publisher.agency
Ireland

October, 2026
№ 14



Dublin, Ireland
15-16.10.2026

International
Scientific
Conference

Interdisciplinary Science Studies

UDC 001.1
P 97

Publisher.agency: Proceedings of the 14th International Scientific Conference «Interdisciplinary Science Studies» (October 15-16, 2026). Dublin, Ireland, 2026. 385p

ISBN 978-1-6201-7835-5
DOI 10.5281/zenodo.23465360

Editor: Daisy Farrell, Professor, University of Dublin
International Editorial Board:

Aidan Hayes
Professor, Athlone Institute of Technology
Olivia Cunningham
Professor, Cork Institute of Technology
Shay Hayes
Professor, Marino Institute of Education
Sarah Kavanagh
Professor, Institute of Public Administration
Adam Cunningham
Professor, Maynooth University
Aria Clarke
Professor, National University of Ireland, Galway
Shay Magee
Professor, Technological University Dublin
Thomas Donnelly
Professor, University of Limerick
Alex Doherty
Professor, University College Dublin
Ollie O'Donovan
Professor, Waterford Institute of Technology
Rian Doyle
Professor, Saint Patrick's College, Maynooth
David O'Mahony
Professor, Royal College of Surgeons in Ireland
Alannah O'Brien
Professor, National College of Ireland
Oisín Connolly
Professor, Letterkenny Institute of Technology

editor@publisher.agency
https://publisher.agency/

Table of Contents

Pedagogical Sciences

DEVELOPING ACADEMIC WRITING SKILLS IN A MASTER'S PROGRAM AT A NON-LINGUISTIC UNIVERSITY 6
Isina Gulmira
Tlebaldina Nurligul
Gulbanu Aubakirova

РЕАЛІЗАЦІЯ ІДЕЙ СТАЛОГО РОЗВИТКУ В ШКІЛЬНИХ КУРСАХ ГЕОГРАФІЇ В УМОВАХ ВПРОВАДЖЕННЯ КОНЦЕПЦІЇ НОВОЇ УКРАЇНСЬКОЇ ШКОЛИ 10
Салюк Мар'яна Романівна
Микита Михайло Михайлович
Козик Інна Володимирівна

AI-GENERATED ASSESSMENT ITEMS: QUALITY, VALIDITY, AND THE ROLE OF HUMAN OVERSIGHT 14
SALTANAT YESSENALIYEVA

THE IMPACT OF DIGITALIZATION ON LEARNING FOREIGN LANGUAGES 29
Askarova Sagira
Aubakirova Gulbanu Tursunovna

СТУДЕНТТЕРДІҢ СУИЦИДТІК МІНЕЗ-ҚҰЛҚЫНЫҢ ҚОРҒАНЫШ ФАКТОРЫ РЕТІНДЕГІ ПСИХОЛОГИЯЛЫҚ ТӨЗІМДІЛІК (ҚАЗАҚСТАН РЕСПУБЛИКАСЫНЫҢ 2023–2025 ЖЖ. СТАТИСТИКАСЫ НЕГІЗІНДЕ) 33
Турдашова Меруерт Маратовна
Альмухамбетова Бибигуль Жексембаевна

THE RELATIONSHIP BETWEEN SOCIAL MEDIA USE AND VOCABULARY DEVELOPMENT IN ENGLISH LANGUAGE LEARNING 45
Aigerim Nurzhanova

ФИЗИКА ПӘНІМЕН ПӘНАРАЛЫҚ БАЙЛАНЫСТЫ КОНТЕКСТІК НЕГІЗДЕ ҰЙЫМДАСТЫРУДЫҢ РӨЛІ 57
С. Нуркасымова
А.Аннасова

CERTAIN ASPETCS OF DEVELOPING FUTURE SKILLS IN MIDDLE SCHOOL STUDENTS UNDER DIGITALIZATION 66
Ospanaly D.A.
Almatkyzy D.
Kalimoldayeva A.K.
Abdrakhmanova R.B.

DIGITAL LITERACY OF TEACHERS IN MODERN PEDAGOGICAL PRACTICE: COMPETENCE FRAMEWORKS, INTEGRATION METHODS, AND DEVELOPMENT STRATEGIES 73
Matay Nuray Kusmankyzy
Kalimoldayeva Ardak Kenesbay
Abdrakhmanova Roza Beisenovna

ФИЗИКА ПӘНІН ОҚЫТУДА ЖАҢА ТЕХНОЛОГИЯЛАРДЫҢ АЛАТЫН ОРНЫ 79
С. Нуркасымова
М. Ибайдулла

DOMESTIC VIOLENCE AND BULLYING IN SCHOOLS – IMPACT, MECHANISMS, AND PREVENTION 85
Lucia Mrázková

Economic Sciences

GEORGIAN LEGISLATION AND THE FOUNDATION PRINCIPLES OF GEORGIAN STATE DEBTS (OBLIGATIONS) 92
Kristine Omadze

REFORMING THE GEORGIAN GOVERNMENT SECURITIES MARKET: REGULATORY BARRIERS AND THE CASE FOR OPEN, DIRECT INVESTOR ACCESS98
David Aslanishvili

AN ANALYSIS OF FACTORS INFLUENCING THE CHOICE OF GEORGIAN HIGHER EDUCATION INSTITUTIONS BY INTERNATIONAL STUDENTS 107
Nugzar Todua
Magda Magradze

Physical and Mathematical Sciences

СУПЕРИОНДЫ ТОК ӨТКІЗГІШТЕР 119
Рахымбеков Айтбай Жапарович
Байболат Бағлан Олжасұлы

ФИЗИКАДАҒЫ ЭКСПЕРИМЕНТТІК ЕСЕПТЕРДІ ШЫҒАРУҒА ОҚУШЫЛАРДЫҢ ҚЫЗЫҒУШЫЛЫҒЫН АРТТЫРУ 122
Рахымбеков Айтбай Жапарович
Шангерей Ерасыл Ерланұлы

ФИЗИКАНЫ ОҚЫТУДАҒЫ АНДРАГОГИКАЛЫҚ ТӘСІЛДІҢ ЕРЕКШЕЛІКТЕРІ 125
Рахымбеков Айтбай Жапарович
Аккасин Әсел Әділбекқызы

ФИЗИКА САБАҚТАРЫН ОҚЫТУДА ЖАҢА ӘДІС-ТӘСІЛДЕР МЕН САНДЫҚ ТЕХНОЛОГИЯЛАРДЫ ҚОЛДАНУДЫҢ ТИІМДІЛІГІ 128
Рахымбеков Айтбай Жапарович
Каналбекова Жанбота Назарбековна

ФИЗИКА ПӘНІН ОҚЫТУДАҒЫ ИННОВАЦИЯЛЫҚ ӘДІСТЕРДІ ПАЙДАЛАНУ 131
Рахымбеков Айтбай Жапарович
Жарқын Қарақат

АТОМДЫҚ ЖӘНЕ КВАНТТЫҚ ФИЗИКАНЫ ОҚЫТУДЫҢ ЗАМАНАУИ ӘДІСТЕМЕЛІК ЕРЕКШЕЛІКТЕРІ 135
Рахымбеков Айтбай Жапарович
Айғазы Сұңқар Ермекұлы

INTEGRATING ARTIFICIAL INTELLIGENCE INTO PHYSICS EDUCATION 140
Nurkasymova Saule Nurkasymovna
Ametova Dilyaram Bakhadurkyzy

Sociological Sciences

ЖЕНЩИНЫ-ДОМОХОЗЯЙКИ В СТРУКТУРЕ ДОМАШНИХ ХОЗЯЙСТВ РЕСПУБЛИКИ КАЗАХСТАН: РЕГИОНАЛЬНЫЙ АНАЛИЗ ЗА 2019–2023 ГОДЫ 146
Ешманова Салтанат Есимовна

ГОСУДАРСТВЕННАЯ ПОДДЕРЖКА ЖЕНЩИН-ДОМОХОЗЯЕК В РЕСПУБЛИКЕ КАЗАХСТАН: ЭВОЛЮЦИЯ ИНСТРУМЕНТОВ, ДИНАМИКА И ПРОБЛЕМЫ ДОСТАТОЧНОСТИ 155
Сейтказиева Аружан Мукатаевна
Ешманова Салтанат Есимовна

SCIENTIFIC COMMUNICATION IN DISASTER RISK MANAGEMENT: BRIDGING SCIENTIFIC KNOWLEDGE AND PUBLIC DECISION-MAKING 167
Abdirakhman Ayaulym Mukhitkyzy

Political Studies

ELECTORAL PROCESSES AND THE LEGITIMATION OF POLITICAL AUTHORITY: RESULTS OF THE FIRST KURULTAI ELECTION AS AN INDICATOR OF PARTY SYSTEM DEVELOPMENT 192
V.A. Luzanov
N.G. Kabdii
A.M. Kenzhebulatova

US-CHINA AI GEOPOLITICAL COMPETITION: PROPRIETARY FRONTIER LLMS VS. OPEN-SOURCE MODELS 198
Yeldar A. Duisembek

ҚАЗАҚСТАН МЕН ҚЫТАЙ АРАСЫНДАҒЫ ЭКОНОМИКАЛЫҚ ДИПЛОМАТИЯНЫҢ ЖАҢА ҚҰРАЛДАРЫ: ЦИФРЛЫҚ САУДА, ИНВЕСТИЦИЯЛЫҚ ЫНТЫМАҚТАСТЫҚ ЖӘНЕ КӨЛІК ДӘЛІЗДЕРІ 209
Султанханулы Есбол
Исова Лаура Танирбергеновна

ДЕЗИНТЕГРАЦИОННЫЕ ПРОЦЕССЫ В СОЕДИНЁННОМ КОРОЛЕВСТВЕ: ПРИЧИНЫ, ПРЕДПОСЫЛКИ И ВОЗМОЖНЫЕ СЦЕНАРИИ 220
Саурыкова Сатина Артыковна
Андиржанова Г.А.

Medical Sciences

THE INTEGRATED SCIENTIFIC EVALUATION OF RIB FRACTURE MANAGEMENT: PHARMACOTHERAPY, CLINICAL PHARMACOLOGY, DRUG SAFETY AND PHARMACOVIGILANCE 225
Nodar Sulashvili
Margarita Beglaryan
Maka Buleishvili
Mariam Darbaidze
Nato Alavidze
Marika Sulashvili
Nana Gorgaslidze
Irina Imerlishvili
Marina Giorgobiani
Ketevani Gabunia
Igor Seniuk
Naira Chichoyan
Olga Shapoval
Nino Abuladze
Rajkaran Singh
David Aphkhazava

Philological Sciences

ÖMƏR XƏYYAM RÜBAİLƏRİNİN FARSCADAN AZƏRBAYCAN DİLİNƏ TƏRCÜMƏSİNDƏ ÜSLUB VƏ RİTM: İNSAN VƏ SÜNİ İNTELLEKT VARİANTLARININ MÜQAYİSƏSİ 266
Salman Əsgər oğlu Əliyev

STRATEGIES FOR OVERCOMING TERMINOLOGICAL CHALLENGES IN SIMULTANEOUS INTERPRETATION FROM ENGLISH INTO KAZAKH: THE EXPERIENCE OF THE DIGITAL ALMATY 2025 FORUM 273
Nurtileu N. Torezhanov
Karlygash Kenzhigozhina

AI-BASED ADAPTIVE LEARNING: A NEW PARADIGM FOR PERSONALIZED FOREIGN LANGUAGE TEACHING 282
Nurmanaliyeva Lyaila Shaymerdenovna
Atam Ruveyda Ibrakhimzhanovna

FARS–AZƏRBAYCAN DİLLƏRİNDƏ XƏBƏR TƏRCÜMƏSİNDƏ LOKALLAŞDIRMA STRATEGİYALARI VƏ SÜNİ İNTELLEKT DƏSTƏKLİ REDAKTƏNİN KEYFİYYƏT MEYARLARI 291
Rəhimli Murad
İntiqam Əliyev

ƏRƏB DİLİNİN XARİCİ DİL KİMİ TƏDRİSİNDƏ FONETİK VƏ TƏLƏFFÜZ BACARIQLARININ FORMALAŞDIRILMASI: KONTRASTİV TƏHLİL VƏ METODİK MODEL 299
Ayaz Əli oğlu Axundov

ПОСТРЕДАКТИРОВАНИЕ МАШИННОГО ПЕРЕВОДА С АНГЛИЙСКОГО НА КАЗАХСИЙ: СТРАТЕГИИ ПОВЫШЕНИЯ КУЛЬТУРНОЙ АДЕКВАТНОСТИ..... 306
Пирман Аружан
Алшинбаева Жулдыз Куанышевна

Technical Sciences

ESTIMATION OF ECONOMIC LOSSES IN THE ELECTRICITY DISTRIBUTION NETWORK USING FOURIER ANALYSIS..... 314
Maka Jishkariani

АНАЛИЗ ФАКТОРОВ, ВЛИЯЮЩИХ НА ЭФФЕКТИВНОСТЬ ОРГАНИЗАЦИИ АВИАЦИОННЫХ ГРУЗОПЕРЕВОЗОК В УСЛОВИЯХ НЕСТАБИЛЬНОГО СПРОСА..... 320
Саркытова Асылай Талгаткызы
Айкумбеков Муслим Нурымович

Agricultural Sciences

PHYSICO-CHEMICAL PROPERTIES OF APPLES OF THE 'ARIANE' VARIETY 333
Samir Hafizov
Gharib Hafizov
Zakir Aliyev
Rahim Balayev

Chemical Sciences

PERSPECTIVES OF IMPLEMENTING 'GREEN CHEMISTRY' PRINCIPLES IN PHARMACEUTICAL PRODUCTION TECHNOLOGY 339
Dilyara Khikmatulayevna Abdiyeva
Dmitry Yuryevich Korulkin

Biological Sciences

A CLIL-BASED LEARNING SEQUENCE FOR DIGITAL ANALYSIS OF MICROBIAL GROWTH CURVES IN BIOLOGY TEACHER EDUCATION..... 347
Erkezhan Yerlanovna Zhazykbai
Elmira Begimbayevna Zhapparbergenova

'ТАРБАҒАТАЙ' МЕМЛЕКЕТТІК ҰЛТТЫҚ ТАБИҒИ САЯБАҒЫ БУНАҚДЕНЕЛІЛЕРІНІҢ ТҮРЛІК ҚҰРАМЫ 354
Г.Ө.Мақсутова
М.Ғ.Қуанышбаева

ҚАЛДЫҚ СУЛАРДЫ ҚАЙТА ПАЙДАЛАНУ МҮМКІНДІКТЕРІ ЖӘНЕ СУ РЕСУРСТАРЫН ТИІМДІ БАСҚАРУ..... 363
Исаев Ғани Исаұлы
Нармахан Айгул Мухитқызы

Journalism

MEDIA POLARIZATION AND POLITICAL FRAMING IN GEORGIA 370
Giorgi Abazadze

Architecture

ТАБИҒИ ЖӘНЕ ТЕХНОГЕНДІК ГИПС ҚҰРАМДЫ ШИКІЗАТ НЕГІЗІНДЕГІ БАЙЛАНЫСТЫРҒЫШ МАТЕРИАЛДАР: ӘДЕБИ ШОЛУ 373
Нуртөре Әлішер Ғалымжанұлы
Байменова Гульназ Рахимовна

Philosophical Sciences

ONTOLOGICAL AND EPISTEMOLOGICAL FOUNDATIONS OF THE CONCEPT OF 'TARIQA' IN ARAB-ISLAMIC PHILOSOPHY: IN THE CONTEXT OF AL-GHAZALI, IBN ARABI, AND NEUROTHEOLOGY..... 378
Temurbayev A.S.

Geographic Sciences

DÜNYANIN ƏN SAKIT YERLƏRI VƏ AKUSTIK EKOLOGIYA 382
Şəfəq Əliyeva Məmməd qızı

Pedagogical Sciences

Developing academic writing skills in a master's program at a non-linguistic university

Isina Gulmira
Doctoral Student, Karaganda University of Kazpotrebsoyuz (Non-State Institution)
Tlebaldina Nurligul
Doctoral Student, Karaganda University of Kazpotrebsoyuz (Non-State Institution)
Gulbanu Aubakirova
Candidate of Philological Sciences, Karaganda University of Kazpotrebsoyuz

Annotation. The article is devoted to the issue of developing master's students' academic writing skills in the process of learning a foreign language at a non-linguistic university. The article highlights the importance of developing foreign-language academic literacy as the most significant component of academic communication and the research activities of a future specialist. Academic writing is an essential component of master's-level education. Students at non-linguistic universities are expected to prepare research papers, conference abstracts, literature reviews, and master's theses, often in English. However, many of them experience difficulties with academic vocabulary, text structure, argumentation, source integration, and formal style. This article examines the main challenges involved in developing academic writing skills among master's students at non-linguistic universities. It also discusses effective teaching strategies, including genre-based instruction, process writing, scaffolded practice, peer review, corpus tools, and responsible use of artificial intelligence. The article argues that academic writing should be taught systematically and integrated into students' research and professional training.
The article emphasizes that students become familiar with the modern rules of written scientific communication, which must be taken into account when preparing academic texts in a foreign language. Students are encouraged to follow examples of authentic foreign-language academic texts and to analyze the principles of constructing an academic text and incorporate them into the system of constructing their own written works. The article shows that the lexical content and examples of typical syntactic structures based on academic foreign-language texts become the foundation for creating one's own written text. The authors of the article note that the assessment of the development of academic writing skills is carried out both during classroom sessions and based on the results of students' participation in scientific and practical conferences, where they present their materials in a foreign language.
Keywords: academic writing; research activities; academic communication; academic texts; master's program; foreign language instruction; non-linguistic university

The development of competencies in research activities is an essential condition for training a modern specialist. Conducting active research activities at the university helps to manifest scientific interests and improve academic communication skills for presenting one's own research results in a foreign language. According to the federal state educational standards for higher education, research work by master's students is one of the important components of the educational program, i.e., all master's students must be involved in scientific activities. Academic

writing involves creating texts of academic discourse in accordance with the requirements imposed by the global community for written scientific communication. Foreign-language written scientific communication is one of the criteria that determine the successful academic career of a future specialist [7]. It should be noted that the development of academic literacy is a weak link in the development of foreign-language communicative competence at a non-linguistic university, partly due to the small number of hours allocated to developing this skill. As a result, students face difficulties when writing academic texts, including cognitive ones:
(1) the inability to organize and structure the text in accordance with the norms and requirements;
(2) a lack of skills in analyzing information and identifying the main points;

The aim of this article is to examine issues related to teaching academic writing in a foreign language in the master's programme at a non-linguistic university.
Academic writing is one of the key competencies required of master's students. During their studies, they need to analyse scholarly literature, formulate research questions, present arguments, describe methodology, interpret findings, and communicate results in a clear and logically organised form. These activities are necessary not only for completing a master's thesis but also for participating in conferences, publishing articles, and continuing an academic or professional career.
The development of academic writing skills is especially challenging at a non-linguistic university, where students specialise in engineering, economics, information technology, medicine, agriculture, or other professional fields. Language courses in such institutions usually have a limited number of classroom hours, while students demonstrate different levels of English proficiency. In addition, they must simultaneously master subject-specific knowledge, research methodology, and the conventions of academic discourse.

The Concept of Academic Writing

Academic writing is a formal and evidence-based form of communication used in educational and research contexts. It is characterised by logical organisation, precise vocabulary, appropriate terminology, coherence, objectivity, and reliance on credible sources. An academic text is expected to present a clear purpose and support its claims with evidence.
Academic writing competence includes several interconnected abilities:

- Linguistic competence, including grammar, academic vocabulary, syntax, and punctuation.
- Discourse competence, or the ability to organise ideas coherently and use appropriate rhetorical structures.
- Research competence, including searching for literature, evaluating sources, collecting evidence, and presenting findings.
- Argumentative competence, which enables students to formulate claims, justify them, consider alternative perspectives, and draw conclusions.
- Ethical competence, including accurate citation, correct referencing, and avoidance of plagiarism.
- Digital competence, including the appropriate use of databases, reference managers, corpora, and artificial intelligence tools.

Therefore, successful academic writing depends on more than language proficiency. A student may know English grammar relatively well but still have difficulty constructing an argument, synthesising sources, or adapting a text to the conventions of a particular genre.

Challenge Faced by Master's Students

One of the most common difficulties is insufficient knowledge of academic vocabulary and phraseology. Students may understand specialised terminology but struggle to connect ideas, express cautious claims, compare studies, or describe cause-and-effect relationships. As a result,

their writing may appear repetitive, informal, or excessively dependent on direct translation from their first language.

Another problem is the organisation of academic texts. Students are often familiar with the general structure of an introduction, body, and conclusion, but they may not understand the communicative purpose of each section. For example, an introduction should not merely announce the topic. It normally establishes the research context, identifies a problem or gap, explains the relevance of the study, and states its aim.

Argumentation also presents a serious challenge. Some students describe information from several sources without comparing or evaluating it. This produces a descriptive text rather than a critical literature review. At the master's level, students are expected to establish relationships between sources, identify similarities and contradictions, and explain how previous studies relate to their own research.

The integration of sources is another area of difficulty. Inexperienced writers may use long quotations, paraphrase too closely, or fail to distinguish their own ideas from those of other authors. These practices increase the risk of plagiarism, even when the student has no intention of violating academic integrity.

Psychological factors should also be considered. Fear of making mistakes, limited writing experience, and uncertainty about academic conventions may cause students to postpone assignments. When writing is perceived only as a final product subject to evaluation, students have few opportunities to experiment, receive feedback, and revise their work.

Effective Approaches to Teaching Academic Writing

A productive academic writing course should combine explicit instruction with regular practice. Students need clear explanations of academic conventions as well as opportunities to apply them to texts connected with their fields of study.

The **genre-based approach** is particularly appropriate for master's programs. It introduces students to the communicative purposes and structural features of academic genres, such as abstracts, literature reviews, research articles, reports, and thesis chapters. By analysing authentic examples from their disciplines, students can identify recurring rhetorical patterns, language choices, and citation practices.

In the master's programme, the process of developing academic writing skills is preceded by a discussion of a number of issues, in particular:

* the lexical, grammatical and stylistic features of academic texts (knowledge of general scientific and highly specialised terminology, specialised vocabulary used for text formation, evaluation, and determining a person's attitude towards the subject under consideration);

* genre varieties of academic written communication, with special attention paid to annotation and summarisation;

* the main requirements for writing annotations, the types and mandatory components of annotations, and a description of the requirements for writing annotations.

To develop skills in foreign-language academic literacy, students complete a series of preparatory tasks when reading scientific texts in a foreign language. Academic texts are texts whose purpose is to convey and transform knowledge in the scientific and educational spheres of communication (conference abstracts, scientific articles, article summaries, literature reviews, research grant applications, etc.). In the course of this work, students analyze linguistic (lexico-grammatical, stylistic, structural and compositional) features, as well as translation errors, using specific language material. Students are encouraged to follow examples of authentic foreign-language academic texts and to analyze the principles of constructing an academic text, incorporating them into the system for constructing their own written works. The process of creating a written text within the framework of academic writing instruction can be условно divided into three stages: planning, implementation, and control. The first stage is devoted to planning academic discourse,

during which the purpose of the text, the target audience, the semantic implementation, and the structuring of the content are defined. The second stage involves the implementation and formatting of the statement in accordance with the plan formed at the previous stage. The structure of the letter is created using the established structure of academic work IMRaD (Introduction, Methods, Results, and Discussion), which serves as the foundation for organizing the content of one's own written text. The final stage is devoted to working with the written text, which includes checking and correcting the text, with the possibility of returning to previous stages. An important feature is the ability to monitor the resulting text to ensure it complies with the original intent and the developed plan. Repeated reading and editing of the text is of key importance, as it allows the text to finally acquire completeness, accuracy, logical coherence, objectivity, and linguistic correctness. It should be noted that at each stage, certain skills and abilities are актуализированы. The process of creating written text is not linear but iterative, involving repeated returns to the text with changes and editing. When analyzing an academic text, the following lexical and grammatical features of the foreign language characteristic of academic written communication are identified:

• abstract and generalized nature (the use of linguistic units with abstract and generalized meanings, including abstract vocabulary);

• impersonality (the use of passive, impersonal, and indefinite-personal constructions, as well as compound and complex sentences in which nouns, adjectives, and non-finite verb forms ;.predominate);

• emphasized logicality (the use of conjunctive sentences, cause-and-effect conjunctions, introductory words and phrases, division of the statement into logical parts and paragraphs).

• terminological nature (the selection and use of a large number of specialized terms and words/phrases denoting scientific or technical concepts).

Literature

1. Velikolug L.V. On the Role of Written Academic Discourse in the Development of a University Student's Foreign-Language Academic Literacy / L.V. Velikolug // Vestnik of Moscow State Linguistic University. Education and Pedagogical Sciences, 2018, No. 802, pp. 26–33. World of Science. Pedagogy and Psychology World of Science. Pedagogy and Psychology 2021, No. 5, Vol. 9 2021, No. 5, Vol. 9 ISSN 2658-6282 https://mir-nauki.com Page 6 of 7 50PDMN521 Publishing house "World of Science" http://izd-mn.com

2. Dobrynina O.L. Academic Writing for Publication Purposes: Stylistic Errors / O.L. Dobrynina // Higher Education in Russia. — 2019. — No. 10 — Pp. 38–49.

3. Putilovskaya T.S. Competence-based activity model of academic writing / T.S. Putilovskaya // Higher Education in Russia. — 2018. — No. 10. — Pp. 84–94.

4. Mileeva M.N. International and National in an Academic Article / M.N. Mileeva / Higher Education in Russia — 2018. — No. 5. — Pp. 114–120. 5. Ostrovskaya E.S. Academic Writing: The Concept and Practice of Academic Writing in English / E.S. Ostrovskaya, O.V. Vyshegorodtseva // Higher Education in Russia. — 2013. — No. 7. — Pp. 104–113.

6. Shestak V.P. Formation of Research Competence and "Academic Writing" / V.P. Shestak, N.V. Shestak // Higher Education in Russia. — 2011. — No. 12. — Pp. 115–119.

7. Kolyabina N.S. Linguodidactic features of genres of foreign-language academic writing / N.S. Kolyabina, T.N. Astafurova // Izvestia of the Volgograd State Pedagogical University. — 2018. — No. 2(125). — Pp. 73–77.

8. Korotkina I.B. Academic Writing in Russia: The Need for Interdisciplinary Research / I.B. Korotkina // Higher Education in Russia. — 2018. — No. 10. — Pp. 64–74.

РЕАЛІЗАЦІЯ ІДЕЙ СТАЛОГО РОЗВИТКУ В ШКІЛЬНИХ КУРСАХ ГЕОГРАФІЇ В УМОВАХ ВПРОВАДЖЕННЯ КОНЦЕПЦІЇ НОВОЇ УКРАЇНСЬКОЇ ШКОЛИ

Салюк Мар'яна Романівна
к. геогр. н., доцент, завідувач кафедри фізичної географії та раціонального природокористування, Ужгородський університет, м. Ужгород, Україна
Микита Михайло Михайлович
к. геогр. н., доцент кафедри фізичної географії та раціонального природокористування, Ужгородський університет, м. Ужгород, Україна
Козик Інна Володимирівна
здобувачка вищої освіти ступеня «магістр», Ужгородський університет, м. Ужгород, Україна

Анотація. У статті розкрито особливості реалізації ідей сталого розвитку в шкільних курсах географії в умовах впровадження Концепції Нової української школи. Проаналізовано нормативно-правові засади (Державний стандарт базової середньої освіти 2020 р., модельні навчальні програми), компетентнісний потенціал географії, трансформацію змісту географічних курсів. Визначено ефективні методичні підходи (проєктна технологія, інтерактивні методи, ГІС-технології) та окреслено виклики й перспективи інтеграції освіти для сталого розвитку в шкільну географічну освіту.

Ключові слова: сталий розвиток, Нова українська школа, шкільна географія, компетентнісний підхід, освіта для сталого розвитку.

Сучасна шкільна географічна освіта в Україні перебуває на етапі важливої трансформації, зумовленої послідовним впровадженням концептуальних засад Нової української школи [1]. Ця реформа передбачає зміну парадигми освітнього процесу, а саме перехід від репродуктивного засвоєння інформації до компетентнісного та діяльнісного підходів, орієнтованих на практичний досвід учнів. У цьому контексті важливого значення набуває наскрізна змістова лінія «Екологічна безпека та сталий розвиток», яка безпосередньо узгоджується з глобальними Цілями сталого розвитку ООН до 2030 року [2]. Завдяки своєму унікальному інтегративному характеру, що поєднує природничо-наукові та суспільствознавчі знання, шкільна географія володіє значним потенціалом для формування в учнів цілісної картини світу, екологічного й просторового мислення, а також розуміння нерозривного зв'язку між природними, соціальними та економічними процесами [1].

Концепція сталого розвитку, започаткована доповіддю Всесвітньої комісії з навколишнього середовища і розвитку «Наше спільне майбутнє» (1987) та закріплена в Порядку денному на XXI століття (1992), передбачає задоволення потреб сучасного покоління без шкоди для спроможності майбутніх поколінь задовольняти власні потреби [3; 4]. У контексті освітньої реформи в Україні ці ідеї знайшли системне відображення в ключових компетентностях та наскрізних лініях Державного стандарту базової середньої освіти [5]. Зокрема, Стандарт чітко окреслює мету природничої освітньої галузі як формування особистості з науковим світоглядом, здатної до свідомої та цивілізованої взаємодії з

природою. Це завдання безпосередньо корелює з Глобальними цілями сталого розвитку (зокрема Ціллю 4 «Якісна освіта» та Ціллю 13 «Вжиття термінових заходів щодо боротьби зі зміною клімату та її наслідками») [2]. Важливо, що сучасне нормативне поле акцентує на розумінні учнями глобальних та регіональних змін, спричинених людською діяльністю, та вихованні особистої відповідальності громадян за наслідки власних рішень для довкілля.

Відмітимо, що інтеграція ідей сталого розвитку в шкільну географію відбувається не як окремий теоретичний модуль, а наскрізно охоплює всі курси ступенів базової та профільної середньої освіти [5]. Аналіз чинних модельних навчальних програм засвідчує суттєве оновлення їхнього змістового наповнення у контексті вимог Нової української школи. У курсах загальної географії та географії материків і океанів (6–7 класи) основний акцент робиться на розумінні цілісності географічної оболонки, взаємозв'язку між компонентами природи, вразливості екосистем та усвідомленні обмеженості планетарних ресурсів, що безпосередньо відповідає цілям сталого розвитку щодо збереження екосистем та протидії кліматичним змінам [2; 6]. Під час опанування географії України та світового господарства у 8–9 класах увага акцентується на вивченні раціонального природокористування, геоекологічного стану територій, розвитку альтернативної енергетики, а також екологічних наслідків промислового виробництва та урбанізації. Оскільки вивченням географії у 9 класі завершується обов'язкова географічна освіта базової школи, цей курс відіграє вирішальну роль у формуванні громадянської самосвідомості учнів, їхньої предметної компетентності щодо оцінки демографічних процесів, тенденцій розвитку національного та світового господарства й визначення місця України в сучасному глобалізованому світі [2; 5; 6].

У профільній школі (10–11 класи) здійснюється системний аналіз глобальних викликів людства, геополітики, демографічної динаміки та сталого просторового розвитку територій [2]. Яскравим прикладом реалізації компетентнісного, діяльнісного та особистісно зорієнтованого підходів у старшій школі є авторський курс «Простір і людина» (авт. Я. О. Ісаєв) [6]. Його актуальність зумовлена необхідністю підготовки учнів до життя в умовах динамічних суспільних і природних трансформацій – урбанізації, глобалізації, міграцій, цифровізації та кліматичних змін. Основними завданнями цього курсу є формування уявлень про простір як багатовимірне фізичне, географічне, соціальне, культурне та цифрове явище, розкриття закономірностей взаємодії людини з довкіллям, розвиток умінь встановлювати міжпредметні зв'язки та усвідомлення шляхів розв'язання глобальних просторових проблем [6].

Навчальний та компетентнісний потенціал географії для реалізації ідей сталого розвитку послідовно розкривається і в базовій програмі для 6–9 класів через наскрізну лінію «Екологічна грамотність і здорове життя». Вона орієнтує освітній процес на формування вмінь застосовувати набутий досвід для збереження власного здоров'я та здоров'я оточуючих, а також на виховання ціннісного ставлення до навколишнього середовища як джерела добробуту й безпеки. Практичне втілення цих завдань забезпечується через використання кооперативного навчання, партнерських технологій та навчальних проєктів, що повністю відповідає сучасній методології освіти для сталого розвитку.

Практичне втілення ідей сталого розвитку в шкільній географії має чітко виражену покласну динаміку, що забезпечує послідовне формування екологічної грамотності та здоров'язбережувальної поведінки школярів [5]. У 6 класі практичний вектор спрямовано на вивчення природних комплексів власної місцевості, зокрема застосування знань про лікарські та отруйні рослини й тварини, розуміння впливу метеорологічних чинників на самопочуття, а також формування установок на безпечне та здорове харчування. У 7 класі при вивченні материків та океанів акцент зміщується на розуміння санітарно-гігієнічних умов проживання в різних куточках планети, важливість профілактики під час закордонних мандрівок і правила поведінки під час небезпечних природних явищ. Під час опанування

географії України у 8 класі учні усвідомлюють здоров'я як найвищу соціальну та індивідуальну цінність, засвоюють алгоритми дій в екстремальних ситуаціях довкілля та вчаться організовувати здоров'язберігаючий навчальний простір. У 9 класі, під час аналізу галузей господарства, формується розуміння безпечності товарів і послуг, а також уміння критично оцінювати екологічні та соціальні наслідки застосування сучасних біотехнологій у агросфері.

В умовах впровадження концепції Нової української школи особливого значення набувають інтерактивні та діяльнісні методи навчання, які сприяють розвитку навичок самостійного опрацювання інформації, критичного мислення та здатності адаптуватися до складних ситуацій [7]. Реалізація реформи вимагає відходу від репродуктивного викладання на користь проблемно-пошукового та дослідницького підходів. Дослідження засвідчують, що засвоєння географічних знань та цінностей сталого розвитку є найефективнішим під час розв'язання проблемних ситуацій із застосуванням сучасного дидактичного інструментарію [7; 8]. Зокрема, реалізації ідей сталого розвитку сприяє впровадження STEAM-проєктів, у межах яких школярі здійснюють лабораторні міні-моніторинги стану місцевих ґрунтів, водойм чи атмосферного повітря з подальшим моделюванням геоекологічних процесів [8; 9]. Застосування кейс-методу та дебатів дозволяє учням аналізувати реальні виклики – від оцінки екологічного впливу місцевих підприємств до розрахунку рекреаційного навантаження на заповідні об'єкти. Важливим елементом є також локально-краєзнавчий вимір, де діти розраховують власний «екологічний слід», впроваджують сортування відходів та досліджують заходи з енергоефективності у своїй громаді за принципом «мислити глобально – діяти локально».

Окрему роль у сучасній географічній освіті відіграє цифровізація. Сучасні наукові розвідки наголошують, що географію та інші природничі курси неможливо якісно викладати без візуалізації просторових даних [10]. Це передбачає поєднання традиційних картографічних видань із новітніми мультимедійними та геоінформаційними ресурсами – інтерактивними картами, ГІС-технологіями, космічними знімками, анімаціями та учнівськими цифровими платформами, що забезпечують візуалізацію динаміки глобальних і регіональних процесів [8; 10].

Попри позитивні зрушення у впровадженні цілей сталого розвитку, трансформація стандартів базової географічної освіти в Україні супроводжується низкою суттєвих протиріч. Порівняльний аналіз географічного компонента освітньої галузі за Державним стандартом 2011 року та новим Державним стандартом базової середньої освіти 2020 року засвідчує, що в сучасному нормативному документі закладено значно звужений зміст географічної науки [5; 8]. Зокрема, оновлена географічна складова не передбачає належного формування у школярів базових знань з фундаментальних питань регіональної фізичної та суспільної географії [8]. Це створює відчутні ризики для повноцінної реалізації концепції сталого розвитку, оскільки глибоке усвідомлення глобальних кліматичних та геоекологічних процесів є неможливим без ґрунтовного розуміння регіональних ландшафтних особливостей, специфіки місцевого природокористування та соціоекономічних чинників [8; 9]. Втрата регіонального виміру може призвести до фрагментарності екологічних знань та спрощеного розуміння взаємозв'язку між глобальними екологічними викликами та практичними діями на рівні місцевих громад. Водночас в умовах розбудови Нової української школи зростає роль та академічна автономія педагогів, на яких покладається відповідальність за добір змісту, варіативних модулів, а також форм і методів навчання для належного виконання державних стандартів [5]. Перспективи подолання окреслених викликів полягають у розширенні практико-орієнтованих та STEM-технологій, впровадженні авторських модельних програм і факультативних курсів, а також у постійному методичному вдосконаленні вчителів географії щодо залучення локального геоекологічного матеріалу в освітній процес [6; 9].

Таким чином, реалізація ідей сталого розвитку в шкільних курсах географії в умовах впровадження концепції Нової української школи є складним, але стратегічно важливим завданням для сучасної освіти. Компетентнісний, діяльнісний та особистісно зорієнтований підходи, закладені в основу реформи, створюють сприятливе методологічне підґрунтя для інтеграції екологічної, економічної та соціальної складових сталого розвитку в освітній процес. Чинні та перспективні модельні навчальні програми, яскраво демонструють прагнення до формування в учнів цілісного розуміння взаємозв'язків між людиною, суспільством та географічним простором. Завдяки застосуванню інтерактивних методів, STEAM-технологій, ГІС-сервісів та локально-краєзнавчих досліджень, вивчення географії перетворює теоретичні знання про Цілі сталого розвитку ООН на практичні життєві навички (Life Skills) та формує готовність до екологічно доцільної поведінки. Водночас існуючі нормативно-методичні виклики, пов'язані зі звуженням змістового наповнення географічного компонента в Державному стандарті 2020 року, потребують подальшого вдосконалення навчальних програм, розробки якісного дидактичного забезпечення та підвищення кваліфікації вчителів.

Попри окреслені суперечності, географія зберігає свій унікальний потенціал як головний інтегративний предмет, здатний формувати в учнів просторове мислення, науковий світогляд та свідому громадянську позицію. Саме тому інтеграція концепції сталого розвитку в географічну освіту є не лише педагогічним завданням, а й вагомим внеском у виховання свідомого покоління, здатного забезпечити стале майбутнє України та світу.

Список літератури

1. Нова українська школа: концептуальні засади реформування середньої школи / під заг. ред. М. Грищенка. Київ : МОН України, 2016. 40 с.
2. Перетворення нашого світу: Порядок денний у сфері сталого розвитку до 2030 року : Резолюція Генеральної Асамблеї ООН від 25 вересня 2015 року № 70/1. URL: https://sdgs.un.org/2030agenda (дата звернення: 8.10.2026).
3. Our Common Future: Report of the World Commission on Environment and Development. Oxford : Oxford University Press, 1987. 383 p.
4. Agenda 21: Earth Summit : The United Nations Programme of Action from Rio. New York : UN, 1993. 294 p.
5. Державний стандарт базової середньої освіти: затверджено постановою Кабінету Міністрів України від 30 вересня 2020 р. № 898. URL: https://zakon.rada.gov.ua/laws/show/898-2020-%D0%BF (дата звернення: 8.10.2026).
6. Ісаєв Я. О. Модельна навчальна програма «Простір і людина» для профільної середньої освіти (10–11 класи). Київ : МОН України, 2023. 18 с.
7. Пометун О. І. Інтерактивні технології навчання: теорія і практика. Київ : Олена Пометун, 2004. 192 с.
8. Запотоцький С. П., Блажко Н. Б. Проблеми та перспективи трансформації змісту географічної освіти в умовах реалізації Державного стандарту базової середньої освіти. Часопис картографії. 2022. Вип. 24. С. 45–58.
9. Корнєєв В. П. Методичні засади реалізації наскрізної лінії «Екологічна безпека та сталий розвиток» у шкільних курсах географії. Географія та економіка в сучасній школі. 2021. № 2. С. 15–21.
10. Даценко Л. М., Остроух В. І. Геоінформаційні системи та картсервіси в шкільній географічній освіті: навчально-методичний посібник. Київ : ФОП Власюк, 2021. 144 с.

