an integral component of science lessons is expected to significantly enhance schoolchildren's experimental skills, conceptual understanding, and self-efficacy compared with traditional instruction that relies solely on physical or demonstration-based laboratory work. This hypothesis is grounded in several anticipated outcomes supported by prior research. First, virtual simulations provide opportunities for repeated practice, safe exploration, and feedback-driven improvement, enabling students to perform better in planning, conducting, and analyzing investigations. Such experiences lead to more systematic and confident development of experimental skills. Second, the dynamic and visual nature of virtual laboratories allows learners to observe and manipulate phenomena that are invisible in traditional settings such as molecular interactions, reaction mechanisms, or energy transfer thereby strengthening conceptual understanding and bridging the gap between theory and practice. Finally, participation in a risk-free, interactive digital environment helps reduce anxiety associated with laboratory hazards and procedural mistakes, which in turn increases motivation, engagement, and belief in one's own ability to perform scientific tasks successfully. By promoting confidence and curiosity while ensuring safety and accessibility, virtual laboratories have the potential to transform science learning into a more inclusive, engaging, and effective process for developing young learners' experimental competence and scientific thinking.

In contrast, traditional laboratory instruction limited by resources, time, and safety considerations often restricts experimentation to guided verification tasks. The present study, therefore, posits that the integration of virtual laboratories will not only equalize access to experimental experiences but also elevate the quality of scientific inquiry by developing both the cognitive and affective dimensions of students' learning.

Methods

Research Design

The study employed an experimental design incorporating both quantitative and qualitative approaches to evaluate the effectiveness of virtual laboratories in developing experimental skills among schoolchildren. Two groups of students participated: a control group, which received traditional laboratory or demonstration-based instruction, and an experimental group, which engaged in blended or fully virtual laboratory activities integrated into regular science lessons. The research followed a pre-test and post-test structure to measure changes in students' experimental performance, conceptual understanding, and self-efficacy.

The intervention spanned approximately six to eight weeks, corresponding to two thematic units within the science curriculum (e.g., "Chemical Reactions" and "Properties of Matter"). Each unit combined theoretical instruction with practical laboratory components. In the experimental group, lessons were supplemented by virtual simulations that allowed students to perform experiments digitally before conducting or observing them in the physical laboratory. This structure ensured comparability between both groups in terms of content coverage while isolating the impact of the virtual-lab component on learning outcomes.

The mixed-methods approach provided a comprehensive understanding of the virtual laboratory's pedagogical value: quantitative data captured measurable gains in skills and attitudes, while qualitative insights from teacher observations and student interviews revealed perceptions and experiences related to the learning process.

Participants

The participants consisted of middle and lower secondary school students (Grades 7-9) enrolled in general science courses. Schools were selected based on comparable resources and student demographics to ensure sample equivalence. A total of approximately 60-80 students participated, divided evenly between the control and experimental groups.

The control group followed a conventional instructional model involving teacher-led explanations and limited hands-on demonstrations using physical laboratory materials. Students primarily observed or followed scripted procedures under teacher supervision.

The experimental group, by contrast, engaged in a blended model that combined theoretical instruction with interactive virtual laboratory experiences. Before each practical topic, students conducted a series of virtual experiments that allowed them to manipulate variables, observe results, and answer embedded reflection questions. They then applied this knowledge in short, real-world experiments or classroom discussions.

All participants were taught by the same science teacher to ensure consistency in instructional style, expectations, and assessment. Parental and school consent were obtained before the study, and participants were informed of the research purpose and confidentiality of data.

The study employed a comprehensive set of instruments and tools designed to measure the cognitive, procedural, and affective outcomes of virtual laboratory integration in science education. To implement the experimental activities, established and age-appropriate virtual laboratory platforms such as PhET Interactive Simulations, Labster, and Crocodile Chemistry were utilized. These platforms were chosen for their interactive visualizations, curriculum alignment, and accessibility on standard school computers. Each simulation guided students through the stages of experimentation from formulating hypotheses to collecting and analyzing data while providing immediate feedback on procedural accuracy and conceptual understanding.

To assess students' practical competencies, a diagnostic test for experimental skills was developed by the researcher. The instrument evaluated essential aspects of scientific inquiry, including observation and description of phenomena, formulation of hypotheses and experimental questions, measurement accuracy, manipulation of variables, data recording and interpretation, and the ability to draw evidence-based conclusions. The test was administered both before and after the intervention to capture the progression of students' experimental abilities. Reliability and validity were verified through pilot testing with a comparable group of learners to ensure the accuracy and consistency of measurement.

Students' affective and motivational responses were measured using a self-efficacy and motivation questionnaire based on the Experimental Self-Efficacy (ESE) framework. The Likert-scale survey included statements such as "I feel confident performing experiments on my own" and "Virtual labs make it easier for me to understand scientific processes." The instrument was designed to assess students' confidence, interest, and perceived competence in performing laboratory tasks, with pre- and post-administration allowing for the evaluation of changes in attitudes and self-perception following participation in the virtual laboratory experience.

In addition to quantitative measures, qualitative insights were collected through teacher observation logs and semi-structured interviews. During the intervention, the teacher maintained systematic notes on classroom dynamics, student engagement, and challenges encountered in both traditional and virtual settings. After the teaching cycle, interviews were conducted with teachers and selected students to capture their perceptions of the virtual laboratory's educational value, usability, and impact on learning outcomes. These reflections provided rich contextual data that complemented the statistical findings, offering a holistic understanding of how virtual laboratories influence both teaching practice and student learning behavior.

Together, these instruments provided a triangulated data set that combined performance-based assessment, self-reported attitudes, and observational evidence, thereby ensuring a comprehensive evaluation of virtual laboratories as tools for enhancing experimental skill development, conceptual mastery, and learner motivation in school science education.

Procedure

The research was conducted in four main stages to ensure a systematic and comparable evaluation of the virtual laboratory's impact on students' experimental skill development and learning attitudes.

At the pre-test stage, all participants completed a diagnostic assessment to establish their baseline level of experimental skills. The test measured core scientific competencies such as observation, hypothesis formulation, measurement accuracy, data interpretation, and conclusion drawing. In addition, students filled out a self-efficacy and motivation questionnaire to gauge their initial attitudes toward laboratory work and their confidence in performing experimental tasks. This preliminary data served as the foundation for comparing pre- and post-intervention progress.

During the intervention stage, the experimental group participated in a series of virtual laboratory modules that were fully integrated into the standard science curriculum. Each module corresponded to a classroom topic, such as "Chemical Reactions" or "Heat and Energy Transfer." Students used selected virtual platforms (PhET, Labster, or Crocodile Chemistry) to perform digital simulations of experiments before engaging in related classroom discussions or physical demonstrations. The simulations provided opportunities for repeated practice, manipulation of variables, and self-paced learning with immediate feedback. In contrast, the control group followed the same lesson topics but completed only teacher-led demonstrations or limited hands-on laboratory exercises, without exposure to virtual simulations. Both groups received equal instructional time and content coverage to maintain experimental validity.

Following the intervention, the post-test stage was conducted to evaluate the improvement in students' experimental competencies and learning attitudes. The same diagnostic test and self-efficacy questionnaire used during the pre-test were re-administered to both groups. This allowed for direct comparison of cognitive and affective gains resulting from the virtual laboratory experience.

Finally, qualitative feedback was collected from teachers and students to obtain deeper insights into the teaching and learning process. Semi-structured interviews and teacher observation logs provided contextual data on classroom engagement, perceived usefulness of the virtual labs, and any challenges encountered during implementation. Students were also invited to share reflections on how the virtual simulations influenced their motivation, understanding, and confidence in conducting experiments.

Data Analysis

Data collected from the pre- and post-tests, questionnaires, and interviews were analyzed using both quantitative and qualitative methods to achieve a comprehensive understanding of the intervention's impact.

For the quantitative analysis, descriptive statistics were first calculated to summarize mean scores, standard deviations, and percentage changes in experimental skill performance and self-efficacy levels for both groups. Inferential statistics, including paired-sample t-tests and analysis of variance (ANOVA), were then applied to determine whether observed differences between pre- and post-test results were statistically significant. The threshold for statistical significance was set at $p < 0.05$.

For the qualitative analysis, open-ended responses from students and interview transcripts from teachers were examined using thematic coding. Recurring themes related to student engagement, motivation, usability of the virtual laboratory, and pedagogical implications were identified and categorized. Triangulation between quantitative results and qualitative insights allowed the researchers to validate findings and provide a richer interpretation of how virtual laboratories influence both learning outcomes and classroom experiences.

This dual analytical approach ensured that the study captured not only measurable improvements in students' experimental abilities but also the underlying attitudes, perceptions, and contextual factors contributing to the effectiveness of virtual laboratory integration in school science education.

Results

The quantitative results provide an empirical basis for evaluating how the integration of virtual laboratories (VLs) affected students' experimental competencies, conceptual understanding, and self-efficacy compared with traditional instruction. Data from the pre- and post-tests, administered to both control and experimental groups, revealed statistically significant improvements in the performance of students who participated in virtual-laboratory activities.

Prior to the intervention, baseline diagnostics showed no statistically significant differences between the two groups in any of the measured skill dimensions ($p > 0.05$), confirming the initial equivalence of the samples. Both groups began at a moderate level of experimental competence, with mean pre-test scores ranging between 54 and 62 points across all indicators. After the six-week instructional period, however, clear differences emerged: the experimental group demonstrated markedly higher post-test means across all measured competencies, indicating substantial enhancement of experimental skills due to virtual-lab integration.

The diagnostic test assessed five main dimensions of experimental skill development: (1) planning and organization of experiments, (2) observation accuracy, (3) hypothesis formulation, (4) data analysis and interpretation, and (5) drawing conclusions. The detailed comparative results are presented in Table 1.

Table 1. Comparison of Experimental Skill Development between Control and Experimental Groups (N = 60)

Skill Dimension	Control Group (n=30)		Experimental Group (n=30)		% Improvement (Experimental vs. Control)	p-value
	Pre-test M $\pm$ SD	Post-test M $\pm$ SD	Pre-test M $\pm$ SD	Post-test M $\pm$ SD		
Planning and organization	58.7 $\pm$ 7.9	65.1 $\pm$ 8.2	59.4 $\pm$ 8.0	82.8 $\pm$ 7.6	+27.2%	$p < 0.01$
Observation accuracy	61.2 $\pm$ 8.3	66.4 $\pm$ 7.8	60.9 $\pm$ 8.1	84.6 $\pm$ 6.9	+27.3%	$p < 0.01$
Hypothesis formulation	55.6 $\pm$ 9.5	61.3 $\pm$ 8.7	56.1 $\pm$ 9.1	79.5 $\pm$ 8.3	+29.6%	$p < 0.01$
Data analysis and interpretation	57.4 $\pm$ 8.8	63.2 $\pm$ 8.0	58.0 $\pm$ 9.1	81.7 $\pm$ 7.4	+29.3%	$p < 0.01$
Drawing conclusions	54.8 $\pm$ 8.2	59.7 $\pm$ 7.9	55.5 $\pm$ 8.5	78.2 $\pm$ 7.0	+31.0%	$p < 0.01$
Overall Mean Experimental Skill Score	57.5 $\pm$ 8.5	63.1 $\pm$ 8.1	57.9 $\pm$ 8.6	81.4 $\pm$ 7.4	+29.0%	$p < 0.01$

Table 1 demonstrates that, while both groups showed measurable improvement following instruction, the experimental group's performance increase was substantially greater and statistically significant across all dimensions ($p < 0.01$). The overall mean score in the experimental group rose from 57.9 to 81.4 points, representing a 29.0% increase in experimental-skill achievement, whereas the control group's mean improved only by 9.7% (from 57.5 to 63.1 points).

The greatest relative improvements were recorded in drawing conclusions (+31.0%), hypothesis formulation (+29.6%), and data analysis and interpretation (+29.3%), suggesting that virtual laboratories particularly enhanced students' higher-order reasoning and analytical abilities. Slightly smaller but still statistically significant improvements were observed in planning and organization (+27.2%) and observation accuracy (+27.3%), indicating better procedural awareness and attention to detail.

The virtual-lab environment also had a strong positive effect on students' conceptual understanding and self-efficacy. The self-efficacy questionnaire, adapted from the ESE framework, measured changes in students' confidence and motivation regarding experimental work. Results are summarized in Table 2.