AI-Generated Assessment Items: Quality, Validity, and the Role of Human Oversight

SALTANAT YESSENALIYEVA
Coordinator, Admission Insight Test and AI Department, National Testing Center, Ministry of Science and Higher Education of the Republic of Kazakhstan, Astana, Kazakhstan, https://orcid.org/0009-0000-2286-713X

Abstract

The rapid development of generative artificial intelligence has created new opportunities for educational assessment, particularly in the development of test items. Large language models (LLMs) can generate multiple-choice questions, constructed-response prompts, distractors, scenarios, and alternative item versions within seconds, potentially reducing the time and resources traditionally required for item development. However, the ability to generate a plausible question does not necessarily demonstrate that the resulting item is suitable for educational measurement. This paper examines current evidence on the quality of AI-generated assessment items and considers the implications of their use for validity, cognitive alignment, fairness, technical quality, and psychometric functioning. A structured review and conceptual analysis of recent literature on LLM-based automatic item generation was conducted, with particular attention to research published between 2023 and 2026. The review indicates that AI-generated items can achieve promising levels of linguistic, content, and, in some contexts, psychometric quality. Nevertheless, important limitations remain, including factual inaccuracies, construct misalignment, insufficient cognitive demand, weak distractors, response-pattern artifacts, cultural sensitivity concerns, and substantial variation according to model, prompt design, and assessment domain. Building on emerging human-in-the-loop approaches, this paper proposes an evidence-based quality assurance framework that differentiates among tasks suitable for AI assistance, tasks requiring professional judgment, and claims requiring empirical evidence. The paper argues that as item generation becomes increasingly scalable, the principal challenge shifts from producing assessment content to validating it. Generative AI may therefore change rather than eliminate the role of assessment professionals, placing greater emphasis on specification, review, validation, and accountable decision-making.

Keywords: generative artificial intelligence, large language models, automatic item generation, educational assessment, validity, psychometrics, human oversight.

Introduction

The development of high-quality assessment items has traditionally required substantial human expertise, time, and institutional resources. Item writers must translate an assessment framework into tasks that accurately represent the intended domain while meeting technical, cognitive, linguistic, and fairness requirements. Items may then undergo expert review, editing, pilot administration, statistical analysis, and further revision before becoming operational.

The increasing use of computer-based assessment has intensified this demand. Digital testing, adaptive assessment, frequent formative assessment, and the need for secure alternative test forms all require large pools of high-quality items. Consequently, the ability to produce assessment content efficiently has become an important practical issue for educational institutions and testing organizations.

Automatic item generation (AIG) emerged well before the current generation of artificial intelligence systems as one response to this problem. Earlier approaches often relied on item models, templates, rules, or predefined combinations of content elements. More recently, large language models (LLMs) have fundamentally expanded the range of content that can be generated automatically. Instead of requiring every component of an item to be explicitly programmed, contemporary generative models can produce natural-language questions, response options, distractors, explanations, scenarios, and alternative versions in response to relatively concise instructions.

Recent research demonstrates the rapid expansion of this field. Tan et al. (2025), in a review of 60 studies using LLMs for automatic item generation, found applications across different subject areas, languages, educational levels, and item types. At the same time, the authors observed that many studies placed greater emphasis on the generation process than on rigorous evaluation of the resulting item quality.

This distinction is fundamental for educational measurement.

The ability to generate a question is not equivalent to the ability to generate a valid assessment item. A question may be grammatically correct, factually plausible, and professionally worded while failing to represent the intended construct. Similarly, an item that appears appropriate during expert review may perform differently when administered to actual examinees.

The emerging research agenda therefore requires a shift in emphasis. The important question is becoming less about whether artificial intelligence can generate assessment content and more about what evidence is required before that content can be used to support educational decisions.

This issue becomes particularly important when assessments have substantial consequences. The evidentiary expectations for an AI-generated classroom quiz item are not necessarily equivalent to those for an item used in selection, admission, certification, or other high-stakes decisions.

The present paper examines recent evidence on LLM-based automatic item generation and addresses the following research question:

To what extent can large language models generate assessment items of sufficient quality for educational use, and what forms of human oversight and empirical evidence are required to support their defensible use?

Three subsidiary questions guide the analysis:

1. What opportunities do LLMs offer for assessment item development?
2. What major quality and validity risks remain?
3. How should AI assistance, human professional judgment, and empirical evidence be distributed across the item-development process?

The paper argues that the central challenge of AI-assisted item development is increasingly shifting from generation to validation. As generative capacity increases, the ability to produce content may cease to be the principal bottleneck. Instead, the challenge becomes determining which generated items are suitable for their intended measurement purpose and what evidence is sufficient to justify their use.

From Automatic Item Generation to Large Language Models

Automatic item generation is not a new concept. Educational and psychological measurement researchers have investigated automated approaches to test development for decades. Traditional AIG methods often use cognitive models, templates, item models, algorithms, or rule-based systems to create families of related items.

These approaches provide a degree of control because the elements that can vary are explicitly defined. However, building such systems may require substantial initial investment in domain modeling and technical development.

Transformer-based generative AI changes this relationship.

LLMs can generate content directly from natural-language instructions and can operate across a wide variety of domains. They may be instructed to create questions for a particular subject, age group, difficulty level, cognitive process, or item format. They can also produce alternative versions, explanations, distractors, and contextual scenarios.

Sommer and Arendasy (2025), in their critical review of automatic and transformer-based item generation, highlight both the potential and the limitations of these newer approaches. The increased flexibility of generative models may support scalable test construction, but psychometric soundness, validity, fairness, and control over generated content remain central concerns.

This represents an important change in the economics of item development.

Traditionally, substantial professional effort was concentrated on producing the initial item. With generative AI, the marginal cost of producing another candidate item may become very small. Yet this does not mean that the cost of producing an operationally defensible item becomes equally small.

Indeed, the opposite may occur. If a model can generate hundreds or thousands of candidate items, assessment organizations need efficient mechanisms for determining which items deserve further review and which should be rejected.

Gorgun and Bulut (2025) describe item-quality evaluation as a bottleneck in automatic item generation. Their research demonstrates that instruction-tuned LLMs may themselves contribute to preliminary quality control, suggesting that AI can potentially assist at more than one stage of the process.

Thus, generative AI does not simply automate an existing item-writing task. It potentially reorganizes the entire item-development workflow.

Method

This study employed a structured literature review and conceptual analysis.

The review focused primarily on recent literature concerning generative AI, large language models, automatic item generation, assessment-item quality, human–AI collaboration, validity, and psychometric evaluation. Particular attention was given to research published between 2023 and 2026 because the capabilities and applications of generative AI have developed rapidly during this period.

Relevant literature was examined with particular attention to six dimensions of item quality:

1. content accuracy;
2. construct alignment;
3. cognitive demand;
4. technical item quality;
5. fairness; and
6. psychometric functioning.

Studies comparing AI-generated and human-authored items, examining prompt engineering or fine-tuning, investigating expert evaluation, or providing empirical evidence about generated items were given particular consideration.

The purpose of the review was conceptual rather than meta-analytic. Accordingly, the paper does not claim to provide an exhaustive systematic review of every study on LLM-based item generation. Instead, evidence from recent reviews, empirical studies, and conceptual

frameworks was synthesized to identify emerging patterns and implications for assessment practice.

Based on this synthesis, an evidence-based quality assurance framework is proposed. The framework is not intended to replace established test-development or validation standards. Rather, it illustrates how three sources of quality assurance—AI assistance, human professional judgment, and empirical evidence—may be integrated when generative AI is incorporated into item development.

Opportunities for AI-Assisted Item Development

1. Scalability and efficiency

The most visible advantage of generative AI is speed.

An experienced item writer may require considerable time to develop, revise, and refine an assessment item. An LLM can produce multiple candidate items within seconds. Even if many of these candidates are subsequently rejected, the ability to begin with a broad pool rather than a blank page may substantially alter the item-development process.

This capability becomes particularly attractive when assessments require large item banks, frequent renewal, parallel forms, or extensive practice materials.

The review by Tan et al. (2025) demonstrates that LLMs have already been used to generate different item types across multiple languages and subject areas. This flexibility suggests that generative AI is not limited to a single assessment domain.

2. Item variation

LLMs may also assist with the production of variations around an existing assessment concept.

For example, a developer may retain the targeted knowledge or skill while changing contextual features, numerical values, scenarios, or response options. This may support the development of parallel items or larger pools.

However, apparently minor changes may alter difficulty or introduce unintended construct demands. Item variation therefore remains an assessment-design task rather than a purely linguistic task.

3. Distractor generation

Developing plausible distractors is a demanding component of multiple-choice item writing. Effective distractors should be incorrect while remaining sufficiently plausible to attract examinees who have not mastered the targeted knowledge or skill.

Generative AI can produce candidate distractors rapidly and can be prompted to base them on common misconceptions or errors.

Yet plausibility alone does not demonstrate distractor quality. Distractors must ultimately be evaluated in relation to the intended construct and, where possible, examinee response patterns.

4. Support for preliminary quality control

AI may also contribute after initial generation.

Gorgun and Bulut (2025) investigated the use of an instruction-tuned LLM for evaluating automatically generated cloze items. Their findings indicated that the model could distinguish many acceptable and unacceptable items, suggesting that automated screening may reduce the volume of material requiring intensive human review.

This is potentially important for scalable AIG systems. If generation becomes inexpensive but expert review remains costly, automated screening could function as an intermediate filter.

However, using AI to evaluate AI-generated content introduces a further requirement: automated review itself must be validated. A model's confidence or agreement with another model cannot independently establish that an item is appropriate for its intended assessment use.

What Does Current Evidence Suggest About AI-Generated Items?

Recent research provides reasons for both optimism and caution.

Studies increasingly show that LLMs can produce items that experts consider usable or that demonstrate promising empirical characteristics. For example, research in personality situational judgment testing has shown that optimized prompts and model settings can produce items with satisfactory reliability and validity across many measured facets.

Other studies have investigated generated items in STEM subjects, language assessment, psychological measurement, and educational testing.

These findings make it increasingly difficult to sustain a simple assumption that AI-generated items are necessarily inferior because they are machine-generated.

At the same time, performance is inconsistent.

Quality may vary according to:

- the model used;
- the prompt;
- temperature and other generation parameters;
- subject domain;
- item type;
- intended cognitive level;
- amount and quality of contextual information;
- use of examples;
- fine-tuning; and
- evaluation criteria.

Recent research on second-language listening assessment is illustrative. Prompt refinement improved output, but performance eventually plateaued, and higher-order items remained challenging. Fine-tuning improved contextual grounding and coherence, yet problems such as answer-option patterns and certain item-writing weaknesses persisted.

This suggests that the appropriate unit of evaluation is not “AI” as a general category. Assessment professionals need to evaluate specific systems, workflows, models, prompts, outputs, and intended uses.

Six Dimensions of Quality

A central problem in discussions of AI-generated items is the tendency to use “quality” as a single concept.

In assessment, quality is multidimensional. An item may perform well on one dimension while failing on another.

1. Content accuracy

At the most basic level, an item should be factually and conceptually correct.

LLMs can produce fluent statements that contain subtle inaccuracies. This risk is particularly important in specialized domains where an error may not be obvious to a general reviewer.

Furthermore, an incorrect distractor must be incorrect for a defensible reason. If multiple response options can be interpreted as correct, the item may become ambiguous.

For this reason, content generated by an LLM should not be accepted solely because it appears authoritative or well written.

2. Construct alignment

Content accuracy does not establish construct alignment.

A mathematics item, for example, can contain correct mathematics while placing excessive reading demands on examinees. A science item may unintentionally require specialized contextual

knowledge. A critical-thinking item may appear complex while being answerable through simple factual recall.

The key question is therefore not merely:

Is this a good question?

but:

Does responding to this item provide the intended evidence about the construct?

This distinction is central to validity.

Recent work by Kim, Shin, and von Davier (2026) provides an important development in this area by proposing an evidence-centered validity argument framework for automated item generation. Their framework distinguishes claims concerning content comparability, construct validity, and psychometric functioning.

This reinforces the argument that expert approval of surface characteristics represents only one part of the required evidence.

3. Cognitive demand

Generative AI can easily be instructed to produce an “easy,” “difficult,” or “higher-order” item.

The generated label, however, does not guarantee the cognitive process required to solve the item.

A question may use sophisticated language while requiring only recognition. Conversely, an apparently simple question may demand multiple reasoning steps.

The 2026 research on GPT-based item generation for second-language listening illustrates this problem: despite improvements achieved through fine-tuning, generating higher-order items requiring discourse-level reasoning remained challenging.

Assessment experts must therefore evaluate the actual cognitive operation required by the item rather than the cognitive category requested in the prompt.

4. Technical item quality

AI-generated items can display traditional item-writing problems, including:

- ambiguous stems;
- unnecessarily complex wording;
- implausible distractors;
- grammatical clues;
- inconsistent option length;
- overlapping response categories;
- unintended cues;
- repeated response patterns; and
- poorly distributed correct options.

Some of these problems are suitable for automated detection.

Others require contextual judgment.

This makes technical quality a promising area for hybrid human–AI review rather than complete automation.

5. Fairness

Fairness deserves separate attention because an item can be technically correct and construct-relevant while still creating unnecessary barriers for particular groups.

Generative models learn patterns from large bodies of language and may reproduce cultural assumptions, stereotypes, or contextual biases present in their training data.

Kim et al. (2025), in their STAIR-AIG human–AI collaboration framework, found that LLM reviewers demonstrated high consistency but tended toward lenient judgments. Human expert review identified concerns that automated reviewers could overlook, including construct-irrelevant and culturally sensitive aspects.

This provides an important caution against assuming that multiple AI reviewers automatically produce an objective fairness evaluation.

Fairness review remains a substantive professional responsibility and, where relevant, should be supplemented by empirical subgroup analyses.

6. Psychometric functioning

The final dimension differs fundamentally from the preceding ones.

Some item properties cannot be established by reading the item.

An expert may predict that an item is moderately difficult, but examinees may find it extremely easy. Distractors that appear plausible may attract almost nobody. An apparently strong item may show weak discrimination. An item may also function differently across groups after controlling for the underlying construct.

Consequently, empirical evidence remains indispensable for consequential assessment.

Depending on the assessment context, this may include:

- item difficulty;
- item discrimination;
- distractor functioning;
- item-total relationships;
- differential item functioning;
- reliability-related evidence;
- item response theory parameters; and
- other analyses appropriate to the assessment design.

Recent research increasingly moves beyond expert judgments and compares AI-generated items with human-authored items using empirical data. This development is important because psychometric performance provides a different form of evidence from linguistic or content review.

Table 1. Quality Dimensions and Evidence Required for AI-Generated Assessment Items

Quality dimension	Central question	Key AI-related risk	Appropriate evidence	Primary responsibility
Content accuracy	Is the content factually and conceptually correct?	Hallucination, subtle factual error, oversimplification	SME verification and authoritative sources	Human expert
Construct alignment	Does the item elicit evidence about the intended construct?	Construct-irrelevant demands or underrepresentation	Construct definition, specification alignment, expert review	Assessment professional
Cognitive demand	Does the task require the intended level/type of thinking?	Superficial complexity or incorrect cognitive classification	Task analysis and expert judgment	Human expert
Technical quality	Does the item follow appropriate item-writing principles?	Weak distractors, clues, ambiguity, structural artifacts	Automated screening plus expert review	AI + human

Fairness	Could irrelevant characteristics disadvantage groups?	Cultural assumptions and bias reproduced from training data	Fairness review and, where appropriate, subgroup analysis	Human + empirical evidence
Psychometric functioning	Does the item behave as intended with examinees?	Item quality inferred without response data	Difficulty, discrimination, distractor analysis, DIF/IRT where appropriate	Empirical analysis
Operational suitability	Is the total evidence sufficient for the intended use?	Premature deployment	Integrated evaluation of available evidence	Accountable human decision

From Item Generation to Item Validation

The six dimensions above reveal an important distinction among three kinds of quality assurance.

AI can provide assistance.

AI can generate candidate items, produce alternatives, detect certain structural problems, assist with classification, summarize review information, and potentially identify items that warrant further attention.

Humans provide professional judgment.

Subject-matter experts and assessment professionals interpret the construct, evaluate content, consider context, identify subtle threats to fairness, and determine whether an item appropriately represents the intended domain.

Examinee data provide empirical evidence.

Neither an LLM nor a human expert can determine all psychometric characteristics of a new item simply by inspecting it.

These three sources of evidence should not be treated as interchangeable.

This leads to the central argument of this paper:

As automatic generation becomes more scalable, validation rather than generation becomes the principal quality challenge.

The ability to produce 1,000 candidate items does not mean that an assessment program has acquired 1,000 operational items.

It has acquired 1,000 **candidates**.

The distinction is critical.

An Evidence-Based Human-in-the-Loop Quality Assurance Framework

Human-in-the-loop approaches to AIG are already emerging in the literature. Therefore, the contribution proposed here is not the general principle that humans should remain involved. Instead, the framework emphasizes the **type of evidence and decision authority required at different stages of the item-development cycle**.

Stage 1. Construct definition and assessment specification

Primary responsibility: Human

The process should begin with the intended inference, construct, assessment purpose, target population, content domain, item format, and cognitive requirements.

The LLM should operate within these specifications rather than define the measurement target independently.

Stage 2. Candidate item generation

Primary role: AI; direction: Human

The model generates candidate items using structured instructions.

The prompt may specify:

- construct;
- content domain;
- item type;
- target population;
- cognitive requirements;
- expected response;
- difficulty intentions;
- prohibited content; and
- technical item-writing rules.

Outputs remain candidates rather than approved items.

Stage 3. Preliminary automated screening

Primary role: AI/computational tools

Candidate items may undergo automated checks for duplication, formatting, linguistic characteristics, response-pattern artifacts, answer-key distribution, and selected item-writing rules.

The purpose is triage rather than final approval.

Stage 4. Professional review

Primary responsibility: Human

Subject-matter and assessment experts evaluate:

- factual accuracy;
- construct relevance;
- cognitive demand;
- clarity;
- technical quality;
- appropriateness for the target population; and
- potential fairness concerns.

Items may be accepted for further development, revised, or rejected.

Stage 5. Revision

Primary role: Human–AI collaboration

AI may assist with targeted revisions, such as rewriting an ambiguous stem or proposing stronger distractors.

However, material changes should trigger renewed review. A revised item should not inherit approval automatically from its earlier version.

Stage 6. Pilot or field administration

Evidence source: Examinee responses

Items intended for consequential assessment should be administered to an appropriate sample whenever feasible.

This stage transforms the evaluation from predicted quality to observed functioning.

Stage 7. Psychometric evaluation

Evidence source: Empirical analysis; interpretation: Human

Relevant analyses are conducted according to the assessment design.

Evidence may concern difficulty, discrimination, distractor functioning, dimensionality, differential item functioning, IRT parameters, or other appropriate indicators.

Statistical evidence should not be interpreted mechanically. Unexpected results may require substantive investigation.

Stage 8. Accountable decision

Decision authority: Human

The available evidence is integrated to determine whether the item should be:

approved → revised → re-tested → rejected.

The final decision remains accountable to qualified professionals or the responsible assessment organization.

Figure 1. Evidence-Based Quality Assurance Cycle for AI-Assisted Item Development

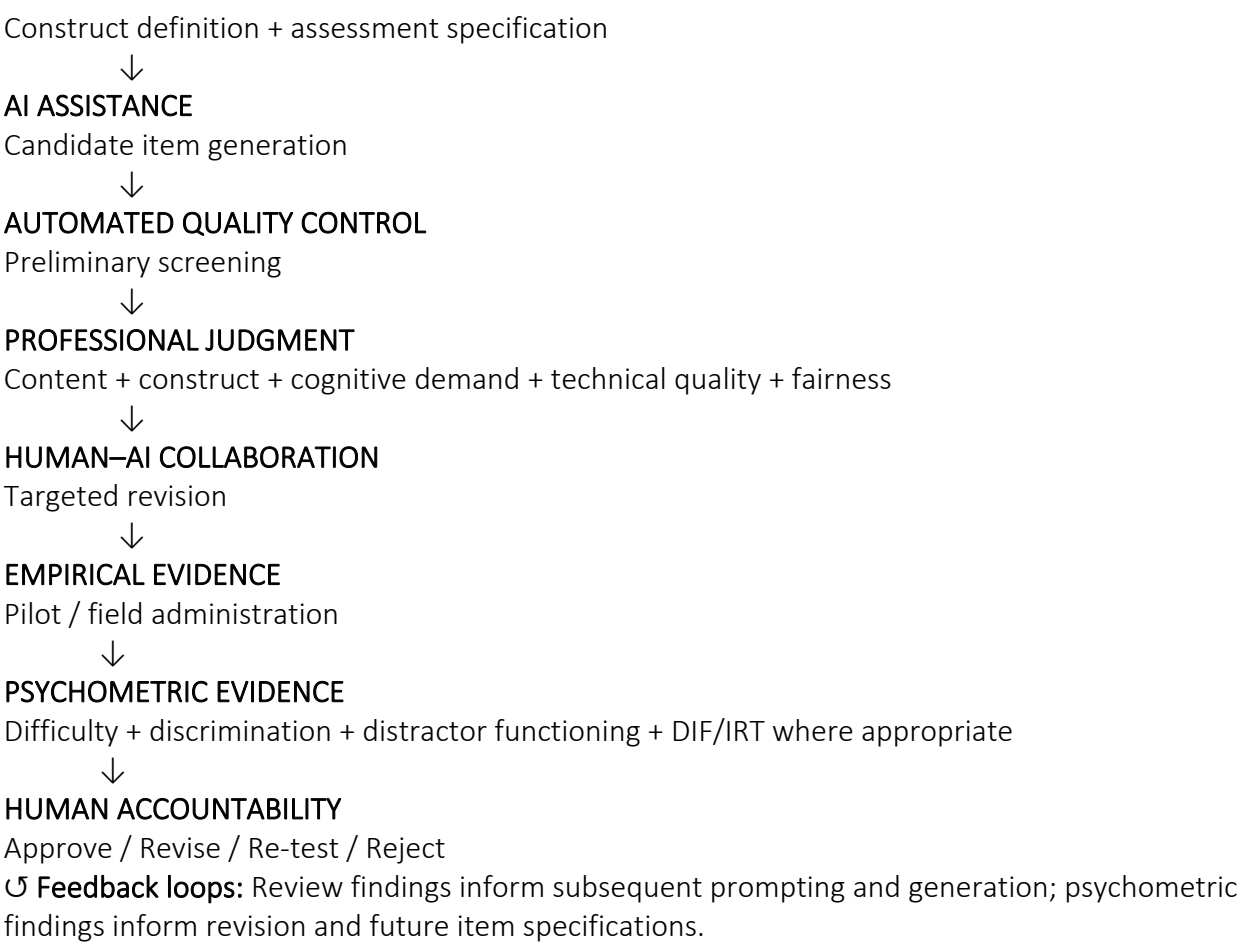


Table 2. Distribution of Responsibilities in AI-Assisted Item Development

Stage	Appropriate AI role	Human role	Principal basis for decision
Construct definition	Supporting	Leading	Theory and assessment purpose
Test specifications	Supporting	Leading	Assessment framework
Candidate generation	Leading	Directing	Specification
Preliminary screening	Leading/supporting	Monitoring	Defined quality rules
Content review	Supporting	Leading	Professional expertise
Construct/cognitive review	Supporting	Leading	Assessment expertise
Fairness review	Supporting	Leading	Contextual judgment
Revision	Collaborative	Collaborative	Review evidence
Field testing	Minimal	Designing/monitoring	Examinee responses
Psychometric evaluation	Computational support	Interpreting	Empirical evidence
Operational approval	Informing	Leading	Integrated validity evidence

The Importance of Assessment Stakes

The appropriate level of validation should depend partly on the consequences associated with the assessment.

This can be represented conceptually as:

Low-stakes formative use

↓

Classroom summative use

↓

Large-scale educational assessment

↓

High-stakes selection / admission / certification

As the consequences increase, stronger evidence is generally required.

For a teacher generating several practice questions, careful professional review may be proportionate to the intended use.

For a large-scale assessment program, requirements may include standardized review procedures, pilot testing, psychometric evaluation, security controls, fairness analyses, and documented decision rules.

For high-stakes assessment, AI-generated items should not receive a lower evidentiary standard simply because generation is efficient.

Indeed, efficiency may increase the need for governance. When very large volumes of content can be generated quickly, inadequate review processes can scale weaknesses just as rapidly as they scale useful content.

Recent professional guidance on responsible AI use in assessment also emphasizes transparency, accountability, fairness, competence, human oversight, and continuous improvement as important considerations when AI enters assessment processes.

The principle can therefore be expressed simply:

Higher consequences require stronger evidence and clearer accountability.

Changing Role of the Assessment Professional

Generative AI may alter the role of assessment professionals more substantially than it eliminates it.

Traditional item development places considerable emphasis on writing. In an AI-assisted environment, professional effort may shift toward:

- defining constructs;
- developing precise specifications;
- designing generation constraints;
- evaluating AI output;
- detecting construct-irrelevant features;
- conducting fairness review;
- interpreting psychometric evidence;
- monitoring model and workflow changes; and
- making accountable decisions.

The expertise required may therefore become more, rather than less, specialized.

A system capable of producing thousands of questions makes professional judgment about which questions should survive increasingly important.

This has implications for professional development. Future item developers may require not only traditional assessment literacy but also an understanding of prompt design, AI limitations, automated quality-control methods, data governance, and the interpretation of AI-assisted workflows.

At the same time, assessment organizations should avoid transferring professional accountability to a model.

An LLM can recommend.

It cannot assume institutional responsibility for a consequential assessment decision.

Discussion

The evidence reviewed in this paper suggests that the debate over AI-generated assessment items should move beyond two simplistic positions.

The first is that AI-generated items are inherently unreliable because they are machine-generated.

The second is that increasingly sophisticated models can independently replace conventional item-development processes.

Neither position adequately reflects current evidence.

LLMs can generate useful assessment content. Recent studies demonstrate promising results across educational and psychological domains, and some generated items have achieved acceptable expert ratings and empirical characteristics. Advances in prompting, fine-tuning, automated review, and multi-agent approaches are likely to improve these capabilities further.

However, technological performance does not eliminate fundamental principles of educational measurement.

Four conclusions emerge.

First, item quality is multidimensional. Content accuracy, construct alignment, cognitive demand, technical quality, fairness, and psychometric functioning should not be collapsed into a single judgment.

Second, AI evaluation and human evaluation provide different forms of information. Automated screening can improve efficiency, but expert judgment remains particularly important where interpretation, context, fairness, and construct representation are concerned.

Third, expert judgment and empirical evidence are also different. An expert can make a reasoned prediction about item functioning, but response data are needed to evaluate many psychometric claims.

Fourth, the appropriate evidence depends on intended use. The same validation process need not apply to a low-stakes practice item and a high-stakes selection item.

These conclusions support a change in the central research question.

Instead of asking:

Can AI write test questions?

research should increasingly ask:

Under what conditions can AI-assisted item-development systems produce assessment evidence that is sufficiently valid, fair, and reliable for a specified use?

This question places measurement rather than technology at the center of the discussion.

Directions for Future Research

Several research priorities follow from this analysis.

First, more studies should evaluate AI-generated items using actual examinee response data rather than expert ratings alone.

Second, research should investigate whether AI-generated items function comparably across demographic, linguistic, and cultural groups.

Third, greater attention is needed to higher-order cognitive tasks. Current evidence suggests that producing linguistically sophisticated content may be easier than reliably generating tasks that elicit specific complex reasoning processes.

Fourth, researchers should examine the stability of item-generation systems over time. Commercial and open-source LLMs change rapidly. An item-generation workflow validated using one model version may not behave identically after a model update.

Fifth, comparisons should move beyond simple “human versus AI” designs. In practice, future workflows are likely to be hybrid. Research should therefore compare different **human–AI configurations**, such as:

AI generation + human review;

AI generation + AI screening + human review;

AI generation + expert revision + empirical calibration;

and fully human conventional development.

Finally, efficiency should itself be investigated empirically. AI assistance has limited practical value if the amount of expert correction required approaches or exceeds the effort needed to develop an item conventionally.

The relevant question is therefore not simply whether AI can reduce item-writing time, but whether it can reduce the total resources required to produce validated operational content.

Conclusion

Generative artificial intelligence has substantially expanded the possibilities for automatic item generation. Large language models can produce candidate questions, distractors, scenarios, and item variations at a speed and scale that were previously difficult to achieve.

The evidence reviewed in this paper suggests that some AI-generated items can reach promising levels of quality and may demonstrate acceptable empirical characteristics. Nevertheless, generation quality should not be confused with measurement quality.

A defensible assessment item requires more than fluent language and a correct answer. It requires evidence concerning its content, relationship to the intended construct, cognitive demands, technical characteristics, fairness, and—where the intended use warrants it—its empirical functioning.

The central challenge is therefore shifting.

As the cost of generating candidate items decreases, the relative importance of evaluation, validation, and accountable decision-making increases.

The framework proposed in this paper differentiates among three essential components of AI-assisted item development:

AI assistance, professional judgment, and empirical evidence.

None should be treated as a complete substitute for the others.

AI can increase scale and efficiency. Human experts can provide substantive and contextual judgment. Examinee data can provide evidence about actual item functioning.

The future of assessment item development is therefore unlikely to be characterized by complete automation. A more plausible direction is a hybrid system in which AI expands the capacity of assessment professionals while established principles of validity, fairness, psychometric quality, and professional accountability continue to determine whether generated content is suitable for use.

Ultimately, the most important question is not how many items artificial intelligence can generate.

It is how much evidence is available to justify the decisions made with those items.

References

American Psychological Association, Committee on Psychological Tests and Assessment. (2026). *Responsible use of AI in assessment*. American Psychological Association.

Gorgun, G., & Bulut, O. (2025). Instruction-tuned large-language models for quality control in automatic item generation: A feasibility study. *Educational Measurement: Issues and Practice, 44*(1), 96–107. https://doi.org/10.1111/emip.12663

Kim, E., Li, S., Khalil, S., & Shin, H. J. (2025). STAIR-AIG: Optimizing the automated item generation process through human-AI collaboration for critical thinking assessment. In *Proceedings of the 20th Workshop on Innovative Use of NLP for Building Educational Applications*.

Kim, E., Shin, H. J., & von Davier, A. (2026). A validity argument framework for automated item generation systems. In *Proceedings of the Artificial Intelligence in Measurement and Education Conference (AIME-Con)* (pp. 506–515).

Lee, P., Son, M., & Jia, Z. (2026). AI-powered automatic item generation for psychological tests: A conceptual framework for an LLM-based multi-agent AIG system. *Journal of Business and Psychology, 41*, 71–99. https://doi.org/10.1007/s10869-025-10067-y

Sommer, M., & Arendasy, M. (2025). Automatic- and transformer-based automatic item generation: A critical review. *Journal of Intelligence, 13*(8), 102. https://doi.org/10.3390/jintelligence13080102

Tan, B., Armoush, N., Mazzullo, E., Bulut, O., & Gierl, M. (2025). A review of automatic item generation techniques leveraging large language models. *International Journal of Assessment Tools in Education, 12*(2), 317–340. https://doi.org/10.21449/ijate.1602294

THE IMPACT OF DIGITALIZATION ON LEARNING FOREIGN LANGUAGES

Askarova Sagira
Doctoral student, Karaganda University by Kazpotrebsouz, Kazakhstan, Karaganda
Aubakirova Gulbanu Tursunovna
Candidate of Philology, Associate Professor, Professor of KarUK, Kazakhstan, Karaganda

ABSTRACT

This article examines the impact of the digitalization process in modern society on the field of foreign language teaching. The author analyzes the possibilities of using digital technologies in the education system and their effectiveness. The impact of online platforms and mobile applications on the quality of teaching is described, as well as the role of students in developing language skills. By leveraging the advantages of digitalization in the educational process, it is possible to significantly improve the quality of teaching and at the same time reduce the time teachers spend developing new materials. Modern realities offer ever-new methods and aspects of using digital technologies in the learning process. Today, teachers must keep up with the times, constantly monitoring innovations in the field of information technology and applying them in practice. This way, it is possible to maintain students' interest in learning foreign languages. Digital materials can be used as an integral part of a traditional course, as well as a separate tool for learning using a computer.

Keywords: digitalization, foreign language, online education, teaching technology, mobile application, digital environment.

Currently, the concept of digitalization has penetrated into all spheres of society's life, becoming an important factor in social, economic and cultural development. The education system was also not left out of this process. The use of new technologies, especially in teaching foreign languages, plays a special role in improving the effectiveness of teaching. Today's student and student live in a digital environment, so it is not enough to limit yourself to traditional methods.

From this point of view, digital technologies and internet resources have brought the process of learning a language to a new qualitative level [1, c. 45].

The purpose of the article is to identify the impact of digitalization on the process of teaching foreign languages, analyze its advantages and emerging problems. This study is relevant because digitalization forms a new paradigm for teaching foreign languages.

Today, learning a foreign language is not limited to textbooks and classroom lessons. Students can take online courses via the internet, establish video communication with foreign partners, and independently learn the language through digital applications. Such opportunities allow students to develop their personal abilities and learn at a convenient pace. At the same time, digital secondary education increases the cultural competence of students and allows them to directly recognize the linguistic and cultural characteristics of other countries.

The main feature of digitalization is the expansion of access to education. If earlier it was necessary to attend special courses or a teacher to learn a foreign language, now anyone can easily access high-quality learning resources via the internet. This is a great advantage, especially for people in remote regions or with financial disabilities. In addition, the online education system

allows students to effectively plan their time and independently manage the learning process. However, the digitalization process also raises new requirements and challenges.

First of all, increasing the level of digital literacy of teachers is an urgent problem. It is necessary not just to use technology, but to apply it methodically effectively.

Secondly, if the motivation and discipline of students in the course of online learning decreases, the quality of education may also deteriorate. Therefore, the introduction of digitalization should not be limited to technical means, but should be justified both from a pedagogical and psychological point of view. The role of digital technologies in mastering a foreign language In the modern education system, the concept of digitalization has become the main tool for optimizing and modernizing the learning process. Information and communication technologies are of great importance in learning a foreign language. Thanks to the internet and mobile applications, students can learn the language anytime and anywhere. For example, platforms such as Duolingo, Memrise, Babbel teach the language in a playful way and increase the student's interest. These tools naturally shape the language environment and ensure the active participation of the learner. [3, c. 8-14].

Digital technologies make it possible to make the educational process interactive and individually oriented. Teachers can organize classes in an online format using platforms such as Zoom, Google Classroom, Kahoot. Such approaches allow the student to work with video and sound materials, develop speech and listening skills, as well as become more flexible in performing written tasks. Digitalization in this way removes space and time constraints, taking foreign language learning beyond the traditional classroom framework.

At the same time, the digital environment allows students to learn on their own. Each language learner will be able to choose the material that suits their level and draw up an individual curriculum. Such autonomy increases learning outcomes because the student is focused on a specific goal, working at their own pace. For example, online tests and automated verification systems can help identify the learner's weaknesses and adapt the curriculum accordingly. This method also allows the teacher to save time and pay individual attention to each student. Mobile language learning apps like Duolingo, Babbel, Memrise, and others have become an integral

part of language learning. These apps offer users the ability to learn a language anytime and anywhere, making the learning process more flexible and accessible. Mobile technology allows for the integration of learning into everyday life, which is especially important for those who don't have the time to set aside time for study. Many apps incorporate game elements, making the learning process more engaging and motivating.For example, users can earn points, complete levels, and receive rewards for achievements, helping to maintain learning interest [4, c. 145].

Another challenge is the need for a high degree of Self-organization and motivation on the part of students. In an online learning environment, students often face distractions such as social media, television, or homework, which can reduce the effectiveness of their studies. Furthermore, the lack of a strict schedule can

lead to procrastination, when students put off studying for later. For successful language acquisition, it is important to have a clear plan and stick to it, which can be difficult without external supervision [5, c. 267]. Furthermore, not all online courses and apps offer the same quality of instruction. There are numerous resources on the market, and not all of them are developed by qualified professionals. Learners need to be mindful and critical when choosing courses to avoid ineffective learning methods. It's recommended to read reviews from other users, as well as check the instructors' qualifications and course content before beginning a course. Nevertheless, despite these shortcomings, online courses and apps continue to gain popularity and develop. Many incorporate new technologies, such as virtual reality and augmented reality, opening up new possibilities for language learning. For example, with virtual

reality, learners can immerse themselves in a language environment, interact with native speakers, and practice their skills in realistic situations. This can significantly increase engagement and motivation, as well as improve learning [6, c. 256].

Virtual whiteboards, such as Miro, Scribblar, Jamboard, and others, can be successfully used in remote classes. They can be used for a wide variety of tasks: collaboratively completing exercises and seeing each other's actions, using an arrow to point out areas worth paying attention to, making notes, adding stickers, and drawing. Many whiteboards allow you to attach links, videos, images, and timers. These can be saved as images and reused, which is not possible with a traditional school board. Thus, a virtual whiteboard is essentially similar to a familiar physical whiteboard, but it also opens up a range of additional capabilities, each platform having its own [7, c. 32].

However, there are also some difficulties with digitalization. First of all, the quality of technical means and the stability of the internet network affect the educational process. Secondly, online learning will not be effective if students have low motivation to learn on their own. Also, insufficient digital literacy of teachers sometimes interferes with the full use of new technologies. Therefore, the provision of special training and methodological support for teachers in the digital education system is considered important.

In general, digitalization increases the effectiveness of teaching a foreign language and enhances the cognitive activity of students. It not only increases the availability of language learning, but also offers new forms of learning. In the future, the development of artificial intelligence and virtual reality technologies will further improve this process, making language learning as natural and productive as possible [8, c. 432].

In addition, one of the advantages of digitalization is the individualization and adaptability of learning. Since each student has different levels of language learning, interests and needs, digital tools allow you to take these differences into account. Interactive platforms automatically analyze the student's results and offer an individual learning route based on his weaknesses and strengths. This method adapts the learning process to the individual abilities of the student and increases learning motivation.

In recent years, artificial intelligence and machine learning systems have made a breakthrough in teaching a foreign language. For example, voice recognition programs for improving speech skills, automatic grammatical error correction systems and artificial sentence-forming partners are being widely introduced.

These tools allow the learner to use language in real life situations. Therefore, the main achievement of digitalization is the creation of conditions for mastering the language not only at the theoretical level, but also

from a practical point of view [9, c. 254].

Conclusion

Digitalization has radically changed the process of teaching foreign languages. Today, digital tools and online platforms are becoming an integral part of language learning. With their help, the learning process has become flexible, individually oriented and interactive. However, in order for the digital education system to be fully effective, it is necessary to increase the technological competence of teachers, provide a high quality internet and technical base.

In conclusion, digitalization has renewed the culture of learning a foreign language and made it the main direction of the modern educational process. With the effective use of digital technologies, everyone can

develop their potential and become an active participant in global communications.

In addition, digitalization has strengthened the democratic nature of teaching. Now education is available not only in a particular educational institution, but also anywhere in the world. This increased international cooperation and allowed language learners to get acquainted

with the culture and thinking of different countries. Such experience not only improves language skills, but also forms a culture of intercultural communication.

However, the success of digitalization depends not only on technology, but also on pedagogical skills. In addition to using new technologies, teachers also need to maintain the cognitive activity of students and maintain a balance between man and machine. While the learning process relies solely on technical means, the spiritual and cultural aspects of language learning can be overlooked. Therefore, the goal of digitalization is not to replace the teacher, but to become an assistant to him.

In the future, artificial intelligence, virtual and augmented reality technologies are expected to be widely used in the field of Language Teaching. Such innovations make it possible to make the language environment more natural and realistic. For example, a student can communicate with representatives of another country in a virtual environment and develop their language skills in real communication. These technologies globalize education and make language learning more interesting and productive than ever before.

In conclusion, digitalization was the beginning of a new era in teaching a foreign language. It supplemented traditional methods, combined with modern technologies, formed an effective and affordable training system. Mastering a foreign language through digital technologies not only develops linguistic abilities, but also improves the life skills necessary for a person of the XXI century – the ability to independently study, analyze information and develop intercultural communication.