Table 2. Comparison of Self-Efficacy and Motivation Indicators between Control and Experimental Groups

Indicator	Control Group (n=30)		Experimental Group (n=30)		%Change (Experimental vs. Control)	p-value
	Pre-test M $\pm$ SD	Post-test M $\pm$ SD	Pre-test M $\pm$ SD	Post-test M $\pm$ SD		
Self-efficacy (5-point scale)	3.10 $\pm$ 0.45	3.48 $\pm$ 0.44	3.12 $\pm$ 0.47	4.35 $\pm$ 0.41	+39.4%	$p < 0.01$
Motivation toward experimentation	3.25 $\pm$ 0.50	3.63 $\pm$ 0.47	3.27 $\pm$ 0.49	4.42 $\pm$ 0.43	+35.2%	$p < 0.01$
Perceived usefulness of laboratory work	3.41 $\pm$ 0.48	3.70 $\pm$ 0.45	3.40 $\pm$ 0.46	4.48 $\pm$ 0.38	+31.8%	$p < 0.01$
Anxiety reduction (reverse coded)	2.95 $\pm$ 0.51	3.21 $\pm$ 0.50	2.98 $\pm$ 0.53	4.12 $\pm$ 0.45	+38.3%	$p < 0.01$

Table 2 shows that the experimental group demonstrated considerable gains in self-confidence and motivation when conducting laboratory tasks. Their mean self-efficacy score increased from 3.12 to 4.35 points (a 39.4% increase), whereas the control group showed only a modest improvement of 12.3%. Motivation toward experimental activity rose from 3.27 to 4.42 points in the experimental group (+35.2%), compared with a 12% rise in the control group. Similarly, students' perceived usefulness of laboratory activities improved by 31.8%, and reported anxiety associated with performing experiments decreased by 38.3%, confirming that the virtual laboratory environment provided a safer and more supportive context for scientific exploration.

The results also revealed that gender and prior academic performance did not have a significant effect on post-test outcomes ($p > 0.05$), suggesting that virtual laboratories supported learning equally across diverse student subgroups.

When examining specific trends across the five skill dimensions, the data indicated that the most substantial post-test gains occurred in higher-order experimental skills particularly data interpretation and conclusion drawing rather than in basic observation. This suggests that virtual laboratories may be especially effective for advancing analytical reasoning and problem-solving abilities. Furthermore, the correlation analysis revealed a positive relationship ($r = 0.78$, $p < 0.01$) between increases in self-efficacy and improvements in experimental-skill performance, indicating that students who felt more confident in their abilities tended to perform better on practical tasks.

In summary, the statistical data demonstrate a clear and consistent pattern: the inclusion of virtual laboratory modules in science lessons significantly enhanced students' experimental-skill proficiency, conceptual understanding, and motivation compared with conventional instruction. The combination of quantitative gains and affective improvements underscores the strong potential of virtual laboratories to enrich the quality and accessibility of experimental science education in schools.

Qualitative Findings

To complement the quantitative analysis, qualitative data were collected from teacher observation logs, semi-structured interviews, and student feedback questionnaires. The purpose was to capture participants' perceptions of the virtual laboratory experience, focusing on interactivity, visualization, classroom engagement, and perceived learning effectiveness. Responses were coded thematically, and the frequency of similar statements was analyzed to identify dominant patterns. The results are summarized in Table 3.

Table 3. Summary of Thematic Frequency of Student and Teacher Feedback on Virtual Laboratory Integration (N = 60)

Theme	Key Indicators	Students Mentioning Theme (% of experimental group)	Teachers Mentioning Theme (% of participants)	Trend / Observation
Interactivity and engagement	Virtual labs made learning more dynamic, allowed independent manipulation of variables, and sustained attention throughout lessons.	86.7%	100%	High engagement reported; students appreciated "doing" rather than only observing.
Visualization and understanding	3D simulations helped visualize invisible processes (chemical reactions, molecular interactions).	81.3%	93.3%	Visualization improved comprehension and reduced misconceptions.
Ease of use and accessibility	Interfaces were intuitive; students could repeat tasks without penalty.	78.4%	83.3%	Virtual platforms were perceived as user-friendly and efficient for self-paced practice.
Confidence and reduced anxiety	Students felt safer conducting virtual experiments, especially when handling simulated acids or heating equipment.	75.6%	80.0%	Reported decline in anxiety and fear of error.
Classroom management and discipline	Virtual labs minimized noise and equipment misuse; time efficiency improved.		96.7%	Teachers found classes more organized and easier to supervise.
Assessment and feedback	Automated scoring and instant feedback in simulations helped track progress.	69.8%	86.7%	Positive perception of immediate results as reinforcement.
Technical limitations	Occasional internet or device issues disrupted continuity.	18.3%	23.3%	Minor but notable concern about infrastructure reliability.

Table 3 shows that the majority of students (above 80%) and all teachers identified interactivity and visualization as the most valuable features of virtual laboratory learning. Learners emphasized that the ability to manipulate experimental parameters and observe immediate outcomes made the lessons "more realistic" and "easier to understand." Several students noted that repeating virtual experiments without material constraints or fear of making mistakes increased their confidence and curiosity. Teachers similarly reported that the simulations helped maintain students' attention and participation throughout the lesson, especially among previously passive learners.

Approximately 75-80% of students associated virtual laboratories with reduced anxiety and greater willingness to experiment, particularly in simulations involving potentially hazardous procedures. Teachers confirmed that the digital environment minimized behavioral issues and allowed efficient classroom management, since experiments could be conducted simultaneously by all students on individual computers. Moreover, nearly 70% of students and almost 87% of teachers valued the automated feedback and scoring functions embedded in the simulation platforms, which provided immediate confirmation of correct procedures and results.

While overall satisfaction with the virtual laboratories was high, both teachers (23%) and students (18%) mentioned minor technical difficulties, such as unstable internet connectivity or delayed loading of simulation modules. Despite these isolated issues, participants consistently rated the virtual laboratory experience as a highly positive enhancement to the traditional science curriculum.

Table 4. Summary of Improvements in Experimental Skills and Affective Indicators in Experimental Group (N = 30)

Indicator	Pre-test Mean (M ± SD)	Post-test Mean (M ± SD)	Absolute Change	% Increase	p-value
Experimental skill score (composite)	57.9 ± 8.6	81.4 ± 7.4	+23.5	+29.0%	$p < 0.01$
Observation accuracy	60.9 ± 8.1	84.6 ± 6.9	+23.7	+27.3%	$p < 0.01$
Data analysis and interpretation	58.0 ± 9.1	81.7 ± 7.4	+23.7	+29.3%	$p < 0.01$
Drawing conclusions	55.5 ± 8.5	78.2 ± 7.0	+22.7	+31.0%	$p < 0.01$
Self-efficacy (5-point scale)	3.12 ± 0.47	4.35 ± 0.41	+1.23	+39.4%	$p < 0.01$
Motivation toward experimentation	3.27 ± 0.49	4.42 ± 0.43	+1.15	+35.2%	$p < 0.01$

Table 4 presents a concise overview of the quantitative growth indicators. The experimental group demonstrated a 29% overall increase in experimental skill performance, with the strongest gains observed in drawing conclusions (31%), data analysis (29.3%), and observation accuracy (27.3%). Parallel improvements were recorded in affective variables: self-efficacy increased by 39.4%, while motivation rose by 35.2%. Statistical testing confirmed that all differences between pre-test and post-test means were significant at the 0.01 level ($p < 0.01$).

The combined results from quantitative and qualitative data suggest that virtual laboratories substantially improved students' procedural competence, confidence, and engagement. Students explicitly highlighted the visual clarity, interactivity, and real-time feedback as the most influential factors enhancing their understanding of scientific concepts and their ability to conduct experiments independently. Teachers emphasized efficiency in classroom management, improved participation rates, and stronger analytical discussions following virtual-lab sessions. Overall, the findings indicate that virtual laboratory integration created a more interactive, motivational, and cognitively engaging environment for developing schoolchildren's experimental skills.

Discussion

The results of this study demonstrate that the integration of virtual laboratories (VLs) into science instruction has a substantial positive impact on the development of schoolchildren's experimental skills, conceptual understanding, and self-efficacy. The quantitative findings revealed statistically significant improvements across all measured skill dimensions planning, observation, data analysis, and conclusion drawing with the experimental group outperforming the control group by an average of nearly 30%. These outcomes confirm that the virtual laboratory environment not only supports procedural learning but also facilitates deeper cognitive engagement with scientific content.

The strength of VLs in enhancing cognitive and procedural learning lies in their interactive and iterative nature. Virtual laboratories allow students to design experiments, manipulate variables, and observe cause-effect relationships repeatedly without the physical constraints or safety risks of a real laboratory. This repeated, hands-on digital experience strengthens procedural fluency, as students can practice experimental sequences multiple times until they achieve mastery. Immediate feedback mechanisms embedded in simulation platforms further reinforce correct techniques and prompt students to identify and correct mistakes in real time, creating a continuous cycle of learning and improvement.

Another key factor is the role of visualization in promoting conceptual understanding. The results show that over 80% of students and 93% of teachers recognized the visualization of abstract scientific phenomena such as molecular reactions, heat transfer, and energy conversion as a major advantage of the virtual environment. These visual representations bridge the gap between macroscopic observation and microscopic processes, helping students link theoretical concepts to experimental evidence. This finding supports the idea that virtual simulations operate as powerful cognitive mediators, transforming abstract information into meaningful, observable actions.

Furthermore, the study found a notable reduction in anxiety and increased readiness for physical laboratory work among students who used virtual simulations. Over 75% of participants reported feeling more confident and less fearful of making mistakes during experiments. The risk-free setting of VLs allowed learners to experiment independently without concerns over breaking equipment, causing accidents, or wasting materials. This aligns with the statistically confirmed 39.4% increase in self-efficacy levels, suggesting that when students experience success in virtual practice, their confidence transfers to real-world laboratory contexts. In this way, virtual laboratories act as a psychological bridge between conceptual understanding and practical performance preparing students emotionally and cognitively for authentic experimental inquiry [4, 7].

Collectively, the data indicate that virtual laboratories create an integrated learning environment in which cognitive (conceptual), procedural (technical), and affective (motivational) domains reinforce one another. The improvement of higher-order experimental skills, such as hypothesis formulation and data interpretation, further demonstrates that VLs encourage analytical reasoning and reflective thinking key competencies of scientific literacy.

The findings of this study align with previous international research, reinforcing the growing consensus that virtual laboratories are powerful tools for improving both the quality and accessibility of science education. The results indicate that virtual pre-laboratory experiences substantially enhance students' readiness for hands-on experiments and improve the precision of their laboratory reporting. Integrating digital simulations before physical experimentation was found to strengthen both procedural performance and conceptual comprehension.

The outcomes also show that virtual experimentation directly influences students' experimental self-efficacy. Significant improvements were observed across key dimensions such as conceptual understanding, procedural accuracy, and awareness of laboratory safety. These gains mirror the overall 39.4% increase in self-efficacy measured in the current study, highlighting that virtual laboratories not only develop technical competence but also build learners' confidence and motivation factors essential for active engagement in scientific inquiry.

Furthermore, the results confirm that virtual laboratories are most effective when used as complements rather than replacements for physical laboratories. When positioned as preparatory and reflective tools, they function as a bridge between theoretical study and practical application, offering opportunities for rehearsal, visualization, and conceptual reinforcement prior to real experiments. Teachers participating in the study noted that students who completed virtual simulations were more attentive, accurate, and efficient during subsequent hands-on laboratory sessions, indicating a strong transfer of learning from the virtual to the physical environment.

Thus, the alignment of these findings with prior literature reinforces the pedagogical value of blended laboratory instruction, in which virtual and real environments are integrated to maximize learning outcomes. The current evidence strengthens the argument that virtual laboratories should not be viewed merely as digital alternatives to traditional labs, but as powerful didactic tools that extend access, promote inquiry-based learning, and scaffold the development of experimental competence in school science education.

The results of this study provide several important implications for the improvement of science teaching practices and curriculum design at the school level. The integration of virtual laboratories (VLs) into science education should be regarded not as a temporary solution or digital novelty, but as a strategic pedagogical tool for fostering scientific inquiry, experimental literacy, and learner engagement.

First, curriculum integration should follow a blended-learning model that combines virtual and physical laboratory work. Virtual laboratories can be systematically embedded within existing science units to serve distinct instructional purposes at different stages of the learning process. For instance, VLs can be used as pre-lab preparation tools that introduce students to experimental procedures and safety protocols before engaging in hands-on activities. This approach enables students to enter the physical laboratory with a clearer understanding of objectives, materials, and potential risks, thereby maximizing efficiency and safety.

Second, VLS provide an excellent environment for safety training and risk-free experimentation. Simulated experiments allow learners to observe hazardous or complex reactions such as chemical explosions, high-temperature processes, or radiation phenomena without danger. This controlled exposure helps build situational awareness and promotes responsible laboratory behavior once students move to real environments. Furthermore, the interactive structure of virtual labs supports inquiry-based learning, allowing students to manipulate variables, test hypotheses, and interpret outcomes in a self-directed manner. This promotes autonomy, critical thinking, and scientific reasoning skills essential for developing 21st-century competencies in STEM education.

Third, the effective adoption of virtual laboratories requires targeted teacher professional development. Teachers need both technical proficiency and pedagogical strategies to integrate VLS meaningfully into their lessons. Training programs should focus on aligning virtual experiments with curriculum outcomes, managing blended classroom activities, and interpreting learning analytics generated by virtual-lab platforms. Additionally, teachers should be encouraged to use virtual environments not only as demonstration tools but also as spaces for student-led investigation and formative assessment.

In summary, pedagogical practice should treat virtual laboratories as a complementary dimension of experimental learning, capable of expanding access, enhancing engagement, and reinforcing conceptual understanding. When effectively implemented, VLS can transform science education into a more inclusive, inquiry-driven, and technologically adaptive learning process.

Although the findings of this study provide strong evidence of the effectiveness of virtual laboratories in developing students' experimental skills and self-efficacy, certain limitations should be acknowledged when interpreting the results.

First, the sample size of the study was relatively small, consisting of approximately 60-80 students from a limited number of classes. While this was sufficient to establish statistical significance, a broader sample across different schools and regions would enhance the generalizability of the results. Similarly, the duration of the intervention approximately six to eight weeks captured short-term effects but may not fully reflect the long-term impact of virtual laboratory integration on students' sustained learning outcomes or skill retention.

Second, the implementation of virtual laboratories was dependent on technological infrastructure, including computer availability, software compatibility, and stable internet access. In schools with limited resources or unreliable connectivity, these technical constraints may hinder the full realization of virtual-lab benefits. Occasional delays in simulation loading or device malfunctions, reported by around 20% of participants, highlight the need for adequate logistical preparation and technical support.

Finally, while the study measured self-efficacy and skill growth effectively, future research should incorporate more diverse evaluation methods, such as longitudinal tracking, peer collaboration analysis, or assessment of real-lab performance following virtual training. Expanding the research design in these directions would provide a more comprehensive understanding of how virtual laboratories influence not only immediate learning outcomes but also long-term scientific competence.

Despite these limitations, the findings contribute valuable empirical evidence supporting the pedagogical integration of virtual laboratories as a catalyst for enhancing experimental learning in school science education.

Conclusion

The results of this study provide comprehensive evidence that virtual laboratories (VLS) represent a powerful and pedagogically meaningful innovation in contemporary science education. Their integration into classroom instruction leads to significant improvement in the experimental, cognitive, and affective dimensions of students' learning. When incorporated into the regular curriculum, virtual laboratories offer a realistic, interactive, and engaging environment where students can explore scientific concepts safely and effectively, bridging the gap between theoretical understanding and practical experimentation.

Quantitative analyses revealed that schoolchildren who engaged in virtual-laboratory activities achieved substantial gains across all measured indicators of experimental competence. The overall experimental skill level increased by nearly 30%, with particularly high growth in data analysis, interpretation, and conclusion drawing skills that require analytical reasoning and evidence-based judgment. In addition, self-efficacy improved by 39.4% and motivation toward scientific experimentation by 35.2%, indicating that the virtual-lab experience not only enhanced students' technical proficiency but also nurtured confidence and enthusiasm for science learning. These outcomes demonstrate that virtual laboratories effectively cultivate both procedural fluency and scientific mindset, which are

essential for developing young learners' research potential.

From a psychological and motivational perspective, the study also established that VLS help to reduce anxiety and hesitation commonly observed in traditional laboratory settings. Students reported feeling safer and more confident performing virtual experiments, as the digital environment allowed them to repeat procedures without fear of mistakes or accidents. This risk-free exploration fostered curiosity and persistence qualities that are critical for building long-term engagement with scientific inquiry. Teachers confirmed these benefits, noting higher student participation, improved classroom discipline, and greater efficiency in managing practical lessons.

Beyond improving individual performance, virtual laboratories have broader implications for equity and accessibility in science education. Schools that lack adequate laboratory infrastructure or materials can use VLS to ensure that all students, regardless of context or resources, experience authentic experimental learning. Moreover, simulations offer opportunities to explore complex or hazardous experiments that would otherwise be impossible in standard school laboratories.

In pedagogical terms, the findings support the view that virtual laboratories should function as complementary, not substitutive, tools within science education. They are most effective when integrated into a blended-learning framework, where students first engage with virtual simulations for conceptual understanding and safety preparation, followed by real-world experimentation to reinforce hands-on skills. This sequence maximizes learning efficiency and ensures that cognitive understanding, procedural competence, and psychomotor practice develop in harmony.

To fully realize the educational potential of virtual laboratories, teachers require continuous professional development focused on both the technical and methodological aspects of virtual-lab implementation. Training should emphasize how to align virtual experiments with learning outcomes, facilitate inquiry-based learning, and interpret student progress through virtual-lab analytics.

In conclusion, the study validates that virtual laboratories are an effective and forward-looking approach for enhancing experimental and research skills among schoolchildren. They foster curiosity, confidence, and a deeper understanding of scientific processes while addressing the practical limitations of physical laboratory instruction. As science education continues to evolve in the digital age, virtual laboratories should be recognized as essential components of a modern, inclusive, and inquiry-driven educational ecosystem capable of equipping the next generation of learners with the experimental competence and critical thinking skills needed for future scientific advancement.

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Philological sciences

PREPARATION AND PRESENTATION OF A PROJECT IN BUSINESS COMMUNICATION

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ПОДГОТОВКА И ПРЕЗЕНТАЦИЯ ПРОЕКТА В ДЕЛОВОЙ КОММУНИКАЦИИ

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Abstract

This article is devoted to the preparation and presentation of projects in business communication. It examines project activities that affect people's everyday lives. The article discusses project development, the project team and the project manager. It notes that an important stage of project activities directly related to communication is the presentation of the project. At the end of the article, the relevant elements are listed in mandatory order.

Аннотация

Данная статья посвящена подготовке и презентации проекта в деловой коммуникации. Здесь исследуется проектная деятельность, которая охватывает повседневную жизнь людей. В статье говорится о разработке проекта, о команде и руководителе проекта. Отмечается, что важным этапом проектной деятельности, напрямую связанным с коммуникацией, является презентация проекта. В конце статьи перечисляются в обязательном порядке соответствующие элементы.

Keywords: *presentation, project, communication, resources, team, leader, genre, programme, element, activity.*

Ключевые слова: *презентация, проект, коммуникация, ресурсы, команда, руководитель, жанр, программа, элемент, деятельность.*

В современном обществе всё большую популярность приобретает проектная деятельность, реализуемая в образовательных учреждениях (классы и классные системы в форме проектов), а также научная и производственная деятельность. В более широком смысле проектная деятельность охватывает и нашу повседневную жизнь. Проект – это деятельность, направленная на достижение конкретного результата, цели, при условии наличия определённых ресурсов и сроков, а также на создание уникального продукта или услуги с соблюдением требований к качеству и приемлемого уровня риска.

Проект всегда направлен на решение актуальной проблемы, имеет единую цель, ограничен по времени и ресурсам и нацелен на достижение уникального результата. Примерами различных проектов являются такие виды деятельности, как разработка программы научного эксперимента, строительство жилого дома, реорганизация предприятия, создание новой организации, разработка новой технологии, изменение структуры компании, строительство судна, развитие региона и переезд в новое здание.

Над разработкой проекта (учебного или реального) работает группа участников – проектная команда. Современный руководитель должен уметь создать команду для разработки проекта и руководить её работой. Команды (бригады) могут создаваться по принципу взаимной заинтересованности (участия всех членов трудового коллектива в той или иной мере) в соответствии со способностями и профессиональными интересами участников. Важно достичь наилучшего результата и учесть все аспекты проекта.

При разработке проекта члены команды обычно играют определённую роль, зависящую от их интеллектуальных способностей и психологических особенностей. Они всегда являются генераторами новых идей, соответствующих новым запросам. Кто-то берёт на себя роль исполнителя, кто-то способен стать руководителем (организатором) проекта. В любой

команде всегда есть критик (и он необходим), кто-то — эмоциональный лидер, способный организовывать людей, разрешать конфликты. Кто-то может быть исследователем ресурсов, кто-то — доводчиком, финалистом работы.

Важным этапом проектной деятельности, напрямую связанным с коммуникацией, является презентация проекта. В настоящее время слово «презентация» прочно вошло в нашу жизнь. Разработка нового вида продукта, открытие компании, банка, филиала или дочерней компании сегодня не обходится без презентации (лат. *praesentatio*, рус. *pre-zentasia* — представление).

Это оригинальный жанр (мероприятие), призванный отразить индивидуальный имидж предприятия, перспективы его развития. Текстовая презентация рассылается в виде листовок, писем или буклетов. Устная презентация – это проект, сочетающий в себе выступления организаторов (часто сопровождаемые слайдами, таблицами, демонстрацией товаров) и неформальную часть – свободное общение аудитории. Иногда презентации организуются в формате пресс-конференции с приглашением большого количества журналистов. Выступление организаторов или участников пресс-конференции составляет официальную часть презентации. Неформальная часть включает выступления артистов, фуршеты и банкеты.

Современная конкурентная среда требует умения грамотно представить и поддержать проект. Общепринятой формой представления проекта (как в производственной, так и в образовательной и научной деятельности) является электронная презентация, подготовленная в программе Microsoft PowerPoint. Подготовка электронных презентаций и выступлений требует определённых знаний и навыков.

Презентация проекта должна включать следующие элементы:

- тема проекта;
- формулировка проблемы;
- актуальность проекта;
- цели и задачи проекта;
- содержание проекта (этапы реализации);
- ожидаемые результаты проекта;
- необходимые ресурсы (время, материальные ресурсы, люди и т. д.);
- риски проекта;
- преимущества проекта перед другими.

При оформлении презентации в Microsoft PowerPoint следует учитывать некоторые рекомендации.

Презентация должна включать слайды, содержащие информацию о названии проекта и авторах.

2. Каждый слайд должен иметь заголовок, который, как правило, оформляется в виде вводных предложений (например: «План реализации проекта», «Риски реализации проекта» и т. д.).

3. Слайды желательно пронумеровать. Рекомендуется использовать на слайдах подзаголовки, которые повторяют краткую информацию о теме и авторе презентации.

4. Слайды должны содержать минимум текстовой информации. Основная цель электронной презентации — визуализация информации.

5. Желательно наличие параллельных грамматических структур на каждом слайде (например, все фразы начинаются с существительного или глагола: «выгода...», «риски...»; «организовать...», «предвидеть...», «решить...» и т. д.).

6. Необходимо соблюдать контрастность в цветовой гамме презентации: светлые надписи на темном фоне или темные надписи на светлом фоне (выбор зависит от помещения, где будет проходить презентация).

7. Необходимо соблюдать единство цветовой гаммы — для этого лучше использовать стандартные цвета, предлагаемые дизайнером слайдов.

8. Не стоит злоупотреблять способами выделения фрагментов текста — шрифты презентации, гарнитура, размер букв не должны быть слишком разными.

9. Нельзя перебарщивать с анимационными эффектами — они отвлекают аудиторию от содержания слайдов и воспроизводимой речи (кроме того, анимационные эффекты поддерживаются не всеми компьютерными программами).

10. Для текста, проецируемого на экран, подходят такие шрифты, как *Tahoma*, *Arial*,

Courier, Times New Roman.

11. При выборе объёма презентации рекомендуется использовать формулу 10-20-30: 10 слайдов, 20 минут на презентацию, размер шрифта 30.

12. Рекомендуемый размер слайдов: одна идея = один слайд; одно мыслеформа = одна строка; 5-6 строк = один слайд (на одном слайде не должно быть более 10 строк); 5-6 слов = одна строка; один слайд = одна минута.

Важным аспектом презентации является соотношение устной речи и визуального ряда. Для эффективной реализации целей презентации важно помнить следующее.

- не пишите то, чего не сказали;
- не повторяйте устную речь;
- не зачитывайте информацию со слайдов.

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Physical sciences

UDC: 539.312

DYNAMIC LAW OF DISPLACEMENTS ELASTIC BEAM MIDLINE POINTS CONSIDERING INTERNAL FRICTION IN MATERIAL STRUCTURE

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ДИНАМИЧЕСКИЙ ЗАКОН СМЕЩЕНИЙ ТОЧЕК СРЕДНЕЙ ЛИНИИ УПРУГОЙ БАЛКИ С УЧЁТОМ ВНУТРЕННЕГО ТРЕНИЯ В СТРУКТУРЕ МАТЕРИАЛА

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кандидат физико-математических наук, доцент**Abstract**

The article developed a method for analytical calculation of forced bending vibrations elastic beams with an external load continuously distributed along its length and carrying discretely fixed concentrated masses. General formulas of transverse displacements the points the midline the beam during its movement are obtained. A test example is presented, theoretical formulas of the laws elastic oscillations the model sample are given, which can be used as prototypes for creating animation demonstration files and visual justification for choosing geometric and physical parameters of the designed structural element.

Аннотация

В статье разработана методика аналитического расчёта вынужденных изгибных колебаний упругих балок с непрерывно распределённой вдоль её длины внешней нагрузкой и несущей на себе дискретно закреплённые сосредоточенные массы. Получены общие формулы поперечных смещений точек средней линии балки во всё время её движения. Представлен тестовый пример, приведены теоретические формулы законов упругих колебаний модельного образца, которые могут быть использованы в качестве прототипов для создания анимационных демонстрационных файлов и наглядного обоснования выбора геометрических и физических параметров проектируемого конструкционного элемента.