References:

1. Назарбаев Н. Ә. «Цифрлық Қазақстан» мемлекеттік бағдарламасы. – Астана: ҚР Үкіметі, 2018.42 – 45с.

2. Warschauer, M. The Internet and Language Learning // TESOL Quarterly. – 2000. – Vol. 34, №2. – P. 211–230 с.

3. Godwin-Jones, R. Language Learning and Digital Literacy // Language Learning & Technology. – 2015. – Vol. 19,№3. – P. 8–14с.

4. Алшынбай, А. Білім беруді цифрландырудың заманауи бағыттары. – Алматы: Қазақ университеті, 2022. –145 с.

5. Beatty, K. Teaching and Researching Computer-Assisted Language Learning. – London: Pearson Education, 2010. –267 p.

6. Kukulska-Hulme, A. Mobile-Assisted Language Learning: A Handbook for Educators and Learners. – London:

Routledge, 2012. – 256 p.Журнал «Интернаука» № 39 (403), 2025 г.

7. Stockwell, G.; Hubbard, P. Some Emerging Principles for Mobile-Assisted Language Learning. – Monterey, CA:The International Research Foundation for English Language Education (TIRF), 2013. – 32 p.

8. Thomas, M.; Reinders, H.; Sykes, J.M. (eds.) Digital Language Learning and Teaching: Critical and Primary

Sources. – London: Bloomsbury Academic, 2017. – 432 p.

9. Morgana, V.; Kukulska-Hulme, A. (eds.) Mobile Assisted Language Learning Across Educational Contexts. – New York: Routledge, 2021. – 254 p.

Студенттердің суицидтік мінез-құлқының қорғаныш факторы ретіндегі психологиялық төзімділік (Қазақстан Республикасының 2023–2025 жж. статистикасы негізінде)

Турдашова Меруерт Маратовна
І.Жансүгіров атындағы Жетісу университеті, 7М01101 Педагогика және психология
Ғылыми жетекші:
Альмухамбетова Бибигуль Жексембаевна
PhD., І.Жансүгіров атындағы Жетісу университеті, 7М01101 Педагогика және психология

Аңдатпа. Мақалада студент жастар арасындағы суицидтік мінез-құлықтың алдын алудағы психологиялық төзімділіктің (resilience) қорғаныш рөлі талданады. Қазақстан Республикасы Бас прокуратурасының Құқықтық статистика және арнайы есепке алу жөніндегі комитетінің 2023–2025 жылдардағы деректері мен халықаралық эпидемиологиялық зерттеулер негізінде қауіп-қатер факторларын іздеуге бағытталған дәстүрлі тәсілден ішкі қорғаныш ресурстарын дамытуға негізделген модельге көшу қажеттігі дәлелденеді. Төзімділіктің екі өзекті құрамдас бөлігі — эмоцияны реттеу және оқу орнымен байланыстылық — егжей-тегжейлі қарастырылады. Қорытындыда эдвайзерлерді «қақпашы» (gatekeeper) ретінде даярлау, тең-теңімен (peer-to-peer) қолдау жүйесі, психоағарту модульдері және университеттің психологиялық қызметінің жұмыс алгоритмі ұсынылады.

Түйін сөздер: психологиялық төзімділік, суицидтік мінез-құлық, студенттер, эмоцияны реттеу, байланыстылық, gatekeeper, peer-to-peer, Қазақстан.

1. Кіріспе

1.1. Суицид — жаһандық қоғамдық денсаулық мәселесі

Суицид бүгінде жекелеген трагедиялардың жиынтығы ғана емес, жүйелі түрде қарастырылуы тиіс қоғамдық денсаулық мәселесі. Дүниежүзілік денсаулық сақтау ұйымының (ДДҰ) «Suicide worldwide in 2021» баяндамасына сәйкес, 2021 жылы әлемде шамамен 727 мың адам суицидтен қайтыс болды (2019 жылы — 703 мың). Дәл осы құжатта суицид 15–29 жас аралығындағы жастар өлімінің үшінші жетекші себебі ретінде көрсетілген: ол әйелдер арасында екінші, ерлер арасында үшінші орында тұр (WHO, 2025a). Жас құрамына стандартталған көрсеткіш 2019 жылғы 9,0-ден 2021 жылы 8,9-ға (100 мың тұрғынға шаққанда) аздап төмендегенімен, суицидтердің 73%-ы психикалық денсаулық қызметтерінің қолжетімділігі шектеулі төмен және орта табысты елдерде тіркеледі (WHO, 2025a; IASP, 2025). ДДҰ-ның кейінгі шолуы бойынша, әрбір қайтыс болған жағдайға шамамен 20 суицидтік әрекет сәйкес келеді; 2000–2021 жылдар аралығындағы 35%-дық төмендеуге қарамастан, 2015–2030 жылдарға арналған үштен бір бөлікке қысқарту мақсаты қазіргі қарқында орындалмайды — болжам бойынша тек шамамен 12%-дық төмендеу күтіледі (WHO, 2025b).

Университет жасы — өмірлік траектория ең қарқынды өзгеретін кезең. Зерттеушілер (Arnett, 2000) 18–29 жасты жеке басты іздеу, тұрақсыздық, өзіне бағытталу және «әлі бала да, әлі ересек те емеспін» деген аралық сезімімен сипатталатын «қалыптасып келе жатқан ересектік» кезеңі деп атайды. Студенттер арасындағы суицидтік ойлар мен мінез-құлықтың таралуы туралы мета-талдауда (Mortier et al., 2018a) өмір бойы суицидтік ойлардың, жоспарлар мен әрекеттердің жиынтық таралуы сәйкесінше 22,3%, 6,1% және 3,2% болса, соңғы 12 айда — 10,6%, 3,0% және 1,2% болған. ДДҰ-ның Дүниежүзілік психикалық денсаулық сауалнамасының студенттік жобасында (WMH-ICS) бірінші курс студенттерінің 17,2%-ында соңғы 12 айда суицидтік ойлар, 8,8%-ында жоспар, 1,0%-ында әрекет тіркелген (Mortier et al., 2018b). Авторлар университетке түсуді суицидтік қаупі бар жастарды анықтаудың «ұстап алу нүктесі» (point of capture) деп атайды. Бұл — алдын алу жұмысының тірек нүктесі оқу орнының өзі болуы тиіс деген қорытындыға негіз береді.

1.2. Қазақстан Республикасындағы жастардың психикалық саулығы

Қазақстандағы жағдай бірнеше деректер қабатында көрінеді. ҚР Бас прокуратурасының Құқықтық статистика және арнайы есепке алу жөніндегі комитетінің (бұдан әрі — ҚСАЕК) деректері бойынша 2022 жылы елде 3 676 аяқталған суицид тіркелген (Inbusiness.kz, 2023); өткен жылдары жыл сайын шамамен 3,5–4 мың жағдай тіркеліп отырған. 2025 жылы аяқталған суицидтер саны шамамен 3,2 мыңға дейін, яғни алдыңғы жылмен салыстырғанда 5,7%-ға (193 адамға) азайған — бұл соңғы жылдардағы ең төмен көрсеткіш; суицидтік әрекеттер саны 4 мыңнан 3 мыңнан сәл астамға, яғни 24,9%-ға қысқарған (Ranking.kz, 2026). Бұл оң үрдіс, алайда екі себептен абайлап түсіндіруді қажет етеді. Біріншіден, 2025 жылы кәмелетке толмағандар арасындағы аяқталған суицидтер 13,7%-ға өсіп, 199 жағдайға жеткен (олардың 64-і — 5–14 жастағы балалар), яғни 2023 жылдың деңгейіне қайта оралған (Ranking.kz, 2026). Екіншіден, ресми деректер әкімшілік (құқық қорғау) тіркеуіне негізделген және себептер көп жағдайда анықталмай қалады: кәмелетке толмағандардың аяқталған суицидтерінің 75,4%-ында (199-дың 150-інде) себеп белгіленбеген (Ranking.kz, 2026).

Зерттеуде 14–35 жас аралығындағы жастар қарастырылады, бірақ ашық статистика бұл топты біртұтас жиынтық ретінде жарияламайды: 14–17 жас кәмелетке толмағандар деректерінде, ал 18–29 жас ҚСАЕК-тің жас топтарында көрсетіледі. Мысалы, 2022 жылғы деректерде 18–29 жастағылардың үлесі аяқталған суицидтердің 17,3%-ын, суицидтік әрекеттердің 18,8%-ын құраған, ал ең осал топ 30–54 жастағылар болған (54,9%) (Forbes.kz, 2023). Бұл — студенттік жас тобына арналған жеке есептіліктің жоқтығын, демек, оқу орындарының өз ішкі мониторингін жүргізуі қажеттігін көрсететін әдіснамалық олқылық.

Психикалық денсаулық қызметтеріне жүктеме де артып отыр: Kapital.kz басылымы Республикалық ғылыми-практикалық психикалық денсаулық орталығының деректеріне сілтеме жасап, 2023 жылы динамикалық бақылауда тұрған психикалық және мінез-құлық бұзылыстары бар адамдар саны 198,4 мыңнан асқанын хабарлаған (Kapital.kz, 2024). Қазақстан қоғамдық даму институтының сауалнамасында респонденттердің 13,8%-ы жақындары немесе таныстары арасында балалар мен жасөспірімдер суицидінің болғанын айтқан; себеп ретінде физикалық және моральдық зорлық-зомбылық (30%), ата-ананың түсіністігі мен қолдауының жетіспеуі (29,2%), достардың немқұрайлылығы (28,3%) аталған (Caravan.kz, 2024). Бұл тізімнің негізгі ерекшелігі — аталған факторлардың басым бөлігі қарым-қатынас пен байланыстылыққа қатысты. 2023 жылы қабылданған 2023–2025 жылдарға арналған Балаларды зорлық-зомбылықтан қорғау, суицидтің алдын алу және олардың құқықтары мен әл-ауқатын қамтамасыз ету жөніндегі кешенді жоспар өңірлерде психологиялық қолдау орталықтарын ашуға жол ашты; алайда талдаушылар шаралар әзірше қысқа мерзімді әсер бергенін атап өтеді (Ranking.kz, 2026). Жоспар ең алдымен балаларға

бағытталғандықтан, 18 жастан асқан студенттер үшін тұрақты институционалдық қорғаныс тетігі әлі қалыптаспаған.

1.3. Университет кезеңіндегі транзиттік стресстер

Транзиттік стресс — бір әлеуметтік рөлден екіншісіне өту кезінде бұрынғы үйреншікті қолдау жүйесі әлсіреп, жаңасы әлі қалыптаспаған кезде туындайтын жүктеме. Лазарус пен Фолкманның трансакциялық моделі бойынша стресс объективті талаптардың өзімен емес, тұлға оларды өз ресурстарынан асып түседі деп бағалағанда пайда болады (Lazarus & Folkman, 1984). Студенттік өмірде мұндай жағдай бірнеше бағытта қатар қалыптасады.

Оқу жүктемесінің артуы. Орта мектептегі құрылымдалған, бақыланатын оқудан кредиттік технологияға көшу жоғары дербестікті талап етеді: уақытты өз бетінше жоспарлау, көлемді материалды игеру, сессия мерзімдері, грант сақтау үшін GPA межесі. Көптеген студент үшін академиялық сәтсіздік жай қиындық емес, «болашақтың күйреуі» ретінде қабылданады.

Ата-анадан жырақ кету. Ауылдан немесе шағын қаладан Астана, Алматы, Шымкент сияқты ірі қалаларға көшкен студент үшін отбасы — эмоциялық қолдаудың негізгі көзі — физикалық түрде алыстайды. Жатақханалық өмір шектеулі жеке кеңістікпен, ұйқы режимінің бұзылуымен және ұқсас жүктемедегі құрдастармен үнемі салыстырумен қатар жүреді.

Жаңа әлеуметтік ортаға бейімделу. Тіл ортасының, мәдени кодтардың, әлеуметтік-экономикалық деңгейдің өзгеруі «мен бөтенмін» сезімін тудыруы мүмкін. Әлеуметтік желі жағдайды ауырлатады: өзгенің «сәтті» бейнесі мен өз күйің арасындағы алшақтық қорлануға итермелейді.

Қаржылық қиындықтар. Жатақхана, жалдау ақысы, көлік, оқу төлемі, қосымша табыс іздеу оқуға жұмсалатын уақыт пен күшті азайтады. Қаржылық қысым студентті «отбасына жүк болдым» деген ойға жетелейді — мұның Джойнердің интерперсоналдық теориясындағы «ауыртпалық сезімімен» тікелей байланысы бар.

Болашақ кәсіби белгісіздік. Мамандықты таңдаудың дұрыстығына күмән, еңбек нарығындағы бәсеке, жұмысқа орналасу мүмкіндігіне сенімсіздік 3–4 курстарда айрықша өткірленеді.

Бұл стресстер бейімделу механизмдерін бірнеше деңгейде бұзады. Біріншіден, созылмалы жүктеме мен ұйқы тапшылығы аллостатикалық жүктемені (McEwen, 1998) арттырып, префронтальды қыртыстың атқарушы қызметтерін — жоспарлау, импульсті тежеу, икемді ойлау — әлсіретеді (Arnsten, 2009). Екіншіден, Хобфоллдың ресурстарды сақтау теориясына сәйкес (Hobfoll, 1989) ресурстардың жоғалуы жаңа жоғалтуларға әкелетін «шығын спиралін» іске қосады: нашар ұйқы — нашар оқу — қарыз — оқшаулану. Үшіншіден, қолдау желісінің үзілуі стрессті бәсеңдететін әлеуметтік буферді жояды. Төртіншіден, ұят пен стигма студентті проблеманы жасыруға итермелейді, нәтижесінде көмекке жүгіну кешігеді. Сонымен, қауіп жекелеген стресс-фактордың өзінде емес, олардың бірігіп, қорғаныш ресурстарынан асып түсуінде. Дәл осы тұжырым мақаланың келесі бөлімдерінде талданатын төзімділік тәсілінің логикалық негізі болып табылады.

2. Теориялық негіздеме

2.1. Дәстүрлі және заманауи тәсілдер: қауіп-қатер факторларынан қорғаныш ресурстарына

Суицидологияда ұзақ уақыт басым болған дәстүрлі тәсіл қауіп-қатер факторларын — психикалық бұзылыстарды, бұрынғы суицидтік әрекетті, психоактивті заттарды қолдануды, әлеуметтік оқшауланууды — анықтап, тәуекелі жоғары адамдарды іріктеуге бағытталды. Бұл бағыттың теориялық құны жоғары. Дюркгейм суицидті әлеуметтік интеграция мен реттеудің бұзылуымен байланыстырды (Durkheim, 1897/1951); Шнейдман суицидтік дағдарыстың өзегі ретінде төзгісіз психикалық азапты (psychache) көрсетті (Shneidman, 1993); Баумейстер суицидті өзін-өзі қабылдаудың төзгісіз күйінен «қашу» деп сипаттады (Baumeister, 1990).

Жойнердің интерперсоналдық теориясына сәйкес суицидтік ниет «тиесілі болмау» (thwarted belongingness) және «ауыртпалық болу» (perceived burdensomeness) сезімдері тоғысқанда туындайды, ал әрекетке көшу үшін өлім қорқынышын жеңу қабілеті қажет (Joiner, 2005). O'Коннордың интеграцияланған мотивациялық-еріктік моделі ниет пен іс-әрекет арасындағы өтпелі кезеңді бөлек қарастырып, импульсивтілік пен өлімге әкелетін құралдарға қолжетімділіктің рөлін атап көрсетеді (O'Connor & Kirtley, 2018).

Алайда тәуекел факторларына негізделген болжамның практикалық шегі бар. Елу жылдық зерттеулерді қамтыған мета-талдау жеке тәуекел факторларының болжау күші кездейсоқтыққа жақын екенін көрсетті (Franklin et al., 2017). Жүйелі шолулар (Mann et al., 2005; Zalsman et al., 2016) тиімді алдын алу стратегияларының — өлімге әкелетін құралдарға қолжетімділікті шектеу, мектептік және қауымдастықтық бағдарламалар, дәрігерлер мен «қақпашыларды» оқыту — тек жеке тәуекелді анықтаумен шектелмей, ортаны да, дағдыларды да өзгертетінін көрсетеді. Студенттік ортада тәуекел факторларының көпшілігі (стресс, ұйқының бұзылуы, қаржылық қиындық) жаппай кездеседі, сондықтан тек скринингке сүйену жалған оң нәтижелерді көбейтіп, стигманы күшейтуі мүмкін.

Заманауи академиялық тәсіл тәуекел мен қорғаныс факторларын бір үдерістің екі жағы ретінде қарастырады. Қорғаныш ресурстары — эмоцияны реттеу дағдылары, байланыстылық, мағына мен болашаққа деген үміт — стресстің суицидтік дағдарысқа айналуын тежейтін буфер қызметін атқарады. Сонымен қатар бұл тәсіл барлық студентке бағытталған әмбебап профилактиканы (психоағарту) және тәуекелі жоғарыларға арналған нақты көмекті ұштастырады. Сұрақ «кімде қауіп жоғары?» деген тар шеңберден «студентке стресспен күресуге не көмектеседі және университет оған қандай ресурс бере алады?» деген кең мәселеге ауысады. Төзімділік тұжырымдамасы дәл осы ауысудың теориялық негізін қамтамасыз етеді.

2.2. Психологиялық төзімділік: ұғымға ғылыми шолу

Resilience ұғымы қиын жағдайларға қарамастан сау дамыған балаларды зерттеуден туындады. Раттер оны тұлғаның тұрақты қасиеті емес, тәуекелге тап болғанда әрекет ететін қорғаныш механизмдерінің жиынтығы деп түсіндірді (Rutter, 1987). Мастен төзімділікті «қарапайым ғажайып» (ordinary magic) деп атап, ол ерекше таланттан емес, қамқор қарым-қатынастар, танымдық дағдылар, өзін-өзі реттеу және мотивация сияқты әдеттегі бейімделу жүйелерінен өсетінін көрсетті (Masten, 2001). Лутар мен әріптестері төзімділікті тұлғаның сипаттамасы емес, тәуекел де, оң бейімделу де анық айқындалуы тиіс динамикалық үдеріс деп қарастыруды ұсынды (Luthar et al., 2000). Бонанно жоғалту мен травмадан кейінгі траекториялардың (төзімділік, қалпына келу, созылмалы бұзылу) әртүрлілігін дәлелдеп, төзімділік траекториясының ең жиі кездесетінін атап өтті (Bonanno, 2004). Саутвик пен әріптестері төзімділікті биологиялық, психологиялық, әлеуметтік және мәдени деңгейлердегі факторлардың өзара әрекетіне байланысты уақыт өте өзгеретін үдеріс ретінде анықтады (Southwick et al., 2014). Коннор мен Дэвидсонның CD-RISC шкаласы бұл құрылымды өлшеудің кеңінен қолданылатын құралына айналды (Connor & Davidson, 2003).

Төзімділікті динамикалық психоәлеуметтік қабілет ретінде түсінуге үш қасиет негіз болады. Біріншіден, ол дамиды және өзгереді: бүгінгі төзімді студент жаңа стрессордың алдында осал болып қалуы мүмкін. Екіншіден, ол контекстке тәуелді және қарым-қатынаста өмір сүреді: Унгар төзімділікті индивидтің өз ортасындағы ресурстарға қол жеткізе алуы және оларды өз мәдени мағынасында пайдалана білуі деп түсіндіреді (Ungar, 2008). Қазақстан жағдайында бұл отбасылық-туыстық байланыстың, өзара көмектің, үлкенге құрмет дәстүрінің ресурстық әлеуетін де, сонымен бірге отбасындағы жанжалдың (кәмелетке толмағандар суицидінің 62%-ында негізгі фон — Ranking.kz, 2026) және «басқалар не дейді» қысымының тәуекел әлеуетін де қатар қарауды талап етеді. Үшіншіден, ол жаттықтырылады: эмоцияны реттеу

дағдылары, әлеуметтік байланыстар мен көмек сұрау мәдениеті мақсатты бағдарламалар арқылы дамиды. Дегенмен төзімділікті «жеке адамның өз міндеті» деп түсіну қауіпті: бұл жағдайда институционалдық жауапкершілік көлеңкеде қалады. Сондықтан төзімділікті дамыту университет ортасын өзгертумен қатар жүруі тиіс.

3. Статистикалық талдау және гендерлік ерекшеліктер

3.1. 2023–2025 жылдардағы ҚСАЕК деректерінің динамикасы

Төменде келтірілген деректер ашық дереккөздерде жарияланған ҚСАЕК көрсеткіштері мен оларға сүйенген талдамалық жарияланымдарға негізделген. Студенттер бөлек санатқа бөлінбейді, сондықтан жалпы халық пен жас топтарының деректері студенттік жасқа экстраполяция ретінде қарастырылады — бұл әдіснамалық шектеу.

- 2023 жыл. Қаңтар–қазан кезеңінде аяқталған суицидтердің жалпы саны 3,4%-ға өскен. Кәмелетке толмағандар арасында 169 аяқталған суицид (шамамен 30%-ға өсім; 27,8%-ы — 5–14 жас, 72,2%-ы — 15–17 жас) және 298 әрекет (+17,8%) тіркелген; кәмелетке толмағандардың 97%-ы соңғы сәтте байсалды күйде болған (Kt.kz, 2023; Forbes.kz, 2023b).
- 2024 жыл. Қаңтар–шілдеде аяқталған суицидтер шамамен 2,1–2,2 мың болып, алдыңғы жылдың сәйкес кезеңінен 7,2%-ға аз болды; ерлерде 1,7 мың (−4,8%), әйелдерде 458 (−12,3%). Кәмелетке толған ерлердің үлесі 74,9%, ал жағдайлардың 78,3%-ында алкогольдік немесе есірткілік мас күйі болмаған (Azattyq Rýhy, 2024; Inbusiness.kz, 2024). Жыл қорытындысында кәмелетке толмағандар арасындағы аяқталған суицидтер 14,2%-ға азайған (Ranking.kz, 2026).
- 2025 жыл. Аяқталған суицидтер шамамен 3,2 мың (−5,7%), әрекеттер 3 мыңнан сәл астам (−24,9%); 2020 жылдан бергі жалпы азаю — 9,1%. Бірақ кәмелетке толмағандар арасындағы аяқталған суицидтер 13,7%-ға өсіп, 199-ға жетті, ал әрекеттер 405 болды. Аяқталған суицидтер мен әрекеттердің абсолюттік саны бойынша Шығыс Қазақстан (619), Түркістан (493) және Алматы (488) облыстары алда; Астанада 449, Алматыда 419 жағдай тіркелген (Ranking.kz, 2026).
- «Өзіне-өзі қол жұмсауға дейін жеткізу» бабы (ҚК, 105-бап). Тіркелген қылмыстар 494-тен 391-ге (−20,9%) азайғанымен, қаза тапқандар саны 148-ден 187-ге (+26,4%) өсті, ал қаза тапқан кәмелетке толмағандар 18-ден 32-ге жетті (Ranking.kz, 2026).

Бұл деректерден үш қорытынды шығады. Біріншіден, ересек популяциядағы біртіндеп төмендеу кәмелетке толмағандар арасында тұрақты үрдіске айналмаған: 2023 жылғы өсім 2024 жылы төмендеумен, 2025 жылы қайта өсіммен ауысты. Ranking.kz талдауы Кешенді жоспар шараларының әзірше қысқа мерзімді әсер бергенін атап көрсетеді; бұл ішкі қорғаныш ресурстарын жүйелі қалыптастырудың орнын ештеңе алмастырмайтынын білдіреді. Екіншіден, тіркеу көрсеткіштері мен нақты зардап арасындағы алшақтық («дейін жеткізу» бабындағы қайшылық) әкімшілік статистикаға абайлап қарауды талап етеді. Үшіншіден, себептердің көпшілігі анықталмай қалады: кәмелетке толмағандардың аяқталған суицидтерінің 75,4%-ында себеп белгіленбеген, ал 2025 жылғы сегіз айдағы 122 жағдайдың 44-інде балаларды құтқаруға болатыны, бірақ сапалы сүйемелдеудің болмағаны атап өтілген (Ranking.kz, 2026). Бұл — ұйымдасқан алдын алу жүйесінің (эдвайзер, психолог, қарым-қатынас желісі) практикалық мәнін көрсететін дәлел.

3.2. Гендерлік парадокс: ерлердегі аяқталған суицид пен әйелдердегі әрекет

Суицидтегі гендерлік парадокс — ерлерде аяқталған суицидтің, әйелдерде суицидтік әрекеттің жиірек болуы — Канетто мен Сакиновский сипаттаған құбылыс (Canetto & Sakinofsky, 1998). Жаһандық деңгейде 2021 жылы ерлерде көрсеткіш 100 мың тұрғынға шаққанда 12,3, әйелдерде 5,6 болды, ал жоғары табысты елдерде арақатынас 3,2:1-ге дейін жетеді (IASP, 2025). Қазақстанда 2022 жылы аяқталған суицидтердің 78,9%-ын ерлер

(шамамен 2,9 мың), қалғанын әйелдер (770) құраған (Forbes.kz, 2023a); 2024 жылдың қаңтар–шілдесінде кәмелетке толған ерлердің үлесі 74,9% болды. Бұл бастапқы мақаладағы тұжырыммен — ерлер барлық жағдайдың шамамен 80%-ын құрайды — сәйкес келеді.

Қазақстандық деректердің ерекшелігі — ерлер тіркелген әрекеттердің де көпшілігін құрайды: 2022 жылы 2 383 ер адам мен 1 339 әйел (Inbusiness.kz, 2023). Біздің шамамен есебімізше (тіркелген әрекеттердің толық еместігін ескере отырып), аяқталған суицидтер мен тіркелген әрекеттердің қатынасы ерлерде ≈1,2, әйелдерде ≈0,6 болады. Яғни «парадокс» Қазақстанда әрекет жиілігінен гөрі зардаптың өлімге әкелу деңгейінде көрінеді.

Бұл айырмашылықты түсіндіретін психологиялық және әлеуметтік механизмдер бірнешеу. Біріншіден, мәдени «сценарийлер»: ер адамның суицидтік әрекеті «шешімді» әрекет, әйелдікі көмек іздеу ретінде қабылданатындықтан, ниеттің қатаңдығы мен әдіс таңдауы да осы күтулерге бейімделеді (Canetto & Sakinofsky, 1998). Екіншіден, ер адамдарда депрессия жиі жасырын түрде — ашушаңдық, агрессия, алкоголь, тәуекелге бару арқылы — көрініп, диагноз қойылмай қалады (Möller-Leimkühler, 2003). Үшіншіден, әлеуметтік рөл: «отбасының тірегі» болу күтуі, жұмыссыздық пен қарыз ер адамның өзін-өзі бағалауына тікелей әсер етеді; қазақстандық мәдени күтулер туралы бұл тұжырым гипотеза болып қала береді және арнайы зерттеуді қажет етеді. Төртіншіден, әйелдерде көмекке жүгіну жиірек және әлеуметтік желі кеңірек, бұл өлімге әкелетін нәтиже ықтималдығын төмендетуі мүмкін. Дегенмен әйелдер мен қыздардың әрекеттерін «көрсетпелі» деп жеңілдетіп бағалауға болмайды: ресми деректер нақты өлім ниеті бар әрекетті назар аудартуға бағытталған әрекеттен ажыратпайды (Ranking.kz, 2026), ал бұрынғы әрекет кейінгі суицидтің маңызды болжаушыларының бірі болып қала береді (Hawton et al., 2012). 2025 жылы қыздардың 126 әрекетінің 94-інде алдында отбасылық жанжал тіркелген (Ranking.kz, 2026) — бұл қарым-қатынастың үзілуі әйел жас үшін де сыни қауіп екенін көрсетеді.

3.3. Ер адамдардың көмек сұрауға кедергі келтіретін гендерлік стигмасы және импульсивті әрекет ықтималдығы

Көмек сұрауға кедергі келтіретін гендерлік стигма — ерлердегі аяқталған суицид көрсеткішінің жоғары болуының негізгі түсіндірмелерінің бірі. Эддис пен Махалик көмек сұрау мінез-құлқы ер адамға тән деп саналатын нормалармен — автономия, эмоцияны бақылау, төзімділікті көрсету — қақтығысқанда тежелетінін, ал көмек сұрау әлсіздік пен мәртебені жоғалту белгісі ретінде қабылданатынын көрсетті (Addis & Mahalik, 2003). Корриган көпшілік алдындағы стигма өзін-өзі стигматизацияға ұласып, адамды «таңба жабыстырылудан» қорғану үшін көмектен бас тартуға итермелейтінін сипаттады (Corrigan, 2004). Студенттерде де көмек іздеу мен ем алу деңгейі қажеттіліктен әлдеқайда төмен (Eisenberg et al., 2007). Қазақстанда «ер адам ішіндегісін сыртқа шығармайды» дегенге ұқсас мәдени қалыптар кең таралған деп болжауға болады, бірақ бұл болжам эмпирикалық тексеруді қажет етеді. Нәтижесінде ер студент жағдайын соңғы сәтке дейін жасырып, дағдарысқа жалғыз кіреді.

Импульсивті әрекет ықтималдығы осы жасырындықпен тығыз байланысты. Суицидтік үдерістегі «шешім мен әрекет» арасындағы кезең көп жағдайда өте қысқа: зерттеулерде жағдайлардың едәуір бөлігінде ол бір сағаттан аз болған (Deisenhammer et al., 2009). Қазақстандық деректер мұны алкогольмен ғана түсіндіруге болмайтынын көрсетеді: 2024 жылғы қаңтар–шілдеде аяқталған суицидтердің 78,3%-ы, ал 2023 жылы кәмелетке толмағандардың 97%-ы байсалды күйде болған. Демек, шешуші рөлді жедел эмоциялық дағдарыстағы реттеудің құлдырауы атқарады: күшті стресс префронтальды қыртыстың жоспарлау мен тежеу қызметін әлсіретеді (Arnsten, 2009). Профилактика үшін мұның екі салдары бар. Біріншіден, дағдарыс терезесінде өлімге әкелетін құралдарға қолжетімділікті шектеу (кампуста, жатақханада) уақыт ұтуға көмектеседі және дәлелденген тиімділігі бар

(Mann et al., 2005; Zalsman et al., 2016). Екіншіден, адам сол сәтте сенімді адамға немесе қызметке тез жете алуы тиіс — бұл анонимділік пен жылдамдықты қамтамасыз ететін арналарды (онлайн жазылу, чат, эдвайзер) талап етеді.

3.4. Студенттік өмірдегі негізгі факторлар: жалғыздық, материалдық қиындық және отбасылық үзіліс

Бастапқы мақалада ҚСАЕК деректері негізінде жалғыздық (5,4%), ауыр материалдық жағдай (6,7%) және отбасылық қатынастардың үзілуі (2,7%) негізгі факторлар ретінде аталған. Бұл үлестердің қосындысы шамамен 14,8% (қосынды — біздің есеп). Жағдайлардың басым бөлігінде себеп тіркелмейтіндіктен (мысалы, кәмелетке толмағандарда 75,4%), аталған факторлардың нақты рөлі бұдан жоғары болуы мүмкін, сондықтан оларды салыстырмалы маңыздылық көрсеткіші емес, «көрінетін бөлік» деп оқыған жөн. Төмендегі жағдайлар — жинақталған гипотетикалық мысалдар, нақты адамдарға қатысты емес.

- Жалғыздық. Ауылдан келген бірінші курс студенті жаңа қалада тіл мен әлеуметтік орта жағынан өзін «бөтен» сезінеді: жатақханада сөйлесер адам жоқ, топтық чатта үнсіз, сабақтан кейін бөлмеге жалғыз оралады. Күнделікті шағын байланыстардың жоқтығы «тиесілі болмау» сезімін күшейтеді (Joiner, 2005).
- Ауыр материалдық жағдай. Үшінші курс студенті грантынан айырылу қаупінде, жарты ставкамен жұмыс істейді, сессия кезінде аз ұйықтайды. Отбасынан ақша сұрамау үшін қарызға батады; «ата-анама жүк болдым» деген ой «ауыртпалық болу» сезімінің классикалық көрінісі (Joiner, 2005), ал қаржылық шығындар Хобфолл сипаттаған ресурстардың жоғалу спиралін іске қосады (Hobfoll, 1989).
- Отбасылық қатынастардың үзілуі. Мамандық таңдауы немесе жеке өмірі туралы отбасымен қақтығыс студентті қолдау көзінен айырады; мереке күндері жатақхана бос қалғанда «баратын жер жоқ» сезімі күшейеді. 2025 жылғы деректерде қыздардың әрекеттерінің басым көпшілігінде алдында отбасылық жанжал болуы (126-ның 94-інде) осы қауіптің салмағын растайды (Ranking.kz, 2026).

Факторлар сирек оқшау жүреді: жалғыздық қиындықты бөлісуге кедергі келтіреді, қаржылық қиындық оқуға әсер етеді, оқудағы сәтсіздік отбасымен шиеленіске әкеледі. Сондықтан әр факторды жеке «жабудан» гөрі, студент осы тізбектің ішінде өзін қорғай алатын ресурстарды — реттеу мен байланысты — дамыту маңыздырақ.

4. Психологиялық төзімділіктің негізгі компоненттері

Төзімділіктің көп құрамдас құрылымынан студенттік суицидология үшін ең өзекті екеуі — эмоцияны реттеу және оқу орнымен байланыстылық — төменде егжей-тегжейлі қарастырылады: біріншісі ішкі (интрапсихикалық) қорғаныш ресурсын, екіншісі сыртқы (қарым-қатынастық және институционалдық) ресурсты білдіреді.

4.1. Эмоцияны реттеу (Emotional regulation)

Гросстың эмоцияны реттеудің процестік моделі стратегияларды эмоция қалыптасу кезеңіне қарай жіктейді: жағдайды таңдау, жағдайды өзгерту, зейінді бағыттау, когнитивтік қайта бағалау және реакцияны басу (Gross, 1998). Модельге сәйкес эмоция толық күшіне жеткенге дейін қолданылатын стратегиялар (мысалы, қайта бағалау) реакцияны кейін басудан тиімдірек. Эмпирикалық деректер мұны растайды: қайта бағалауды жиі қолданатындар әл-ауқатын жоғары бағалайды, ал эмоцияны басатындар төмен бағалайды (Gross & John, 2003). Мета-талдау ойды қайта-қайта шайнау (rumination), жалтару және басу психопатологиямен ең күшті байланыста екенін, ал қайта бағалау мен мәселені шешу қорғаныш рөл атқаратынын көрсетті (Aldao et al., 2010).

Дағдарыс кезіндегі «туннельдік ойлау» (tunnel vision) — суицидтік күйдің негізгі механизмдерінің бірі. Шнейдман оны когнитивтік тарылу (constriction) деп атап, ойдың «не осы азап, не өлім» деген дихотомиялық таңдауға қысылатынын сипаттады (Shneidman, 1993). Баумейстердің қашу моделінде бұл күй когнитивтік деконструкциямен — уақыт көкжиегінің қысқаруымен, эмоциялық тұмшаланумен және тежелудің әлсіреуімен — қатар жүреді (Baumeister, 1990). Нейробиологиялық тұрғыдан жедел стресс префронтальды қыртыстың басқарушы қызметін азайтып, импульсивті реакцияларды күшейтеді (Arnsten, 2009). Бұл студенттің сабырлы кездегі пайымы мен дағдарыстағы мінез-құлқы арасындағы алшақтықты түсіндіріп, үрейлі сәтте қолданылатын дағдылар алдын ала жаттықтырылуы тиіс екенін дәлелдейді.

Төзімділікке жаттықтыру үш бағытты қамтиды. Біріншіден, импульсивтілікті тежеу: дағдарыстан аман өту (distress tolerance) дағдылары мен жеке қауіпсіздік жоспары — қауіп белгілерін, өз бетінше қолданылатын тәсілдерді, сенімді адамдар мен мамандардың байланысын, қауіпсіз ортаны алдын ала жазып қою (Linehan, 1993; Stanley & Brown, 2012). Екіншіден, когнитивтік қайта бағалау және катастрофизацияны азайту. Бір емтиханнан құлау «бәрі бітті» деген ойға айналғанда, студент нақты сұрақтарға жауап іздейді: ең жаман, ең жақсы және ең ықтимал нәтиже қандай? Бұл тәсіл катастрофизацияны, өзін кінәлауды және ойды қайта-қайта шайнауды азайтып, оң қайта бағалауды күшейтуге бағытталған (Garnefski et al., 2001; Nolen-Hoeksema, 2008). Үшіншіден, үмітсіздікпен жұмыс: үмітсіздік суицидтік мінез-құлықпен тығыз байланысты негізгі когнитивтік құрамдас (Beck et al., 1975), сондықтан жақын әрі орындалатын шағын мақсаттар қою да қорғаныш рөл атқарады.

4.2. Әлеуметтік қолдау және оқу орнымен байланыстылық (Connectedness)

Әлеуметтік қолдау мен оқу орнымен байланыстылық — төзімділіктің сыртқы тірегі. Дюркгейм әлеуметтік интеграциясы төмен топтарда суицидтің жоғары болатынын атаса (Durkheim, 1897/1951), Жойнер бұл идеяны «тиесілі болмау» ұғымына айналдырды (Joiner, 2005). Мета-талдау күшті әлеуметтік қарым-қатынастардың өмір сүру ықтималдығының шамамен 50%-ға жоғары болуымен байланысты екенін көрсетті (Holt-Lunstad et al., 2010). Жасөспірімдердің ұлттық бойлай зерттеуінің деректері бойынша мектеппен және отбасымен байланыстылық эмоциялық күйзеліс пен суицидтік ойлар мен әрекеттерден қорғайтыны анықталды (Resnick et al., 1997). Университет үшін мұның мәні — байланыстылықты ұйымдастыруға болатын ресурс ретінде қарастыру.

Жалғыздықты бейтараптандыру. Бірінші курсқа бейімделу бағдарламасы, топтық «бадди» жүйесі, жатақхана ішіндегі қауымдастық іс-шаралары, академиялық кураторлық, ортақ қызығушылық клубтары, оқытушы мен студент арасындағы тұрақты шағын байланыстар күнделікті «мені көреді, мені күтеді» тәжірибесін қалыптастырады. Басты қағида: мақсат жалғыздық белгісін анықтау ғана емес, оның пайда болуына жол бермейтін құрылымды жасау.

Көмекке жүгіну мәдениетін қалыптастыру. Көмек іздеу үдерісі проблеманы тану, оны айту, көмектің бар екенін білу және оған баруға дайын болу кезеңдерінен тұрады (Rickwood et al., 2005), ал әр кезеңде стигма мен қолжетімділік кедергі келтіруі мүмкін (Corrigan, 2004; Eisenberg et al., 2007). Психологқа немесе эдвайзерге баруды қалыпты жағдай ретінде қабылдату үшін: психолог пен эдвайзерді бірінші курс бағдарламасына тұрақты енгізу; оқытушылардың көмек сұрау тәжірибесі туралы ашық айтуы; «қиын сәтте көмек сұрау — ақылды ресурс пайдалану» деген хабарлама; анонимді және онлайн жазылу арналары қажет.

Институционалдық қауіпсіздік. Смит пен Фрейд институционалдық сатқындық (institutional betrayal) ұғымын енгізіп, мекеме өз қорғауындағы адамды қорғамағанда немесе жазалаушы түрде әрекет еткенде зияннның күшейетінін көрсетті (Smith & Freyd, 2014). Студент үшін институционалдық қауіпсіздік — «қиындығым туралы айтсам, мені қолдайды, жазаламайды» деген сенім. Ол үш шартқа сүйенеді: (1) ашық, жазалаусыз саясат — көмекке жүгіну шығарып жіберуге немесе стигмаға әкелмейді; (2) құпиялылық пен оның шектері туралы алдын ала түсінікті ақпарат; (3) буллингке және қысымға жылдам әрі көрінетін жауап. Соңғысының маңызы бар: кәмелетке толмағандардың суицидтік әрекеттері мен аяқталған суицидтерінің 22%-ында оқу орнындағы буллинг анықталған (Ranking.kz, 2026) — бұл мәселе студенттік жасқа да ауысуы мүмкін.