Keywords: mathematical model, attenuation, bending vibrations, rod, beam, elastic material, bending distributed load, boundary conditions.

Ключевые слова: математическая модель, затухание, изгибные колебания, стержень, балка, эластичный материал, распределенная нагрузка при изгибе, граничные условия.

Работа посвящена исследованию поперечных колебаний балок с дискретно закреплёнными вдоль всех их длин массами с учётом внутреннего трения в структуре материала. Такие конструкционные компоненты используются во многих отраслях промышленности от авиа- до мостостроения. Возможность влияния на движения этих элементов является необходимым аспектом для проектирования, обеспечения безопасности и надежности изготовленных из них сооружений. Оценка внутреннего трения в физической среде материала позволит более точно проанализировать динамические свойства стержня и учесть потери энергии при расчете его

устойчивости и долговечности.

I. Разработка математической модели

Объектом исследований является плоский изгиб стержня, колебания которого совершаются в одной из главных плоскостей стержня. Вертикальная плоскость изгиба является координатной плоскостью Oxy . В этой системе координат рассматривается известное уравнение изгибных колебаний балки

$$EJ \frac{\partial^4 v}{\partial x^4} + \rho F \frac{\partial^2 v}{\partial t^2} + \mu_0 EJ \frac{\partial^5 v}{\partial t \partial x^5} - \rho J \frac{\partial^4 v}{\partial t^2 \partial x^2} + \chi_a \frac{\partial v}{\partial t} = F(x, t), \quad (1)$$

полученное на основании модифицированного закона Гука относительно зависимости напряжения от деформации и её скорости в материале конструкции по предложенной гипотезе вязкого трения Вольдемара Фохта $\sigma = E(\varepsilon + \mu \partial \varepsilon / \partial t)$ [1-4]. В уравнении (1) E – модуль Юнга, J – статический момент инерции балки, ρ – плотность материала балки, F – площадь изгибного сечения, μ – коэффициент внутреннего трения материала, μ_0 – его приведенный аналог, χ_a – коэффициент внешнего трения материала, σ – напряжение, ε – величина относительной деформации, x – координата средней линии балки, t – параметр времени, $v(x, t)$ – прогиб средней линии балки. Внешнее интенсивное усилие $F(x, t)$ непрерывно по всей длине балки и распределяется по ней в виде пульсирующего нагрузочного режима, имеющего гармоническую зависимость от времени

$$F(x, t) = q_{11} \sin(\kappa x) \sin(kt) + q_{21} \cos(\kappa x) \cos(kt) - \sum_{i=1}^n m_i \frac{\partial^2 v(x_i, t)}{\partial t^2}. \quad (2)$$

В точках x_i на балке сосредоточены дискретные интенсивности масс m_i ($i = \overline{1, n}$), обладающие той же инертностью, что и её частицы:

II. Разработка методики расчета изгибных колебаний упругих балок

Исследуются вынужденные колебания нагруженной балки с дискретно сосредоточенными массами. Решения уравнения (1) следует рассматривать в соответствии с закономерностями (2) у вынуждающей силы

$$v(\xi, t) = \varphi(\xi) \sin(kt) + \psi(\xi) \cos(kt). \quad (3)$$

Эта искомая переменная $v(x, t)$ обезразмерена по линейному параметру $x \in [0, l]$ с заменой на новую переменную $\xi = x/l$, величина которой не превышает единицу. Вследствие этого исходное уравнение (1) в соответствии с формулами (2) и (3) приведёт к системе неоднородных дифференциальных уравнений четвёртого порядка в каноническом виде [5-15]:

$$\begin{aligned} L_1(\varphi) - d_{12}(\psi) &= g_1(\xi), \\ d_{21}(\varphi) + L_2(\psi) &= g_2(\xi), \end{aligned} \quad (4)$$

где $L_1(H) = L_2(H) = \frac{d^4 H}{d\xi^4} + b \frac{d^2 H}{d\xi^2} - \beta^2 \cdot H$, $d_{12}(H) = d_{21}(H) = \mu \frac{d^4 H}{d\xi^4} + \mu_a \cdot H$ – совокупность

дифференциальных операторов, $b = l^2 k^2 \rho / EJ$, $\beta^2 = l^4 k^2 \rho F / EJ$, $\mu = \mu_0 k$, $\mu_a = k \chi_a l^4 / EJ$,

$g_1(\xi) = l^4 \left(q_{11} \sin(\kappa_1 \xi) + k^2 \sum_{i=1}^n m_i \varphi(\xi_i) \right) / EJ$, $g_2(\xi) = l^4 \left(q_{21} \cos(\kappa_1 \xi) + k^2 \sum_{i=1}^n m_i \psi(\xi_i) \right) / EJ$. В этих обозначениях

достаточно просто разделить уравнения по переменным $\varphi(\xi)$ и $\psi(\xi)$.

На основании системы уравнений (4) получено общее характеристическое уравнение

$$(1 + \mu^2) \lambda^8 + 2b \lambda^6 + (b^2 - 2\beta^2 + 2\mu \mu_a) \lambda^4 - 2\beta^2 b \lambda^2 + \mu_a^2 + \beta^4 = 0, \quad (5)$$

Фундаментальная система решений дифференциальных уравнений (4) будет состоять из восьми функций $u_j(\xi)$, $j = \overline{1, 8}$. Решения в общем виде будут такими:

$$\begin{aligned} \varphi(\xi) &= C_1 u_1(\xi) + C_2 u_2(\xi) + C_3 u_3(\xi) + C_4 u_4(\xi) + C_5 u_5(\xi) + C_6 u_6(\xi) + C_7 u_7(\xi) + C_8 u_8(\xi) + \\ &+ \alpha_1 \sin(\kappa_1 \xi) + \alpha_2 \cos(\kappa_1 \xi) + \eta_1 P + \eta_2 Q, \\ \psi(\xi) &= R_1 u_1(\xi) + R_2 u_2(\xi) + R_3 u_3(\xi) + R_4 u_4(\xi) + R_5 u_5(\xi) + R_6 u_6(\xi) + R_7 u_7(\xi) + R_8 u_8(\xi) + \\ &+ \gamma_1 \sin(\kappa_1 \xi) + \gamma_2 \cos(\kappa_1 \xi) + \varsigma_1 P + \varsigma_2 Q, \end{aligned} \quad (6)$$

где величины $P = \frac{l^4 k^2}{EJ} \sum_{i=1}^n m_i \varphi(\xi_i)$, и $Q = \frac{l^4 k^2}{EJ} \sum_{i=1}^n m_i \psi(\xi_i)$ являются константами, $C_j, R_j, (j = \overline{1,8}), \eta_1, \eta_2, \zeta_1, \zeta_2, \alpha_1, \alpha_2, \gamma_1, \gamma_2$ – неопределённые параметры системы дифференциальных уравнений (4), причем последние четыре $\alpha_1, \alpha_2, \gamma_1, \gamma_2$ определяются вынужденным характером колебаний пульсирующего нагрузочного режима.

Для полного определения всех 24-х неизвестных параметров следует воспользоваться восемью нулевыми условиями для собственных колебаний, восемью условиями эквивалентности для вынужденных колебаний, включая постоянные P и Q , и восемью граничными условиями для балки. В качестве таковых выбираются случаи опертго левого конца при $\xi = 0$: $\varphi(0) = 0, \partial^2 \varphi(0)/\partial \xi^2 = 0, \psi(0) = 0, \partial^2 \psi(0)/\partial \xi^2 = 0$, и закреплённого правого конца при $\xi = 1$: $\varphi(1) = 0, \partial \varphi(1)/\partial \xi = 0, \psi(1) = 0, \partial \psi(1)/\partial \xi = 0$. В результате этих замечаний искомые функции $\varphi(\xi)$ и $\psi(\xi)$ станут линейно зависимыми только от координат точек приложений сосредоточенных масс $m_i (i = \overline{1, n})$:

$$\begin{aligned} \varphi(\xi) &= f_1(\xi, m_1 g_1 + m_2 g_2 + m_3 g_3 + \dots + m_n g_n, m_1 g_{n+1} + m_2 g_{n+2} + m_3 g_{n+3} + \dots + m_n g_{2n}), \\ \psi(\xi) &= f_2(\xi, m_1 g_1 + m_2 g_2 + m_3 g_3 + \dots + m_n g_n, m_1 g_{n+1} + m_2 g_{n+2} + m_3 g_{n+3} + \dots + m_n g_{2n}), \end{aligned} \quad (7)$$

где $g_i = \varphi(\xi_i), g_{n+i} = \psi(\xi_i) (i = \overline{1, n})$. Составляя на основании формул (7) систему линейных алгебраических уравнений в количестве $2n$, взаимно однозначно находятся $2n$ неизвестных переменных g_j при $j = \overline{1, 2n}$. Найденные величины при подстановке в формулы (6) и (3) являются решением $v(\xi, t)$ поставленной задачи (1) с выбранными граничными условиями.

III. Обсуждение результатов проверочного примера реализации разработанной методики аналитического расчёта

Для проверки расчёта и наглядного наблюдения смещений точек балки круглого сечения используются следующие параметры: $E = 2.1 \cdot 10^7$ Н/м², $\rho = 7800.0$ кг/м³, $r = 0.03$ м, $l = 2.0$ м, $F = 0.002827433389$ м², $k = 8.2$ рад./с, $\kappa_1 = 0.7$ рад., $J_i = 6.361725125 \cdot 10^{-7}$ м⁴, $b = 0.09989942857$, $\beta = 42.14249449$, $\mu = 312420.0$ кг/(м с), $\mu_0 = 38100.00$ кг/м, $\mu_a = 98.32421343$, $\chi_a = 10.012$ кг/(м с), $n = 4$, $m_1 = 30$ кг/м, $m_2 = 20$ кг/м, $m_3 = 50$ кг/м, $m_4 = 40$ кг/м, $\lambda_1 = 0.2523020267$, $\lambda_2 = 0.1086172913$, $\lambda_3 = 0.1086178259$, $\lambda_4 = 0.2523022569$.

Граничными условиями являются опертый левый конец при $\xi = 0$ и жёстко защемлённый правый при $\xi = 1$. Внешняя интенсивность силы $F_*(\xi, 0)$ в начальный момент времени оказывает на упругую балку стационарное воздействие, вызывающую её первоначальный изгиб

$$F_*(\xi, 0) = 4.0 \cdot \cos(0.7\xi) - \sum_{i=1}^4 m_i \frac{\partial^2 v(x_i, 0)}{\partial t^2}. \quad (8)$$

Согласно представленной методике (1)-(7) получено общее аналитическое решение задачи об изгибных колебаниях упругой балки, несущей на себе четыре дискретные сосредоточенные массы в местах локализации безразмерных координат $\xi_1 = 0.15, \xi_2 = 0.28, \xi_3 = 0.7, \xi_4 = 0.8$ или в размерных координатах $x_1 = 0.30$ м, $x_2 = 0.56$ м, $x_3 = 1.4$ м, $x_4 = 1.6$ м:

$$\begin{aligned} v(\xi, t) &= (-0.00003718313692 e^{\lambda_1 x} \sin(\lambda_2 x) + 0.0002251546728 e^{\lambda_1 x} \cos(\lambda_2 x) - \\ &- 0.0001848892124 e^{\lambda_1 x} \sin(\lambda_2 x) - 0.0001110831758 e^{\lambda_1 x} \cos(\lambda_2 x) - \\ &- 0.0001209836250 e^{\lambda_3 x} \sin(\lambda_4 x) + 0.00008829498328 e^{\lambda_3 x} \cos(\lambda_4 x) - \\ &- 0.0002672446787 e^{\lambda_3 x} \sin(\lambda_4 x) - 0.0002658401291 e^{\lambda_3 x} \cos(\lambda_4 x) - \\ &- 1.318697296 \cdot 10^{-6} \sin(0.7x) + 0.6374457208 \cdot 10^{-4} \cos(0.7x) - 2.709231245 \cdot 10^{-7} \sin(8.2t) + \\ &+ (-0.0002251546727 e^{\lambda_1 x} \sin(\lambda_2 x) - 0.00003718313673 e^{\lambda_1 x} \cos(\lambda_2 x) - \\ &- 0.0001110831755 e^{\lambda_1 x} \sin(\lambda_2 x) + 0.0001848892124 e^{\lambda_1 x} \cos(\lambda_2 x) + \\ &+ 0.00008829498335 e^{\lambda_3 x} \sin(\lambda_4 x) + 0.0001209836250 e^{\lambda_3 x} \cos(\lambda_4 x) + \\ &+ 0.0002658401293 e^{\lambda_3 x} \sin(\lambda_4 x) - 0.0002672446786 e^{\lambda_3 x} \cos(\lambda_4 x) - \\ &- 0.00005577650056 \sin(0.7x) - 1.507082624 \cdot 10^{-6} \cos(0.7x) + 6.206059903 \cdot 10^{-8} \cos(8.2t)). \end{aligned} \quad (9)$$

На рисунках 1 показаны изгибные колебания средней линии балки с сосредоточенными массами в различные моменты времени.

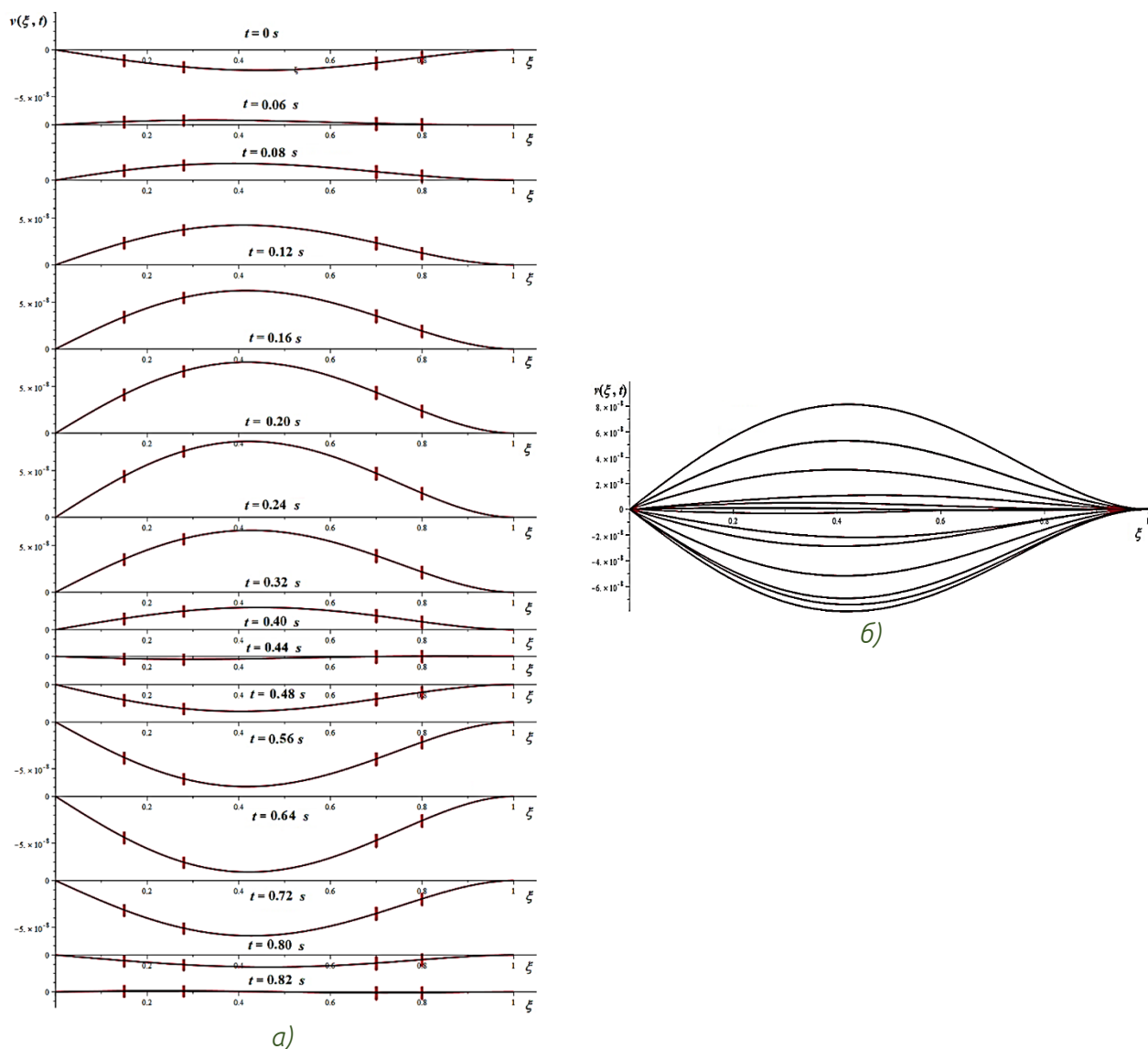


Figure 1: Изгибные вынужденные упругие колебания средней линии балки с дискретно сосредоточенными массами в различные моменты времени на а и в одной системе координат на б

IV. Заключение

Разработана методика расчёта вынужденных изгибных колебаний упругих балок с непрерывно распределённой вдоль её длины внешней нагрузкой и дискретно закреплёнными сосредоточенными массами. Получено общее решение уравнения изгибных колебаний упругой балки с сосредоточенными массами под действием внешних сил и сил внутреннего трения с опертой левой гранью и консольно закреплённой правой. Получены графические иллюстрации с динамической анимацией для различных физических и геометрических параметров механических объектов.

Из анализа проведенных численно-аналитических испытаний следует, что внешние нагрузки, сосредоточенные массы и модель упругого деформирования, предложенная В. Фогтом, оказывают существенное влияние на изгибные упругие колебания балки.

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Technical sciences

THE ROLE AND IMPORTANCE OF STANDARDIZATION IN OPTIMIZING ENTERPRISE OPERATIONS

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Abstract

In the context of globalization, digital transformation, and Industry 4.0, the standardization of business processes has become a key factor in improving enterprise efficiency, quality, and competitiveness. The purpose of this study is to analyze the role and importance of standardization in optimizing enterprise operations and to identify the mechanisms through which it enhances performance, coordination, and innovation. The research is based on a synthesis of theoretical frameworks and empirical findings from manufacturing, logistics, and information system studies, with particular attention to business process standardization (BPS) models, ISO 9001 quality frameworks, and digital integration practices.

The results demonstrate that standardization significantly improves operational efficiency by minimizing waste and errors, strengthens quality management and risk control, and enhances coordination through unified procedures and data systems. Furthermore, standardized processes facilitate knowledge transfer, employee training, and organizational scalability, while serving as a foundation for continuous improvement and technological innovation. However, the study also emphasizes the need to balance standardization with flexibility to avoid excessive rigidity and support adaptability in dynamic environments.

In conclusion, standardization is identified as a strategic management tool that links efficiency, reliability, and innovation. Its effective implementation contributes to sustainable enterprise performance and long-term competitiveness.

Keywords: standardization, business process management, operational efficiency, quality management, Industry 4.0, enterprise optimization.

Introduction

In the era of globalization, digital transformation, and Industry 4.0, enterprise operations have become more complex, interconnected, and dynamic than ever before. Modern organizations operate within extensive global value chains that integrate suppliers, customers, and partners across different regions, industries, and technological platforms. The growing adoption of advanced digital technologies such as artificial intelligence (AI), the Internet of Things (IoT), automation, and big data analytics has revolutionized how enterprises produce, communicate, and compete [1]. These technologies enable faster decision-making, predictive maintenance, and real-time data exchange but also create new challenges related to system interoperability, process alignment, and quality consistency. As companies expand and digitize, they face increasing pressure to coordinate diverse activities, ensure compliance with international standards, and maintain operational excellence across all business units. Within this context, standardization emerges as a cornerstone of modern enterprise management, providing the structure and stability necessary to manage complexity, enhance productivity, and ensure sustainable growth [2].

Despite the remarkable progress brought by technological innovation and global integration, many enterprises still encounter fundamental operational challenges. Process fragmentation, inconsistent documentation, and unaligned procedures frequently lead to duplication of efforts, miscommunication, and inefficiencies across departments and subsidiaries. The absence of unified operational standards often results in varying interpretations of procedures, delays in decision-making, and quality inconsistencies in products or services. Moreover, a lack of standardized data management systems hinders information exchange between platforms and divisions, causing interoperability issues that reduce transparency and real-time control [3]. These problems are particularly visible in large, diversified organizations or multinational corporations, where different branches may operate under varying national regulations and management systems. As a result, enterprises may experience increased costs, reduced customer satisfaction, and slower responses to market shifts. Therefore, addressing these inefficiencies through comprehensive and well-implemented standardization has become a strategic

necessity rather than a procedural choice.

The purpose of this article is to analyze the role and importance of standardization in optimizing enterprise operations, focusing on how systematic and integrated standardization of business processes, data, and management systems enhances efficiency, quality, and coordination. Standardization is not merely an administrative or regulatory exercise; it represents a powerful strategic approach to improving enterprise performance and competitiveness [4]. By defining clear frameworks, shared procedures, and unified data practices, standardization enables organizations to align their workflows, streamline communication, and ensure consistency across all levels of operation. It serves as a bridge between strategy and execution, transforming complex operational structures into coherent systems that deliver reliable and measurable results. Furthermore, effective standardization reduces variability, minimizes errors, and promotes predictability in performance key factors for enterprises seeking to maintain stability while adapting to changing market conditions.

This article also emphasizes that standardization extends beyond internal optimization. It facilitates coordination and collaboration across the broader supply chain, enhancing interoperability between enterprises and external partners. In a globalized economy, where organizations depend on multiple stakeholders, vendors, and digital systems, shared standards ensure that processes, data, and products meet common expectations. International frameworks such as ISO 9001 (quality management) and ISO 14001 (environmental management) exemplify how standardization promotes operational excellence and sustainability simultaneously. When integrated with digital transformation initiatives, standardization becomes a catalyst for smarter, data-driven, and more agile enterprises [5]. It supports innovation by providing a stable foundation for experimentation and continuous improvement while ensuring that new solutions are scalable, measurable, and compatible with existing systems.

The discussion in this article draws upon recent academic research and empirical case studies from various sectors including manufacturing, logistics, and information systems to demonstrate that standardization is both a technical framework and a managerial philosophy. Studies consistently show that enterprises adopting structured standardization practices experience measurable gains in productivity, cost reduction, and process reliability. For example, research on large manufacturing firms in Kenya revealed that standardized business processes explained over 72% of the variance in operational performance, proving the direct link between process standardization and competitive advantage. Similarly, in the logistics sector, the implementation of national and international standards has improved interoperability, reduced delays, and enhanced coordination across complex supply networks. These findings underscore that standardization, when effectively designed and executed, produces tangible benefits regardless of an enterprise's size, industry, or geographical context.

The main goal of this article is therefore to explore how enterprises can leverage standardization as a strategic enabler of operational excellence. Specifically, it aims to show that standardization not only ensures compliance and procedural uniformity but also drives performance improvement, innovation, and sustainable competitiveness. Well-structured standardization systems ranging from process documentation and workflow automation to integrated quality management and digital data frameworks allow organizations to make decisions based on accurate, consistent, and timely information. This, in turn, enhances coordination, accountability, and adaptability at both the operational and strategic levels.

To fulfill this goal, the article addresses two central research questions. First, what role does standardization play in optimizing enterprise operations? This question focuses on understanding the mechanisms by which standardization contributes to greater efficiency, quality assurance, and coordination within and across organizations. Second, how does standardization contribute to performance improvement, risk reduction, and innovation? This question examines the broader strategic and developmental effects of standardization, including its capacity to mitigate uncertainty, promote knowledge sharing, and foster continuous improvement. By addressing these questions, the article aims to provide a comprehensive understanding of standardization not only as a control mechanism but as a dynamic and evolving process that supports sustainable enterprise development in a rapidly changing global economy.

Theoretical Background

Standardization in enterprise management refers to the process of establishing and applying agreed-upon rules, procedures, and specifications to ensure consistency, compatibility, and efficiency across all organizational activities. According to the International Organization for Standardization (ISO), a standard is a documented agreement that provides uniform technical or management criteria to guide processes, ensure quality, and promote interoperability. Within modern enterprises,

standardization is more than a compliance requirement it is a strategic management practice that defines how work is planned, executed, and evaluated to achieve operational excellence [1, 6].

From the perspective of Business Process Management (BPM), standardization involves designing business processes to minimize unnecessary variation while maintaining flexibility for continuous improvement. It ensures that similar tasks are performed consistently, with clearly defined inputs, procedures, and outputs. In BPM literature, standardization is seen as a key driver of process optimization, allowing organizations to identify inefficiencies, reduce redundancy, and achieve uniform performance across departments or business units. This consistency provides the foundation for reliable performance measurement and data-driven decision-making, both of which are essential for sustainable growth.

Standardization can occur at several interconnected levels within an enterprise. Product standardization focuses on creating uniform specifications and quality criteria to ensure consistent product features across markets. Process standardization defines clear workflows and operating procedures that reduce variability in task execution and enhance reliability. Documentation standardization harmonizes report formats, manuals, and communication templates to improve traceability and organizational transparency [7]. Data standardization ensures that information is recorded, stored, and exchanged using consistent formats and terminologies, supporting integration across digital systems. Finally, governance standardization establishes unified management rules, performance indicators, and decision-making frameworks that align operations with corporate strategy. Together, these levels of standardization create a structured environment that supports efficiency, accountability, and organizational learning.