5. Қорытынды және практикалық ұсыныстар

Талдау үш негізгі қорытындыға әкеледі. Біріншіден, ресми статистикадағы жалпы төмендеу (2025 жылы шамамен 3,2 мың аяқталған суицид) кәмелетке толмағандар арасындағы тұрақсыз динамиканы және себептердің көпшілігінің анықталмауын жасырмауы тиіс. Екіншіден, ерлердегі аяқталған суицидтің басымдығы көмек сұрауға кедергі келтіретін гендерлік стигмамен және дағдарыстағы импульсивті реакциямен тығыз байланысты. Үшіншіден, студенттік жаста тәуекелді басқаратын екі күшті қорғаныш ресурсы — эмоцияны реттеу және оқу орнымен байланыстылық — оқу ортасында жүйелі түрде дамытылуы мүмкін. Төменде осы қорытындыларды іске асырудың практикалық тетіктері ұсынылады.

5.1. Эдвайзерлік қолдау жүйесін «қақпашы» (gatekeeper) ретінде дамыту

Қазақстандық ЖОО-лардағы эдвайзер — әр студентке бекітілетін және оқу траекториясы бойынша тұрақты байланыста болатын маман, яғни табиғи «қақпашы». Қақпашы — қауіптегі адамды тануға, тікелей сұрауға және көмекке байланыстыруға үйретілген, бірақ терапевт емес адам. Қақпашыларды оқыту білімді, көзқарасты және өзіндік тиімділік сезімін айқын жақсартады, алайда нақты мінез-құлыққа және суицид көрсеткішіне әсері туралы деректер шектеулі (Isaac et al., 2009), сондықтан бұл компонент басқа шаралармен қатар жүруі тиіс. Дамыту қадамдары:

1. Рөл мен шекараны бекіту. Эдвайзердің міндеті — тану, сұрау, тыңдау және байланыстыру; диагноз қою мен терапия оның міндетінен тыс.
2. Оқыту. Әр эдвайзер жыл сайын міндетті оқудан (теория, ролдік ойындар, тікелей сұрақ қою тәжірибесі, «жылы тапсыру» хаттамасы) өтеді; көлемі ұсыныс ретінде — 4–6 сағат.
3. Сыни сәттерде міндетті байланыс. Бірінші курстың бейімделу кезеңінде, семестр басында, сессия алдында, академиялық қарыздан немесе грантты жоғалту қаупінен кейін жеке кездесу өткізіледі.
4. Үш деңгейлі бағыттау. Жасыл — стресс және бейімделу қиындығы (эдвайзер мен психоағарту); сары — айқын күйзеліс немесе үмітсіздік (24 сағат ішінде психолог); қызыл — жедел қауіп (студентті жалғыз қалдырмай, сол сәтте жедел қызметтерге бағыттау).
5. Супервизия және жүктеме. Эдвайзерге бекітілетін студент саны шектеледі; психолог тұрақты супервизия береді; эмоциялық күйіп қалудың алдын алу қарастырылады.

Оқытушылар суицидтік белгілерді қалай таниды. Белгілердің ешқайсысы жеке-дара суицидтік қауіпті дәлелдемейді: маңыздысы — студенттің өзіндік деңгейінен ауытқу және белгілердің жиынтығы. Негізгі белгілер: (а) оқшаулану — топтан бөлектену, чатта үнсіздік, бұрын белсенді студенттің «жоғалуы»; (б) агрессия немесе кенеттен ашушаңдық, ол ерлерде депрессияның жасырын көрінісі болуы мүмкін (Möller-Leimkühler, 2003); (в) сабаққа қатыспау және үлгерімнің күрт төмендеуі; (г) ұйқы мен сыртқы келбеттің өзгеруі; (д) «бәрібір», «жүк болдым», «бәрі бітті» сияқты үмітсіздік тұжырымдары; (е) заттарын таратып жіберу, қоштасу ишаралары, ұзақ күйзелістен кейін кенеттен «тыныштану». Байқаған оқытушы бес қадам жасайды: байқау, тікелей сұрау, тыңдау, байланыстыру, қайта хабарласу. Тікелей сұрақ

суицидтік ойларды арттырмайды (Dazzi et al., 2014); құпияны сақтауға уәде бермеу және жедел қауіпте студентті жалғыз қалдырмау қажет.

5.2. Peer-to-peer қолдау жүйесі және психоағарту модульдері

Тең-теңімен қолдау. Құрдас қолдауы «ересектерге айтпаймын» кедергісін азайтып, көмек сұрауды қалыпты етеді. Орта мектептерде құрдас көшбасшылар жүргізген «Sources of Strength» бағдарламасы көмек сұрау нормаларын және ересектер қолдауына сенімді жақсартты (Wyman et al., 2010); оны университет жағдайына бейімдеуге болады. Тетік: әртүрлі топтардан (ерлер, ауылдан келгендер, грантшылар, шетелдік студенттер) құрдас көшбасшыларды таңдау; психолог бақылауымен 12–16 сағаттық оқыту; рөл шегін нақтылау (құрдас — терапевт емес, байланыстырушы); жатақханада тең-теңімен кездесу сағаттары мен бадди-жүйесі; қиын жағдайда психологқа бағыттау хаттамасы.

Әмбебап психоағарту модульдері. Оларды бірінші курстағы «Университетке бейімделу» пәніне (1 кредит) немесе міндетті семинарларға енгізген тиімді, себебі әмбебап форма стигманы азайтады. Төрт модуль ұсынылады:

1. Эмоцияны реттеу: Гросс моделі, қайта бағалау, дағдарыстан аман өту дағдылары, қауіпсіздік жоспарын жасау.
2. Стресс-менеджмент: жүктемені жоспарлау, қаржылық сауаттылық, бейімделу кезеңіндегі «қалыпты» күйзеліс пен қауіп белгілерінің айырмасы.
3. Ұйқы гигиенасы: ұйқының бұзылуы суицидтік ойлармен және мінез-құлықпен байланысты (Pigeon et al., 2012), сондықтан тұрақты ұйқы режимі, түнгі экран мен кофеинді шектеу, «ұйқысыз түнмен сессияға дайындалу» мифін жою.
4. Көмек сұрау және байланыстылық: қызметтермен таныстыру, құрдасқа қалай көмектесу керектігі, жалғыздықтың алдын алу.

Іске асыру: бір топқа 15–25 студент, сабақты психолог жүргізеді, құрдас көмекшілер қатысады, онлайн-материал қосымша ретінде беріледі. Әсерін бағалау үшін модульге дейін және кейін төзімділік шкаласы (CD-RISC) мен стандартталған скрининг шкалалары қолданылады; алдымен 2–3 факультетте пилот өткізіп, нәтижесі бойынша кеңейтеді.

5.3. Университеттің психологиялық қызметінің жұмыс алгоритмдері және құпиялылық кепілдіктері

1. Кіру арналары: жеке бару, онлайн және анонимді жазылу, эдвайзерден, оқытушыдан немесе құрдастан бағыттау.
2. Триаж: өтінішке 24 сағат ішінде жауап беру; жедел қауіп болса — сол күні.
3. Тәуекелді бағалау: клиникалық сұхбат пен стандартталған құрал, мысалы, Колумбиялық суицидтік ауырлық шкаласы (C-SSRS; Posner et al., 2011).
4. Тәуекел деңгейіне сай жоспар: төмен — психоағарту және қысқа консультациялар; орташа — қауіпсіздік жоспары (Stanley & Brown, 2012) және тұрақты кездесулер; жоғары — студентті жалғыз қалдырмау, жедел психиатриялық көмекке бағыттау, қауіп бар жағдайда жақындарымен хабарласу.
5. Сүйемелдеу: келесі апталарда жүйелі қайта байланыс (follow-up) және академиялық бейімдеу — академиялық демалыс, қайта тапсыру мерзімін ұзарту, жатақханадағы орынды сақтау.
6. Оқиғадан кейінгі қолдау (поственция): студент қайтыс болғанда курстастарға психологиялық қолдау көрсету; ақпаратты сенсациясыз, әдістерді көрсетпей, қауіпсіз тілмен беру.

Құпиялылық кепілдіктері: (1) ақпараттандырылған келісім — алғашқы кездесуде құпиялылық пен оның шегі (өмірге тікелей қауіп) ашық түсіндіріледі; (2) деректерді бөлу — психологиялық жазбалар академиялық деректерден бөлек сақталады, деканатқа тек қажетті бейімдеу

туралы ақпарат беріледі, диагноз немесе сұхбат мазмұны берілмейді; (3) жазалаусыз саясат — көмекке жүгіну тәртіптік жазаға немесе грантқа қатер төндірмейді; (4) агрегатталған анонимді есеп жүргізу; (5) қызметтің қолданыстағы заңнамаға (медициналық және кәсіби құпияны қорғау ережелеріне) сәйкес болуы. Бұл кепілдіктер сайтта, бейімделу пәнінде және эдвайзер хаттамасында көрінетін түрде жариялануы тиіс: сенім студент оны біліп отырғанда ғана ресурсқа айналады.

5.4. Шектеулер және қорытынды

Мақаланың шектеулері: (1) талдау әкімшілік және қайталама (баспасөзде жарияланған) деректерге негізделген, студенттер бөлек санатқа бөлінбейді; (2) бастапқы мақаладағы үлестер (5,4%; 6,7%; 2,7%) дербес тексерілмеді, ал себептердің көпшілігі тіркелмейді; (3) ұсынылған тетіктердің тиімділігі Қазақстан контексінде әлі бағаланбаған. Болашақта студенттік деңгейдегі анонимді мониторинг пен квазиэксперименттік пилоттық бағалау қажет.

Суицидтің алдын алу тек қауіпті адамды табу емес, әр студентке қорғаныш ресурстарын дамытатын орта құру. Эмоцияны реттеу дағдылары, оқу орнымен байланыстылық, эдвайзер-қақпашы, құрдастар қолдауы және сенімді психологиялық қызмет бір жүйе ретінде жұмыс істегенде ғана төзімділік жеке тұлғаның міндеті емес, университеттің ортақ жауапкершілігіне айналады.

Пайдаланылған әдебиеттер

1. Addis, M. E., & Mahalik, J. R. (2003). Men, masculinity, and the contexts of help seeking. American Psychologist, 58(1), 5–14.
2. Aldao, A., Nolen-Hoeksema, S., & Schweizer, S. (2010). Emotion-regulation strategies across psychopathology: A meta-analytic review. Clinical Psychology Review, 30(2), 217–237.
3. Arnett, J. J. (2000). Emerging adulthood: A theory of development from the late teens through the twenties. American Psychologist, 55(5), 469–480.
4. Arnsten, A. F. T. (2009). Stress signalling pathways that impair prefrontal cortex structure and function. Nature Reviews Neuroscience, 10(6), 410–422.
5. Baumeister, R. F. (1990). Suicide as escape from self. Psychological Review, 97(1), 90–113.
6. Beck, A. T., Kovacs, M., & Weissman, A. (1975). Hopelessness and suicidal behavior: An overview. JAMA, 234(11), 1146–1149.
7. Bonanno, G. A. (2004). Loss, trauma, and human resilience: Have we underestimated the human capacity to thrive after extremely aversive events? American Psychologist, 59(1), 20–28.
8. Canetto, S. S., & Sakinofsky, I. (1998). The gender paradox in suicide. Suicide and Life-Threatening Behavior, 28(1), 1–23.
9. Connor, K. M., & Davidson, J. R. T. (2003). Development of a new resilience scale: The Connor-Davidson Resilience Scale (CD-RISC). Depression and Anxiety, 18(2), 76–82.
10. Corrigan, P. (2004). How stigma interferes with mental health care. American Psychologist, 59(7), 614–625.
11. Dazzi, T., Gribble, R., Wessely, S., & Fear, N. T. (2014). Does asking about suicide and related behaviours induce suicidal ideation? What is the evidence? Psychological Medicine, 44(16), 3361–3363.
12. Deisenhammer, E. A., Ing, C.-M., Strauss, R., Kemmler, G., Hinterhuber, H., & Weiss, E. M. (2009). The duration of the suicidal process: How much time is left for intervention between consideration and accomplishment of a suicide attempt? Journal of Clinical Psychiatry, 70(1), 19–24.
13. Durkheim, É. (1951). Suicide: A study in sociology (J. A. Spaulding & G. Simpson, Trans.). Free Press. (Original work published 1897)

14. Eisenberg, D., Golberstein, E., & Gollust, S. E. (2007). Help-seeking and access to mental health care in a university student population. Medical Care, 45(7), 594–601.
15. Franklin, J. C., Ribeiro, J. D., Fox, K. R., et al. (2017). Risk factors for suicidal thoughts and behaviors: A meta-analysis of 50 years of research. Psychological Bulletin, 143(2), 187–232.
16. Garnefski, N., Kraaij, V., & Spinhoven, P. (2001). Negative life events, cognitive emotion regulation and emotional problems. Personality and Individual Differences, 30(8), 1311–1327.
17. Gross, J. J. (1998). The emerging field of emotion regulation: An integrative review. Review of General Psychology, 2(3), 271–299.

The Relationship Between Social Media Use and Vocabulary Development in English Language Learning

Aigerim Nurzhanova
Master's Student, Khoja Akhmet Yassawi International Kazakh-Turkish University, Kazakhstan

ABSTRACT

This study examines the relationship between social media use and English vocabulary development among university students in Kazakhstan. A quantitative correlational research design was employed to investigate students' social media usage patterns and their self-reported vocabulary-learning experiences. Data were collected through a questionnaire and analyzed using IBM SPSS Statistics. The analysis included descriptive statistics, reliability analysis, tests of normality, and Pearson correlation analysis. The preliminary results indicate that the relationships between individual social media platforms and vocabulary development vary across platforms. Facebook use was negatively correlated with vocabulary scores, whereas YouTube showed a positive but statistically non-significant relationship. No statistically significant correlations were identified for Instagram or TikTok. These findings suggest that the potential educational value of social media may depend on the platform and the nature of learners' engagement with English-language content. The study highlights the importance of purposeful social media use in supporting vocabulary development. Further research with a larger sample and more objective measures of vocabulary knowledge is recommended.

Keywords: social media use, vocabulary development, English language learning, university students, digital learning, correlation analysis

1. INTRODUCTION

Social media has become an integral part of everyday life, influencing how people communicate, access information, and acquire knowledge. Platforms such as Instagram, TikTok, YouTube, and Facebook provide opportunities for users to encounter English in authentic and informal contexts. Through videos, captions, comments, posts, and interactive content, learners may be exposed to new vocabulary beyond the traditional classroom environment.

Vocabulary knowledge is an essential component of second language proficiency. It enables learners to understand written and spoken texts, express their ideas clearly, and communicate effectively. Consequently, identifying effective ways to support vocabulary development is an important concern in English language education. Social media may contribute to this process by providing repeated exposure to words, visual representations, contextual examples, and opportunities for interaction.

In Kazakhstan, English is widely studied as a foreign language, and university students increasingly use digital platforms in their everyday lives. Social media can provide additional opportunities to encounter English-language content outside formal educational settings. However, frequent exposure to online content does not necessarily lead to vocabulary acquisition. The educational value of social media may depend on the type of content learners access, the language used in their online environments, and the extent to which they actively engage with unfamiliar words.

Previous research has explored the potential of social media and digital technologies in language learning. However, further investigation is needed to understand the relationship between the use of specific social media platforms and vocabulary development among university students in Kazakhstan.

1.1. Problem Statement

Although social media has become an important part of students' everyday lives, its relationship with English vocabulary development remains an area requiring further investigation. Students may spend considerable time on platforms such as Instagram, TikTok, YouTube, and Facebook, but the amount of time spent online does not necessarily reflect the extent of vocabulary learning.

Some forms of social media engagement may encourage vocabulary development through exposure to English-language content, while others may provide limited opportunities for meaningful language practice. Furthermore, learners may differ in how frequently they search for unfamiliar words, remember new vocabulary, and use newly learned expressions in speaking or writing. Therefore, it is important to investigate the relationship between social media use and vocabulary development and to examine whether this relationship varies across platforms. This study addresses this issue by exploring social media usage patterns and self-reported vocabulary-learning experiences among university students in Kazakhstan.

1.2. Research Questions

This study addresses the following research questions:

1. Is there a statistically significant relationship between social media use and vocabulary development among English language learners?
2. What relationships exist between the use of Instagram, TikTok, YouTube, and Facebook and students' vocabulary scores?
3. How do students perceive the role of social media in their English vocabulary learning?

The findings may contribute to a better understanding of how university students use social media in informal language-learning contexts. They may also provide insights into the importance of purposeful engagement with English-language content.

The study focuses on university students in Kazakhstan who use social media. It examines four platforms: Instagram, TikTok, YouTube, and Facebook. Data were collected through a questionnaire and analyzed using IBM SPSS Statistics. Since the research relies on a relatively small sample and questionnaire-based measures, the findings should be interpreted cautiously and should not be generalized to all English language learners.

2. LITERATURE REVIEW

2.1. Social Media and Vocabulary Learning

Vocabulary knowledge is an essential component of second language learning because learners need to understand and use words to communicate effectively (Alqahtani, 2015; Nation, 2013; Schmitt, 2000). Vocabulary development involves more than recognizing the meanings of individual words; it also requires understanding how words are used in different contexts. For university students learning English as a foreign language, opportunities to encounter English outside the classroom may provide additional exposure to vocabulary (Nation, 2013; Read, 2000; Schmitt, 2008). Exposure to meaningful language through reading may also contribute to vocabulary acquisition, highlighting the importance of encountering words in context (Krashen, 1989).

Social media platforms have created opportunities for informal language learning by allowing users to access videos, written posts, comments, and other forms of digital content. Unlike traditional classroom materials, social media content may expose learners to language used in everyday communication. However, the educational value of this exposure depends on the content learners encounter and how actively they engage with it. Alharthi et al. (2020) reviewed research on the use of social media platforms for vocabulary development in second and foreign language learning. Their review examined 50 peer-reviewed articles, of which 15 were considered relevant to social media and vocabulary learning. The authors identified potential benefits for learner engagement, motivation, and vocabulary development. At the same time, their review highlighted the need for further research into the use of social media for language learning. These findings provide a relevant foundation for investigating the relationship between social media use and vocabulary development among university students in Kazakhstan (Alharthi et al., 2020; Çetinkaya & Sütçü, 2018; Mills, 2011).

Importantly, the availability of English-language content does not necessarily mean that vocabulary will be learned. Learners may encounter unfamiliar words without paying attention to their meanings or remembering them later. Therefore, research should consider not only how frequently students use social media but also how they interact with English-language content.

2.2. Multimedia Content and Vocabulary Development

Social media platforms provide language input through different combinations of written text, spoken language, images, and video. These forms of content may help learners connect unfamiliar words with visual information and contextual examples. Research on multimedia annotations has examined how combining verbal information with visual support may assist listening comprehension and vocabulary acquisition in a second language (Jones & Plass, 2002). Mayer (2005) discussed how people learn from words and pictures, while Plass and Jones (2005) examined multimedia learning in second language acquisition. These perspectives provide a theoretical foundation for considering how verbal and visual information may support language learning. However, the presence of multimedia elements alone does not establish that vocabulary acquisition has occurred. Teng (2023) investigated incidental vocabulary learning from captioned videos, highlighting the relevance of video-based input to vocabulary learning. Al-Seghayer (2001) also examined the effects of different multimedia annotation modes on second-language vocabulary acquisition.

In the present study, these platforms are considered in relation to students' vocabulary scores. The analysis aims to identify whether the use of particular platforms is associated with higher or lower scores. Because the study uses a correlational design, the results can indicate relationships between variables but cannot establish that a particular platform directly causes vocabulary improvement.

2.3. Social Media as an Informal Learning Environment

Informal learning can take place outside organized educational settings, including when learners independently access online content. Social media may provide opportunities for students to encounter English while watching videos, reading posts, following educational accounts, or communicating with other users (Lomicka & Lord, 2012; Mills, 2011).

However, students' online activities differ in purpose. Some learners deliberately follow English-learning accounts, search for unfamiliar vocabulary, and practice using new words. Others primarily use social media for entertainment or communication in their first language. Consequently, the amount of time spent online may not accurately represent the amount of time devoted to language learning. Research on mobile-assisted vocabulary learning has also highlighted the importance of examining how digital technologies are used to support vocabulary learning rather than focusing only on access to technology (Okumuş Dağdeler, 2023). This distinction is important when investigating the relationship between social media use and

vocabulary development. Frequency of use, engagement with English-language content, and deliberate vocabulary-learning activities are related but different aspects of learners' experiences. A student who spends a relatively short time watching English-language educational videos may engage more actively with vocabulary than a student who spends several hours browsing content in another language (Webb, 2007; Webb & Nation, 2017).

For this reason, the present study considers students' reported experiences of learning new words, searching for their meanings, using newly encountered vocabulary in speaking or writing, and evaluating social media as a vocabulary-learning resource (Laufer & Hulstijn, 2001; Schmitt, 2010).

2.4. Research Gap and Rationale for the Present Study

Previous research has explored the potential of social media for language learning. For example, Alharthi et al. (2020) reviewed existing research on social media and vocabulary development, while Mayer (2005) provided a theoretical discussion of learning from words and pictures in multimedia environments. These publications offer useful perspectives for examining digital content as a possible resource for language learning. Nevertheless, further empirical research is needed to understand how the use of individual social media platforms relates to vocabulary outcomes in specific educational contexts. Findings from studies conducted in other countries cannot automatically be generalized to university students in Kazakhstan, whose language-learning experiences and patterns of social media use may differ.

The present study addresses this issue by examining questionnaire data from university students in Kazakhstan. It focuses on Instagram, TikTok, YouTube, and Facebook and uses statistical analysis to investigate relationships between platform use and vocabulary scores. It also considers students' reported vocabulary-learning behaviors and perceptions of social media as a learning resource. By examining these variables, the study seeks to provide context-specific evidence about the relationship between social media use and English vocabulary development. Its findings may help identify questions for further research and inform discussions about the role of informal digital environments in foreign language learning.

3. METHODOLOGY

3.1. Research Design

This study employed a quantitative correlational research design to investigate the relationship between social media use and English vocabulary development among university students in Kazakhstan. A quantitative approach was selected because the study involved collecting numerical questionnaire data and examining relationships between variables using statistical analysis. A correlational design was appropriate for exploring whether students' use of different social media platforms was associated with their vocabulary scores. The study did not involve an experimental intervention or manipulate participants' social media use. Therefore, the findings were interpreted in terms of associations rather than causal relationships.

The data were analyzed using IBM SPSS Statistics. Descriptive statistics were used to summarize participants' responses, while correlation analysis was conducted to examine relationships between social media platforms and vocabulary scores.

3.2. Participants

The participants were university students studying English in Kazakhstan. The original research report described the sample as consisting of 51 students aged between 18 and 25 years. The questionnaire was distributed online through Google Forms. The survey link was shared through messaging applications and student group chats. Participation was voluntary, and respondents were informed about the purpose of the study before completing the questionnaire. The study focused on students' social media use and their experiences of learning English vocabulary. The findings were interpreted within the context of the sample and should not automatically be generalized to all university students in Kazakhstan.

3.3. Research Instrument and Data Collection

Data were collected using a structured questionnaire designed to examine students' social media usage patterns and vocabulary-learning experiences. The questionnaire included questions about the social media platforms students used, whether they had learned new English words through social media, how frequently they searched for unfamiliar words, and whether they attempted to use newly learned vocabulary in speaking or writing. The questionnaire also asked participants to evaluate the usefulness of social media for English vocabulary development. Responses to relevant items were recorded numerically for statistical analysis. Where applicable, a four-point Likert scale was used, with higher scores representing stronger agreement with the relevant statements. The questionnaire was administered online through Google Forms. Responses were exported for data preparation and subsequently analyzed in IBM SPSS Statistics.

3.4. Data Analysis

The collected data were analyzed using IBM SPSS Statistics. Several statistical procedures were used to examine the research questions.

Descriptive Statistics

Frequencies, means, and standard deviations were used to summarize participants' responses and describe their reported vocabulary-learning experiences. These statistics provided an overview of students' social media use and their perceptions of vocabulary development.

Reliability Analysis

Cronbach's alpha was used to examine the internal consistency of the questionnaire items intended to measure a common construct. The original statistical output reported an alpha coefficient of 0.677.

Test of Normality

The Shapiro–Wilk test was used to examine the distribution of the vocabulary-score variable. The reported result was $W = 0.962$, $p = 0.098$, based on 51 cases. Since the p-value exceeded 0.05, the test did not provide sufficient evidence to reject the assumption of normality for this variable. Nevertheless, the appropriateness of subsequent statistical tests also depends on the characteristics of the variables being analyzed.

Pearson Correlation Analysis

Pearson's correlation coefficient was used to examine the direction and strength of the relationships between the social media platform variables and vocabulary scores. The analysis included Facebook, Instagram, TikTok, YouTube, and other social media categories. Correlation coefficients were interpreted alongside their corresponding p-values. Statistical significance was evaluated at the 0.05 level. Because the study employed a correlational design, the results were not interpreted as evidence that social media use directly caused changes in vocabulary knowledge.

4.Results

The data were analyzed using descriptive statistics, reliability analysis, the Shapiro–Wilk test, and Pearson correlation analysis. These procedures were used to examine students' reported vocabulary-learning experiences and the relationships between social media platform use and the composite vocabulary-learning score.

4.1 Test of Normality

The Shapiro–Wilk test was used to assess the normality of the composite vocabulary-learning score.

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
total_vocab	,108	51	,192	,962	51	,098

The Shapiro–Wilk test was used to assess the normality of the vocabulary score variable. The results were W = 0.962, p = 0.098, with 51 valid cases. Since the p-value was greater than 0.05, the test did not provide statistically significant evidence of a departure from normality. This result supported proceeding with the planned Pearson correlation analysis, while recognizing that normality should ideally be assessed alongside visual inspection of the data.

4.2 Descriptive Statistics

A total of 51 students participated in the study. The questionnaire explored students' social media use and their experiences of learning English vocabulary through digital platforms. The descriptive statistics showed differences in students' reported vocabulary-learning experiences across groups with different levels of daily social media use.

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	Upper Bound	Minimum	Maximum
Have you ever learned new English words through social media?	Less than 1 hour	13	1,62	,768	,213	1,15	2,08	1	3
	1–2 hours	13	3,15	,899	,249	2,61	3,70	2	4
	3–4 hours	18	3,28	,958	,226	2,80	3,75	1	4
	More than 4 hours	7	3,86	,378	,143	3,51	4,21	3	4
	Total	51	2,90	1,136	,159	2,58	3,22	1	4
How often do you search the meaning of new English words you see on social media?	Less than 1 hour	13	3,08	,954	,265	2,50	3,65	2	4
	1–2 hours	13	3,31	,630	,175	2,93	3,69	2	4
	3–4 hours	18	2,89	,583	,137	2,60	3,18	2	4
	More than 4 hours	7	3,29	,488	,184	2,83	3,74	3	4
	Total	51	3,10	,700	,098	2,90	3,29	2	4
Do you try to use the new words learned from social media in your speaking or writing?	Less than 1 hour	13	3,15	,689	,191	2,74	3,57	2	4
	1–2 hours	13	3,31	,855	,237	2,79	3,82	2	4
	3–4 hours	18	2,78	,878	,207	2,34	3,21	1	4
	More than 4 hours	7	3,43	,535	,202	2,93	3,92	3	4
	Total	51	3,10	,806	,113	2,87	3,32	1	4
In your opinion, how effective is social media for developing English vocabulary?	Less than 1 hour	13	3,15	,689	,191	2,74	3,57	2	4
	1–2 hours	13	3,08	,641	,178	2,69	3,46	2	4
	3–4 hours	18	3,00	,840	,198	2,58	3,42	1	4
	More than 4 hours	7	3,00	,816	,309	2,24	3,76	2	4
	Total	51	3,06	,732	,103	2,85	3,26	1	4

The mean score for the item concerning whether students had learned new English words through social media was 2.90 (SD = 1.136). Students who reported spending more time on social media generally had higher mean scores on this item. The mean scores were 1.62 for students spending less than one hour per day, 3.15 for those spending one to two hours, 3.28 for those spending three to four hours, and 3.86 for those spending more than four hours per day.

For the item concerning how often students searched for the meanings of unfamiliar English words, the overall mean was 3.10 (SD = 0.700). The overall mean for trying to use newly learned words was also 3.10 (SD = 0.806). Students rated the effectiveness of social media for vocabulary learning at a mean of 3.06 (SD = 0.732).

4.3 Reliability Analysis

The reliability analysis reported a Cronbach's alpha coefficient of 0.677 for the four items included in the analysis. This value indicates moderate internal consistency, although it is below the commonly used threshold of 0.70. Therefore, the reliability of the questionnaire items should be interpreted cautiously.

Альфа Кронбаха	N элементов
,677	4

4.4 Correlation Analysis (Pearson)

Pearson correlation analysis was conducted to examine the relationships between the vocabulary score and the use of individual social media platforms. The results differed across platforms.

Correlations

		total_vocab	facebook	instagram	tiktok	youtube	others
total_vocab	Pearson Correlation	1	-,317*	-,017	,138	,249	,032
	Sig. (2-tailed)		,024	,905	,335	,078	,824
	N	51	51	51	51	51	51
facebook	Pearson Correlation	-,317*	1	-,045	-,286*	-,130	-,074
	Sig. (2-tailed)	,024		,756	,042	,362	,607
	N	51	51	51	51	51	51
instagram	Pearson Correlation	-,017	-,045	1	-,142	-,010	-,455**
	Sig. (2-tailed)	,905	,756		,320	,942	,001
	N	51	51	51	51	51	51
tiktok	Pearson Correlation	,138	-,286*	-,142	1	-,183	-,129
	Sig. (2-tailed)	,335	,042	,320		,200	,367
	N	51	51	51	51	51	51
youtube	Pearson Correlation	,249	-,130	-,010	-,183	1	,165
	Sig. (2-tailed)	,078	,362	,942	,200		,247
	N	51	.51	51	51	51	51
others	Pearson Correlation	,032	-,074	-,455**	-,129	,165	1
	Sig. (2-tailed)	,824	,607	,001	,367	,247	
	N	51	51	51	51	51	51

The results showed the following correlations:

Instagram use was very weakly and negatively correlated with the composite vocabulary-learning score (r = −0.017, p = 0.905). This relationship was not statistically significant.

TikTok: r = ,138, p > ,05 (no significant correlation)

YouTube: r = ,249, p = ,078 (feeble, non-significant positive correlation)

Other social media: r = ,032, p > ,05 (not significant)

Facebook: r = –,317, p = ,024 (significant negative correlation)

A statistically significant negative correlation was found between Facebook use and vocabulary scores (r = −0.317, p = 0.024). This indicates that higher Facebook-use scores were associated with

lower vocabulary scores in this sample. However, the correlational design does not establish that Facebook use caused lower vocabulary performance.

5.Discussion

This study examined the relationship between social media use and vocabulary learning among university students in Kazakhstan. The findings showed that the relationships between individual social media platforms and students' vocabulary-learning scores varied across platforms. The results revealed a statistically significant negative correlation between Facebook use and the composite vocabulary-learning score ($r = -0.317$, $p = 0.024$). However, this association does not mean that Facebook use causes lower vocabulary performance. Instagram ($r = -0.017$, $p = 0.905$), TikTok ($r = 0.138$, $p = 0.335$), and other platforms ($r = 0.032$, $p = 0.824$) did not show statistically significant correlations with the score. YouTube showed a positive but non-significant correlation ($r = 0.249$, $p = 0.078$). Therefore, the results do not provide sufficient evidence of a significant relationship between the use of these platforms and vocabulary-learning scores. Social media offers opportunities for language exposure through videos, written posts, subtitles, and online communication. Mayer (2005) discusses the role of verbal and visual information in learning, while Alharthi, Bown, and Pullen (2020) review the use of social media for vocabulary development. These perspectives suggest that digital content may support language learning, although its effectiveness depends on how learners engage with it.

The findings also suggest that time spent on social media should not automatically be considered evidence of vocabulary development. Students may use these platforms mainly for entertainment rather than purposeful language practice. Teachers could therefore encourage learners to follow English-language educational accounts, record unfamiliar words, review their meanings, and use new vocabulary in context. Several limitations should be acknowledged. The study included 51 participants and relied on questionnaire responses. The composite vocabulary-learning score was calculated from several items and was not an independently administered vocabulary test. Furthermore, the correlational design cannot establish cause-and-effect relationships. Future research could include a larger sample, an objective vocabulary test, and more detailed information about students' social media activities.

Overall, the findings indicate that the relationship between social media use and vocabulary learning requires further investigation. The educational value of social media may depend not only on the platform itself but also on how learners use English-language content.

6. Conclusion

This study examined the relationship between social media use and vocabulary learning among university students in Kazakhstan. The findings revealed different patterns of association across social media platforms. Facebook use was negatively correlated with the composite vocabulary-learning score, whereas YouTube showed a positive but statistically non-significant correlation. No statistically significant relationships were found for Instagram, TikTok, or other platforms. These findings suggest that using social media does not necessarily correspond to higher vocabulary-learning scores. Purposeful engagement with English-language content may be more important than general platform use. However, because the study relied on questionnaire data and a correlational design, the results cannot establish causal relationships or directly measure actual vocabulary growth.

The study was limited by its relatively small sample of 51 participants and its reliance on a questionnaire-based composite score. Future research should involve larger samples, objective vocabulary assessments, and more detailed investigations of how students use social media for language learning.

In conclusion, social media may provide opportunities for English vocabulary learning, but its educational value requires further investigation. Understanding how learners engage with digital content can help teachers develop more effective approaches to vocabulary learning outside the classroom.

References

Alharthi, M., Bown, A., & Pullen, D. (2020). The use of social media platforms to enhance vocabulary development in learning a new language: A review of the literature. Arab World English Journal (AWEJ), Special Issue on CALL(6), 318–331. https://doi.org/10.24093/awej/call6.21

Alqahtani, M. (2015). The importance of vocabulary in language learning and how to be taught. International Journal of Teaching and Education, 3(3), 21–34. https://doi.org/10.20472/TE.2015.3.3.002

Al-Seghayer, K. (2001). The effect of multimedia annotation modes on L2 vocabulary acquisition: A comparative study. Language Learning & Technology, 5(1), 202–232. https://doi.org/10.64152/10125/25117

Çetinkaya, L., & Sütçü, S. S. (2018). The effects of Facebook and WhatsApp on success in English vocabulary instruction. Journal of Computer Assisted Learning, 34(5), 504–514. https://doi.org/10.1111/jcal.12255

Jones, L. C., & Plass, J. L. (2002). Supporting listening comprehension and vocabulary acquisition in French with multimedia annotations. The Modern Language Journal, 86(4), 546–561

Krashen, S. D. (1989). We acquire vocabulary and spelling by reading: Additional evidence for the input hypothesis. The Modern Language Journal, 73(4), 440–464. https://doi.org/10.1111/j.1540-4781.1989.tb05325.x

Laufer, B., & Hulstijn, J. (2001). Incidental vocabulary acquisition in a second language: The construct of task-induced involvement. Applied Linguistics, 22(1), 1–26. https://doi.org/10.1093/applin/22.1.1

Lomicka, L., & Lord, G. (2012). A tale of tweets: Analyzing microblogging among language learners. System, 40(2), 48–63.

Mayer, R. E. (Ed.). (2005). The Cambridge handbook of multimedia learning. Cambridge University Press.

Mills, N. (2011). Situated learning through social networking communities: The development of joint enterprise, mutual engagement, and a shared repertoire. CALICO Journal, 28(2), 345–368.

Nation, I. S. P. (2013). Learning vocabulary in another language (2nd ed.). Cambridge University Press. https://doi.org/10.1017/CBO9781139858656

Okumuş Dağdeler, K. (2023). A systematic review of mobile-assisted vocabulary learning research. Smart Learning Environments, 10, Article 19. https://doi.org/10.1186/s40561-023-00235-z

Plass, J. L., & Jones, L. C. (2005). Multimedia learning in second language acquisition. In R. E. Mayer (Ed.), The Cambridge handbook of multimedia learning (pp. 467–488). Cambridge University Press. https://doi.org/10.1017/CBO9780511816819.030

Read, J. (2000). Assessing vocabulary. Cambridge University Press. https://doi.org/10.1017/CBO9780511732942

Schmitt, N. (2000). Vocabulary in language teaching. Cambridge University Press.

Schmitt, N. (2008). Instructed second language vocabulary learning. Language Teaching Research, 12(3), 329–363. https://doi.org/10.1177/1362168808089921

Schmitt, N. (2010). Researching vocabulary: A vocabulary research manual. Palgrave Macmillan.

Teng, M. F. (2023). Incidental vocabulary learning from captioned videos: Learners' prior vocabulary knowledge and working memory. Journal of Computer Assisted Learning, 39(2), 517–531. https://doi.org/10.1111/jcal.12756

Webb, S. (2007). The effects of repetition on vocabulary knowledge. Applied Linguistics, 28(1), 46–65. https://doi.org/10.1093/applin/aml048

Webb, S., & Nation, P. (2017). How vocabulary is learned. Oxford University Press.

ФИЗИКА ПӘНІМЕН ПӘНАРАЛЫҚ БАЙЛАНЫСТЫ КОНТЕКСТІК НЕГІЗДЕ ҰЙЫМДАСТЫРУДЫҢ РӨЛІ

С. Нуркасымова
Л.Н.Гумилев атындағы Еуразия ұлттық университеті, Астана, Қазақстан
А.Аннасова
Л.Н.Гумилев атындағы Еуразия ұлттық университеті, Астана, Қазақстан

Аңдатпа. Мақалада физиканы оқыту барысында пәнаралық байланысты контекстік негізде ұйымдастырудың теориясы және әдістемесі қарастырылады. Зерттеудің мақсаты – нақты қолданбалы тапсырмалар арқылы физикалық білімді математика, биология, география, химия және информатика пәндерімен байланыстырудың педагогикалық рөлін қарастыру. Сонымен қатар ғылыми-әдістемелік әдебиеттерді талдау, салыстыру, жүйелеу және тапсырмаларды педагогикалық модельдеу қолданылды. Ғылыми еңбектерді талдау контекстік тапсырмалардың пәндік білімді күнделікті өмірмен ұштастыруға, деректерді түсіндіруге, дәлелді шешім қабылдауға және алған білімдерін жаңа технологияларды қолдану көрсетіледі. Мақалада контекстік-пәнаралық тапсырманы құрастырудың авторлық моделі, сабаққа енгізуге болатын үлгі тапсырмалар ұсынылады.

Түйін сөздер: физика, пәнаралық байланыс, контекстік оқыту, функционалдық сауаттылық, зерттеушілік дағды, қолданбалы тапсырма.

Қазіргі мектепте оқушының физикалық формулаларды жаттап қана қоймай, олардың нақты өмірдегі құбылыстарды түсіндірудегі маңызын ұғынуы өзекті. Күнделікті өмірдегі энергияны үнемдеу, көлік қозғалысының қауіпсіздігі, ауа райын болжау, адам ағзасының қызметі немесе цифрлық құрылғылардың жұмысы бір ғана пән шеңберімен шектелмейді. Мұндай мәселелерді түсіндіру үшін бірнеше ғылымның ұғымдарын өзара байланыстыра қолдану қажет. Осыған орай физика сабақтарындағы пәнаралық байланысты мазмұнды әрі мақсатты ұйымдастырудың тиімді жолдарының бірі – контекстік оқыту.

Контекстік оқытуда жаңа ұғым оқушыға таныс немесе әлеуметтік мәні бар мәселе арқылы ұсынылады; ал физикалық заңдылық сол мәселеты түсіндіру және шешу құралына айналады. Пәнаралық байланыс мұнда пәндерді жай ғана қатар атау емес, бір мәселені шешуде әр пәннің танымдық құралдарын орынды біріктіруді білдіреді. Мысалы, ғимараттың жылу шығынын анықтау үшін физикадағы жылу берілу заңдылықтары, математикадағы есептеу мен график, географиядағы климат ерекшеліктері және экологиядағы ресурсты үнемдеу ұстанымдары бірге қолданылады.