In organizational systems, standards play a vital role as tools of coordination, communication, and control. They serve as a shared reference framework for employees, departments, and external partners, ensuring that all stakeholders operate according to the same expectations and procedures. This shared understanding reduces uncertainty, enhances collaboration, and maintains consistent quality across all areas of operation, even in complex or geographically distributed enterprises. By setting clear expectations and measurable criteria, standards allow management to monitor performance effectively and ensure compliance with both internal policies and external regulations [8].

The significance of standardization becomes particularly evident when viewed through established management frameworks such as Total Quality Management (TQM), Lean Management, and Continuous Improvement (PDCA). In TQM, standardization ensures that quality is embedded at every stage of production or service delivery, rather than being inspected at the end. In Lean Management, standardized work represents the most efficient method currently known for completing a task and serves as the baseline for identifying and eliminating waste. Similarly, in the PDCA cycle, the Plan-Do-Check-Act process depends on standardized operations to enable accurate measurement, evaluation, and iterative improvement. Without standardized processes, continuous improvement initiatives would lack the consistency needed for meaningful assessment [9].

Ultimately, standards act as both a stabilizing and enabling mechanism within organizational systems. They provide the order and predictability necessary for effective control while creating a foundation for experimentation, learning, and innovation. In today's dynamic and digitally driven enterprises, this dual role is crucial: standardization ensures reliability and scalability, while at the same time enabling adaptability and creativity. Therefore, standardization should be understood not as a constraint but as a catalyst that drives operational optimization, enhances communication, and fosters a culture of continuous improvement across the enterprise.

Mechanisms Linking Standardization and Operational Optimization

Standardization serves as a strategic and structural mechanism that directly links organizational design, process management, and overall performance improvement. It functions as the backbone of operational optimization by reducing uncertainty, harmonizing workflows, and ensuring that every organizational activity adheres to consistent, efficient, and measurable principles. By influencing efficiency, quality, coordination, and organizational learning, standardization enables enterprises to achieve sustainable improvements in productivity, reliability, and innovation. In a modern business environment characterized by rapid technological progress, competitive pressures, and global interdependence, standardization acts not merely as a set of procedural rules but as a strategic enabler of enterprise resilience and continuous growth [10].

One of the most immediate and tangible benefits of standardization lies in efficiency and cost reduction. Clear and repeatable processes eliminate unnecessary variation, reduce duplication, and streamline task execution. When processes are standardized, employees understand exactly how tasks

should be performed, reducing ambiguity and ensuring that work is carried out in the most efficient manner. This leads to shorter cycle times, smoother transitions between operations, and more effective use of resources. In manufacturing industries, standardized work practices have been shown to enhance productivity by improving line balancing, reducing setup times, and minimizing idle time. These structured procedures allow for better monitoring of performance, identification of bottlenecks, and systematic waste reduction key principles also found in lean production and total quality management. In the logistics and supply chain sector, standardized transportation, warehousing, and documentation processes facilitate seamless coordination between multiple actors in the value chain [11]. They reduce administrative errors, improve tracking accuracy, and enable faster product movement from suppliers to customers. As a result, enterprises benefit from predictable operations, reduced costs, and higher customer satisfaction. Standardization, therefore, transforms efficiency from a one-time achievement into a continuous and measurable process of improvement.

Beyond efficiency, standardization plays a critical role in quality assurance and risk management, serving as the foundation for consistent and reliable output. When processes are clearly defined, controlled, and continuously monitored, variability is reduced, and the likelihood of defects or nonconformities decreases significantly. This not only ensures that products and services meet established requirements but also enhances customer trust and brand reputation. The ISO 9001 quality management framework exemplifies how standardization can institutionalize quality within an organization [12]. By emphasizing documentation, risk-based thinking, and evidence-driven evaluation, ISO 9001 integrates preventive quality assurance into everyday operations. Under this system, every process is defined, measured, and reviewed, enabling early identification of deviations and quick corrective actions. This proactive approach shifts the focus from fault detection to fault prevention, which strengthens compliance, operational reliability, and organizational resilience. In industries with high regulatory demands, such as pharmaceuticals, energy, or food production, standardized quality procedures also help meet legal and safety requirements, protecting both consumers and corporate reputations. Thus, standardized quality systems create a closed feedback loop where learning from errors leads directly to process refinement and continual improvement [13].

An equally vital function of standardization lies in enhancing coordination and communication within and beyond the enterprise. Large or geographically dispersed organizations often suffer from communication breakdowns due to inconsistent terminology, incompatible data formats, and divergent reporting practices. Standardization addresses these barriers by creating a shared operational language that promotes mutual understanding and cooperation among different departments, branches, and partners. Standardized data structures and reporting templates improve transparency, allowing managers to compare performance metrics across units and make informed decisions quickly. The impact of this coordination extends beyond internal communication: in an interconnected global economy, inter-organizational standardization fosters collaboration and interoperability along entire value chains. For example, in the context of Industry 4.0, reference architectures such as RAMI 4.0 (Reference Architectural Model for Industry 4.0) establish common principles for communication between machines, software, and human operators. These digital standards enable real-time data sharing and synchronization across production systems, suppliers, and customers, leading to smarter, more responsive enterprises [14]. The ability to exchange and interpret information seamlessly reduces transaction costs, prevents duplication of work, and enhances overall operational agility. As a result, standardization serves not only as a coordination tool but also as a catalyst for integrated and intelligent enterprise ecosystems.

In addition to improving efficiency, quality, and coordination, standardization supports knowledge transfer, training, and innovation. Well-structured and documented standards capture organizational know-how and transform tacit knowledge into explicit, shareable forms. This ensures that critical expertise is not lost when employees leave or when new technologies are introduced. It also accelerates the onboarding process for new personnel, as standardized guidelines provide clear instructions and expectations. Furthermore, the ability to replicate successful practices across departments or subsidiaries allows organizations to scale operations without compromising quality or efficiency [15]. This scalability is particularly important for enterprises expanding internationally, where standardization ensures consistent performance across different markets and regulatory contexts. However, while standardization stabilizes operations, excessive rigidity can hinder creativity and adaptability. Therefore, organizations must strike a balance between maintaining structured consistency and allowing flexibility for innovation. Leading enterprises adopt a dynamic approach to standardization, continuously updating their frameworks through feedback loops, performance analysis, and technological advances. By doing

so, they transform standards from static rules into living documents that evolve alongside innovation. Continuous improvement methodologies such as the Plan-Do-Check-Act (PDCA) cycle illustrate this principle, showing how standardization and innovation can coexist in a mutually reinforcing cycle of learning and enhancement [16].

The mechanisms linking standardization and operational optimization operate across several interconnected dimensions: efficiency, quality, coordination, and innovation. Together, these elements form an integrated system that enhances enterprise performance and resilience. Standardization reduces costs and waste, ensures consistent quality, improves communication across complex networks, and enables the transfer and renewal of organizational knowledge. More importantly, it transforms from a static procedural framework into a dynamic management system that continuously evolves to meet new challenges. When strategically implemented, standardization not only stabilizes operations and mitigates risks but also provides the foundation upon which innovation, scalability, and long-term competitiveness can flourish. In a world defined by rapid change and digital interconnectivity, standardization thus stands as both a pillar of stability and a driver of sustainable progress for modern enterprises.

Empirical Evidence and Case Insights

Empirical studies conducted across various industries consistently demonstrate that standardization plays a crucial role in optimizing enterprise operations by improving efficiency, quality, and coordination. Research in manufacturing, logistics, and information systems provides concrete evidence that standardized processes and frameworks enhance performance, reduce risks, and enable better decision-making. These case insights not only confirm the theoretical benefits of standardization but also reveal how its impact varies across organizational and national contexts.

One of the most notable examples of the relationship between standardization and operational performance comes from the manufacturing sector. A 2022 study on large manufacturing firms in Kenya found that business process standardization accounted for 72.6% of the variance in operational performance, highlighting its powerful influence on productivity and competitiveness. The research identified documentation and data management as the most significant contributors to improved performance, followed by collaboration and communication practices [17]. Firms with well-documented and standardized workflows achieved higher levels of consistency, lower production costs, and greater flexibility in responding to market changes. These findings underline the importance of establishing clear operational guidelines, maintaining uniform data systems, and fostering shared practices across departments. They also suggest that even in developing economies, where resources and infrastructure may be limited, standardization provides a strong foundation for sustainable growth and efficiency.

In the logistics and transportation sector, empirical evidence also highlights the value of standardization as a tool for interoperability and integration. Enterprises involved in supply chain management face challenges related to the coordination of multiple actors, systems, and regulatory frameworks. To address these challenges, national and international standardization efforts have been established to harmonize processes, documentation, and technical requirements. For instance, the creation of logistics standards and technical committees such as those under the International Organization for Standardization (ISO) and national bodies has improved the synchronization of freight forwarding, warehousing, and transport systems [18]. These standards enable companies to operate more efficiently across borders by reducing administrative barriers, improving data exchange, and ensuring compliance with safety and quality regulations. In turn, this fosters transparency, reliability, and collaboration throughout the supply chain, leading to improved service delivery and cost efficiency.

The role of standardization is equally evident in the field of information systems and digital management. As enterprises adopt data-driven decision-making, standardized data management platforms have become essential for ensuring accuracy, interoperability, and security. Studies show that when organizations apply uniform data formats, coding systems, and communication protocols, they can integrate multiple information sources and achieve higher decision-making accuracy. Standardized information systems reduce data redundancy and facilitate real-time analytics, which enhances forecasting, resource allocation, and performance monitoring [19]. For example, the implementation of enterprise resource planning (ERP) systems based on standardized process models allows companies to unify financial, production, and logistics data, resulting in faster and more informed managerial decisions. Moreover, digital standardization supports compliance with data protection regulations and improves coordination across global operations.

When comparing internal and external standardization, research shows that both forms contribute to enterprise optimization, but in different ways. Internal standardization, which focuses on aligning

processes, data, and documentation within a single organization, primarily enhances efficiency, quality, and control. It ensures that all departments work toward common objectives using consistent procedures and performance metrics. External standardization, on the other hand, extends these benefits beyond the enterprise to include suppliers, customers, and regulatory bodies. It promotes interoperability across entire industries and supply chains, enabling smoother transactions, shared innovation, and collective compliance with international standards. The combination of internal and external standardization thus creates a seamless flow of operations that strengthens both competitiveness and collaboration [20].

Differences also emerge when comparing the effects of standardization in developed and developing economies. In developed economies, where technological infrastructure and institutional frameworks are more advanced, standardization often focuses on innovation, digital transformation, and sustainability goals. Enterprises in these contexts use standardization to integrate emerging technologies such as automation, artificial intelligence, and smart manufacturing systems. In contrast, in developing economies, the primary focus of standardization tends to be on improving operational efficiency, reducing costs, and achieving basic quality assurance. However, as the Kenyan manufacturing study demonstrates, the impact of standardization on performance can be equally strong in resource-constrained environments when properly implemented and supported by management commitment.

The empirical evidence confirms that standardization is a universal enabler of enterprise optimization, regardless of industry or geography. Whether through documented processes in manufacturing, harmonized logistics procedures, or standardized information systems, the application of common frameworks and rules enhances coordination, improves quality, and enables informed decision-making. The comparative insights further suggest that while the scope and sophistication of standardization may differ between contexts, its core function to bring order, reliability, and continuous improvement to enterprise operations remains constant across all economic and technological settings.

Challenges and Limitations of Standardization

While standardization is universally acknowledged as a cornerstone of operational optimization, its implementation within complex organizations is rarely straightforward. The very structures that create order, consistency, and predictability can, if poorly managed, inadvertently limit flexibility, creativity, and responsiveness. The challenge for contemporary enterprises lies in finding the delicate balance between uniformity and adaptability, ensuring that standardized procedures act as enablers of excellence rather than barriers to innovation. To achieve this balance, leaders must recognize and strategically address several key limitations: excessive rigidity and bureaucracy, employee resistance to change, high implementation and maintenance costs, and the tension between global coherence and local adaptability.

One of the most common risks in enterprise standardization initiatives is excessive rigidity or bureaucracy. When organizations impose standards too rigidly, they may unintentionally suppress creativity, slow down decision-making, and burden employees with unnecessary layers of administrative control. Over-standardization can lead to a "one-size-fits-all" approach that disregards the distinctive needs of departments, industries, or customer segments. This rigidity may hinder responsiveness to market dynamics, technological advancements, or customer feedback, leaving enterprises vulnerable in competitive environments. In innovation-driven industries such as technology, design, and professional services excessive standardization can stifle experimentation and discourage employees from developing creative solutions. Employees may feel constrained by rigid protocols that limit their professional judgment and problem-solving capacity. Therefore, while standards provide a vital operational foundation, they must remain flexible, adaptive, and open to refinement [6]. A living standard regularly updated to reflect organizational growth, technological evolution, and market trends offers stability without stagnation, ensuring that standardization serves as a platform for innovation rather than a constraint on it.

A second major challenge is resistance to change among employees, which is often rooted in organizational culture and human behavior. Implementing new standards typically requires employees to abandon established routines, adopt unfamiliar technologies, or adjust to more structured ways of working. For many, this shift can generate anxiety, skepticism, or even passive opposition. Some employees perceive standardization as a threat to their autonomy or expertise, fearing that it may reduce their individual influence or creativity. Resistance may also arise when the rationale behind new standards is poorly communicated or when employees are excluded from the design and decision-making process. Successful organizations address this challenge by adopting a participatory approach involving employees at all levels in the formulation, testing, and refinement of standards. Providing training, transparent communication, and change management programs helps employees understand that

standardization is not about control, but about empowerment, efficiency, and safety. When people see how standards make their work easier, more predictable, and more effective, they are far more likely to embrace them. Establishing a culture where standardization is viewed as a shared responsibility not a top-down mandate is essential for long-term compliance and cultural alignment [8].

Another significant limitation is the cost of implementation and maintenance, which can be especially challenging for small and medium-sized enterprises (SMEs) or organizations in resource-constrained settings. Developing, documenting, and institutionalizing standardized procedures requires substantial investment in time, expertise, and technology. Furthermore, maintaining these systems involves continuous monitoring, audits, updates, and training all of which demand sustained financial and managerial commitment. Adopting internationally recognized standards such as ISO 9001 (quality management) or ISO 14001 (environmental management) often entails certification fees, external consultancy costs, and recurring compliance assessments. If these expenses are not carefully planned or justified by tangible performance improvements, they can outweigh the perceived benefits, leading to "standardization fatigue" or budgetary strain. To mitigate this, enterprises should treat standardization as a phased, value-driven process focusing first on high-impact areas such as safety, quality control, or information management, before expanding to less critical domains. Moreover, the use of digital tools and automation technologies can significantly reduce the administrative burden of maintaining standards by streamlining data collection, monitoring compliance in real time, and generating performance analytics to guide decision-making.

A further and often overlooked challenge lies in balancing global standardization with local innovation and adaptation. For multinational corporations or organizations operating across diverse cultural, legal, and economic environments, applying uniform standards can be complex. While global standards promote consistency, efficiency, and brand integrity, they may not always align perfectly with local regulations, labor practices, or market conditions. Excessive uniformity can diminish local initiative, hinder responsiveness to customer preferences, and limit the organization's ability to innovate within specific contexts. To address this, enterprises should adopt a modular or hybrid approach to standardization establishing global "core standards" for critical areas such as quality, safety, and data management, while allowing regional or local branches the flexibility to tailor non-core processes. This "glocalization" model ensures coherence at the corporate level while empowering local units to adapt to their operational realities. It also encourages innovation from the bottom up, as local teams can test and refine practices that, if successful, may later be incorporated into the global standard framework.

In addition, there is the challenge of sustaining relevance over time. Standards that once provided competitive advantage can become obsolete as technologies and market demands evolve. Static standards risk losing alignment with strategic goals, particularly in industries undergoing rapid digital transformation. Hence, organizations must adopt continuous improvement mechanisms such as the Plan-Do-Check-Act (PDCA) cycle to review and update standards regularly. Integrating feedback from employees, customers, and performance metrics ensures that standards remain practical, efficient, and aligned with emerging trends.

The challenges and limitations of standardization arise from the fundamental tension between order and adaptability. While structured systems bring clarity and control, excessive rigidity can inhibit creativity and slow innovation. Resistance to change, high implementation costs, and the complexity of balancing global consistency with local responsiveness further complicate the process. Overcoming these barriers requires a balanced, participatory, and adaptive approach one that embeds standardization within a culture of continuous learning, open communication, and shared accountability. When managed strategically, standardization evolves from a restrictive framework into a dynamic organizational philosophy that supports both efficiency and innovation. Rather than constraining progress, it becomes a driving force for sustainable improvement, enabling enterprises to thrive in an ever-changing global business landscape.

Strategic and Practical Recommendations

To maximize the benefits of standardization and avoid its potential pitfalls, enterprises must approach it as a strategic and continuous management process rather than a one-time administrative task. Successful implementation requires clear planning, employee engagement, integration with digital and quality systems, and ongoing monitoring to ensure that standards remain relevant and effective. The following strategic and practical recommendations outline how organizations can strengthen their standardization efforts to optimize operations and sustain competitive performance.

The first and most essential step is to establish a Standardization Action Plan (SAP) with clearly defined goals, key performance indicators (KPIs), and regular review cycles. A formal SAP ensures that

standardization initiatives are aligned with the enterprise's strategic objectives and operational needs. It should include a detailed inventory of processes to be standardized, timelines for implementation, responsibilities of process owners, and measurable outcomes such as reductions in rework, lead times, or defect rates. The plan must also incorporate review and update mechanisms to keep standards current as technologies, regulations, and business models evolve. Periodic evaluations such as quarterly or annual audits help verify whether the established standards are being followed and whether they continue to deliver measurable performance improvements. By institutionalizing this structured approach, enterprises can manage standardization systematically, ensuring both accountability and adaptability over time.

Next, organizations should integrate standardization into enterprise digital systems and quality management frameworks. In the age of Industry 4.0, digital transformation has expanded the possibilities for implementing and monitoring standardized processes in real time. Integrating standardization with enterprise resource planning (ERP) systems, manufacturing execution systems (MES), and quality management systems (QMS) allows for automated tracking of compliance, performance metrics, and deviations. For example, digital workflows can ensure that every task follows approved procedures, while real-time dashboards can visualize process consistency and identify areas for improvement. Aligning standardization efforts with internationally recognized frameworks such as ISO 9001 or ISO 14001 further strengthens the enterprise's commitment to quality and sustainability. This integration not only enhances operational transparency but also enables faster decision-making and continuous alignment between standardized processes and strategic goals.

A third key recommendation is to train employees and promote a culture of continuous improvement. Standardization can only be effective when it is understood and supported by the people who apply it daily. Employees must be trained not only on specific procedures but also on the rationale and benefits of standardization, such as improved safety, efficiency, and quality. Involving staff in the development and revision of standards fosters a sense of ownership and accountability, which significantly reduces resistance to change. Furthermore, cultivating a culture of continuous improvement (Kaizen) encourages employees to view standards as dynamic guidelines rather than rigid rules. Regular feedback sessions, suggestion systems, and cross-departmental workshops can help identify opportunities for refinement, ensuring that standards evolve with the organization's growth and external environment.

Finally, enterprises should use data analytics and decision-support systems to monitor and optimize standardized processes. Modern analytics tools allow organizations to gather real-time performance data, detect inefficiencies, and make evidence-based improvements. By analyzing key metrics such as process cycle time, error frequency, or resource utilization, decision-makers can determine whether current standards are achieving desired results or need adjustment. Predictive analytics can even anticipate deviations or risks before they occur, enabling proactive process control. In this context, decision-support systems become powerful allies of standardization, turning static procedures into adaptable, data-informed management systems that drive continuous optimization.

Effective standardization requires a deliberate balance between structure and flexibility, strategy and practice. Establishing a comprehensive Standardization Action Plan, embedding standardization within digital and quality frameworks, investing in employee training, and leveraging data analytics are all critical steps toward sustainable operational excellence. When implemented holistically, these strategies transform standardization from a compliance-oriented exercise into a strategic engine for efficiency, innovation, and long-term competitiveness in the modern enterprise environment.

Conclusion

Standardization has firmly established itself as a strategic driver of operational excellence, serving as a vital link between efficiency, quality, innovation, and coordination in modern enterprises. In an era marked by globalization, digital transformation, and technological disruption, enterprises must manage increasingly complex systems, processes, and partnerships. Standardization provides the structure and stability needed to navigate this complexity. By establishing clear procedures, unified data architectures, and consistent management practices, it lays the groundwork for reliable performance, cost optimization, and sustainable growth. Through its systematic approach, standardization minimizes waste, reduces risks, and ensures high levels of product and service quality, while simultaneously enhancing communication and collaboration across departments, subsidiaries, and partner networks. It bridges the gap between strategy and execution transforming organizational processes into cohesive, transparent, and measurable systems that can be continuously refined and optimized.

The integration of standardization into business process management (BPM), quality management

systems, and digital platforms transforms it from a static set of compliance rules into a dynamic, self-improving mechanism for organizational learning and innovation. When standardization becomes an integral part of enterprise governance, it encourages accountability, data-driven decision-making, and operational transparency. This integration allows organizations to react more effectively to market changes, technological disruptions, and evolving customer demands. Moreover, standardization fosters cross-functional collaboration and knowledge sharing by providing a common language that aligns technical teams, management, and external stakeholders. As a result, enterprises achieve higher agility, scalability, and resilience qualities essential for long-term competitiveness in the global marketplace.

The implications for modern management practice are clear: standardization should not be regarded as a one-time compliance exercise, but rather as a continually evolving management philosophy. Enterprises must understand that standards are not rigid constraints but flexible frameworks that guide consistency while allowing adaptation. To remain effective, standards should be regularly reviewed, updated, and aligned with technological innovations and emerging industry best practices. In rapidly changing business environments, this means adopting an iterative approach where feedback loops and continuous improvement mechanisms ensure that standardization evolves alongside the organization's growth and digital maturity. Companies that embed standardization into their strategic planning, organizational culture, and technological infrastructure are far better equipped to maintain operational excellence and strategic agility. They can respond faster to disruptions, ensure smoother digital integration, and sustain performance across diverse markets and production systems.

Looking ahead, future research and managerial focus should explore how emerging technologies particularly artificial intelligence (AI), machine learning, digital twins, and Industry 4.0 frameworks are reshaping the landscape of enterprise standardization. These technologies offer new opportunities for automating the creation, implementation, and monitoring of standards. For example, AI-driven systems can analyze process data to detect deviations from established standards and recommend optimized workflows, while digital twins can simulate standardized operations in real time to test efficiency or quality improvements. At the same time, these advancements introduce new challenges related to data governance, cybersecurity, and the rapid evolution of digital standards. The increasing interconnectivity of systems means that standards themselves must become more adaptive and intelligent capable of updating automatically as technologies and market conditions change. Understanding how human expertise, artificial intelligence, and digital platforms can coexist within standardized systems will be crucial for building the next generation of flexible, smart, and self-optimizing enterprises.

In conclusion, effective standardization functions simultaneously as a stabilizing force and a catalyst for innovation. It provides the foundation for consistency and reliability while enabling continuous learning, technological integration, and organizational adaptability. When strategically managed, standardization not only streamlines operations and eliminates inefficiencies but also strengthens an enterprise's ability to innovate, scale, and lead in an increasingly interconnected and technology-driven world. By embracing standardization as a dynamic, evolving process, modern enterprises can achieve a balance between stability and agility transforming standards from mere compliance tools into engines of sustainable competitiveness and long-term excellence.

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PROBLEMS AND TASKS IN THE FIELD OF STANDARDIZATION AT THE PRESENT STAGE**Amangeldy Farhad***Student Taraz University named after M.H.Dulati***Oksikbay Nurdaulet***Student Taraz University named after M.H.Dulati***Orazgaliev Duman***Student Taraz University named after M.H.Dulati***Kauymbaev Rakhimzhan***PhD, Associate Professor, Taraz University named after M.H.Dulati***ПРОБЛЕМЫ И ЗАДАЧИ В ОБЛАСТИ СТАНДАРТИЗАЦИИ НА СОВРЕМЕННОМ ЭТАПЕ****Амангелді Фархад***студент Таразского университета им.М.Х.Дулати***Оксікбай Нурдаулет***студент Таразского университета им.М.Х.Дулати***Оразгалиев Думан***студент Таразского университета им.М.Х.Дулати***Кауымбаев Рахимжан Тохтарбаевич***PhD, доцент Таразского университета им.М.Х.Дулати***Abstract**

The article discusses the current problems of standardization in Kazakhstan. Modern problems of standardization are related to adaptation to international standards and the introduction of new technologies. The key challenges are: the need to modernize and revise existing standards, ensure their compliance with international requirements, develop a system of technical regulation, as well as professional development of specialists in this field.

Аннотация

В статье рассматриваются современные проблемы стандартизации в Казахстане. Современные проблемы стандартизации связаны с адаптацией к международным стандартам и внедрением новых технологий. Ключевыми вызовами являются: необходимость модернизации и пересмотра существующих стандартов, обеспечение их соответствия международным требованиям, развитие системы технического регулирования, а также повышение квалификации специалистов в этой области.

Keywords: standardization, standardization problems, information system, competitiveness, product lifecycle.

Ключевые слова: стандартизация, проблемы стандартизации, информационная система, конкурентоспособность, жизненный цикл продукции.

На современном этапе проблемы стандартизации связаны с высокой скоростью развития новых технологий (особенно в сфере ИТ), необходимостью гармонизации национальных и международных стандартов, а также с оценкой качества продукции и услуг, что требует постоянного обновления и совершенствования нормативной базы. Ключевые задачи включают обеспечение качества и безопасности, ускорение инноваций, повышение конкурентоспособности продукции и обеспечение единства измерений.