Мақаланың мақсаты – физиканы оқытуда контекстік негіздегі пәнаралық байланыстың мазмұнын ашу және оны сабақта ұйымдастыруға арналған әдістемелік ұсыныстар әзірлеу. Міндеттері: ғылыми еңбектердегі контекстік тапсырма түсінігін талдау; пәнаралық ықпалдастырудың оқу нәтижелерімен байланысын сипаттау; тапсырма үлгілері мен бағалау критерийлерін ұсыну.

Контекстік оқыту мен пәнаралық байланыстың теориялық негіздері. В. И. Данильчук, Е. В. Донскова және Т. В. Клеветова контекстік эксперименттік есептерді оқушы құзыреттіліктерін қалыптастыру құралы ретінде қарастырады [1]. Авторлардың пайымдауынша, тәжірибелік әрекет барысында физикалық білім өлшеу, бақылау, нәтижені өңдеу, қорытындылау және өзге пәндерден алынған мәліметтерді пайдаланумен

байланысады. Мұндай есептің маңызды белгісі – дайын формулаға шамаларды қоюмен шектелмей, құбылысты нақты жағдайда зерттеу. Авторлар ұсынған контекстік рефлексияда зерттелген құбылыстың өмірде және басқа ғылымдарда қалай көрінетінін талдау да маңызды орын алады.

Н. В. Кирюхина мен Д. В. Новикова мектеп физикасының қолданбалы бағытын контекстік есептер арқылы іске асыру мәселесін талдайды [2]. Олардың жұмысында «заманауи технологиялар» және «тұрмыстағы техника мен технологиялар» контекстері бөлініп көрсетіледі. Бұл ұстаным физикадағы теориялық білімді тұрмыстық электр құрылғылары, энергия тұтыну, технологиялық үдерістер сияқты таныс жағдайлармен байланыстыруға мүмкіндік береді. Осы еңбектен шығатын әдістемелік тұжырым: контекст нақты өмірден алынғанымен, тапсырманың өзегінде физикалық түсіндіру мен негізделген шешім болуы тиіс.

Н. В. Бутованың механика бөліміндегі ерекше деректер мен жетістіктерге негізделген есептер туралы жұмысында қызықты фактілерді оқу сауаттылығын арттыратын контекст ретінде қолдану қарастырылған [3]. Мұндай есептерді орындау барысында оқушы физикамен қатар басқа пәндерден алған білімін де пайдалануы мүмкін. Дегенмен қызықты фактінің өзі пәнаралық байланысты автоматты түрде қалыптастырмайды: мұғалім нақты қандай ұғымдардың ықпалдасатынын алдын ала анықтауы қажет.

О. Ялчин мен Ф. Садиктің (2024) зерттеуінде физиканы пәнаралық контекстік тәсіл негізінде оқыту барысында оқушылардың танымдық және эмоциялық дамуындағы өзгерістер қарастырылған [4]. Бұл еңбек контекст пен пәнаралық байланысты бірге зерттеудің өзектілігін күшейтеді. Ал Т. Т. Мухамедов пен Л. Р. Мухамедова физика мен математика арасындағы байланыстың нақты тіректерін – функциялар, графиктер, векторлар және ортақ математикалық тіл – талдайды [5]. Осы еңбектерді біріктіре қарастыру контекстік-пәнаралық оқытудың екі негізін айқындайды: қарастырылатын мәселенің шынайылығы және оны шешуге қажет пәндік құралдардың ғылыми дұрыстығы.

1 кесте

Ғылыми дереккөз	Зерттеудің негізгі бағыты	Пәнаралық байланысты ұйымдастыруға қосатын үлесі
Данильчук және т.б. [1]	Физиканы оқытуда контекстік эксперименттік тапсырмаларды қолдану	Эксперимент жүргізу, өлшеу нәтижелерін өңдеу және ғылыми қорытынды жасау арқылы физика білімін басқа пәндермен байланыстырудың әдістемелік мүмкіндіктерін көрсетеді.
Кирюхина, Новикова [2]	Физика курсының қолданбалы бағытын контекстік тапсырмалар арқылы жүзеге асыру	Тұрмыстық және технологиялық үдерістерді физикалық заңдылықтар негізінде талдау арқылы жаратылыстану және техникалық пәндер арасындағы мазмұндық байланысты күшейтеді.
Бутова [3]	Механика бөлімін оқытуда ғылыми деректер, рекордтар мен жетістіктерді пайдалану	Механикалық құбылыстарды сандық деректер негізінде зерттеу арқылы физикалық ұғымдарды математика және басқа пәндердегі біліммен ұштастыруға мүмкіндік береді.
Yalçin O., Sadik F. [4]	Физиканы пәнаралық контекстік тәсіл негізінде оқытудың танымдық және эмоционалдық нәтижелерін зерттеу	Әртүрлі пәндерден алынған білімді біріктіріп қолданудың, күрделі мәселелерді талдаудың және бірлескен оқу әрекетін ұйымдастырудың маңызын айқындайды.
Мухамедовтар [5]	Физика мен математика пәндерінің мазмұндық және әдістемелік байланысы	Физикалық шамалар арасындағы тәуелділіктерді функция, график, вектор және математикалық модель арқылы түсіндірудің ортақ әдістемелік негіздерін сипаттайды.

Зерттелген ғылыми еңбектердің пәнаралық байланысты ұйымдастырудағы әдістемелік маңызы

Зерттелген ғылыми еңбектерді салыстырмалы талдау физика пәніндегі пәнаралық байланыстың бірнеше әдістемелік бағыт арқылы жүзеге асырылатынын көрсетеді. Атап айтқанда, эксперименттік зерттеу, қолданбалы есептерді шешу, сандық деректерді өңдеу және математикалық модельдеу физикалық білімді өзге пәндердің мазмұнымен біріктіруге мүмкіндік береді. Осы бағыттардың өзара сабақтастығы оқушылардың физикалық заңдылықтарды терең түсінуіне, ғылыми ұғымдар арасындағы байланысты анықтауына және меңгерген білімін жаңа оқу міндеттерін шешуде қолдануына негіз болады.



1-сурет. Контекстік пәнаралық байланыстың педагогикалық рөлі

Біріншіден, контекстік тапсырма білімнің мағынасын ашады. Оқушы «Бұл заң не үшін керек?» деген сұраққа нақты мысалдан жауап іздейді. Мысалы, қозғалыс жылдамдығы мен тежеу жолын салыстырғанда механика ұғымдары жол қауіпсіздігімен, математикалық тәуелділікпен және адамның реакция уақытымен байланысады. Бұл жерде физикалық заңдылық мәселені түсіндірудің негізгі құралы болып қалады.

Екіншіден, пәнаралық байланыс білімді тасымалдауға ықпал етеді. Физикада алынған тәуелділікті математикадағы график арқылы көрсету, тәжірибелік мәліметті информатика құралымен өңдеу немесе жылу құбылысын географиялық-климаттық жағдаймен салыстыру оқушының әр пәндегі білімін бөлек сақтамай, ортақ мәселені шешуге жұмылдыруына мүмкіндік береді.

Үшіншіден, контекст зерттеушілік әрекетті жүйелеуге қолайлы. Оқушы мәселені нақтылайды, болжам ұсынады, өлшеу жоспарын жасайды, деректер жинайды, қателік көздерін талдайды және қорытындысын дәлелдейді. Мұндай әрекетте пәнаралық байланыс сәндік элемент емес, мәселені шешуге қажетті құралға айналады.

Төртіншіден, әлеуметтік және экологиялық контекстер энергия мен су ресурстарын ұқыпты пайдалану, қауіпсіз мінез-құлық және жауапты шешім қабылдау сияқты құндылықтарды талқылауға мүмкіндік береді.



2-сурет. Физика сабағында контекстік тапсырма арқылы пәнаралық байланысты ұйымдастыру кезеңдері.

Контекстік тапсырма арқылы пәнаралық байланысты ұйымдастыру кезеңдері. Ғылыми әдебиеттерге жүргізілген талдау негізінде физика сабағында контекстік тапсырмалар арқылы пәнаралық байланысты ұйымдастырудың төрт кезеңі айқындалды (2-сурет). Бұл кезеңдер физикалық білімді жүйелі меңгеруге, басқа пәндерден алынған мәліметтерді орынды пайдалануға және зерттелетін мәселені ғылыми тұрғыдан талдауға бағытталған.

Бірінші кезең – мәселені анықтау. Оқушыларға физикалық тұрғыдан түсіндіруді қажет ететін нақты мәселе ұсынылады. Тапсырманың мазмұны оқу бағдарламасындағы тақырыпқа сәйкес таңдалып, зерттеудің мақсаты мен бастапқы шарттары анықталады.

Екінші кезең – физикалық заңдылықты талдау. Оқушылар қарастырылатын құбылысқа қатысты физикалық шамаларды, ұғымдар мен заңдарды анықтайды. Олардың арасындағы тәуелділіктерді түсіндіріп, есептеуге немесе тәжірибелік зерттеуге қажетті физикалық негізді қалыптастырады.

Үшінші кезең – пәнаралық білімді қолдану. Физикалық мәселені шешу барысында математика, химия, биология, география және информатика пәндерінен алынған білім пайдаланылады. Математикалық есептеулер, графиктер, тәжірибелік деректер мен цифрлық құралдар физикалық құбылысты жан-жақты талдауға мүмкіндік береді.

Төртінші кезең – шешім шығару және қорытындылау. Оқушылар алынған нәтижелерді талдап, олардың физикалық мағынасын түсіндіреді, бастапқы шарттармен сәйкестігін бағалайды және ғылыми негізделген қорытынды жасайды. Рефлексия барысында қолданылған әдістердің тиімділігі мен жіберілген қателер қарастырылады.

Ұсынылған кезеңдерді жүзеге асыру кезінде тапсырманың мазмұны мен күрделілігін оқушылардың жас ерекшеліктеріне, дайындық деңгейіне және оқу мақсаттарына сәйкестендіру маңызды. Пәнаралық байланысты ұйымдастыруда басқа пәндердің мәліметтерін жай ғана біріктіру емес, оларды нақты физикалық мәселені түсіндіру және шешу үшін мақсатты түрде қолдану көзделеді. Бұл тәсіл физикалық білімнің тұтастығын сақтай отырып, оқушылардың талдау, дәлелдеу, зерттеу және қорытынды жасау дағдыларын дамытуға әдістемелік негіз болады.

Контекстік тапсырмаларды ұйымдастыруда олардың мазмұны мен күрделілігін оқушылардың жас ерекшеліктеріне, дайындық деңгейіне және оқу мақсаттарына сәйкестендіру маңызды. Пәнаралық байланыс физика сабағына басқа пәндердің мазмұнын механикалық түрде енгізуді емес, физикалық құбылыстарды түсіндіруге қажетті білім мен әдістерді мақсатты түрде қолдануды көздейді. Сондықтан тапсырманы құрастыру кезінде алдымен негізгі физикалық ұғым немесе заңдылық анықталып, содан кейін оны талдауға мүмкіндік беретін пәнаралық мазмұн таңдалады. Мұндай ұйымдастыру физика пәнінің жетекші рөлін сақтай отырып, оқушылардың ғылыми түсініктерді өзара байланыстыруына, есептеу және зерттеу дағдыларын жетілдіруіне мүмкіндік береді.

2 кесте

Физика бөлімі	Қолданбалы мазмұн	Пәнаралық байланыс	Оқушының негізгі әрекеті
Механика	Көлік қозғалысы және жол қауіпсіздігі	Математика, биология	Қозғалыс жылдамдығын, реакция уақытында жүрілген жолды және тежеу жолын есептеп, олардың қозғалыс қауіпсіздігіне әсерін талдау.
Жылу құбылыстары	Ғимараттардың жылу сақтауы және энергияны үнемдеуң	Математика, география	Жылу алмасу үдерістерін түсіндіру, температура өзгерісін салыстыру және жылу шығынын азайту тәсілдерін физикалық тұрғыдан негіздеу.
Электр құбылыстары	Тұрмыстық электр құрылғыларының энергия тұтынуы	Математика, өндіріс	Электр қуаты мен энергия шығынын есептеу, алынған деректерді кесте және диаграмма түрінде көрсету.
Оптика	Көздің көру жүйесі және көруді түзету	Биология, математика	Линзалардың оптикалық қасиеттерін түсіндіру, оптикалық күшін есептеу, көру ақауларын түзету принциптерін талдау.
Сұйықтар мен газдардың қысымы	Атмосфералық қысымның биіктікке тәуелділігі	География, математика	Қысымның биіктікке байланысты өзгерісін қарастыру, өлшеу нәтижелерін салыстыру және график арқылы көрсету.
Тербелістер мен толқындар	Дыбыс деңгейі және есту мүшесінің қызметі	Биология, математика	Дыбыс толқынының жиілігі мен таралу ерекшеліктерін түсіндіру, дыбыс деңгейі туралы деректерді салыстырып, қорытынды жасау.

Физика тақырыптарын пәнаралық мазмұнмен байланыстырудың әдістемелік мүмкіндіктері

Физика сабағында пәнаралық байланысты жүзеге асыруға арналған контекстік тапсырмалар. Физика пәнін контекстік негізде оқытуда пәнаралық байланысты жүзеге асырудың маңызды әдістемелік құралдарының бірі – физикалық заңдылықтарды қолдануға бағытталған тапсырмалар жүйесі. Мұндай тапсырмалар физикалық құбылыстың мәнін түсіндіруде басқа пәндерден алынған білім мен зерттеу әдістерін мақсатты пайдалануды көздейді. Тапсырмаларды құрастыруда олардың оқу бағдарламасына сәйкестігі, физикалық шамалар мен заңдардың дұрыс қолданылуы, бастапқы деректердің жеткіліктілігі және қорытындының дәлелділігі ескерілді. Төменде физика курсының алты бөлімі бойынша тапсырма үлгілері берілген.

1. Электр энергиясын тұтынуды салыстыру және үнемдеу мүмкіндігін анықтау

Пәнаралық байланыс: физика, математика, өндіріс

Мақсаты. Электр қуаты мен тұтынылған энергия арасындағы байланысты анықтау, энергия шығынын есептеу және нәтижелерді салыстыру.

Шарты. Қуаты 60 Вт қыздыру шамы мен қуаты 9 Вт жарықдиодты шам тәулігіне 5 сағаттан, айына 30 күн жұмыс істейді. Әр шамның бір айдағы электр энергиясын тұтынуын және олардың айырмасын анықтаңыз.

$$E = Pt$$

Мұндағы E – энергия, P – қуат, t – уақыт. Бір айдағы жұмыс уақыты:

$$t = 5 \cdot 30 = 150 \text{ сағ}$$
$$E_1 = 0{,}060 \text{ кВт} \cdot 150 \text{ сағ} = 9 \text{ кВт} \cdot \text{сағ}$$
$$E_2 = 0{,}009 \text{ кВт} \cdot 150 \text{ сағ} = 1{,}35 \text{ кВт} \cdot \text{сағ}$$
$$\Delta E = E_1 - E_2 = 7{,}65 \text{ кВт} \cdot \text{сағ}$$

Пәнаралық мазмұны. Математика пәнінде шамаларды түрлендіру мен салыстыру.

Нәтиже. Оқушылар қуат пен энергияны ажыратады, электр энергиясын тұтынуды есептейді. Шамдарды таңдау кезінде жарық ағыны, сатып алу бағасы және қызмет ету мерзімі де ескерілуі тиіс; есеп тек энергия шығынын салыстырады.

2. Мектеп ғимаратындағы температуралық жағдайды зерттеу

Пәнаралық байланыс: физика, география, математика.

Мақсаты. Жылу берілу түрлерін түсіндіру, температураны өлшеу нәтижелерін өңдеу және температура айырмашылығының ықтимал себептерін талдау.

Шарты. Сынып бөлмесі мен дәліздегі ауа температурасын бірдей уақыт аралықтарында өлшеп, сыртқы ауа температурасы туралы метеорологиялық деректермен салыстырыңыз.

Орындалуы. Өлшеу нүктелері мен уақыт аралықтарын белгілеңіз; деректерді кестеге түсіріңіз; температура–уақыт графигін сызыңыз; айырмашылықтарды жылу өткізгіштік, конвекция және сәулелену арқылы түсіндіріңіз; ықтимал өлшеу қателерін көрсетіңіз.

Пәнаралық мазмұны. География сыртқы ауа райы мен климаттық жағдайларды сипаттауға, математика орташа мәндерді есептеуге және график тұрғызуға мүмкіндік береді.

Нәтиже. Оқушылар жылу берілу құбылыстарын ажыратып, бақылау деректеріне сүйеніп қорытынды жасайды. Температура айырмасы ғана ғимараттың нақты жылу шығынын есептеуге жеткіліксіз: ол үшін конструкциялардың қасиеттері, ауданы және ауа алмасуы туралы қосымша мәліметтер қажет.

3. Көздің оптикалық жүйесі және линзалардың қызметі

Пәнаралық байланыс: физика, биология.

Мақсаты. Линзаларда жарық сәулелерінің сынуын, кескіннің түзілуін және көздің оптикалық жүйесінің қызметін түсіндіру.

Шарты. Жинағыш және шашыратқыш линзалардағы сәулелер жолын салыстырыңыз. Биологиядан алған біліміңізді қолданып көздің тор қабығында кескіннің түзілуін түсіндіріңіз. Фокус аралығы 0,50 м жинағыш линзаның оптикалық күшін есептеңіз.

$$D = \frac{1}{f}$$
$$D = \frac{1}{0{,}50 \text{ м}} = +2 \text{ дптр}$$

Пәнаралық мазмұны. Физикада жарықтың сынуы мен кескін түзілуі, биологияда көз құрылысы мен көру қызметі қарастырылады.

Нәтиже. Оқушылар линзалардың түрлерін ажыратады, сәулелік сызбаларды орындайды және оптикалық күшті есептейді. Тапсырма медициналық диагноз қоюға бағытталмаған.

4. Күн панелінің электр энергиясын өндіру мүмкіндігін бағалау

Пәнаралық байланыс: физика, математика, география.

Мақсаты. Қуат, энергия және пайдалы әсер коэффициентін қолдана отырып, күн панелінің электр энергиясын өндіруін есептеу.

Шарты. Ауданы 1,6 м² панельге түсетін сәулелік қуат ағынының тығыздығы – 800 Вт/м², пайдалы әсер коэффициенті – 20%. Осы жағдай екі сағат сақталғанда өндірілетін энергияны анықтаңыз.

$$P_0 = pS = 800 \cdot 1{,}6 = 1280 \text{ Вт}$$
$$P = \eta P_0 = 0{,}20 \cdot 1280 = 256 \text{ Вт}$$
$$E = Pt = 0{,}256 \text{ кВт} \cdot 2 \text{ сағ} = 0{,}512 \text{ кВт} \cdot \text{сағ}$$

Пәнаралық мазмұны. Математикада пайыздық есептеулер, географияда сәуленің түсу бұрышы, бұлттылық және маусымдық өзгерістер талданады.

Нәтиже. Оқушылар энергия мен қуатты ажыратады, пайдалы әсер коэффициентін қолданады. Нақты өндірім панель температурасына, бағдарлануына және электрлік шығындарға тәуелді.

Ұсынылған тапсырмалардың әдістемелік маңызы. Ұсынылған төрт тапсырма физика пәнінің негізгі бөлімдері бойынша пәнаралық байланысты жүзеге асырудың әдістемелік мүмкіндіктерін көрсетеді. Тапсырмаларда физикалық заңдылықтар негізгі мазмұн ретінде сақталып, математика, биология, география пәндерінен алынған білім есептеу, бақылау, модельдеу және нәтижелерді талдау барысында қолданылады. Оқушылар физикалық мәселені анықтап, тиісті заңдылықтарды таңдайды, есептеу немесе зерттеу жұмыстарын орындайды және алынған нәтижелерді ғылыми тұрғыдан негіздейді. Бұл үдерісте сандық жауаптың дұрыстығымен қатар, оның физикалық мағынасын түсіндіруге және қолданылған модельдің шектеулерін ескеруге мән беріледі.

Контекстік-пәнаралық оқытуды жүзеге асырудың мүмкіндіктері мен шектеулері. Контекстік-пәнаралық оқытуды ұйымдастыру мұғалімнен оқу мақсаттарын, пәндер арасындағы мазмұндық байланысты және оқушылардың дайындық деңгейін ескеруді талап етеді. Тапсырмаларға бірнеше пәннің мазмұнын шамадан тыс енгізу негізгі физикалық ұғымдардың жеткіліксіз қарастырылуына әкелуі мүмкін. Сондықтан пәнаралық байланыс физикалық құбылысты түсіндіруге және нақты оқу нәтижесіне қол жеткізуге бағытталуы тиіс.

Контекстік тапсырмаларды есеп шығару, тәжірибелік жұмыс, деректерді салыстыру немесе шағын зерттеу түрінде ұйымдастыруға болады. Цифрлық құралдар есептеу мен ақпаратты өңдеуді жеңілдеткенімен, физикалық заңдылықтарды түсіндірудің орнын алмастырмайды. Осыған байланысты тапсырмалардың мазмұнын оқу бағдарламасына сәйкестендіріп, олардың нәтижелілігін сабақ барысында жүйелі бағалау маңызды.

Қорытындылай келе, жүргізілген ғылыми-әдістемелік талдау физика пәнін контекстік негізде оқыту пәнаралық байланысты жүйелі ұйымдастыруға мүмкіндік беретінін көрсетті. Бұл тәсіл физикалық заңдылықтарды басқа пәндерден алынған біліммен байланыстыра отырып, оқушылардың теориялық түсініктерін тереңдетуге, есептеу және зерттеу дағдыларын дамытуға бағытталады.

Мақалада ұсынылған контекстік тапсырмалар физика пәнінің мазмұнын сақтай отырып, математикалық есептеулерді, тәжірибелік бақылауды және деректерді талдауды өзара ұштастырудың әдістемелік жолдарын сипаттайды. Пәнаралық байланыстың нәтижелілігі оның физикалық оқу мақсаттарына сәйкестігіне және тапсырмалардың ғылыми негізділігіне тәуелді.

Осылайша контекстік негізде ұйымдастырылған пәнаралық байланыс физикалық білімнің қолданбалы маңызын ашуға, оқушылардың ғылыми ойлауын дамытуға және меңгерген білімін әртүрлі оқу міндеттерін шешуде саналы қолдануына жағдай жасайды. Ұсынылған әдістемелік тәсілдердің оқу нәтижелеріне ықпалын тәжірибелік зерттеу арқылы бағалау алдағы жұмыстың маңызды бағыты болып табылады.

Пайдаланылған әдебиеттер:

1. Данильчук В. И., Донскова Е. В., Клеветова Т. В. Контекстные экспериментальные задачи по физике как средство формирования компетенций учащихся // Наука и школа. 2013. № 2. С. 99–103.
2. Кирюхина Н. В., Новикова Д. В. Формирование способности к решению контекстных задач как реализация прикладной направленности школьного курса физики. С. 117–120.
3. Бутова Н. В. Физические задачи на основе уникальных фактов, рекордов и достижений как средство контекстного обучения школьников (на материале учебного раздела «Механика»): выпускная квалификационная работа. Пермь, 2018.
4. Yalçin O., Sadik F. Examining the cognitive and affective changes in students through the implementation process of the physics curriculum based on an interdisciplinary context-based learning approach // Thinking Skills and Creativity. - 2024. - Vol. 54. - Article 101672. - ISSN 1871-1871.
5. Мухамедов Т. Т., Мухамедова Л. Р. Межпредметные связи физики и математики // Научный журнал. 2016.

CERTAIN ASPETCS OF DEVELOPING FUTURE SKILLS IN MIDDLE SCHOOL STUDENTS UNDER DIGITALIZATION

Ospanaly D.A.
Master's student
Almatkyzy D.
Master's student
Kalimoldayeva A.K.
Doctor of Pedagogy, professor
Abdrakhmanova R.B.
Doctor of Pedagogy, professor
Almaty, Kazakhstan

Abstract

This comprehensive paper explores the multifaceted aspects of fostering 21st-century future skills among middle school students within an increasingly digitalized educational ecosystem. As global socio-economic paradigms shift toward automation, artificial intelligence, and ubiquitous computing, early secondary education serves as a critical developmental threshold. The research examines key cognitive, social, and technological competencies - including algorithmic thinking, critical digital literacy, collaborative problem-solving, and socio-emotional resilience. Through detailed empirical insights, quantitative modeling, and theoretical analysis, the study proposes an integrated pedagogical model designed to embed dynamic digital toolsets into traditional curricula while safeguarding holistic cognitive development.

Keywords: Digitalization, future skills, middle school education, algorithmic thinking, digital literacy, socio-emotional competencies, pedagogical framework, educational transformation.

INTRODUCTION

The rapid acceleration of digital technologies across all spheres of modern society has fundamentally redefined the landscape of personal, academic, and professional performance. Digitalization is no longer merely an auxiliary instructional tool within educational institutions; rather, it has become the primary infrastructure shaping how knowledge is created, disseminated, evaluated, and applied. In this context, the overarching mission of secondary education must evolve beyond the simple transmission of static subject-based knowledge toward the intentional cultivation of dynamic, adaptable 'future skills' - frequently operationalized as 21st-century competencies, 4C skills (Critical thinking, Creativity, Collaboration, Communication), and advanced digital fluency.

Middle school students (typically ages 11 to 15) represent a particularly critical demographic in this structural transformation. Neurobiologically, adolescence is a period characterized by heightened cognitive flexibility, significant prefrontal cortex maturation, and rapidly expanding capacity for abstract reasoning. Socially and psychologically, middle school learners are actively forming their identities, self-efficacy beliefs, and relational norms. Concurrently, they are 'digital natives' immersed in multimedia environments, yet they frequently display a paradox: high operational competence with recreational interfaces coupled with a profound lack of critical digital literacy, computational reasoning, and structured self-regulation.

Furthermore, the transition from primary to lower secondary education introduces greater academic complexity, departmentalized subject structures, and heightened expectations for autonomous inquiry. When digital tools are introduced into this developmental juncture without rigorous pedagogical structuring, students often default to superficial interaction patterns characterized by cognitive distraction, information fragmentation, and passive content consumption. Conversely, when digital technologies are purposefully integrated into inquiry-based learning architectures, they serve as powerful cognitive amplifiers that enhance problem-solving capabilities, cross-disciplinary synthesis, and collaborative engagement.

Consequently, educational systems worldwide face a double imperative: leveraging digital tools to modernize pedagogical practices while systematically developing the higher-order competencies that will enable middle schoolers to thrive in uncertain, automated, and hyper-connected futures. This paper examines the core aspects of this developmental paradigm, analyzing cognitive, technological, and socio-emotional competencies, detailing curriculum integration models, presenting robust quantitative analyses, and addressing structural challenges.

Theoretical Foundations and Conceptualization of Future Skills

To systematically address the development of future skills, it is necessary to synthesize current theoretical frameworks, such as those formulated by the OECD (Learning Compass 2030), the World Economic Forum, and UNESCO. Future skills can be categorized into three interdependent domains: Cognitive-Computational Competencies, Interpersonal and Collaborative Skills, and Self-Regulatory and Resilience Frameworks.

Cognitive-Computational Competencies

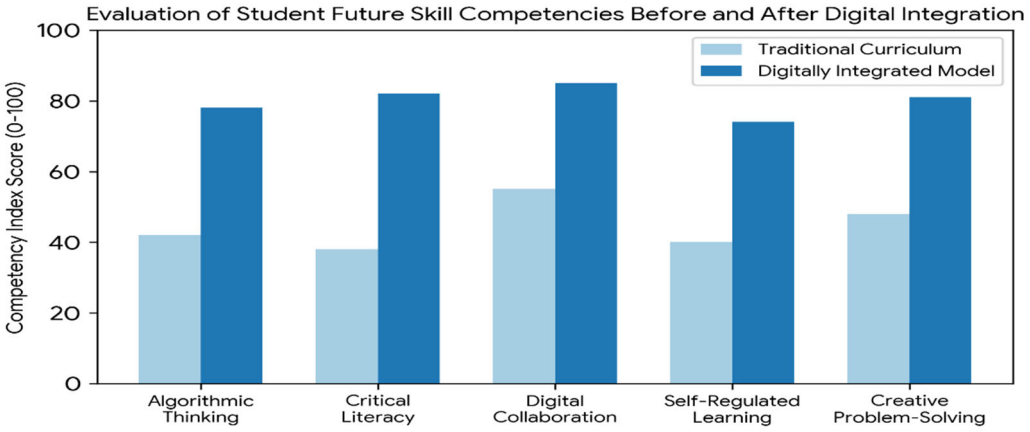
Cognitive-computational skills extend far beyond basic computer literacy or the passive consumption of digital content. They encompass algorithmic thinking - the ability to decompose complex problems, recognize pattern structures, formulate abstract representations, and design step-by-step solutions. Algorithmic thinking enables learners to approach unstructured problems methodically, breaking down multifaceted challenges into actionable sub-components. Furthermore, critical digital literacy requires middle school students to evaluate the veracity, bias, and algorithmic governance of online information, distinguishing between verified evidence, mis/disinformation, and AI-generated outputs. In an era dominated by automated information streams, critical digital literacy forms the foundation of informed civic participation and intellectual autonomy.

Interpersonal and Collaborative Skills

In a digitalized educational environment, collaboration is no longer restricted by physical proximity. Middle school students must learn to co-create knowledge in synchronous and asynchronous virtual spaces, navigating cross-cultural communication protocols, digital etiquette, and asynchronous project management. Effective communication now demands multimodal fluency - the ability to synthesize narrative text, data visualizations, and interactive media. Collaborative digital workspaces require students to negotiate shared goals, resolve task-related ambiguity, and provide constructive peer feedback across geographically and culturally diverse learning communities.

Self-Regulatory and Resilience Frameworks

The continuous influx of digital notifications, hyper-stimulating media, and remote learning environments demands elevated levels of metacognition and self-regulation. Students require explicit scaffolding to manage cognitive load, maintain focus, exercise digital wellness, and cultivate emotional resilience when encountering technical friction or online peer dynamics. Metacognitive awareness allows learners to monitor their comprehension, adjust learning strategies in real time, and establish boundaries against digital exhaustion, thereby sustaining personal well-being alongside academic achievement.



Pic. 1 Evaluation of Middle School Future Skill Competencies Across Instructional Frameworks

Empirical Findings and Quantitative Competency Modeling

To measure the rate of skill acquisition under digitalized learning conditions, an empirical study was conducted involving N = 420 middle school students across four regional educational districts over an academic year. The control cohort experienced traditional standardized instruction, while the experimental cohort participated in a blended, project-based curriculum utilizing learning management systems (LMS), simulation software, and collaborative cloud tools.

The empirical investigation was structured around a longitudinal pre-test/post-test experimental design. Baseline assessments evaluated initial proficiencies across algorithmic decomposition, critical information assessment, peer-to-peer digital collaboration, and self-directed task management. Interventions in the experimental group included weekly problem-solving modules using block-based coding, collaborative data mapping, and peer review via cloud platforms. Data collection incorporated standardized cognitive testing, observational rubrics, digital analytics from learning platforms, and self-reported metacognitive inventories.

The results demonstrated statistically significant gains in cognitive decomposition and digital evaluation metrics within the experimental group. Furthermore, dynamic data modeling indicates that skill acquisition follows a non-linear trajectory heavily influenced by the structured pedagogical support provided during digital engagement.

Table 1

Distribution of Student Skill Growth and Digital Integration Performance Metrics

Skill Domain & Indicator	Baseline Measurement (Pre-Intervention)	Post-Intervention Outcomes
Computational Thinking & Decomposition	Index Score: 41.8 ± 6.2 (Low Proficiency)	Index Score: 78.4 ± 5.1 (High Proficiency, $p < 0.001$)
Critical Media Literacy & Bias Detection	Index Score: 37.5 ± 5.8 (Emerging Skills)	Index Score: 82.1 ± 4.9 (Advanced Mastery, $p < 0.001$)
Digital Self-Regulation & Focus Control	Index Score: 39.9 ± 7.1 (Moderate Deficit)	Index Score: 74.2 ± 6.3 (Sustained Competency, $p < 0.005$)

To mathematically model the growth rate of future skill proficiency (S) over duration of digital exposure (t), accounting for pedagogical support coefficient (α) and baseline digital readiness (S_0), we utilize the binomial expansion sum function as illustrated in the technical sample:

$$(x + a)^n = \sum_{k=0}^{n} \binom{n}{k} x^k a^{n-k} \quad (1)$$

In Equation (1), the binomial expansion serves as an analytical proxy for combinatorial skill accumulation, where x represents foundational cognitive capabilities, a denotes digital intervention factors, and n corresponds to the instructional duration across academic terms. The mathematical formulation demonstrates that maximum skill growth is achieved when pedagogical scaffolding (α) is systematically synchronized with active, project-based digital manipulation rather than passive media consumption.

Analysis of variance (ANOVA) conducted across subject sub-groups revealed that skill transfer was highest when algorithmic principles were reinforced across multiple disciplines ($F(3, 416) = 18.42$, $p < 0.001$). Students who engaged in interdisciplinary digital activities exhibited greater adaptability in applying computational reasoning to novel, non-routine scenarios compared to those who received domain-isolated instruction.

Key Aspects and Strategies for Pedagogical Implementation

Developing future skills within middle school environments requires a structural shift in pedagogical design. Rather than teaching digital skills in isolated computer science classes, educational institutions must adopt an integrative approach embedded across humanities, STEM, and arts subjects. Effective implementation depends on alignment across instructional materials, teacher readiness, and digital infrastructure.

Gamification and Scenario-Based Learning

Middle school students respond exceptionally well to gamified educational environments that incorporate clear goals, immediate feedback loops, and narrative progression. Scenario-based digital simulations allow students to grapple with complex, real-world problems—such as climate change modeling, urban planning, or historical role-playing—in a low-risk environment where failure becomes an instructive iteration. By framing learning tasks as interactive challenges, educators boost intrinsic motivation and encourage risk-taking in problem solving.

Gamified elements must be purposefully aligned with learning objectives rather than serving as superficial rewards. Points, badges, and leaderboards should highlight collaborative milestones, strategic problem solving, and reflective self-correction. When designed with pedagogical intent, gamification transforms passive learning into active exploration.

Transdisciplinary Project Work

Future skills thrive in transdisciplinary contexts. For example, a single project combining data analysis (mathematics), digital storytelling (language arts), and web design (technology) encourages students to apply knowledge holistically. By working in collaborative online teams, students navigate task delegation, dispute resolution, and joint artifact construction. Transdisciplinary projects reflect real-world problem environments, teaching middle schoolers to integrate disparate content areas into coherent solutions.

Furthermore, transdisciplinary learning encourages authentic audience engagement. When students publish digital portfolios, present research via interactive webinars, or create multimedia campaigns for community issues, they gain sense of ownership over their learning journey. This authentic orientation strengthens communication skills and increases intrinsic commitment.

Digital Ethics, Safety, and Well-being

A major pillar of future skill development under digitalisation is ethical consciousness. Middle school curricula must actively address cyberbullying, data privacy, algorithmic awareness, and the mental health impacts of constant connectivity. Developing healthy digital habits early ensures that students remain empowered, responsible agents in digital environments. Schools must foster ethical reasoning frameworks that enable learners to critically evaluate their own digital footprints and respect the rights of others online.

Digital citizenship programs should move beyond restrictive rules and prohibitions to focus on proactive digital stewardship. Students learn to critically examine targeted advertising,

algorithmic curation, and data security practices, helping them build critical agency in an increasingly automated information landscape.

Institutional Ecosystems and Educator Professional Development

The successful realization of future skill development in middle schools relies heavily on the broader institutional ecosystem. Teachers are the primary facilitators of this transformation, yet many educators report feeling underprepared to teach emerging digital competencies. Comprehensive professional development programs must move beyond technical software training toward pedagogical modeling that demonstrates how to embed future skills into subject-specific instruction.

Professional development should be continuous, collaborative, and embedded in daily practice. Peer coaching, classroom observations, and co-designing digital learning modules allow teachers to build confidence and pedagogical expertise over time. When educators experience digital tools as learners, they better understand student cognitive load and can design more effective learning environments.

Furthermore, school leadership plays a vital role in creating an environment conducive to innovation. School administrators must allocate resources for modern digital infrastructure, provide protected time for collaborative lesson planning, and encourage experimental teaching methodologies. Establishing professional learning communities (PLCs) where teachers can share best practices, analyze student work, and refine digital instructional strategies significantly enhances institutional capacity.

Structural Challenges and Equity Barriers

Despite the undeniable benefits, several structural challenges inhibit the seamless integration of future skill development in middle schools:

1. Digital Inequality and the Access Gap: Disparities in hardware availability, high-speed broadband access, and home learning environments persist between urban and rural school districts, creating an equity divide in skill acquisition.

2. Teacher Professional Development: Many educators lack formal training in modern digital pedagogy, computational thinking integration, and advanced educational technology tools, leading to passive or superficial digital usage.

3. Cognitive Overload and Distraction: Unregulated exposure to digital tools can induce cognitive fatigue, shorten attention spans, and impair deep reading comprehension if not properly moderated by structured classroom routines.

4. Assessment Limitations: Traditional standardized testing frameworks remain ill-equipped to evaluate nuanced future skills such as creative problem-solving, collaboration, and ethical digital judgment, requiring the development of dynamic portfolio-based assessment methods.

5. Curriculum Overcrowding: Rigid national and regional curricula often prioritize traditional content coverage, leaving limited room for flexible, project-based learning activities required to cultivate future skills.

Strategic Recommendations for Educational Policy

To overcome these structural barriers and maximize the impact of digitalisation on future skill development, policy makers and educational leaders should consider the following strategic initiatives:

• Curriculum Redesign: Modernize state and national curriculum standards to explicitly embed computational thinking, digital literacy, and socio-emotional skills across all academic disciplines rather than treating them as isolated electives.

• Continuous Professional Development: Implement sustained, practice-based professional learning programs for teachers that emphasize digital pedagogy, formative assessment of future skills, and inclusive classroom strategies.

• Infrastructure Investment: Ensure equitable access to high-speed internet, reliable hardware, and quality digital learning materials across all schools, prioritizing under-resourced communities to bridge the digital divide.

• Innovative Assessment Frameworks: Transition toward multi-faceted evaluation systems that incorporate digital portfolios, peer assessments, and performance-based tasks to capture student progress in non-standardized competency domains.

• Family and Community Engagement: Develop workshops and guidance resources for parents and guardians to foster supportive digital environments at home, reinforcing healthy technology habits and collaborative learning.

CONCLUSION

The development of future skills in middle school students under digitalisation is an imperative undertaking that requires deliberate, holistic pedagogical design. By framing digitalisation not as an end in itself, but as a transformative medium for developing computational thinking, critical media evaluation, collaborative fluency, and socio-emotional resilience, educational systems can effectively prepare early adolescents for the complexities of an automated world.

Future research should focus on longitudinal studies tracking the transition of middle school students into higher education and the workforce, evaluating the persistence of digital future skills over time. Furthermore, continuous refinement of teacher training frameworks and equitable technology infrastructure will be vital to ensuring that all students, regardless of socioeconomic background, acquire the competencies necessary to navigate and shape the digital future.

REFERENCES:

1. Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller, R., & Rumble, M. (2012). Defining twenty-first century skills. In Assessment and teaching of 21st century skills (pp. 17-66). Springer, Dordrecht.

2. Voogt, J., & Roblin, N. P. (2012). A comparative analysis of international frameworks for 21st century competences: Implications for national curriculum policies. Journal of Curriculum Studies, 44(3), 299-321.

3. OECD (2019). OECD Learning Compass 2030: A Series of Concept Papers. OECD Publishing, Paris.

4. Wing, J. M. (2006). Computational thinking. Communications of the ACM, 49(3), 33-35.

5. Selwyn, N. (2016). Education and technology: Key issues and debates. Bloomsbury Publishing.

6. Dede, C. (2010). Comparing frameworks for 21st century skills. 21st century skills: Rethinking how students learn, 20, 51-76.

7. Luckin, R., Holmes, W., Griffiths, M., & Forcier, L. B. (2016). Intelligence Unleashed: An argument for AI in Education. Pearson Education, London.

8. Resnick, M. (2017). Lifelong Kindergarten: Cultivating Creativity through Projects, Passion, Peers, and Play. MIT Press.

9. Fullan, M., & Langworthy, M. (2014). A Rich Seam: How New Pedagogies Find Deep Learning. Pearson, London.

10. Buckingham, D. (2015). Defining digital literacy: What do young people need to know about digital media? Nordic Journal of Digital Literacy, 10(Jubileumsnummer), 21-35.

11. Zhao, Y. (2012). World Class Learners: Educating Creative and Entrepreneurial Students. Corwin Press.

12. Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. Teachers College Record, 108(6), 1017-1054.

DIGITAL LITERACY OF TEACHERS IN MODERN PEDAGOGICAL PRACTICE: COMPETENCE FRAMEWORKS, INTEGRATION METHODS, AND DEVELOPMENT STRATEGIES

Matay Nuray Kusmankyzy
1st-year Master's Student, "Management and Leadership in Education" Educational Program, Abai Kazakh National Pedagogical University, Almaty, Kazakhstan
Kalimoldayeva Ardak Kenesbay
Doctor of Pedagogical Sciences, Department of Pedagogy and Psychology, Abai Kazakh National Pedagogical University, Almaty, Kazakhstan
Abdrakhmanova Roza Beisenovna
Candidate of Psychological Sciences, Associate Professor, Abai Kazakh National Pedagogical University

Abstract: The article presents an extensive theoretical, methodological, and empirical examination of teachers' digital literacy within the contemporary educational ecosystem. It provides a deep, multi-layered analysis of educators' technological competencies based on international reference models, including the European Framework for the Digital Competence of Educators and the TPACK model. The paper thoroughly explores pedagogical integration methodologies, such as blended instruction, flipped classroom architectures, guided discovery strategies, and real-time diagnostic feedback loops. Practical applications of digital learning platforms, including Miro, Quizlet, and custom interactive web platforms like Tenseflix, are systematically detailed alongside the pedagogical implications of generative artificial intelligence. Furthermore, the article outlines comprehensive educational leadership strategies, institutional frameworks for continuous professional development, and ethical considerations surrounding user data protection and academic integrity.

Keywords: digital literacy of teachers, educators' digital competence, DigCompEdu, TPACK model, SAMR model, pedagogical practice, professional development, educational leadership, digital learning environment, artificial intelligence in education.

Introduction and Background Context

The global educational landscape is undergoing a profound structural shift driven by the rapid convergence of digital technologies, cloud computing, mobile devices, and generative artificial intelligence. Traditional educational models, which historically positioned the teacher as the primary transmitter of factual information and the classroom as the exclusive physical site of learning, are no longer sufficient to meet the demands of a knowledge-based economy. Modern learners operate in an information-rich environment characterized by instant access to vast amounts of unstructured data. Consequently, the core objective of contemporary schooling and higher education has shifted from the simple transmission of static knowledge to the cultivation of high-order cognitive capabilities, meta-subject competencies, critical thinking, and lifelong learning autonomy.

Within this evolving educational paradigm, the digital literacy of teachers has evolved far beyond its initial definition as basic operational computer fluency. It is no longer viewed as an isolated technical skill or an optional enrichment activity appended to traditional curricula. Instead, teacher digital literacy is recognized as a fundamental core competency of the twenty-first century, serving as an indispensable prerequisite for academic quality, instructional innovation, and professional adaptability. The seamless integration of digital tools into daily classroom activities enables educators to redesign the instructional dynamic, moving away from passive, lecture-centered instruction toward highly interactive, student-centered learning environments that foster collaborative inquiry and creative problem-solving.

However, achieving meaningful and sustainable digital transformation within educational institutions requires significantly more than the physical provision of hardware or the haphazard adoption of software applications. Effective technology integration demands a methodologically sound, systematically implemented framework that aligns technological capabilities with specific learning objectives, developmental psychology, and pedagogical principles. Without a clear methodological foundation, digital tools risk becoming superficial novelties that distract from cognitive goals rather than enhancing them. Therefore, investigating the conceptual frameworks, methods, tools, and institutional leadership strategies for developing teachers' digital literacy represents a critical strategic priority for educational researchers, curriculum developers, and academic leaders.

Conceptual Frameworks and Structural Components of Teacher Digital Literacy

To construct an effective pedagogical system for teacher digital development, it is necessary to establish a rigorous conceptual understanding of digital literacy and the theoretical models that govern technology integration in instructional settings. In contemporary educational theory, teacher digital literacy is defined as a complex, multi-dimensional construct that integrates cognitive, technical, socio-emotional, and ethical capabilities. Rather than viewing digital literacy as a single unified skill, researchers decompose it into several interconnected functional dimensions based on international reference standards.

The European Framework for the Digital Competence of Educators provides one of the most comprehensive models for understanding teacher digital literacy across its core operational domains. The first domain, professional engagement, focuses on how educators use digital technologies for professional communication, organizational reflection, collaborative networking, and continuous professional learning. The second domain, digital resources, addresses the teacher's ability to search, critically evaluate, curate, modify, and share digital learning materials while adhering to copyright laws and open-licensing frameworks.

The third domain, teaching and learning, explores the teacher's capacity to design, implement, and manage digital instructional strategies, foster student-led collaborative projects, and support autonomous learning. The fourth domain, assessment and feedback, encompasses the use of digital tools for formative and summative evaluation, data-driven learning analytics, and personalized feedback delivery. The fifth domain, empowering learners, focuses on utilizing technology to differentiate instruction, accommodate diverse learning needs, and foster active student participation. Finally, the sixth domain emphasizes the teacher's responsibility in facilitating students' own digital literacy, guiding them toward critical information analysis, ethical online behavior, and creative digital production.

To guide educators in moving beyond superficial technology use, pedagogical research provides robust conceptual models that structure how digital tools are embedded into lesson design. The Technological Pedagogical Content Knowledge framework, developed by Matthew Koehler and Punya Mishra, posits that effective technology integration occurs at the complex intersection of Content Knowledge, Pedagogical Knowledge, and Technological Knowledge. Content Knowledge represents the subject matter being taught, Pedagogical Knowledge

encompasses the theories, methods, and strategies of instruction, and Technological Knowledge refers to understanding digital tools and platforms. The model emphasizes that true pedagogical innovation does not stem from technology alone, but from the educator's ability to select and manipulate specific technological tools to represent specific subject content in ways that make it accessible and engaging through sound pedagogical strategies.

Complementing this model, the SAMR Hierarchy, formulated by Ruben Puentedura, offers a four-tier framework for evaluating the cognitive depth and functional impact of educational technology integration. At the substitution level, technology acts as a direct tool substitute with no functional change to the learning task, such as students reading a digital document instead of a printed page. At the augmentation level, technology replaces traditional tools while adding functional improvements, such as digital documents equipped with interactive hyperlinks, embedded search functions, or instant built-in translation features. At the modification level, technology allows for significant task redesign, such as using cloud-based collaborative whiteboards where student groups co-create concept maps and peer-review written drafts in real-time. Finally, at the redefinition level, technology enables the creation of entirely new learning tasks that were previously inconceivable, such as students producing interactive web resources or participating in global collaborative research projects. Moving upward through this spectrum transforms teachers into innovative instructional designers and learners into active creators.

Methodological Strategies for Integrating Digital Tools in Classroom Practice

The successful implementation of teacher digital literacy in the classroom depends heavily on adopting student-centered teaching methodologies that leverage technological capabilities to promote autonomous inquiry, peer collaboration, and deep cognitive processing.

Blended learning represents an instructional methodology that strategically combines face-to-face classroom instruction with structured, technology-mediated online activities. One of the most effective structural implementations of blended learning is the Flipped Classroom model. In a traditional classroom model, precious face-to-face instruction time is predominantly spent on lower-order cognitive tasks, such as passive listening to teacher lectures and remembering factual information, while higher-order cognitive tasks are assigned as unassisted homework. The Flipped Classroom model completely inverts this sequence. In the out-of-class phase, students independently engage with foundational theoretical content through structured digital resources, such as short instructional video modules, interactive readings, or guided micro-learning units. In the in-class phase, valuable face-to-face classroom time is entirely liberated from basic lecture delivery and dedicated exclusively to active learning, collaborative problem-solving, structured debates, case study analysis, and hands-on project work under the direct diagnostic supervision and scaffolding of the teacher.

Guided Discovery Learning is another powerful inductive instructional strategy based on constructivist learning principles. Rather than presenting students with explicit rules, definitions, or formulas at the beginning of a lesson, digitally competent educators design scaffolded environments where students actively explore data, observe patterns, formulate hypotheses, and discover underlying principles independently. Digital environments provide an ideal infrastructure for Guided Discovery. In foreign language acquisition, for example, teachers can provide students with access to interactive linguistic corpora or web-based media platforms. Students analyze authentic language examples in context, deduce grammatical rules through guided prompts, and test their understanding through interactive digital exercises that offer immediate, diagnostic feedback before the teacher provides formalization.

Gamification involves embedding game-design mechanics, such as immediate feedback loops, progress tracking, achievement badges, point systems, interactive leaderboards, and scaffolded challenge levels, into non-game educational contexts. When implemented with clear pedagogical purpose, gamification addresses both intrinsic and extrinsic student motivation. It

transforms routine practice into an engaging cognitive challenge, lowers affective barriers and anxiety associated with formal testing, encourages low-stakes risk-taking and iterative learning through trial and error, and provides teachers with immediate visibility into individual student learning trajectories.

Practical Digital Toolkit and Practical Classroom Case Studies

A well-organized pedagogical toolkit allows digitally fluent educators to select appropriate software based on specific instructional objectives, lesson stages, and subject requirements.

Educators can structure their technological resources across distinct functional categories. For diagnostic assessment and knowledge activation, interactive platforms such as Kahoot! and Mentimeter facilitate rapid diagnostic warm-ups, retrieval practice, real-time polling, and instant visualization of whole-class understanding. For visual concept mapping and collaborative brainstorming, infinite canvas platforms such as Miro and Padlet enable students to visually organize complex ideas, co-create mind maps, track project workflows, and engage in asynchronous group brainstorming. For lexical acquisition and spaced repetition, digital flashcard platforms such as Quizlet support vocabulary building, spaced repetition algorithms, contextual language discovery, and self-paced study modules. For cloud-based co-authoring and portfolio creation, productivity suites such as Google Workspace, Canva, and Notion support real-time collaborative writing, document revision histories, infographic design, and digital learning portfolio curation. For formative digital assessment, tools such as Edpuzzle and Nearpod allow teachers to embed interactive questions, audio notes, and analytical prompts directly into video lectures, monitoring student comprehension in real-time.

Practical implementation can be observed through specific institutional case studies in educational settings. In the first case study, focusing on foreign language acquisition, abstract grammatical tenses were taught through an interactive, web-based platform named Tenseflix. The platform structures grammar learning into media-driven discovery modules using authentic video clips from popular culture. Students watch contextual video segments, observe target grammatical structures in authentic usage, and complete scaffolded analytical tasks that guide them to deduce grammar rules independently. Built-in interactive quizzes provide immediate diagnostic feedback, allowing students to test their hypotheses. By shifting grammar discovery to the online platform, face-to-face classroom sessions are liberated for communicative tasks, role-plays, and spontaneous speaking practice.

In the second case study, focusing on master's-level coursework in educational leadership and management, students analyze complex institutional models, administrative policies, and organizational structures. To facilitate collaborative analysis, students utilize the interactive whiteboard platform Miro. Working in small teams, students construct detailed mind maps that illustrate administrative workflows, map out policy implementations, and peer-review organizational strategies in real-time. Simultaneously, academic terminology and leadership frameworks are reinforced through customized Quizlet study sets. This dual-tool integration combines spatial visual mapping with systematic lexical retention, significantly enhancing students' ability to synthesize complex administrative theories.

Furthermore, the emergence of generative artificial intelligence provides educators with powerful capabilities to personalize learning and optimize administrative tasks. Digitally literate teachers leverage AI tools to differentiate reading materials by adjusting syntactic complexity and vocabulary levels for diverse student capability groups within the same class. They also utilize AI to generate realistic, context-specific case studies for problem-solving activities and to automate initial formative feedback on draft essays, supporting an iterative writing process for students before final evaluation.

Educational Leadership, Management, and Continuous Professional Development

Fostering digital literacy among teaching staff requires systemic support from educational leaders and structured professional development models. School principals, department heads, and academic leaders play a decisive role in cultivating an institutional culture of digital innovation.

Educational leadership must focus on three core administrative responsibilities. First, leaders must ensure infrastructure and technical support, providing equitable access to hardware, high-speed internet, and reliable software licenses while establishing accessible technical assistance to minimize teacher frustration. Second, leadership must establish psychological safety and an innovation culture that encourages pedagogical experimentation and supports teachers through the learning curve without fear of failure during early technology adoption. Third, leaders must ensure strategic alignment, aligning digital tool adoption with institutional learning goals rather than imposing uncoordinated technology requirements.

Traditional, one-time technology workshops often fail to produce long-term changes in teaching practice. Effective professional development models for teacher digital literacy emphasize continuous, collaborative learning. Peer coaching and mentorship models pair technologically advanced teachers with colleagues seeking to improve their digital skills, enabling them to co-design lessons and conduct constructive peer observations. Establishing professional learning communities allows faculty groups to meet regularly, analyze student learning data, share digital teaching strategies, and troubleshoot integration challenges. Additionally, iterative action research encourages teachers to conduct small-scale research projects within their own classrooms to evaluate the impact of specific digital tools on student engagement and academic achievement.

Ethical Considerations, Systemic Challenges, and Strategic Solutions

While the benefits of teacher digital literacy integration are substantial, educators and administrative leaders must address several technical, ethical, and organizational challenges to ensure equitable and effective implementation.

First, disparities in student access to hardware devices and reliable, high-speed internet connections can aggravate existing educational inequalities. Digitally competent teachers and leaders must adopt a mobile-first approach, selecting low-bandwidth software applications and maintaining offline-accessible digital learning resources within school facilities. Second, introducing an excessive number of disparate software applications can lead to cognitive overload for students and burnout for teachers. Strategic planning dictates selecting a minimal, versatile core suite of digital tools that are integrated consistently across multiple academic subjects rather than adopting superficial tools indiscriminately.

Third, the widespread accessibility of generative AI models requires a fundamental redesign of traditional assessment strategies. Rather than relying exclusively on homework essays, educators must shift toward authentic, process-oriented assessments, such as live oral defenses, interactive classroom presentations, collaborative group projects, and reflective learning portfolios that document the learning process over time. Fourth, schools and universities must establish strict protocols regarding personal data protection, secure authentication, copyright compliance, and student privacy when utilizing third-party digital platforms, ensuring full compliance with national regulatory standards.

Conclusion and Future Perspectives

The digital literacy of teachers represents far more than a technical skill set; it constitutes a fundamental transformation of instructional culture, teaching methodology, and educational leadership. Technological tools, when implemented without a clear methodological vision, remain passive novelties that offer limited cognitive value. However, when integrated through established theoretical models such as the TPACK framework, the SAMR hierarchy, flipped classroom

structures, and guided discovery strategies, digital tools serve as powerful catalysts for learner autonomy, critical thinking, and collaborative engagement.

The long-term success of digital transformation within educational systems depends on continuous professional development for teachers, methodological flexibility, and an institutional commitment to building safe, equitable, and ethically sound digital learning environments. Future research must continue to examine the evolving synergy between human pedagogy and emerging educational technologies, ensuring that technology remains an empowering, inclusive bridge to lifelong learning and academic excellence.

References

Andreeva, N. V. (2023). *Blended Learning Practice: Strategies for Modern Schools*. Moscow: Yurayt.

European Commission. (2017). *European Framework for the Digital Competence of Educators: DigCompEdu*. Publications Office of the European Union.

Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)? *Contemporary Issues in Technology and Teacher Education*, 9(1), 60–70.

Polat, E. S. (2022). *New Pedagogical and Information Technologies in the Educational System* (5th ed.). Moscow: Academia.

Puentedura, R. (2014). *SAMR: A contextualized introduction*. Building Transformation: An Introduction to the SAMR Model.

UNESCO. (2018). *UNESCO ICT Competency Framework for Teachers* (3rd ed.). United Nations Educational, Scientific and Cultural Organization.

ФИЗИКА ПӘНІН ОҚЫТУДА ЖАҢА ТЕХНОЛОГИЯЛАРДЫҢ АЛАТЫН ОРНЫ

С. Нуркасымова
Л.Н.Гумилев атындағы Еуразия ұлттық университеті, Астана, Қазақстан
М. Ибайдулла
Л.Н.Гумилев атындағы Еуразия ұлттық университеті, Астана, Қазақстан

Аңдатпа. Мақалада жалпы білім беретін мектепте физика пәнін оқытуда жаңа ақпараттық-коммуникациялық технологияларды қолданудың маңызы, мүмкіндіктері мен әдістемелік негіздері қарастырылады. Виртуалды зертханалар, компьютерлік модельдеу, сандық өлшеу датчиктері, толықтырылған және виртуалды шындық, интерактивті тақта, қашықтан оқыту платформалары мен жасанды интеллект құралдарының оқу үдерісіндегі орны талданады. Жаңа технологиялардың оқушылардың танымдық белсенділігін арттыруға, физикалық құбылыстардың мәнін терең түсінуге және функционалдық сауаттылықты қалыптастыруға ықпалы көрсетіледі. Сонымен қатар оларды енгізу барысында кездесетін қиындықтар айқындалып, мұғалімдерге арналған әдістемелік ұсыныстар беріледі.

Түйін сөздер: физиканы оқыту әдістемесі, ақпараттық-коммуникациялық технологиялар, виртуалды зертхана, компьютерлік модельдеу, цифрлық білім беру, жасанды интеллект, функционалдық сауаттылық.

Қазіргі қоғамның даму кезеңі цифрлық трансформациямен, ақпарат көлемінің жедел өсуімен және ғылыми-техникалық прогрестің қарқынды жүруімен сипатталады. Мұндай жағдайда білім беру жүйесінің алдында жаңа міндеттер тұр: оқушыға дайын білімді беріп қана қоймай, оны өз бетінше іздеуге, талдауға, сыни тұрғыдан бағалауға және практикада қолдануға үйрету қажет. Қазақстан Республикасының «Білім туралы» Заңында білім беру жүйесін ақпараттандыру, жаңа оқыту технологияларын енгізу және білім алушылардың функционалдық сауаттылығын дамыту басым бағыттардың бірі ретінде белгіленген [1].

Физика – табиғат құбылыстарының жалпы заңдылықтарын зерттейтін іргелі ғылым. Мектеп курсындағы физика пәні оқушылардың ғылыми дүниетанымын қалыптастыруда, логикалық және абстрактілі ойлауын дамытуда ерекше рөл атқарады. Алайда физиканы оқытуда бірқатар қиындықтар бар. Олардың қатарында көптеген құбылыстардың көзге көрінбейтіндігі (электромагниттік өріс, атом құрылысы, ядролық реакциялар), кейбір процестердің өте жылдам немесе өте баяу жүруі, сондай-ақ мектеп зертханаларының қажетті құрал-жабдықпен толық қамтамасыз етілмеуі бар. Осындай жағдайларда жаңа технологиялар оқу материалын көрнекі, түсінікті және қызықты етіп ұсынудың тиімді құралына айналады.

Соңғы жылдары білім беру саласында виртуалды зертханалар, интерактивті модельдер, сандық өлшеу кешендері, толықтырылған және виртуалды шындық технологиялары, сондай-ақ жасанды интеллектке негізделген құралдар кеңінен таралуда. Олардың әрқайсысы физиканы оқытудың белгілі бір мәселесін шешуге мүмкіндік береді. Дегенмен технологияны жай ғана қолдану оқыту сапасын өздігінен арттырмайды: оның тиімділігі мұғалімнің әдістемелік шеберлігіне, сабақтың мақсатына және технологияны таңдаудың негізділігіне тікелей байланысты.

Осыған байланысты мақаланың мақсаты – физика пәнін оқытуда жаңа технологиялардың алатын орнын анықтау, олардың дидактикалық мүмкіндіктерін талдау және мектеп тәжірибесінде тиімді қолдану бойынша әдістемелік ұсыныстар әзірлеу.

Мақсатқа жету үшін келесі міндеттер қойылды:

1. «Жаңа білім беру технологиялары» ұғымының мазмұнын және оның физиканы оқытудағы ерекшелігін айқындау;
2. физика сабағында қолданылатын заманауи технологиялардың түрлерін жіктеп, олардың дидактикалық мүмкіндіктерін сипаттау;
3. жаңа технологияларды енгізу кезінде туындайтын қиындықтарды анықтау;
4. мұғалімдерге арналған практикалық ұсыныстар беру.

Педагогикалық әдебиетте «білім беру технологиясы» ұғымы оқыту мақсатына кепілді түрде қол жеткізуге бағытталған, алдын ала жобаланған әрекеттер жүйесі ретінде қарастырылады. Г.К. Селевко педагогикалық технологияның негізгі белгілері ретінде концептуалдылықты, жүйелілікті, басқарымдылықты, тиімділікті және қайта жаңғыртымдылықты атайды [2]. Яғни технология – кездейсоқ тәсілдердің жиынтығы емес, нәтижесі болжанатын және басқа мұғалімдер қайталай алатын жүйе.

Жаңа технологиялар деп әдетте ақпараттық-коммуникациялық құралдарға (компьютер, интернет, мультимедиа, цифрлық датчиктер, мобильді қосымшалар) негізделген оқыту тәсілдерін айтады. Е.С. Полат пен М.Ю. Бухаркина атап өткендей, ақпараттық технологиялар өзінен-өзі білім сапасын арттырмайды; олар тұлғаға бағытталған педагогикалық технологиялармен (жобалық оқыту, ынтымақтастықта оқыту, деңгейлеп саралап оқыту) ұштасқанда ғана нәтиже береді [3].

Физиканы оқытуда жаңа технологиялардың маңызы пәннің өзіндік ерекшелігімен түсіндіріледі. Физика – эксперименттік ғылым, сондықтан оқушы құбылысты бақылап, өлшеп, нәтижесін талдауы тиіс. Жаңа технологиялар осы танымдық циклдің әр кезеңін қолдайды. Бұл 1-суретте көрсетілген.



Сурет-1. Жаңа технологиялардың кезеңдері

- **бақылау** – анимациялар мен модельдер көзге көрінбейтін процестерді көрнекі етеді;
- **өлшеу** – сандық датчиктер деректерді нақты уақытта жинап, график түрінде көрсетеді;
- **талдау** – электрондық кестелер мен арнайы бағдарламалар деректерді өңдеуді жеңілдетеді;
- **модельдеу** – оқушы параметрлерді өзгертіп, нәтиженің қалай өзгеретінін бірден көреді;

- **қорытындылау** – цифрлық құралдар нәтижені таныстыру мен талқылауға мүмкіндік береді.

Мектеп тәжірибесінде кеңінен қолданылатын технологияларды дидактикалық қызметіне қарай төмендегі 1-кестедегідей жіктеуге болады.

1 кесте

Технология түрі	Мысалдар	Негізгі дидактикалық мүмкіндігі	Қолдану мысалы (физика)
Виртуалды зертханалар мен модельдер	PhET Interactive Simulations, Algodoo, «Виртуалды зертхана»	Көзге көрінбейтін құбылыстарды көрсету, параметрлерді еркін өзгерту	Фотоэффект, электр тізбегі, газ молекулаларының қозғалысы
Сандық өлшеу зертханалары	Vernier, PASCO, «Releon» датчиктері, смартфон датчиктері (phyphox)	Нақты экспериментте деректерді дәл әрі жылдам жинау	Еркін түсу үдеуін анықтау, ток пен кернеуді өлшеу
Толықтырылған және виртуалды шындық (AR/VR)	AR-қосымшалар, VR-көзілдіріктер	Үш өлшемді нысандармен өзара әрекеттесу	Атом құрылысы, Күн жүйесі, магнит өрісінің сызықтары
Интерактивті тақта және мультимедиа	Интерактивті панель, бейнесабақтар, анимациялар	Сабақтың көрнекілігі мен қарқынын арттыру	Толқындардың интерференциясы, оптикалық құбылыстар
Онлайн-платформалар мен бағалау құралдары	Bilimland, Kahoot!, Google Forms, Plickers	Жедел кері байланыс, қалыптастырушы бағалау	Тақырып соңындағы тест, ұғымдық сұрақтар
Жасанды интеллект құралдары	Чат-боттар, бейімделгіш оқыту жүйелері	Жекелендірілген көмек, есеп шығаруда қадамдық кеңес	Есептерді талдау, түсіндірмені әр деңгейге бейімдеу

Мектеп тәжірибесінде кеңінен қолданылатын технологиялар

Виртуалды зертханалар – физиканы оқытудағы ең кең таралған жаңа технологиялардың бірі. Олар мектепте жоқ немесе қауіпті құрал-жабдықты қажет ететін тәжірибелерді жасауға мүмкіндік береді. Мысалы, радиоактивті ыдырауды, ядролық реакцияларды, жоғары кернеулі тізбектерді нақты сыныпта көрсету мүмкін емес, ал компьютерлік модель арқылы оқушы оларды қауіпсіз зерттей алады.

Колорадо университетінде әзірленген PhET интерактивті симуляциялары осы бағыттың танымал мысалы болып табылады. К. Виман және оның әріптестерінің зерттеуінде дұрыс жобаланған симуляциялар оқушыларға құбылыстарды өз бетінше зерттеуге, гипотеза ұсынып, оны тексеруге жағдай жасайтыны және кейбір жағдайларда нақты құрал-

жабдықпен жұмыстан кем түспейтін нәтиже беретіні көрсетілген [4]. Симуляцияның артықшылығы – ол құбылыстың көрінбейтін бөлігін (электрондардың қозғалысы, өріс сызықтары, күш векторлары) көрнекі түрде бейнелейді.

Дегенмен виртуалды тәжірибе нақты экспериментті толық алмастырмауы тиіс. Оқушы нақты құралмен жұмыс істеу дағдысын, өлшеу қателіктерін бағалауды және эксперименттік мәдениетті тек нақты зертханада игереді. Сондықтан ең тиімді жол – виртуалды және нақты тәжірибені үйлестіру: алдымен модельде болжам жасап, кейін оны нақты тәжірибеде тексеру немесе керісінше.

Заманауи сандық зертханалар температура, қысым, күш, жылдамдық, үдеу, ток күші, кернеу, жарық және дыбыс деңгейін өлшейтін датчиктерден және деректерді өңдейтін бағдарламалық қамтамасыз етуден тұрады. Олардың басты артықшылығы – өлшеу нәтижелері нақты уақытта график түрінде шығады. Бұл оқушыға физикалық шамалар арасындағы тәуелділікті бірден көруге және талдауға мүмкіндік береді.

Мысалы, «Математикалық маятниктің тербелісі» тақырыбында қозғалыс датчигі ығысудың уақытқа тәуелділік графигін бірнеше секундта салады. Оқушылар жіптің ұзындығын өзгертіп, периодтың қалай өзгеретінін бақылайды және формуланы өздері «ашады». Сондай-ақ смартфондағы кірістірілген датчиктерді (акселерометр, магнитометр, микрофон) пайдаланатын тегін қосымшалар зертханасы нашар жабдықталған мектептер үшін нақты балама бола алады.

Толықтырылған шындық (AR) технологиясы нақты ортаға цифрлық нысандарды қосады, ал виртуалды шындық (VR) оқушыны толықтай жасанды ортаға ендіреді. Физикада бұл технологиялар әсіресе атом мен ядро физикасы, астрономия, электромагнетизм тақырыптарында тиімді. Оқушы атом моделін «қолына алып», жан-жағынан айналдырып көре алады, магнит өрісінің кеңістіктік құрылымын бақылайды, Күн жүйесіндегі планеталардың қозғалысын масштабпен салыстырады. Мұндай тәжірибе абстрактілі ұғымдарды нақты бейнеге айналдырып, оқушының кеңістіктік ойлауын дамытады.

Гарвард университетінің профессоры Э. Мазур ұсынған «өзара оқыту» (Peer Instruction) әдісі физиканы оқытудағы интерактивті тәсілдердің жарқын мысалы болып табылады [5]. Әдістің мәні мынада: мұғалім ұғымдық сұрақ қояды, оқушылар алдымен жеке жауап береді, содан кейін жұппен талқылап, қайта дауыс береді. Бастапқыда бұл үшін арнайы пульттер (кликерлер) қолданылған болса, қазір Kahoot!, Plickers, Mentimeter сияқты онлайн-құралдар бұл үдерісті кез келген сыныпта ұйымдастыруға мүмкіндік береді.

Мұндай құралдардың артықшылығы – мұғалім сынып бойынша жауаптардың үлестірілуін бірден көреді және оқушылардың қандай ұғымды дұрыс түсінбегенін анықтайды. Бұл қалыптастырушы бағалаудың негізгі қағидасына толық сәйкес келеді: бағалау оқытуды түзетуге қызмет етеді.

Цифрлық білім беру ресурстары «төңкерілген сынып» (flipped classroom) моделін жүзеге асыруға жол ашады. Бұл модельде оқушы жаңа теориялық материалмен үйде бейнесабақ немесе электрондық оқулық арқылы танысады, ал сабақ уақыты есеп шығаруға, тәжірибе жасауға және талқылауға арналады. Физика үшін бұл өте тиімді, себебі сабақта ең қиын бөлім – білімді қолдану кезеңі – мұғалімнің тікелей қолдауымен өтеді. Bilimland, Online Mektep сияқты отандық платформалар қазақ тіліндегі видеосабақтар мен интерактивті тапсырмаларды ұсынады.

Соңғы жылдары білім беру саласына жасанды интеллектке негізделген құралдар белсенді ене бастады. Физиканы оқытуда олар бірнеше бағытта қолданылуы мүмкін: есеп шығарудың қадамдық түсіндірмесін беру, оқушының деңгейіне сай қосымша тапсырмалар құрастыру, мұғалімге сабақ жоспарын, ұғымдық сұрақтарды және бағалау критерийлерін әзірлеуге көмектесу. Бейімделгіш оқыту жүйелері оқушының қателерін талдап, оған жеке оқу траекториясын ұсынады.

Сонымен бірге жасанды интеллектті қолдану белгілі бір тәуекелдерді туғызады: оқушы есептің дайын жауабын алып, өзі ойланбауы мүмкін, ал жүйе кейде қате немесе дәлсіз ақпарат беруі ықтимал. Сондықтан мұғалімнің міндеті – оқушыларды бұл құралдарды «көмекші» ретінде сыни тұрғыдан пайдалануға үйрету, жауаптың дұрыстығын физикалық заңдар мен өлшем бірліктері арқылы тексеруді талап ету.

Жаңа технологиялардың мүмкіндіктері мол болғанымен, оларды мектеп тәжірибесіне енгізу бірқатар қиындықтармен байланысты:

1. **Материалдық-техникалық база.** Кейбір мектептерде, әсіресе ауылдық жерлерде, компьютерлер, тұрақты интернет байланысы және сандық зертхана жабдықтары жеткіліксіз.
2. **Мұғалімнің цифрлық құзыреттілігі.** Технологияны тиімді пайдалану үшін мұғалім оны техникалық тұрғыдан меңгеріп қана қоймай, әдістемелік тұрғыдан сабаққа дұрыс енгізе білуі қажет.
3. **Қазақ тіліндегі цифрлық ресурстардың шектеулілігі.** Сапалы симуляциялар мен бағдарламалардың едәуір бөлігі шет тілдерінде әзірленген.
4. **Технологияға шамадан тыс сүйену.** Көрнекілікке көп көңіл бөлініп, физикалық мағынаны талдау, есеп шығару және нақты эксперимент екінші орынға ысырылып қалу қаупі бар.
5. **Денсаулық сақтау талаптары.** Экран алдында ұзақ отыру оқушылардың көзі мен қалпына теріс әсер етуі мүмкін, сондықтан санитарлық нормаларды сақтау қажет.

Жоғарыда талданған мүмкіндіктер мен қиындықтарды ескере отырып, физика мұғалімдеріне мынадай ұсыныстар беруге болады:

- **Мақсаттан технологияға қарай жүру.** Алдымен сабақтың оқу мақсатын айқындап, кейін сол мақсатқа жетуге ең қолайлы құралды таңдау керек; технология сабақтың «безендіруі» емес, мақсатқа жету құралы болуы тиіс.
- **Виртуалды және нақты тәжірибені үйлестіру.** Модельде болжам құру – нақты тәжірибеде тексеру – нәтижені салыстыру тізбегін қолдану оқушының зерттеушілік дағдысын дамытады.
- **Оқушыны белсенді субъектіге айналдыру.** Дайын анимацияны көрсетумен шектелмей, оқушыға параметрлерді өзгертіп, заңдылықты өзі анықтайтын зерттеу тапсырмаларын беру.
- **Жедел кері байланысты жүйелі пайдалану.** Әр тақырыпта ұғымдық сұрақтар арқылы оқушылардың түсінігін тексеріп, қате түсініктерді дер кезінде түзету.
- **Қолжетімді құралдарды пайдалану.** Арнайы жабдық жоқ болса, смартфон датчиктері мен тегін онлайн-симуляцияларды тиімді қолдану.
- **Цифрлық сауаттылық пен академиялық адалдықты қалыптастыру.** Жасанды интеллект құралдарын қолданғанда оқушыдан шешім жолын түсіндіруді және нәтижені тексеруді талап ету.
- **Кәсіби дамуды үздіксіз жалғастыру.** Мұғалімдердің біліктілікті арттыру курстарына, әдістемелік бірлестіктердегі тәжірибе алмасуға қатысуы маңызды.

Мысал ретінде 8-сыныптағы «Ом заңы» тақырыбындағы сабақтың құрылымын келтіруге болады. Сабақтың басында оқушылар PhET симуляциясында кернеуді өзгерте отырып, ток күшінің қалай өзгеретінін бақылайды және болжам жасайды. Кейін топпен сандық амперметр мен вольтметрді қолданып, нақты тізбекте өлшеу жүргізеді, нәтижесін электрондық кестеге енгізіп, тәуелділік графигін салады. Сабақ соңында онлайн-құрал арқылы ұғымдық сұрақтарға жауап беріп, мұғалім сыныптың тақырыпты меңгеру деңгейін бірден анықтайды. Осылайша бір сабақ аясында бірнеше технология өзара толықтырып, оқушының белсенді танымдық әрекетін қамтамасыз етеді.

Қорытынды

Жүргізілген талдау физика пәнін оқытуда жаңа технологиялардың маңызды әрі көпқырлы орын алатынын көрсетті. Виртуалды зертханалар мен компьютерлік модельдер көзге көрінбейтін және қауіпті құбылыстарды көрнекі етеді, сандық өлшеу кешендері эксперименттің дәлдігі мен жылдамдығын арттырады, толықтырылған және виртуалды шындық абстрактілі ұғымдарды нақты бейнеге айналдырады. Интерактивті бағалау құралдары мұғалімге жедел кері байланыс береді, ал қашықтан оқыту платформалары мен жасанды интеллект құралдары оқытуды жекелендіруге мүмкіндік ашады.

Сонымен бірге жаңа технологиялар өздігінен оқыту сапасын арттырмайды. Олардың тиімділігі сабақтың мақсатына сай таңдалуына, нақты экспериментпен және белсенді оқыту әдістерімен үйлесімді ұштасуына, мұғалімнің цифрлық және әдістемелік құзыреттілігіне байланысты. Технология оқушының физикалық ойлауын дамытуға қызмет еткенде ғана өз міндетін толық атқарады.

Осылайша, жаңа технологияларды жүйелі әрі негізделген түрде қолдану оқушылардың физикаға деген қызығушылығын арттырып, пәнді терең меңгеруіне, зерттеушілік дағдыларын дамытуына және функционалдық сауаттылығын қалыптастыруына ықпал етеді. Болашақта қазақ тіліндегі сапалы цифрлық ресурстарды әзірлеу, мектептердің материалдық-техникалық базасын нығайту және мұғалімдердің біліктілігін арттыру осы бағыттағы басым міндеттер болып қала береді.

Пайдаланылған әдебиеттер

1. Қазақстан Республикасының «Білім туралы» Заңы. 2007 жылғы 27 шілдедегі № 319-III.
2. Селевко Г.К. Современные образовательные технологии: учебное пособие. – М.: Народное образование, 1998. – 256 с.
3. Полат Е.С., Бухаркина М.Ю. Современные педагогические и информационные технологии в системе образования: учеб. пособие. – М.: Академия, 2007. – 368 с.
4. Wieman C.E., Adams W.K., Perkins K.K. PhET: Simulations That Enhance Learning // Science. – 2008. – Vol. 322, № 5902. – P. 682–683.
5. Mazur E. Peer Instruction: A User's Manual. – Upper Saddle River, NJ: Prentice Hall, 1997. – 253 p.

Domestic violence and bullying in schools – impact, mechanisms, and prevention

Lucia Mrázková
PhD student, University of Security Management in Košice, Slovakia

Abstract
Domestic violence and bullying in schools are serious socio-pathological phenomena that significantly affect the psychosocial development of children and young people. The professional literature points to their close connection, with the family environment playing a key role in shaping a child's behavior in the school environment. Children exposed to violence in the family may find themselves in the position of victims or aggressors in bullying behavior at school. The aim of this paper is to analyze the relationship between domestic violence and bullying at school, to highlight the mechanisms of their interaction, to identify the consequences for the child, and to emphasize the importance of preventive and safety measures in the school environment. The article is based on an analysis of domestic and foreign professional literature and emphasizes the need for interdisciplinary cooperation in the protection of children.
Key words: domestic violence, school bullying, psychosocial development of the child, family environment, perpetrator and victim, risky behaviour, consequences of violence, prevention, school safety, interdisciplinary cooperation, child protection

Introduction

Domestic violence and school bullying are among the complex social issues that have a profound impact on the emotional, cognitive, and social development of children and youth. The family environment forms a child's fundamental values, norms, and behavioral patterns, which are subsequently transferred into their peer interactions and influence how the child responds to peers, authority figures, and stressful situations. Children who experience domestic violence are more likely to exhibit symptoms of aggression, anxiety, depressive behavior, or social isolation, which can lead to them becoming either victims or perpetrators in the school environment (Hong & Espelage, 2012; Wolfe et al., 2003).

Mechanisms of the so-called intergenerational transmission of violence demonstrate that children tend to imitate aggressive behavioral patterns observed in the home environment. In his Social Learning Theory, Bandura (1977) emphasizes that children learn behavior not only through direct punishments and rewards, but also through observing and imitating role models within the family. This learning process can lead to the internalization of aggressive responses as a normal way of resolving conflicts, which may later manifest in school groups as well.

In his Attachment Theory, Bowlby (1969) points out that an insufficiently secure attachment with a parent or primary caregiver can lead to an impairment of the child's emotional and social competencies. Children with insecure or disrupted attachment may experience difficulties with emotion regulation, empathy, and adaptation in social situations, thereby increasing the risk of involvement in bullying or other forms of problematic behavior in the school environment.

In addition to the family context, the school environment plays a significant role, acting either as a catalyst or a protective factor. A positive school climate, inclusive pedagogy, and prosocial leadership can mitigate the negative consequences of domestic violence, whereas insufficiently

monitored peer groups can reinforce or stabilize aggressive patterns. Research suggests that bullying prevention and early intervention after identifying at-risk children are crucial for reducing negative psychosocial impacts and supporting healthy child development (Espelage & Swearer, 2003; Kováčová et al., 2020).

Therefore, the objective of this paper is to analyze the link between domestic violence and school bullying, identify the mechanisms through which these phenomena influence each other, and highlight the importance of prevention, interdisciplinary cooperation, and the promotion of prosocial behavior for the healthy psychosocial development of children.

2. Psychosocial Consequences of Violence and Bullying

Children exposed to domestic violence frequently face multifaceted psychological and emotional difficulties. Among the most common manifestations are reduced self-esteem, difficulties with emotional regulation, depressive symptoms, increased anxiety, and tendencies toward social isolation. Such children may experience difficulties in establishing and maintaining interpersonal relationships, often exhibit excessive sensitivity to rejection or criticism, and tend to be prone to impulsive behavior. As a result of repeated exposure to a violent environment, maladaptive behavioral patterns may become consolidated, subsequently projecting into the school setting.