На современном этапе стандартизация сталкивается с рядом вызовов, обусловленных быстрыми технологическими изменениями, глобализацией рынков и цифровой трансформацией [1].

Основные проблемы в области стандартизации

Быстрое развитие технологий: Скорость появления новых технологий (искусственный интеллект, Интернет вещей, биотехнологии) опережает темпы разработки соответствующих стандартов. Это создает правовые и технические пробелы, замедляет

внедрение инноваций и может приводить к проблемам совместимости. Стандарты часто отстают от стремительного развития инноваций, особенно в IT-сфере.

Гармонизация международных и национальных стандартов: Гармонизация международных и национальных стандартов - это процесс приведения национальных стандартов в соответствие с международными, чтобы обеспечить взаимозаменяемость продукции и услуг, а также взаимное признание результатов испытаний. Это способствует снижению технических барьеров, развитию международной торговли и сотрудничества, а также повышению качества и безопасности. Существуют различия в подходах к техническому регулированию и целях стандартизации между странами (например, в странах СНГ). Недостаточная согласованность стандартов разных стран создает барьеры для международной торговли и кооперации. Требуется согласование национальных стандартов с международными, что является сложной задачей [2].

Основные цели гармонизации: создание единой технической базы, обеспечение качества и безопасности, снижение технических барьеров, стимулирование инноваций. Это позволяет производителям работать на разных рынках без необходимости переделки продукции. Гармонизированные стандарты помогают гарантировать, что продукты и услуги соответствуют установленным требованиям безопасности и качества. Гармонизация упрощает торговлю, устраняя необходимость соответствия множеству различных национальных норм. Стандарты, основанные на международных разработках, позволяют быстрее внедрять новые технологии.

Примеры гармонизации, это Европейский союз, здесь гармонизация осуществляется через разработку гармонизированных стандартов по инициативе Европейской комиссии, которые затем используются для подтверждения соответствия законодательству ЕС, а также Евразийский экономический союз (ЕАЭС), в рамках этого объединения также применяются единые гармонизированные стандарты, что упрощает торговлю между странами-членами.

Адаптация международных стандартов: Международные стандарты (например, стандарты ISO или IEC) принимаются в качестве национальных, часто с минимальными изменениями или без них.

Разработка на основе международных стандартов: При разработке национальных стандартов учитываются положения и принципы международных стандартов, чтобы обеспечить их совместимость.

Сокращение жизненного цикла продукции: Продукция и услуги меняются так быстро, что стандарты не всегда успевают актуализироваться, что снижает их эффективность и релевантность.

Управление системой стандартизации: В некоторых странах, включая Россию, существуют проблемы в управлении национальной системой стандартизации и эффективном внедрении уже существующих стандартов.

Информационная система: Несовершенство информационных систем, предоставляющих данные о качестве продукции и ходе разработки стандартов, затрудняет доступ к актуальной информации для всех заинтересованных сторон.

Отсутствие общего словаря: Недостаточно единой терминологии, что затрудняет взаимодействие и понимание.

Недооценка важности: Иногда стандартизация недооценивается на государственном и корпоративном уровнях.

Конкуренция: Острая конкуренция может тормозить разработку и внедрение стандартов [3].

Основные задачи в области стандартизации

Обеспечение совместимости и интероперабельности: Разработка стандартов, гарантирующих бесперебойное взаимодействие между различными системами, устройствами и программным обеспечением, особенно в контексте цифровой экономики. Разработка и совершенствование эталонов, методов и средств измерений для обеспечения достоверности результатов.

Своевременная разработка стандартов для инновационных сфер: Активный мониторинг достижений науки и техники для оперативного определения приоритетных направлений стандартизации (например, в области искусственного интеллекта). Стимулирование инновационной деятельности через разработку стандартов, обеспечивающих совместимость и взаимозаменяемость.

Повышение конкурентоспособности: Использование стандартизации как инструмента для улучшения качества и конкурентоспособности отечественной продукции и услуг на мировых рынках. Улучшение качества продукции казахстанского производства для повышения ее конкурентоспособности на мировом рынке.

Совершенствование нормативно-правовой базы: Дальнейшее развитие и актуализация законодательства в области стандартизации для обеспечения его соответствия современным реалиям и лучшим международным практикам.

Развитие международного сотрудничества: Активное участие в работе международных и межгосударственных технических комитетов для гармонизации национальных стандартов с международными и региональными.

Цифровая трансформация отрасли: Внедрение современных информационных технологий в процесс разработки, распространения и применения стандартов для повышения эффективности и доступности системы [4].

Методы решения проблем стандартизации.

Применение таких методов, как унификация (приведение к единому виду), параметрическая стандартизация (установление параметров и их зависимостей), агрегатирование (создание машин из унифицированных блоков) и комплексная стандартизация (одновременная стандартизация множества объектов).

Усиление исследований в области стандартизации, в том числе и в новых отраслях, таких как информационные технологии, где требуется оперативное реагирование на изменения. Разработка и ведение систем классификации и кодирования технико-экономической информации для унификации данных. Согласование национальных стандартов с международными, что упрощает международную торговлю и способствует обмену информацией.

Проблемы стандартизации решаются в таких конкретных областях, как: в информационных технологиях - постоянное обновление стандартов и создание новых, несмотря на сложность и высокую скорость развития технологий; на государственном уровне - решения принимаются в законодательных органах (например, в Парламенте Республики Казахстан); на уровне предприятий - применение стандартизированных рабочих процессов для повышения качества, предотвращения ошибок, упрощения обучения и распространения лучшего опыта [5].

Таким образом, основные проблемы стандартизации решаются путем применения методов стандартизации (унификация, агрегатирование, параметрическая стандартизация), активного развития исследований, создания систем классификации и кодирования, а также гармонизации национальных и международных стандартов. В области информационных технологий эти проблемы также усугубляются из-за высокой конкуренции и быстрого развития, требуя постоянного обновления стандартов.

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ENVIRONMENTAL PROTECTION OF THE TERRITORIES UNDER THE EXAMPLE OF PRYCARPATHIAN REGION

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The main part of water and hydrocarbons (organic part) is separated from oil sludge. The solid part of oil sludge formed in this process (viscous residue of oil sludge) was transferred to the accumulation pond No. 4 of the CPPN, where 670 tons of viscous residue of oil sludge have accumulated to date. Due to the efficient operation of the centrifuge, only a small amount of water and hydrocarbons enters the solid part of oil sludge. Analysis of the solid part of oil sludge showed that it mainly consists of mechanical impurities.

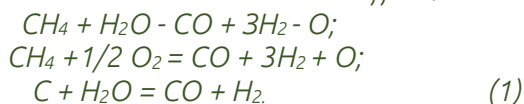
Comparing the composition of the hydrocarbon (organic) part of oil sludge, it was shown that during such centrifugation, hydrocarbons are distributed as follows: the main part of paraffinic, naphthenic, and aromatic hydrocarbons is separated together with the liquid phase. Resins, asphaltenes, and other polar components, which are adsorbed on the surface of solid particles of mechanical impurities, pass into the solid part of the oil sludge.

Considering that the enterprise plans to use metal tanks for technological needs instead of barns, all barns must be liquidated in the next few years.

Therefore, the issue of recycling sludge barn sediments remains unresolved. Despite the low content of hydrocarbons in these wastes, they remain a threat to the environment. Oil sludge and barn sediments are a constant source of toxic, mutagenic, and carcinogenic hydrocarbons. As the duration of the waste in non-reclaimed (unutilized) oil sludge ambergris increases, their toxicity to the environment increases. And this leads to a change in vegetation cover, to its reduction or complete elimination, the accumulation of toxic hydrocarbons in plants, changes. That is, oil pollution poses a threat to flora and fauna, including the population, for a long time.

Let's consider the main methods of purifying gases emitted into the atmosphere from carbon monoxide. Namely, the process of converting the oxide into carbon dioxide.

Let's consider this method using the example of the most common process of obtaining hydrogen by converting natural gas with water vapor or oxygen, as well as gasification of solid fuel. The chemical reactions that occur in this case create an exothermic or endothermic effect:



From chemical reactions it is clear that in three cases, when exposed to water vapor or oxygen, carbon monoxide is released, which can only be eliminated by conversion with water vapor, but in the presence of iron oxide catalysts:



This method is used to change the ratio of H_2 : CO in the synthesis gas, as well as to clean the protective atmosphere.

The industrial conversion catalyst has the form of tablets measuring 6.4 x 6.4 or 9.6 x 9.6 mm. It contains from 70 to 85% Fe_2O_3 and 5-15% Cr_2O_3 , retains activity at temperatures up to 600 °C. In the case of high concentrations of carbon monoxide in the source gas, the catalyst in the contactor is placed in several layers, and measures are provided for heat removal between the layers.

The installation works as follows. The gas mixture formed as a result of the conversion of carbon monoxide with water vapor, as well as hydrogen, oxide and carbon dioxide after leaving the conversion reactor and cooled by adding water vapor with a temperature of up to 370 °C and passed through the

first-stage converter. Here, in the presence of a catalyst, 90-95% of CO is converted into carbon dioxide (CO₂) with the formation of an equivalent amount of hydrogen. The gas is cooled in a water cooler to 35-40 °C and carbon dioxide is removed from it using ethanolamine, which is added to the purified gas. The purified gas is heated in a heater 4, the required amount of water vapor is added, and it is again subjected to conversion and purification from the formed carbon dioxide. In order to obtain purer hydrogen, the process can consist of three stages. After the third stage, the gas contains: 99.7% H₂; 0.02% CO; 0.01% CO₂; 0.27% CH₄. The process temperature is maintained within 315-480°C, the pressure is from 0.2 to 2.5 MPa.

To remove phenol from the wastewater of the enterprise, it is proposed to use extraction and steam circulation methods.

So, for the extraction of phenol from wastewater, we use oxygen-containing organic solvents with a low molecular weight, for which the partition coefficient is 25-100. Benzene, ether, butyl acetate, etc. are used as extractants.

The steam circulation method is based on the distillation of pollutants from wastewater by circulating water vapor. It is used to extract volatile organic substances, which are weak electrolytes, from water.

Before purifying wastewater from phenol by the steam circulation method, it is necessary to first remove NH₃, H₂S and CO₂ from the water. Ammonia increases the acidity of water and a significant part of phenol passes into a dissociated state in which it is not distilled. Free hydrogen sulfide and carbon dioxide reduce the acidity of wastewater, which should contribute to the removal of phenol, but, being distilled simultaneously with phenol, neutralize the alkali solution, due to which the circulating water vapor is washed away from phenol. The alkali solution neutralized by hydrogen sulfide and carbon dioxide stops absorbing phenol from the circulating vapor and the concentration of phenol in it increases to such values that its distillation from wastewater practically stops. The content of these gases in wastewater before feeding to the dephenolization column must be reduced to 10-20 g/l.

The plant operates on the following principle. After separation of free ammonia, hydrogen sulfide and carbon dioxide from the evaporation part of the ammonia column at the boiling temperature, wastewater enters the collector 1, from where it is fed by pump 2 to the upper part of the column 5. This column is divided into two chambers, interconnected by a pipe, through which water vapor is recirculated using a fan 3. In the upper chamber there is a wooden nozzle 6, in the lower one there is a metal nozzle 4. Phenolic wastewater heated to boiling, flowing down the wooden nozzle of the upper chamber, comes into contact with water vapor, which is gradually saturated with phenol vapor. Dephenolated water, which contains ammonium salts, enters the ammonia column for their decomposition and ammonia extraction, and phenol-containing vapor from the upper part of the column is sucked off by a fan and fed to the lower chamber of the column, where the nozzle forms several tiers. An alkali solution with a concentration of 8-14%, heated in the heater 7 (to a temperature of 102-103 °C), is periodically fed to the upper tier by a pump from the collector 1. Phenol absorption occurs according to the reaction:



The lower tiers of the metal packing are heated with circulating phenolate solutions using carriers 2. The heater 7 serves to heat the phenolate solution. The lower tier is irrigated with a more concentrated phenolate solution than the middle one. The concentrated enolate solution from the column tray is periodically transferred to the collector 1.

The enterprise currently has environmental protection measures developed and implemented that only partially protect the environment from the negative impact of the enterprise, therefore it is necessary to carry out further research on reducing the harmful impact of PJSC "Nefthimik Prykarpattya" on the environment.

That is why the paper proposes a justification for a number of environmental protection measures to reduce the negative impact of the enterprise on the air environment and hydrosphere.

To improve the state of the atmosphere of PJSC "Nefthimik Prykarpattya" and purify gases emitted into the atmosphere from carbon monoxide, an industrial unit for converting oxide into carbon dioxide is recommended.

In order to improve the state of the hydrosphere and remove phenol from the enterprise's wastewater, the installation and justification of extraction and steam circulation purification methods are recommended.

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