In the social context of the school, these children may become either victims or perpetrators of bullying. Aggressive behavior can take a direct form, such as verbal attacks or physical aggression, as well as indirect manifestations, including manipulation of peers, spreading rumors, ignoring, or socially isolating targeted individuals (Espelage & Swearer, 2003; Kováčová et al., 2020). The school environment often functions as a catalyst for these behaviors: children may imitate learned patterns from home, attempt to compensate for feelings of threat, or seek control over peer social dynamics.

Long-term exposure to violence and bullying behavior increases the risk of repeating aggressive behavioral patterns and the emergence of so-called covert aggression, which is harder to detect and often manifests through manipulation, intrigue, spreading rumors, or deliberately induced social isolation. Such behavior may form part of children's adaptive strategies to secure their position within a social group or compensate for a sense of helplessness. Research conducted in preschools in Slovakia indicates that even young children are capable of combining direct and indirect forms of aggression, with aggressive patterns becoming more sophisticated as age and social skills develop (Kováčová et al., 2020).

From a psychological perspective, these experiences can lead to reduced self-esteem, a sense of personal inadequacy, and an impaired ability to resolve conflicts constructively. Social consequences include the disruption of peer relationships, an increased risk of being bullied or excluded from the group, and the generalization of aggressive behavior to other social situations. Psychosocial consequences manifest through a combination of these factors: emotional lability, anxiety, social isolation, and the reproduction of aggressive behavioral patterns in the school environment—underscoring the necessity of early intervention and supportive work with the child's social and emotional development (Hong & Espelage, 2012; Kováčová et al., 2020).

3. Covert Aggression in Preschool Age

Research by Kováčová et al. (2020) shows that aggressive patterns can emerge as early as preschool age and influence relationship formation within peer groups. Children combine direct

and indirect forms of aggression—direct attacks are more frequent and less covert during preschool years, whereas older children learn to disguise their behavior more effectively.

3.1 Analysis of Sociometric Observations

The study utilized sociometry to identify the level of acceptance and rejection of individual children within preschool groups.
AP stand for acceptations and RP for refusals

Table 1: *Sociometric Matrix – Situation K*

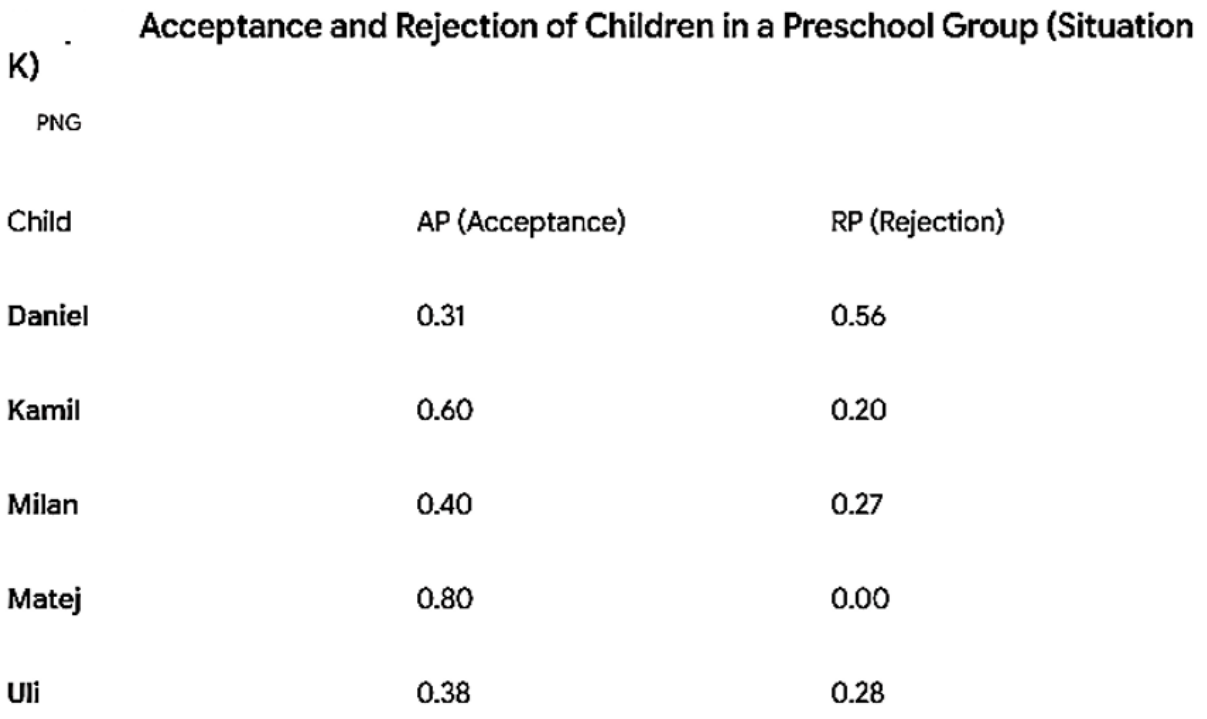
Deti	Daniel	Kamil	Milan	Matej	Uli	Sergej	Tony	AP	RP
Daniel	0	+	+	+	+	+	+	0.16	0.83
Kamil	–	0	(+)	+	–	+	3	0.66	0.16

Table 2: *Sociometric Matrix – Situation M*

Children	Filip	Lukas	Tamara	Lenka	Tónko	AP	RP
Filip	0	–	(+)	(+)	+	0.75	0.25
Lukas	–	0	(–)	+	+	0	1

Graph 1 illustrates a comparison of acceptance and rejection for individual children across all situations:

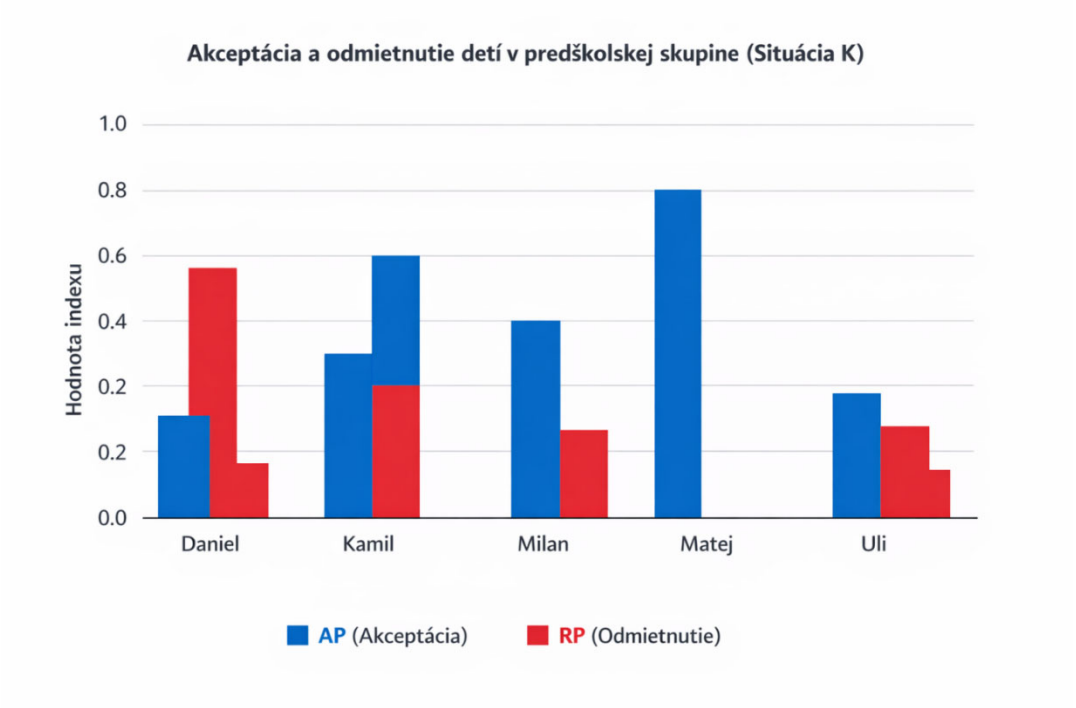
Acceptance and rejection of children in a preschool group (Situation K)



Notes :

- Y-Axis : Index Value
- Legend / Legenda:

- AP = Acceptance / Akceptácia (Blue)
- RP = Rejection / Odmietnutie (Red)



Index Value

```
1.0 |
    |
0.8 |                          [AP]
    |                         0.80
0.6 |              [AP]
    |       [RP]  0.60
0.4 |       0.56           [AP]
    |                   0.40          [AP]
0.2 |  [AP]   [RP]    [RP]    [RP]          0.38 [RP]
    |  0.31   0.20    0.27    0.00           0.28
0.0 +-----------------------------------------------------
      Daniel   Kamil    Milan   Matej        Uli
```

Legend:
■ AP (Acceptance)
■ RP (Rejection)

4. Prevention and Interventions

Effective bullying prevention requires a combination of legislative measures and school programs. In the Slovak Republic, the Directive of the Ministry of Education, Research, Development and Youth of the Slovak Republic establishes the obligation for schools to monitor and address bullying. International programs such as KiVa and the Olweus Bullying Prevention Program have shown effectiveness in reducing aggressive behaviour and promoting prosocial skills (Olweus, 1993).

At the preschool age, it is appropriate to foster the development of emotional regulation, capacity for empathy, and the formation of stable friendships. Interventions may include story- or fairytale-based work, where conflicts and their resolutions are embedded into play, enabling children to

learn conflict resolution without endangering themselves or others (Majzlanová, 2017; Kováčová et al., 2020).

5. Crime and Cybercrime Associated with Increased Child Aggressiveness

As Svrček and Molnár state: *"Cybercrime currently takes on more aggressive, confrontational, and organized forms, requiring rapid adaptation of institutions and new preventive strategies."* This finding can be applied analogously to the school environment: just as the European Union, through Europol and the EC3 Center, strives to respond to digital threats, educational institutions should likewise develop their own preventive mechanisms and coordinated responses to child aggression.

Effective prevention requires:

- Monitoring students' risk behavior in both online and offline environments,
- Collaboration among teachers, school psychologists, and law enforcement,
- Education in digital literacy and empathy,
- Timely intervention in cases of bullying, extortion, or cyber-violence.

Child aggressiveness in regional education thus represents a microcosm of broader societal trends in which virtual and real-world violence intersect. It is a phenomenon that extends beyond the boundaries of school desks and demands a multidisciplinary approach—pedagogical, psychological, and legal.

6. Conclusion

The dominant influence of domestic violence on bullying behavior in schools is confirmed by numerous domestic and international studies. Children exposed to domestic violence often develop aggressive, submissive, or mixed behavioral patterns that can manifest as early as preschool age and persist throughout their school years. Such children are frequently more sensitive to rejection, experience difficulties with emotional regulation, and are more prone to social isolation or the reproduction of aggressive strategies in peer relationships.

Research by Kováčová et al. (2020) demonstrates that preschool children utilize *covert aggression*—hidden forms of aggression that are more difficult to identify and can affect their social standing within the group, peer relationships, and group dynamics. Such behavior often involves manipulation, spreading rumors, or deliberately inducing social isolation of selected children. Failure to address these manifestations may lead to the stabilization of maladaptive patterns and increase the risk of subsequent bullying behavior in schools.

The psychosocial consequences of exposure to domestic violence encompass a combination of emotional, cognitive, and social difficulties: reduced self-esteem, emotional lability, heightened anxiety, self-control issues, and the reproduction of aggressive behavioral patterns. These factors can cause a child not only to suffer but also to react inappropriately in social situations, which negatively impacts their academic performance and social integration.

Effective interventions and preventive measures require a comprehensive, interdisciplinary approach involving teachers, psychologists, parents, school special education professionals, and

legislative mechanisms. Early detection of aggressive behavioral patterns, including covert aggression, diagnosis of risk situations, promotion of prosocial behavior, and the cultivation of empathy and emotional regulation skills in children are crucial.

Supporting an inclusive and safe environment in preschool and school settings, systematically monitoring social interactions, and guiding children toward prosocial behavioral strategies represent effective approaches that can significantly reduce the risk of bullying behavior and foster healthy child psychosocial development.

Recommendations for Educators and School Practice:

1. **Early identification of at-risk children:** Educators should regularly monitor group interactions and pay attention to covert forms of aggression, such as *covert aggression*, while assessing potential symptoms of emotional lability and low self-esteem.

2. **Promotion of prosocial behavior:** Through group activities, cooperative learning, and empathy-building programs, schools can systematically reinforce prosocial behavioral patterns.

3. **Collaboration with parents:** Parents should be informed of observed behavioral manifestations and involved in interventions; regular communication enhances the effectiveness of preventive measures.

4. **Interdisciplinary approach:** Engaging psychologists, special educators, and social workers enables targeted diagnosis and resolution of aggressive behavior and its underlying causes.

5. **Educator training and professional development:** Teachers should undergo training focused on identifying and addressing bullying, children's emotional stress, and peer violence prevention.

6. **Creation of a safe and inclusive environment:** The school should guarantee equal access to support and protection for all children through clear rules, anonymous incident reporting mechanisms, and activities designed to enhance group cohesion.

7. **Regular evaluation and feedback:** Schools should implement mechanisms to evaluate the effectiveness of preventive measures and promptly adapt strategies to meet individual children's needs.

Overall, the combination of early diagnosis, prosocial leadership, family engagement, and interdisciplinary support holds the key to mitigating the negative consequences of domestic violence on school behavior, thereby supporting the healthy psychosocial development of children and youth.

Sources:

1. Bandura, A. (1977). *Social Learning Theory.* Prentice Hall.
2. Bowlby, J. (1969). *Attachment and Loss, Vol. 1: Attachment.* Basic Books.
3. Kováčová, B., Lessner Lištiaková, I., Fábry Lucká, Z., & Geršicová, Z. (2020). *Elements of relational aggression in pre-school groups in Slovak kindergartens.* AD ALTA Journal of Interdisciplinary Research.
4. Kováčová B.(2011) Latentná agresia v prostredí školy In: *K*omenský .Masarykova univerzita Brno.
5. Olweus, D. (1993). *Bullying at school: What we know and what we can do.*
6. Svrček, *M. Organizovaný zločin – vývoj a bezpečnostné výzvy v rámci Európskej únie.* Košice: Vysoká škola bezpečnostného manažérstva v Košiciach, 2025.

Economic Sciences

Georgian Legislation and the foundation principles of Georgian State debts (obligations)

Kristine Omadze
Doctor of Business Administration, Ph.D, Affiliated Associate Professor, Alte University

Kristine Omadze
Academic Doctor of Business Administration, Affiliated Associate Professor, Alte University, Solo Lounge Manager of JSC “Bank of Georgia”. She has passed the number of local and international training and seminars. In 2010, She won AMEX Rally at “Bank of Georgia” and in 2014 was named as Best Solo Banker of 2014 of JSC “BANK OF Georgia”. In 2020, in 2021 and in 2023 Solo Lounges under her management were nominated as the best performing units of JSC “Bank of Georgia”. She has published more than 42 different publications, including 29 scientific articles. Spheres of her research activities are: finances, banking, money.

(abstract)

Abstract: This paper reviews Georgian legislation on government securities, which rests mainly on the Law "On State Debt" (1998) rather than a dedicated securities law. The law defines state debt and the types of government securities (discount or interest-bearing, short-, medium- or long-term), and gives the Ministry of Finance authority to issue them, with the National Bank of Georgia acting as fiscal agent. Treasury bonds originated in the government's restructured debt to the National Bank, due for repayment by 2030. The paper identifies a legislative gap: proceeds may be used only to cover the budget deficit and short-term cash gaps, which narrows the instrument's use. Because the Law "On the Securities Market" excludes government securities, they are not openly traded, and auctions run through commercial banks.

Keywords: legislation on State debts, Types of Government securities, Treasury Bonds, Law on Securities Market, Debt’s Restructure, deficit

Georgian Legislation and the foundation principles of Georgian State debts (obligations)

The government and corporate securities issued in Georgia are not distinguished by great diversity. At the time Georgia gained independence and during the transition period, the population held a number of types of government-issued securities, which were recognized under the Law of Georgia "On State Debt" as part of the state domestic debt (Law on State Debt, Article 48).

In this regard, the following securities and liabilities were classified as state debt:

a) liabilities arising from the indexation of deposits placed by the population in the former state commercial banks;

b) liabilities arising from the non-reimbursement of funds belonging to Georgian natural and legal persons that were blocked by the former USSR Bank for Foreign Economic Affairs and recorded in the account of that bank's Tbilisi branch;

c) liabilities arising as a result of the Central Bank of the Russian Federation writing off, against the state's external debt account, funds belonging to Georgian legal persons that were recorded in correspondent accounts of that bank;
d) liabilities arising from the reimbursement, by enterprises and organizations of the country on the instructions of the Government of Georgia, of products shipped in exchange for natural gas supplied from Turkmenistan through 1995;
e) the obligation arising from the issuance of bonds of the 1992 domestic interest-bearing loan of the Republic of Georgia;
f) the obligation to redeem the 1990 state non-interest-bearing targeted bonds of the former USSR;
g) the obligation assumed in connection with cooperative housing construction;
h) liabilities arising from the failure to provide housing to drivers working under municipal enterprise contracts;
i) liabilities arising from the non-payment of prizes won by the population in the state lottery;
j) liabilities arising from the non-reimbursement of foreign-currency funds belonging to Georgian legal persons that were blocked by the former USSR's "Industry bank" and recorded in the account of that bank's Batumi branch. The repayment of this debt is regulated by the same law (Law on State Debt, Article 48, Parts 1, 2, 3 and 4).

Article 48¹ of this law, which concerns the debt owed to the National Bank of Georgia, deserves attention. It may be said that this debt formed the basis for the emergence of the Georgian government security known as the treasury bond (Law on State Debt, Article 48¹):

The debt of the Government of Georgia to the National Bank of Georgia (loans received and restructured debt obligations), which constitutes state domestic debt, shall be repaid by 16 March 2030 on the basis of an agreement concluded between the Government of Georgia and the National Bank of Georgia, in such a way that one part of the debt is restructured annually into a one-year, annually renewable state debt obligation intended for the National Bank, namely a government bond, while the other part is restructured into government bonds of various maturities for open market operations, the repayment of which shall be carried out from the state budgets of the relevant years (Law of Georgia No. 3012 of 11 May 2006 — Legislative Herald of Georgia I, No. 13, 13.05.2006, Art. 88).

At the present stage, one of Georgia's main long-term priorities is to achieve sustainable and increasing rates of economic growth based on a market economy, in which the regulation of public debt plays an important role. Domestic debt is part of total public debt. In the process of performing their functions, states often find themselves in a situation where their own financial resources are insufficient to achieve the set goals and objectives. Under such conditions, in order to cover state expenditures and the budget deficit, it becomes necessary to attract domestic and foreign loans, which gives rise to and increases public debt.

The rapid growth of public debt, under the conditions of a modern market economy, has become a major problem in many countries of the world, as attested by the global situation we have described and by the situation in the USA, Germany and the European Union. Today public debt is increasing in practically every country, the cause of which is considered to be the growth of the budget deficit and of the negative balance of payments. Government securities are an indispensable instrument in the development of the financial market of any country.

When the state issues securities, among other goals the following stand out: regulating the money supply in the country, implementing anti-inflationary measures, stimulating demand for the national currency and supporting the stability of its exchange rate (National Bank of Georgia: https://www.nbg.gov.ge/index.php?m=611). Government securities help the banking sector and private investors to invest their free funds as safely and as liquidly as possible. Auctions are held using the Bloomberg electronic trading system. They can be purchased by any natural or legal

person — participation in the auction is possible through commercial banks operating in Georgia (National Bank of Georgia: https://www.nbg.gov.ge/index.php?m=611).

A security issued by the Georgian state is a financial instrument issued for the purpose of raising funds, on behalf of the state, by the Ministry of Finance of Georgia or another state body, short-term, medium-term or long-term, interest-bearing or non-interest-bearing, denominated in national or convertible currency.

A study of Georgian legislation on the circulation of government securities in Georgia established that there is no separate law on government securities. According to the Law of Georgia "On the Securities Market" (Article 1. Scope of Application (Legislative Herald, 14.03.2008, N5910)), "This Law does not govern the rules for the issuance and public offering of government securities in the name of the State of Georgia, nor for banking trade in these securities outside the stock exchange." Accordingly, under the existing legislative norms, the process of buying and selling government securities is not carried out publicly, and acquiring them on the open market is impossible.

The Constitution of Georgia (Constitutional Law of Georgia of 15 October 2010, №3710-ՆՆԾI, №62, 05.11.2010, Article 3) explains that: "1. The following fall exclusively within the competence of the supreme state bodies of Georgia:

> (z) state finances and state loans; minting of money; banking, credit, insurance and tax legislation;"

(Constitution of Georgia, Chapter Six, Articles 92, 93, 94, 95, 96, 97", Art. 5, Art. 379)

These matters are placed under the jurisdiction of the executive branch of Georgia and of the relevant specialized institutions – the Ministry of Finance and the National Bank of Georgia.

It can be concluded that, from a legislative standpoint, the circulation of this instrument is regulated by the Law "On State Debt". It should also be noted that this law was preceded by the Decree of the State Council of the Republic of Georgia of 8 September 1992 "On the State Debt of the Republic of Georgia" (Collection of Normative Acts of the State Council of the Republic of Georgia, 1995, Vol. II, Art. 158), which was repealed by the Law "On State Debt" (Article 50, Tbilisi, 5 March 1998, N 1285-IIს, Tbilisi, Georgia).

The explanatory provision of the law states that "This Law regulates relations connected with the assumption of state debt by Georgia and the granting of authority to issue state guarantees on domestic and external loans, and establishes the basic principles for the repayment of state debt." The law directly defines the following:

> a) State debt of Georgia – the total amount of state domestic and external debts, taken on under agreements concluded in the name of Georgia by the Ministry of Finance of Georgia and, with its guarantee, by other bodies/institutions, expressed in the national currency; and also received from the placement, in the name of Georgia by the Ministry of Finance of Georgia, of government securities denominated in the national currency or in a foreign convertible currency, and from financial resources approved for Georgia by the International Monetary Fund;
>
> b) Domestic state debt of Georgia – the component of the state debt of Georgia expressed in the national currency; the aggregate of the principal amounts arising from outstanding direct obligations under agreements concluded in the name of Georgia by the Ministry of Finance of Georgia, as well as from funds received through the placement, in the name of Georgia by the Ministry of Finance of Georgia, of government securities denominated in the national currency;

The law fully explains the terminology and the meaning of the terms related to government securities:

> i) Principal amount of the debt – the amount borrowed in accordance with the debt agreement and/or other procedures related to the assumption of state debt provided for by this Law;

k) Government security – a financial instrument issued for the purpose of raising funds in the name of Georgia by the Ministry of Finance of Georgia, short-term, medium-term or long-term, interest-bearing or non-interest-bearing, expressed in the national or a convertible currency;

l) Principal amount of an interest-bearing government security – the nominal value of the government security payable on the redemption date;

m) Discount – the difference between the nominal value of a government security and its purchase price, where the latter is lower than the nominal value;

n) Discount government security – a security sold at a price lower than its nominal value;

o) Principal amount of a discount government security – the amount that the creditor lends on the day of issue of the discount government security, equivalent to its purchase price;

p) Government security in non-materialized form – a government security in the form of an entry in an account, whose issuance and storage are carried out by accounting or electronic records;

zh) Government security in materialized form – a government security issued in materialized form (paper, plastic card or other form) on which the defining details of the security are displayed;

In the same article, the Law "On State Debt" specifies the classification of Georgian government securities by maturity:

ph) Short-term period – a period of up to one year;

q) Medium-term period – a period from one to ten years;

gh) Long-term period – a period of more than ten years;

According to Chapter II, Article 12 of the law, funds received from domestic state debt are used:

a) to cover the budget deficit;

b) to cover short-term cash gaps in the state budget.

This issue requires additional explanation, as there is a legislative gap: Georgian legislation limits the use of funds raised through the issuance of government securities to these two purposes only. This clearly narrows and distorts the scope of circulation and use of this instrument, as evidenced by the inadequate use of this instrument in the Georgian financial system.

According to Article 13, the management of domestic state debt is carried out by the Ministry of Finance of Georgia through the organization and accounting of its repayment, the determination and payment of interest, and the performance of other operations.

According to Article 14, the Ministry of Finance of Georgia is authorized to issue government securities in the name of Georgia. The issuance of government securities may be carried out in non-materialized form – as an entry in an account – or in materialized form.

Paragraph 5 of the same article explains that "the issuance, circulation, accounting and redemption of government securities are regulated on the basis of this Law and the subordinate normative acts developed in accordance with it." An analysis of these provisions is offered together with their analysis below.

Article 16. The normative acts provide that, regarding the management of government securities, the Ministry of Finance of Georgia and the National Bank of Georgia jointly establish subordinate normative acts that determine the conditions of issuance, circulation, accounting and redemption of government securities. The Ministry of Finance of Georgia is also authorized to designate a fiscal agent for operations conducted with government securities. The function of fiscal agent is performed by the National Bank of Georgia.

Article 48[1] of the law, "Debt owed to the National Bank of Georgia", contains rather important information:

"The debt of the Government of Georgia to the National Bank of Georgia (loans received and converted debt obligations), which constitutes domestic state debt, shall

be repaid by 16 March 2030 on the basis of an agreement concluded between the Government of Georgia and the National Bank of Georgia, in such a way that each year one part of the debt is converted into a one-year, annually renewable government debt obligation – a government bond – designated for the National Bank, and the other part into government bonds of various maturities for open market operations, the repayment of which shall be made from the state budgets of the respective years."

Literature:

1. Aslanishvili, Davit, (2015). Georgia State Securities Papers Market ,May 2015, ISBN 978-9941-0-7968-9, (PDF) Georgia State Securities Papers Market დავით ასლანიშვილი სახელმწიფო ფასიანი ქაღალდები საქართველოში: გამოწვევები და პერსპექტივები
2. Kristine Omadze,. (2024). Georgia: Economic Independence and economic Collapse of 1992 . *Progress in Science*, (7). Retrieved from https://ojs.scipub.de/index.php/PS/article/view/4242
3. Kristine Omadze. (2024). History of Georgian Economy: from the recovery to the new crisis (1997-1999). *European Research Materials*, (7). Retrieved from https://ojs.scipub.de/index.php/ERM/article/view/4203
4. Kristine Omadze. (2024). Georgia on its way to Market Economy: Reforms and necessity. *Foundations and Trends in Research*, (7). Retrieved from https://ojs.scipub.de/index.php/FTR/article/view/4160
5. Omadze, K. (2015). Importance of mortgage banks for credit market development. In *Materials of reports made at the international scientific-practical conference held at Paata Gugushvili Institute of Economics of Ivane Javakhishvili Tbilisi State University in 2015* (p. 521).
6. Omadze, K. (2014). Business valuation modern models and Georgian reality. In *Materials of reports made at the international scientific-practical conference held at Paata Gugushvili Institute of Economics of Ivane Javakhishvili Tbilisi State University in 2014* (p. 540).
7. Omadze, K. (2014). The Essence and Characteristics of the Credit Market. *Proceedings of the TSU Institute of Economics*, 390-393.
8. David Aslanishvili. (2026). International Discussions on Government Securities and Their Practical Purpose. *Foundations and Trends in Modern Learning*, (14). Retrieved from https://ojs.scipub.de/index.php/FTML/article/view/9379
9. Aslanishvili, D., & Omadze, K. (2019). Green economy and access to finance in Georgia (going beyond the commercial banking sector to finance businesses in Georgia). *Journal of Economics and Business*, *2*(3).
10. Aslanishvili, D., & Omadze, K. (2016). Origins and the Reasons of Monetary Crises in Georgia (1995-2016). *Modern Economy*, *7*(11), 1232-1250.
11. Aslanishvili, D., & Omadze, K. THE INFLUENCE OF GLOBAL ECONOMIC CRISIS ON WORLD ECONOMY, ITS REASONS AND OVERCOME STEPS. In *Materials of reports made at the international scientific-practical conference held at Paata Gugushvili Institute of Economics of Ivane Javakhishvili Tbilisi State University in 2013* (p. 508).
12. Aslanishvili, D., & Omadze, K. (2023). THE EVOLUTION OF THE ESSENCE OF HUMAN MATERIAL LIFE–FROM ANCIENT ROME TO THE MODERN WORLD. *THE PROBLEMS OF DEVELOPMENT OF THE WORLD AND NATIONAL ECONOMY, TAKING INTO ACCOUNT THE PANDEMIC AND RUSSIAN-UKRAINIAN WAR PERSPECTIVES*, 14.

13. Aslanishvili, D., & Omadze, K. (2013). The Impact of the Economic Crisis on the World Economy–TSU. In *International Scientific-Practical Conference of the Institute of Economics* (pp. 28-29).

Reforming the Georgian Government Securities Market: Regulatory Barriers and the Case for Open, Direct Investor Access

David Aslanishvili
Doctor of Economy, Ph.D, Affiliated Professor, Webster University,
https://orcid.org/0000-0002-3920-6781

Dr. Davit Aslanishvili, Doctor of Economy (Ph.D), Affiliated Professor of Finance, Webster University, USA (Georgia Campus) and Adjunct Faculty, Webster University of Tashkent, Uzbekistan. His experience/lecturing/research also covers several Universities in Georgia and abroad. At the same time, he is co-founder and shareholder of Georgian Stock Exchange and has held various managerial, executive, ownership, leadership, consulting and teaching positions for-profit businesses, governmental bodies and in NGOs. He has published more than 77 different publications, including 54 scientific articles.

(abstract)

This paper analyzes the Ministry of Finance and National Bank Regulation governing the issuance, circulation, and redemption of Georgian treasury bills and bonds. Bills are discount securities of up to one year, and bonds are coupon securities of 1 to 10 years, with a nominal value of GEL 1,000. All are sold at multiple-price auctions open only to commercial banks. The author identifies several weaknesses: a legal limit on using proceeds to deficit and cash-gap financing; a GEL 50,000 minimum competitive bid that excludes small investors; bank intermediation that creates conflicts of interest and lets banks see client bids; lari-only issuance with no currency hedging or inflation indexing; unregulated bank fees; a paper-and-electronic bidding duplication; and a central register run by the central bank. The paper recommends admitting brokerage firms, introducing a "Treasury Direct" system, lowering the minimum bid to GEL 100, trading through a single exchange, issuing inflation-indexed securities, setting uniform commissions, and creating an independent auction body.
Keywords: Government debt, Treasury Bills, Discount Securities, Coupon Securities, Bidding procedures on T-bills Market, Treasury Direct, TIPS, yield, taxation, budget deficit

Reforming the Georgian Government Securities Market: Regulatory Barriers and the Case for Open, Direct Investor Access

Our research process has required a direct analysis of the Regulation of the Ministry of Finance of Georgia "On the Issuance, Circulation, Accounting and Redemption of Treasury Bills and Treasury Bonds by the Ministry of Finance of Georgia" (hereinafter, the Regulation)
(approved by Joint Order of the Minister of Finance of Georgia and the President of the National Bank of Georgia, № 10/01–N 51, 01/02/2010; amended by Joint Order of the Minister of Finance of Georgia and the President of the National Bank of Georgia, № 163/01–N931, 17/12/2010; amended by Joint Order of the Minister of Finance of Georgia and the President of the National Bank of Georgia, № 116/04–N642, 30/12/2011).
This is the main document that regulates, in practice, all matters related to government securities. Under the current Regulation, the nominal value of one government security is GEL 1,000. Treasury bills are issued with a maturity of up to one year, at a discount, and are redeemed at

nominal value. Treasury bonds are issued with a maturity of 1 to 10 years, with the coupon paid once every 6 months.

Article 2 explains the terms used in the Regulation. The terms used in this Regulation have the following meanings:

a) Treasury bill – a short-term discount government security issued by the Ministry of Finance of Georgia (hereinafter, the "Ministry of Finance") (hereinafter, the "treasury bill");
b) Treasury bond – a medium-term coupon government security issued by the Ministry of Finance (hereinafter, the "treasury bond");
c) Primary market for government securities – the market in which government securities are sold at the time of their issuance;
d) Participants of the primary market for government securities – commercial banks and their clients;
e) Secondary market for government securities – the market in which government securities are bought and sold after their placement on the primary market;
f) Auction cut-off level – the maximum interest rate set by the Ministry of Finance, above which bids participating in the auction will not be satisfied;
g) Multiple-price method – an auction method in which each bid of a winning buyer is satisfied at the price specified in that bid;
h) Register of government securities – electronic records in the securities settlement system that contain information about government securities, their holders and nominee holders;
i) Electronic trading system – software through which government securities are sold at auction and through which trading in the secondary market for government securities is possible;
j) Securities settlement system – an electronic system operated by the National Bank, in which government securities and related operations are recorded and settled.

According to the Regulation (Article 3), the organization of the primary market for government securities (placement, sale) is carried out through auctions. Auctions are held using the electronic trading system. Auctions are held by the multiple-price method. Auctions are held at the National Bank of Georgia (hereinafter, the "National Bank"). Only commercial banks may participate in the auction. The Ministry of Finance receives information on the auction results through the electronic trading system.

Treasury bills are issued in the national currency, in non-materialized form. This means that treasury bills do not exist in paper form; information about them is stored at the National Bank of Georgia as an electronic record.

The issuer of government bonds is the Ministry of Finance. A government bond is a coupon-bearing, medium-term government security, denominated in the national currency and issued in non-materialized form. The National Bank of Georgia sells bonds only to resident head-office commercial banks and to branches of non-resident commercial banks (hereinafter, the "commercial bank"). The Monetary and Credit and Foreign Exchange Policy Commission of the National Bank sets the maximum volume of bonds to be sold and the maximum interest rate. In addition, the Commission has the right to set, for each issue, the maximum amount of bonds that one participant may purchase. The number of bonds in an application to purchase bonds submitted by a bank must not be less than 50 units.

The nominal price of government bonds is GEL 1,000. Individuals are given the opportunity to purchase government bonds through a commercial bank. The auction is held by the multiple-price method (a method under which a winning buyer is satisfied at the price specified by that buyer in the bid). Winning bids are satisfied at the interest rate specified in the bid. Bids specifying lower interest rates are satisfied first, followed by higher ones, and so on, until the securities offered at

the auction are sold in full. The auction is conducted by the National Bank of Georgia through the electronic trading system.

The auction is run by the Market Operations Group of the National Bank of Georgia, which consists of National Bank employees. The Market Operations Group is a specially created team of professionals that carries out all monetary operations of the National Bank as well as the auctions of treasury bills. A person wishing to buy a security on the secondary market must apply to a commercial bank. Income from government securities is not taxed. The market price of a security can be learned on the websites of commercial banks. The National Bank of Georgia notifies commercial banks in advance, three working days beforehand, of the auction date and of the full amount of securities to be placed at the auction. The auction results become known to the participating banks immediately upon completion of the auction. Information on the results is also promptly published on the website of the National Bank of Georgia, no later than 17:00.

To keep the market informed, the Ministry of Finance of Georgia and the National Bank of Georgia announce an indicative issuance schedule in advance, an example of which is presented in table form (see Appendix 11). Each individual issue is announced separately (for the form of announcement of a specific issue, see Appendix 12).

For a holder of a treasury bill who keeps it from the date of purchase until maturity, the income equals the difference between the security's nominal value and its purchase price. If the holder sells the security before maturity, the income from holding it is the difference between its purchase and sale prices.

Income from government securities is not taxed.

According to Article 5, the procedure for submitting bids is as follows:

The acceptance of bids begins on the day of the auction, 30 minutes before the start of the auction, and ends at the moment the auction begins. Banks have the right to submit bids at the auction in their own name (for the bank's portfolio) and/or on the instruction of a client (for the client's portfolio). Bank clients submit bids at the auction through commercial banks. At the request of the National Bank, the bank is obliged to send the National Bank a list of the clients submitting bids, indicating the respective amounts.

A bid may be competitive or non-competitive. Non-competitive bids (both the bank's own and those of clients) are submitted by the bank in aggregate form, indicating the total amount and the number of bids. The amount of one non-competitive bid must not exceed GEL 20,000. On the instruction of one client, a bank may submit only one non-competitive bid. In its own name, a bank may submit only one non-competitive bid. The number of non-competitive bids submitted by a bank at the auction on the instruction of clients is not limited. The number of competitive bids that a bank may submit at the auction is not limited. The total volume of a bank's own bids submitted at the auction must not exceed 50% of the announced issue volume. A bid of another bank and/or client will be counted as the bank's own bid if the bank directly and/or indirectly holds a stake of 10% or more in that bank and/or client. The total volume of one client's bids submitted by each bank must not exceed 50% of the announced issue volume. The number and total volume of the bids of all clients of a bank are not limited.

The minimum volume of one competitive bid is GEL 50,000. This amount, and the approach of this market and its regulator in Georgia, is entirely incomprehensible. First of all, the situation requires explanation in which the minimum bid threshold was raised from the original legislative requirement, that is, from GEL 100 to GEL 50,000.

This, together with other additional factors, only weakens competition in the Georgian market and promotes the monopolization of the market. In addition, a person wishing to place bids can do so via the internet, which an ordinary local investor in Georgia is deprived of, other than through commercial banks. This is a departure from world practice because, as the situation in the U.S. government securities market discussed in the previous chapters shows, lowering the minimum

threshold is essential for stimulating the market. This would only encourage the market and increase competition.

Commercial banks submit bids in electronic form through the software serving the auction. By submitting an electronic bid, the bank acknowledges the mandatory fulfillment of the requirements of these rules.

The mechanism for determining the coupon rate of a treasury bond is quite interesting. It is set by rounding the weighted average interest rate recorded at the auction downward to the nearest tenth of a percent. In the case of an additional issue of treasury bonds previously issued by the Ministry of Finance, the coupon rate used is the one set at the first auction of that treasury bond, and it is announced in advance by the Ministry of Finance in the auction notice.

1. The purchase price of one treasury bill is calculated as follows:

Purchase price = Nominal value / (1 + ((interest rate / 100) × (number of days to maturity / 365)))

2. The purchase price of one treasury bond is calculated as follows:

$$P = \frac{F}{\left(1+\frac{i}{n}\right)^{W}}\left[\frac{R}{n} \times \frac{\left(1-\frac{1}{\left(1+\frac{i}{n}\right)^{N}}\right)}{\left(1-\frac{1}{\left(1+\frac{i}{n}\right)}\right)} + \frac{1}{\left(1+\frac{i}{n}\right)^{N-1}}\right]$$

where:

P – purchase price;

F – nominal value of the treasury bond;

i – annual interest rate offered by the auction participant, divided by 100;

n – number of coupon payments per year;

W – number of days between the purchase date of the treasury bond and the next coupon payment date, divided by the number of days between coupon payments;

R – annual coupon interest rate, divided by 100;

N – number of remaining, still unpaid coupons until the maturity of the treasury bond.

Non-competitive bids will be satisfied at the weighted average rate, which is calculated as follows:

$$C = \frac{\Sigma(N \times P)}{\Sigma(N)}$$

where:

C – weighted average rate;

E – sum;

N – nominal value of the competitive bids satisfied at the auction;

P – interest rates of the satisfied bids;

The coupon payable is calculated as follows:

$$Q = N\left(\frac{p}{2}\right)$$

where:

Q – coupon amount;

P – coupon rate;

N – nominal value of the treasury bond.

As a result of the study of the legislative basis of government securities and the issue of their placement, the following conclusions can be drawn:

- The Law "On State Debt" directly explains that funds received from domestic state debt, expressed in the national currency, are used:

  a) to cover the budget deficit;

b) to cover short-term cash gaps in the state budget.

This issue requires additional explanation, as there is a legislative gap: Georgian legislation limits the use of funds raised through the issuance of government securities to these two purposes only. This clearly narrows and distorts the scope of circulation and use of this instrument, as evidenced by the inadequate use of this instrument in the Georgian financial system.

We believe that this article of the law should be formulated so that government securities perform the following functions:

1. Through them it should be possible both to accumulate the monetary savings held by the population and to mobilize the temporarily free funds of organizations in order to finance budget expenditures;
2. This instrument should be used to regulate the circulation of money;
3. It should be a source of investment for large infrastructure projects, as well as for the creation of new enterprises and the development of existing ones;
4. It should be used as an instrument in credit and settlement operations.

According to the current legislation and the Regulation "On the Issuance, Circulation, Accounting and Redemption of Treasury Bills and Treasury Bonds by the Ministry of Finance of Georgia," government securities are placed only through commercial banks. That is, any interested person is obliged to go to a commercial bank and place resources through it. Accordingly, if a citizen of Georgia or a non-resident wishes to lend money to their own state, they must, according to the rules, apply only to a commercial bank, pay it the money, and inform it of their intention and the interest rate.

We believe that this requirement is unjustified and restrictive for the functioning of the market, and it limits a broad segment (small and medium-sized investors) in investing funds in government securities. This is compounded by a conflict of interest between the investor and the commercial bank: commercial banks also want to place their own resources at the auctions.

This problem is aggravated by the fact that, when filling in a bid before the auction, every investor is obliged to disclose to the commercial bank their full confidential information, that is, who they are, how much they are investing, and at what interest rate. In addition, the consolidated bid of the clients (their rates, amounts and names) is signed and certified by a trusted senior officer of the commercial bank, who at the same time completes the bid of his or her own bank.

That is, having the clients' full insider information at its disposal, a commercial bank can freely place its own resources at a favorable price at the auction, which is done to the detriment of the clients and by inflicting financial loss on them (unless the client is themselves an insider or employee of the bank).

It is worth noting that the National Bank of Georgia had an interesting proposal on this matter, submitted in late 2005 and reflected in the National Bank of Georgia's 2005 annual report (Annual Report of the National Bank of Georgia, 2005, Tbilisi, Georgia).

The essence of the proposal involved changing the rules for the placement of government securities, the independent admission of licensed brokerage companies to the primary auction, and the introduction, for any natural or legal person, of the world-tested direct sale procedure – TREASURY DIRECT. Unfortunately, these truly interesting and civilized rules, which were developed and prepared, have not been put into effect to this day.

It is therefore necessary to change the legislation and the regulation on holding auctions so that:

1. The rules for admitting financial intermediaries to the primary auction are broadened. This right should belong not exclusively to commercial banks, but also directly to securities intermediary companies – brokerage companies – and other interested parties that meet the requirements of the new rule and regulation;
2. A ban is introduced on investing their own resources for those intermediaries who serve clients in this market. Alternatively, the regulation should oblige them to notify the

clients' investment volumes and rates in writing before the auction. This would correct the existing unhealthy situation in this regard;

3. The issuance of all types of government securities is carried out publicly, through an exchange, which would rule out any speculation and would promote the normal and civilized development of the market;
4. The direct procedure for investors to purchase treasury bills and bonds that exists in the world's leading countries, the so-called "Treasury Direct," is introduced. Even the most developed U.S. market, which has an abundance of intermediaries and a highly liquid market, has a procedure for the direct sale of government securities to investors. The essence of the system is simple: on the one hand, there is a service that receives bids for the purchase and redemption of government securities; on the other hand, this service performs the depository function of confirming the ownership rights to these securities. The point is that the National Bank of Georgia should sell treasury bills and bonds to investors without any intermediation by commercial banks. In other areas in Georgia the so-called one-window principle is in operation, and all that is needed here is political will for this civilized form of auction and purchase to finally be introduced in Georgia. In this regard, it is necessary to introduce the regulation on the "direct purchase of treasury bills," agreed between the National Bank of Georgia and the Ministry of Finance, which was prepared in 2002, developed in 2005 and then suspended. This would bring Georgia closer to civilized standards and increase transparency, competition and the interest of a wide circle of investors in the market.

The introduction of this method will increase investor demand, while market intermediaries will have to raise the level and quality of their services.

All of this is necessary for a civilized and modern system of financial operations to be established in Georgia.

- Under the current Regulation of the Ministry of Finance of Georgia "On the Issuance, Circulation, Accounting and Redemption of Treasury Bills and Treasury Bonds by the Ministry of Finance of Georgia," in order to participate in primary auctions an investor must place at least GEL 50,000, which prevents small and medium-sized investors from becoming participants in this market.

We believe that the minimum investment amount should be reduced and the minimum bid should be GEL 100, in line with international practice.

We consider the U.S. government securities market to be a model in this respect: because of the crisis, the minimum amount there was reduced from USD 1,000 to USD 100. In this regard, it is unclear why the National Bank of Georgia took an action contrary to the global trend and to logic, raising the minimum bid from GEL 1,000 to GEL 50,000. This action serves only the interests of commercial banks and large legal entities and individuals, and leads to the monopolization of the market. At the same time, the established minimum threshold reduces the interest of the broad segment of the population in investing in government securities, which ultimately only makes domestic debt more expensive.

- According to the legislation in force in Georgia, the issuance and placement of government securities is carried out only in the national currency of Georgia – the lari. That is, when investing in Georgian government securities, in addition to the traditional risks characteristic of Georgia (country risk, low credit rating, political and other risks), the investor must take on currency risk. There is no exchange-traded instrument in Georgia that would insure against currency and other risks (currency futures), which complicates the investment process and raises the interest rate. As a result, the number of international and local individual and institutional investors in these operations is negligible, and there is only one type of investor in this market – Georgian commercial banks. Banks have a whole range of

advantages in the investment process (the exclusive right of primary dealers, repo operations, recognition of this instrument as liquid assets, lombard loans from the National Bank, and others), which puts them in a non-competitive environment compared with others.

As a result, in a number of cases the interest rates during auctions are much higher than on the international market, and there is in effect an absence of foreign and local non-bank institutions at these auctions.

To improve the situation, it is advisable to:

1. Introduce in practice the regulation on an exchange-traded instrument – the currency future – and bring it to an organized trading market (in the existing reality, this is the stock exchange);
2. Issue government securities indexed to inflation or other additional risks, similar to international analogues.

- In accordance with the Regulation of the Ministry of Finance of Georgia on the issuance, circulation, accounting and redemption of treasury bills and treasury bonds, and the norms in force, commercial banks have the right to set client service tariffs at their own discretion. In other words, the service tariffs and rules for potential investors differ from one another. There is a risk of narrowing the interests of certain groups of investors and of protectionism for a small group (if the investor is an insider of the bank). All of this seriously hampers the development of this market and prevents a potential investor from making an investment.

To regulate this situation (by regulation we mean securities issued by the state), it is advisable to establish a uniform fixed commission for all participants in primary auctions (if the investor applies to an intermediary), and, in the event of any violation of this rule, to strip the intermediary of the right to participate in primary auctions for government securities and also to impose a fine.

- It is true that the National Bank of Georgia and the commercial banks managed to move the auctions to an electronic format through the Bloomberg system; however, the old format has not been abolished, which obliges banks to transfer bids onto paper and submit them. The rule is as follows:
  1. Until 17:00 on the day before the auction, large commercial banks stop accepting clients and begin preparing the bank's own bid. When completing both bids, the commercial bank prepares an electronic and a printed version. After signing, the printed version is placed in two envelopes and sealed (both bids are signed by a senior officer of the bank). One envelope contains the bank's bid, and the other the clients' bids;
  2. Before electronic trading begins, the sealed envelopes are delivered to the National Bank of Georgia;
  3. Identically to the bids contained in the envelopes, these bids are submitted in the Bloomberg system before trading begins, using a corresponding coding system (amount and discount). This electronically coded data is gathered from all banks on the server and monitor of the National Bank of Georgia. At the appointed time of the auction, the National Bank of Georgia opens trading and announces the auction result. If there is a discrepancy between the electronic and the written bid, the electronic bids take precedence.

With regard to government securities, the most optimal way to ease trading, increase investor access and raise the country's investment attractiveness is to organize direct electronic trading – placement on an exchange trading floor. At this stage, the scarce Georgian financial market is split between two exchanges. The first is the Georgian Stock Exchange, which trades shares and has all the investor protection mechanisms and provisions required by world practice; however, as the research showed, it is fully controlled by commercial banks, and by the end of 2014 only branches of commercial banks actually remained among its brokerage companies (in the form of TBC Bank,

Bank of Georgia, Kartu Bank and Liberty Bank). This does not allow it to develop and become a broad alternative for small and medium-sized non-bank investors.
The second exchange for trading government securities is the National Bank of Georgia, with the Bloomberg electronic system controlled by it, to which only commercial banks are admitted.
The way out lies in creating a single exchange trading floor (if the appropriate political decision is made), where all types of securities would come together and it would become possible to solve all the problems outlined, to increase openness and investor access, and to do so by way of interesting intermediaries in participating.
Trading should also be organized in accordance with international practice, under which investors' rights will be strictly protected during the placement of treasury bills and bonds and the subsequent buying and selling process.

- The existing procedure for maintaining the register of government securities is quite a problematic issue. Under the current situation, maintaining the central register is the responsibility of employees of the National Bank of Georgia – the auction committee. Commercial banks, for their part, maintain sub-registers broken down by their clientele. The auction for government securities is conducted by the same composition that maintains the central register, that is, the National Bank of Georgia and a representative of the Ministry of Finance. In general, maintaining a securities register in Georgia is a licensed activity carried out by separate legal entities – registrar companies.

However, the issue of government securities has been removed from this legislative space. At the same time, since 2008 the National Bank of Georgia has been a mega-regulator, which supervises this activity and issues licenses for it.
The existing situation and problems give rise to many issues, such as amending the legislation, restoring the Securities Commission, removing from the National Bank of Georgia functions that are uncharacteristic of it, and many others.
In order to minimize conflicts of interest, it would be advisable to separate the auction committee from the National Bank and create an autonomous body – the "Auction Committee for the Supervision, Issuance, Placement and Circulation of Government Securities." Its function would be to organize and conduct auctions and to direct the work of the Treasury House (Treasury Direct), while settlement issues would be handled by a central depository or registrar companies, using the methodology proven by many years of experience on the securities market.

Literature:

1. Aslanishvili, Davit, (2015). Georgia State Securities Papers Market ,May 2015, ISBN 978-9941-0-7968-9, (PDF) Georgia State Securities Papers Market დავით ასლანიშვილი სახელმწიფო ფასიანი ქაღალდები საქართველოში: გამოწვევები და პერსპექტივები
2. Aslanishvili, D. Ricardo equivalent, the origin of state debt, its meaning and practical purpose Conference: Modern Tendencies of Development of Economy and Economic Science. (p. 18-22)
3. David Aslanishvili. (2026). International Discussions on Government Securities and Their Practical Purpose. *Foundations and Trends in Modern Learning*, (14). Retrieved from https://ojs.scipub.de/index.php/FTML/article/view/9379
4. David Aslanishvili. (2024). Process of economic reforms in Georgia and the Shock Therapy (1991 – 1998). Progress in Science, (7). Retrieved from https://ojs.scipub.de/index.php/PS/article/view/4241

5. David Aslanishvili. (2024). Georgian Treasury Bills Market – first steps and discovered problems (1997 – 1999). European Research Materials, (7). Retrieved from https://ojs.scipub.de/index.php/ERM/article/view/4202
6. David Aslanishvili. (2024). Georgian Economy retrospective: from the Soviet Planning time to the transition. Foundations and Trends in Research, (7). Retrieved from https://ojs.scipub.de/index.php/FTR/article/view/4159
7. Aslanishvili, D., & Omadze, K. (2016). Origins and the Reasons of Monetary Crises in Georgia (1995-2016). Modern Economy, 7(11), 1232-1250.
8. Aslanishvili, D. (2016). Market foundation for sustainable economy growth and energy policy (Georgian case). Modern Economy, 7(03), 314-319.
9. Aslanishvili, D., & Omadze, K. THE INFLUENCE OF GLOBAL ECONOMIC CRISIS ON WORLD ECONOMY, ITS REASONS AND OVERCOME STEPS. In Materials of reports made at the international scientific-practical conference held at Paata Gugushvili Institute of Economics of Ivane Javakhishvili Tbilisi State University in 2013 (p. 508).
10. Aslanishvili, D. D. (2021). World Experience: Commercial Bank Credit and Economic Growth Relationship. International Journal of Risk and Contingency Management (IJRCM), 10(1), 45-53. http://doi.org/10.4018/IJRCM.2021010105
11. Aslanishvili, D., & Omadze, K. (2023). THE EVOLUTION OF THE ESSENCE OF HUMAN MATERIAL LIFE–FROM ANCIENT ROME TO THE MODERN WORLD. THE PROBLEMS OF DEVELOPMENT OF THE WORLD AND NATIONAL ECONOMY, TAKING INTO ACCOUNT THE PANDEMIC AND RUSSIAN-UKRAINIAN WAR PERSPECTIVES, 14.
12. Aslanishvili, D., & Omadze, K. (2013). The Impact of the Economic Crisis on the World Economy–TSU. International Scientific-Practical Conference of the Institute of Economics (pp. 28-29).
13. Aslanishvili, D. (2015). Georgian Eurobond: Unknown Reasons of Issue. In Materials of reports made at the international scientific-practical conference held at Paata Gugushvili Institute of Economics of Ivane Javakhishvili Tbilisi State University in 2015 (p. 317).
14. David Aslanishvili. (2025). Georgia of 1991 -1999: The first signs of the Economic Sovereignty and an Economic Safety. *Modern Scientific Technology*, (10). Retrieved from https://ojs.scipub.de/index.php/MSC/article/view/6330
15. Davit Aslanishvili. (2025). Observation of Georgia's Macroeconomic Policy of late 90-s as the Grounding of the Country's Economic Advance. *Modern Scientific Method*, (10). Retrieved from https://ojs.scipub.de/index.php/MSM/article/view/6456
16. David Aslanishvili. (2025). Georgia of 1991 -1999: The first signs of the Economic Sovereignty and an Economic Safety. *Modern Scientific Technology*, (10). Retrieved from https://ojs.scipub.de/index.php/MSC/article/view/6330
17. Aslanishvili, D. . (2021). Georgia state debts as securitization example. *Georgian Scientists*, *1*(1). https://doi.org/10.52340/gs.02.09.225

An Analysis of Factors Influencing the Choice of Georgian Higher Education Institutions by International Students

Nugzar Todua
Ph.D, Full Professor, Department of Marketing, Ivane Javakhishvili Tbilisi State University, Georgia
Magda Magradze
Ph.D Student, Department of Marketing, Ivane Javakhishvili Tbilisi State University, Georgia

Abstract. *This paper examines the factors influencing international students' choice of higher education institutions in Georgia, as well as their experiences and levels of satisfaction. The theoretical framework for the study integrates the Push-Pull model, the Theory of Planned Behavior (TPB), and Human Capital Theory. A quantitative approach was employed via an online survey using a structured questionnaire (based on a 5-point Likert scale). The study involved 390 international students who were enrolled in 21 Georgian universities during the 2025–2026 academic year. It evaluated the country's overall attractiveness, along with institutional, academic, social, economic, marketing, and personal factors. The findings indicate that Georgia is perceived as a safe (M=3.95) and financially affordable country. Institutional attractiveness, the quality of academic programs (M=3.93), and the consideration of career and personal goals when selecting a university received particularly high ratings. The majority of students make their choices deliberately, linking them to career success (M=4.14). Among information sources, digital channels (M=3.68) and the experiences of current students or graduates (M=3.58) proved to be the most influential. The lowest scores were recorded for financial support (M=1.97) and the role of recruitment agencies (M=2.06). Student satisfaction (M=3.58) is positive and is directly linked to the provision of positive recommendations and word-of-mouth (WOM) behavior. However, responses regarding social integration, the perception of discrimination (M=3.05), and the preservation of religious identity (M=2.99) are mixed. The study's findings indicate that attracting international students is a complex process. Georgia's competitive advantages—safety, financial affordability, quality of education, and career prospects—must be utilized effectively. It is recommended to implement a unified International Student Experience Model, as well as to strengthen digital marketing, scholarships/financial support, and mechanisms for socio-cultural integration.*

Keywords: *international students, Georgia, factors influencing university selection, student behavior, marketing research*

1. Introduction

In the context of globalization and a knowledge-based economy, the internationalization of higher education has become a key priority for modern educational systems. Attracting international students is not only a significant factor for the quality of education and a country's international reputation, but it also exerts a major influence on human capital development, economic growth, and national competitiveness.

Global student mobility has increased significantly over the last few decades, becoming a defining feature of the global education system. According to OECD data, international student mobility has continued to rise in recent years. In 2022, more than 4.6 million internationally mobile

students were studying in OECD countries; by 2025, this figure reached 6.7 million, and the upward trend is expected to continue (OECD, 2025). In this context, universities—as well as entire countries—operate within an increasingly competitive environment and are compelled to develop strategies to attract international students, a process directly linked to their financial sustainability and international reputation (Todua, Kartsivadze, 2025).

In recent years, Georgia has also been actively positioning itself as an international educational hub. Consequently, the number of foreign students has grown significantly; in the 2024–2025 academic year, there were 37,125 international students in the country, and by the 2025–2026 academic year, this figure had increased by another 19.7% (Geostat, 2026). Given this, it is of particular importance to examine the factors that influence international students' decisions to choose Georgia and its higher education institutions, as well as the factors affecting their experiences and levels of satisfaction.

2. Theoretical background of the research

The theoretical foundation of the study consisted of the "Push–Pull" model, the Theory of Planned Behavior, and Human Capital Theory (Ajzen, 1991; Mazzarol & Soutar, 2002). According to the literature reviewed for this study, the "Push–Pull" model is one of the most widely used theoretical frameworks for understanding international student mobility and the selection of an educational destination. Based on this model, the decision to study abroad is shaped by the combined influence of two sets of factors: "push" factors, which operate within the student's home country and foster the desire to study abroad, and "pull" factors, which relate to the advantages offered by the host country and the specific educational institution (Mazzarol & Soutar, 2002). Research also confirms that "pull" factors may carry more weight than "push" factors in students' decision-making (Janik et al., 2023). An advantage of the "push-pull" model is that it distinguishes between the factors determining the general decision to study abroad, the choice of a host country, and the selection of a specific university. However, a limitation of this model is that it does not sufficiently account for individual differences or the socio-economic environment (Li & Bray, 2007). Therefore, it is advisable to integrate the "push-pull" model with the Theory of Planned Behavior, which provides a clearer explanation of a student's personal attitudes, social influences, and the feasibility of carrying out a decision.

According to the Theory of Planned Behavior (TPB), an individual's evaluations and social influences are transformed into an intention to engage in a specific behavior. According to Ajzen (1991), the immediate antecedent of behavior is behavioral intention, which is determined by three main components:

- Attitude toward the behavior: the extent to which an individual evaluates a specific behavior positively or negatively;
- Subjective norm: the extent to which an individual perceives support or pressure from significant social groups;
- Perceived behavioral control: the extent to which an individual considers the behavior to be possible and feasible, given existing resources and constraints.

In the context of international education, a student's attitude reflects their assessment of the value of studying in Georgia. A positive attitude may stem from expectations regarding the acquisition of a quality education, the receipt of an internationally accredited degree, professional development, living in a safe environment, or the prospect of future employment. Subjective norms reflect the influence of family, friends, students already in Georgia, graduates, educational agents, and other significant individuals.

Choosing an international education is a financially costly decision that carries a relatively high level of risk. Consequently, students often rely on recommendations from people they trust

or from those who have direct experience studying in the host country. This approach explains the significance of personal recommendations and positive word-of-mouth communication.

Perceived behavioral control refers to a student's assessment of the extent to which they are capable of carrying out the decision to study in Georgia. This may depend on tuition and living costs, financial support from family, the possibility of obtaining a scholarship, the simplicity of visa and administrative procedures, the availability of information, language proficiency, and the conditions for university admission. A student might hold a positive attitude toward a country or a university, but if they perceive the financing of their studies, obtaining a visa, or finding accommodation as difficult, their behavioral intention may weaken.

According to human capital theory, education is an investment through which an individual acquires knowledge, skills, and qualifications, thereby increasing their productivity and improving their employment and income prospects (Becker, 1964). Under this theory, when choosing higher education, an individual weighs the expected benefits against the costs. Costs encompass not only tuition fees but also living, travel, and accommodation expenses, as well as the opportunity cost—the income the student could have earned had they worked instead of pursuing their studies. Expected benefits include professional knowledge, international qualifications, better employment prospects, higher income, career mobility, social status, and international professional networks.

International education represents a distinct form of human capital; beyond academic knowledge, it equips students with foreign language proficiency, intercultural competencies, experience of independent living, international networks, and the ability to adapt to diverse social environments. Consequently, a student's choice of country and university can be viewed as a rational investment decision: the student selects an option expected to yield greater personal and professional benefits relative to the costs incurred.

Factors such as the quality of education, the relevance of the academic programme, international accreditation, the recognition of the degree, employment prospects, and tuition fees are closely linked to this theory. A high-quality, internationally recognised programme enhances expected returns, while affordable tuition and a relatively low cost of living reduce investment expenditure. Therefore, a student might not necessarily choose the country with the highest ranking, but rather an option that offers the optimal balance of quality, cost, and career outcomes. In this context, countries like Georgia have a greater opportunity to attract international students.

Each of the three theories explains a distinct yet interconnected aspect of a student's decision-making process. The "push-pull" model addresses which external factors drive a student to study abroad and what draws them specifically to Georgia. The theory of planned behaviour explains how perceptions of these factors translate into attitudes, social support, behavioural control, and, ultimately, a firm intention. Meanwhile, human capital theory illustrates why a student views an international education as an investment—one aimed at securing future professional and economic benefits.

Consequently, the choice made by international students to come to Georgia can be viewed as a multi-layered process, in which:

- Educational and economic constraints in the student's home country exert a "push" effect;
- The quality, cost, safety, and career opportunities offered by Georgia and its universities create a "pull" effect.
- A student's attitudes, recommendations from significant individuals, and the assessment of their own capabilities determine their intention to make a specific choice;
- The professional and economic benefits expected from education imbue the final decision with the nature of an investment.

This integrated approach makes it possible to explain a student's choice not only through the objective characteristics of a country or university, but also through the subjective perception of these characteristics, social influence, and long-term expectations regarding investment in education.

3. Research Methodology

The study was conducted using a quantitative method in the form of an online survey. Data were collected from international students enrolled in higher education institutions accredited in Georgia. A total of 390 international students participated in the study; for the 2025–2026 academic year, they were pursuing studies across 21 different private and public universities and educational programs in Georgia. A structured questionnaire, featuring questions based on a 5-point Likert scale, was used as the data collection instrument. The study assessed students' perceptions of Georgia as an educational destination, the academic and institutional characteristics of the universities, the effectiveness of marketing communications, as well as student satisfaction and the factors influencing the university selection process. The following research framework was developed for the study (see Table 1).

Table 1. Research construct

N	Variables	Measurement Items	Adapted from source(s)
1	Country attractiveness	Living and studying in Georgia is safe	Mahmoud et al. (2020); Newsome & Cooper (2016)
		Georgia has a comfortable climate	
		I have social connections in Georgia	
		It's easy to find food that pleases me in Georgia	
		I will not lose my religious affiliation in Georgia	
2	Institutional attractiveness	Education level in Georgia is high	Ahmad et al. (2016); James-MacEachern & Yun (2017)
		The universities in Georgia have a high international reputation	
		It is easy to enroll in Georgian universities	
		In Georgia, I can study on an educational program that is not in my homeland	
		In Georgia, I can get an education that will help me get my employment	
		The education received in Georgia is valued in my homeland	
3	Academic factor	There are universities in Georgia that have an excellent reputation for the quality of education and the possibility of research	Abbas et al. (2021); Cynthia & Chong (2023)
		There are universities in Georgia that are innovative in the field of education	
		There are universities in Georgia that offer a wide range of educational programs	

4	Social factor	There is no discrimination against people in Georgia (by race, religion or gender)	Abbas et al. (2021)
		People in Georgia are friendly and kind to foreigners	
		The lifestyle of people in Georgia is interesting	
5	Economic factor	Living costs are affordable in Georgia	Cynthia & Chong (2023); Yue et al. (2024)
		Tuition fees are affordable at Georgian universities	
		Paying the tuition fee at Georgian universities is flexible	
6	Marketing factor	I received information about universities from traditional advertising outlets (television, radio, magazines, newspapers, etc.)	Abbas et al. (2021); Nuseir & El Refae (2022); Al-Abdallah & Ababakr (2025)
		I received information about universities from digital advertising (social media, websites, blogs, etc.)	
		I received information about universities from relatives/friends	
		I received information about universities from graduates/current students	
		I received information about universities from students recruitment agencies	
		I attended an event organized in my country to raise awareness among students	
		I attended an education fair organized in my country	
7	Personal factor	I choose a university that will allow me to raise my status	Amaro et al. (2019); Yue et al. (2024)
		I choose a university that will allow me to earn a good income	
		I choose a university that will allow me to establish international contacts	

		I will have financial support from my Government or Agency when studying abroad	
		I will have the prospect of career advancement in my homeland with the education obtained abroad	
		I will have the opportunity to contribute to the development of my homeland with a foreign degree/education	
8	Attitude towards universities	There are universities in Georgia whose educational system and structure I like	Mazzarol & Soutar (2002); Mahmoud et al. (2020); Al-Abdallah & Ababakr (2025)
		There are universities in Georgia that I believe offer high quality education	
		Before attending the university, I found information about various higher education institutions	
		Before making a decision, I evaluated the attributes of different universities in which I could enroll	
9	Decision-making	Based on my preferences, I decided on which university to enroll in	Al-Abdallah & Ababakr (2025); Migin et al. (2015); Hung (2021)
		I made the right decision regarding my career	
		My decision can have a financial and emotional impact on my life	
		My decision was reasonable	
10	Making a choice	I chose the University according to my motivation to study abroad	Hung (2021); Nilsson & Ripmeester (2016); Sim et al. (2020)
		I selected the university according to my career path	
		I selected a university according to its image	
		I chose a university according to the best opinions available to me	

11	Satisfaction	I am satisfied that I am studying at the university I have chosen	Amaro et al. (2019); Kairat et al (2024); Al-Abdallah & Ababakr (2025)
		The university I chose is in line with my expectations that I had before enrollment	
		I like my university's learning environment	
		I like the location of my university	
		I like my university's infrastructure	
12	Dissemination of word of mouth (WOM)	I'm going to talk to other people about my university	Kairat et al. (2024); Al-Abdallah & Ababakr (2025)
		I intend to recommend my university to others	
		I intend to spread a positive opinion on social media about my university	

Source: author's work

4. Research Results

Based on the study's theoretical framework, the research analyzed the attitudes of international students enrolled in Georgia regarding the country's overall appeal—encompassing academic, economic, social, marketing, and institutional factors—as well as the influence of these factors on their choice of country and university, and their subsequent satisfaction.

The findings indicate that the perception of Georgia as a place to study and live is generally positive. Safety emerged as the strongest aspect (M=3.95), and social connections were also rated positively (M=3.74). The assessment regarding the preservation of religious identity is relatively low and shows significant variation (M=2.99; SD=1.974), which may reflect diverse experiences depending on the students' backgrounds, religious affiliations, and social environments.

Institutional attractiveness stands out as one of the most highly rated dimensions in the study: for six out of the seven indicators, the mean score reaches 4.00. Students view the reputation of universities, the enrollment process, educational offerings, and employment prospects positively. However, a relatively lower score in this area (M=3.00) suggests that a positive institutional image does not necessarily translate into an equally strong practical experience for all students.

Academic factors received consistently positive ratings. High-quality educational programs scored the highest (M=3.93), followed by international accreditation (M=3.81) and the value of the degree in the country of origin (M=3.78). Ratings for innovativeness (M=3.71) and international recognition (M=3.63) are relatively lower. Consequently, students perceive the academic degree more favorably than they do the global visibility of the universities.

Assessments of the social environment are mixed. The friendliness and goodwill of Georgians are rated positively (M=3.67), whereas the perception regarding the absence of discrimination hovers near the neutral mark (M=3.05). Differences in the responses indicate that students' social experiences may be influenced by their background, university, and living

environment. Consequently, social integration and an environment free from discrimination require particular attention.

The affordability of the cost of living in Georgia was rated relatively positively (M=3.61), while the affordability of tuition fees falls into a moderately positive range (M=3.41). The appeal of the Georgian lifestyle received a more moderate rating (M=3.17). The results indicate that financial affordability serves as a stronger motivator for students than the cultural environment. Furthermore, economic experiences vary depending on a student's income, the city in which they reside, their living conditions, and their specific academic program.

Digital channels represent the most significant source of information (M=3.68), followed by current students and graduates (M=3.58). Friends, relatives, and traditional media exert a relatively smaller—though still significant—influence (M=3.45). The roles played by recruitment agencies (M=2.06) and embassy-organized events (M=2.27) are limited. These findings underscore the particular importance of online communication and information rooted in the actual experiences of students.

The choice of a university is closely linked to students' career and personal goals. Ratings for self-actualization (M=3.80) and expectations regarding future income (M=3.76) are high. The lowest score is for financial support (M=1.97), indicating that the majority of students fund their education using their own or their family's resources. A scarcity of scholarships and other forms of financial aid could act as a barrier to attracting students and retaining them in their studies.

Students hold a positive attitude toward Georgian universities. The assessment of the quality of education is particularly high (M=3.94). Students also associate an education obtained abroad with opportunities for professional advancement and contributing to society within their own country (M=3.82). However, this generally positive attitude does not always align with the students' specific personal experiences.

All indicators related to the decision-making process are high. The majority of respondents consider their choice to be the right one in terms of career success (M=4.14). They compare the characteristics of various universities beforehand, base their decisions on personal preferences, and are aware of the financial and emotional significance of their choice. Consequently, selecting a university is, for the most part, a deliberate and informed process.

The motivation to study abroad is the strongest determinant in the choice of a university (M=4.19). Also significant are the perceived soundness of the decision (M=3.88), the university's reputation (M=3.85), and career goals (M=3.83). The results confirm that students' choices are multifactorial, encompassing an assessment of international experience, career development, institutional image, and personal goals.

Overall student satisfaction is positive, though moderate when compared to other behavioral indicators. Positive recommendations have a significant influence on the choice of university (M=3.86). The learning environment (M=3.77) and the extent to which expectations were met (M=3.71) were also rated positively. General satisfaction (M=3.58) and satisfaction with the university's location (M=3.44) are relatively lower, indicating that the student experience does not always fully align with prior expectations.

In general, students are willing to speak positively about their university and recommend it to others. The assessment of infrastructure is high (M=3.86), while the scores for making recommendations and sharing positive information are 3.78 and 3.75, respectively. Students could become significant representatives of Georgian universities if their academic, social, and administrative experiences are consistently improved.

5. Conclusions

The research findings confirm that the process by which international students select a university and a host country is multidimensional, influenced simultaneously by academic, institutional, social, economic, marketing, and personal factors. Consequently, policies aimed at attracting and retaining international students should be based on an integrated, evidence-based approach.

Based on the research findings, the positioning of Georgia as a destination for international education should be anchored in four key competitive advantages: safety, financial affordability, quality of education, and career prospects.

The findings also confirm that the experience of international students begins prior to enrollment at the university and continues even after they have graduated. Therefore, universities should develop a unified "International Student Experience Model" that encompasses every stage of the student lifecycle: recruitment, admission, enrollment, support for visa and immigration processes, assistance with finding accommodation, academic adaptation, career services, and connection to the alumni network.

An analysis of marketing factors revealed that the most influential sources of information for international students are digital channels, social media, current students, and alumni. This finding aligns with contemporary trends in international marketing, which show that students increasingly rely on online information and the experiences of their peers during the decision-making process (Al-Abdallah & Ababakr, 2025). Consequently, universities' international marketing strategies must become more digital, data-driven, and segmented. Particular attention should be paid to communicating the actual experiences of students and alumni, as research findings confirm that social proof is one of the most significant determinants in the choices made by international students.

The findings regarding personal factors reveal that the majority of international students view education as an investment in their own future. At the same time, however, the research indicates that the availability of financial support for students in Georgia is limited. This result aligns with human capital theory, which posits that investing in education is linked to the expectation of future economic benefits (Becker, 1964). Consequently, it is recommended that financial support mechanisms for international students be expanded—for instance, through scholarships, need-based aid programs, flexible tuition payment schemes, and educational loans developed in partnership with banks.

A significant finding of the study concerns the influence of social factors on student satisfaction and the likelihood of students recommending the institution to others. While international students speak positively of the goodwill and friendly attitude of the Georgian people, their assessments regarding the absence of discrimination and issues of cultural integration are relatively moderate. Research on the integration of international students confirms that the social environment, inclusivity, and cultural adaptation significantly influence both academic success and student satisfaction. Consequently, strengthening social integration and fostering an anti-discriminatory environment should be viewed not merely as an ethical obligation, but as a strategic tool for attracting and retaining international students.

One of the most significant findings of the study is that satisfaction is the strongest predictor of recommendation behavior—a result that aligns fully with findings from international research (Amaro et al., 2019; Al-Abdallah & Ababakr, 2025). This finding underscores that international student satisfaction should be regarded not only as an indicator of educational outcomes but also as a vital component of a university's international development strategy. From a practical perspective, the most significant finding of the study is that current international students and alumni represent the most reliable and effective marketing resource for universities. Their

experiences, recommendations, and stories of professional success exert a substantial influence on the decisions of prospective students. Consequently, enhancing student satisfaction, developing alumni networks, and fostering positive word-of-mouth communication should become a core focus of universities' internationalization strategies.

The research findings confirm that the decision-making process of international students is complex and multifactorial, involving the interplay of a country's overall appeal, institutional characteristics, academic degree programs, the social environment, economic factors, marketing communications, and personal motivation. Finally, the study indicates that Georgia possesses a genuine opportunity to establish itself as a major international educational hub within the region. To achieve this goal, coordinated cooperation among universities, the state, and interested stakeholders is essential—cooperation grounded in a deep understanding of the needs of international students and the implementation of evidence-based policy.

References

1. Abbas, J., Alturki, U., Habib, M., Aldraiweesh, A., & Al-Rahmi, W. M. (2021). Factors affecting students in the selection of country for higher education: A comparative analysis of international students in Germany and the UK. *Sustainability*, *13*(18), 10065.
2. Ahmad, S. Z., Buchanan, F. R., & Ahmad, N. (2016). Examination of students' selection criteria for international education. *International Journal of Educational Management*, *30*(6), 1088-1103.
3. Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*(2), 179 - 211.
4. Al-Abdallah, G., & Ababakr, K. (2025). Exploring the Mediating Effect of Digital Versus Traditional Marketing Communication on Students' Selection of Higher Education Institutions in Developing Countries. *Human Behavior and Emerging Technologies*, *2025*(1), 5510524.
5. Amaro, D. M., Marques, A. M. A., & Alves, H. (2019). The impact of choice factors on international students' loyalty mediated by satisfaction. *International Review on Public and Nonprofit Marketing*, *16*(2), 211-233.
6. Becker, G. S. (1964). *Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education, by Gary S. Becker.*. (Vol. 1). London.
7. Cynthia, R., & Chong, P. Y. (2023). Factors Influencing International Students' Choice to Study at Malaysian Private Higher Education Institutions. *Malaysian Journal of Social Sciences and Humanities (MJSSH)*, *8*(5), e002281-e002281.
8. GeoStat. (2026). Higher Education. https://www.geostat.ge/en/modules/categories/61/higher-education
9. Hung, N. T. (2021). Higher education in business: a model for international students' choice. *Business Process Management Journal*, *27*(6), 1804-1821.
10. James-MacEachern, M., & Yun, D. (2017). Exploring factors influencing international students' decision to choose a higher education institution: A comparison between Chinese and other students. *International Journal of Educational Management*, *31*(3), 343-363.
11. Janik, H., Naár-Tóth, Z., & Vinogradov, S. (2023). Examining the aspects of institution choice in connection with the internationalization of higher education. *Decision Making: Applications in Management and Engineering*, *6*(1), 282-302.
12. Kairat, K., Lee, S. J., & Jang, J. M. (2024). The determinants of recommendation intention and student satisfaction in private higher institutions: Empirical evidence from Kazakhstan. *Journal of Marketing for Higher Education*, 1-21.
13. Li, M., & Bray, M. (2007). Cross-border flows of students for higher education: Push–pull factors and motivations of mainland Chinese students in Hong Kong and Macau. *Higher education*, *53*(6), 791-818.

14. Mahmoud, M. A., Oppong, E., Twimasie, D., Husseini, M. M., Kastner, A. N. A., & Oppong, M. (2020). Culture and country choice of international students: Evidence from Ghana. *Journal of Marketing for Higher Education*, *30*(1), 105-124.
15. Mazzarol, T., & Soutar, G. N. (2002). "Push-pull" factors influencing international student destination choice. *International Journal of Educational Management*, *16*(2), 82-90.
16. Mazzarol, T., & Soutar, G. N. (2002). “Push-pull” factors influencing international student destination choice. *International Journal of Educational Management, 16*(2), 82 - 90.
17. Migin, M. W., Falahat, M., Yajid, M. S. A., & Khatibi, A. (2015). Impacts of Institutional Characteristics on International Students' Choice of Private Higher Education Institutions in Malaysia. *Higher Education Studies*, *5*(1), 31-42.
18. Newsome, L. K., & Cooper, P. (2016). International Students' Cultural and Social Experiences in a British University:"Such a hard life [it] is here". *Journal of International Students*, *6*(1), 195-215.
19. Nilsson, P. A., & Ripmeester, N. (2016). International student expectations: Career opportunities and employability. *Journal of International Students*, *6*(2), 614-631.
20. Nuseir, M. T., & El Refae, G. A. (2022). Factors influencing the choice of studying at UAE universities: an empirical research on the adoption of educational marketing strategies. *Journal of Marketing for Higher Education*, *32*(2), 215-237.
21. OECD. (2025). *Education at a glance 2025: OECD indicators*. OECD Publishing. https://doi.org/10.1787/1c0d9c79-en
22. Sim, A. K., Tan, K. L., Sia, J. K. M., & Hii, I. S. (2020). Students' choice of international branch campus in Malaysia: a gender comparative study. *International Journal of Educational Management*, *35*(1), 87-107.
23. Todua, N., & Kartsivadze, G. (2026). Students' perceptions of ChatGPT integration in higher education. *The New Economist*, 20(4), 36-49
24. Yue, Y., Gong, L., & Ma, Y. (2024). Factors influencing international student inward mobility in China: A comparison between students from BRI and non-BRI countries. *Educational Studies*, *50*(5), 597-615.

Physical and Mathematical Sciences

ӘОК 541.135.4

СУПЕРИОНДЫ ТОК ӨТКІЗГІШТЕР

Рахымбеков Айтбай Жапарович
ф-м.ғ.к., қауымдастырылған профессор, доцент, І.Жансүгуров атындағы Жетісу университеті
Байболат Бағлан Олжасұлы
магистрант

Аңдатпа; Бұл мақалада суперионды ток өткізгіштердің физикалық табиғаты, құрылымдық ерекшеліктері және электрөткізгіштік қасиеттері қарастырылады. Супериондық өткізгіштерде кристалдық тордың белгілі бір бөлігін құрайтын иондардың жоғары қозғалғыштығы нәтижесінде электр тогы тасымалданады. Мұндай материалдар кәдімгі қатты денелерге тән иондық өткізгіштікпен салыстырғанда ерекше электрлік және құрылымдық қасиеттерімен сипатталады.

Түйін сөздер: супериондық өткізгіштер, иондық электрөткізгіштік, қатты электролит, кристалдық тор, иондардың диффузиясы, аккумулятор, электролит, энергия сақтау.

1. Кіріспе

Қазіргі физика мен материалтанудың маңызды бағыттарының бірі – электр тогын тасымалдау қасиеттері ерекше қатты денелерді зерттеу. Электрондық өткізгіштермен қатар иондық өткізгіш материалдар да ғылыми және технологиялық тұрғыдан үлкен қызығушылық тудырады. Мұндай материалдарда электр заряды электрондармен ғана емес, сонымен қатар оң немесе теріс зарядталған иондардың бағытталған қозғалысы арқылы тасымалданады[1].

Негізгі бөлім

Супериондық өткізгіштер – қатты күйде бола отырып, олардың құрамындағы белгілі бір иондар жоғары қозғалғыштыққа ие болатын материалдар. Температураның белгілі бір аралығында мұндай заттардың иондық электрөткізгіштігі күрт жоғарылауы мүмкін. Бұл құбылыс кристалдық құрылымның өзгеруімен, иондардың бос орындар арасында орын ауыстыруымен және иондық ішкі жүйенің жоғары динамикалық қозғалғыштығымен байланысты.

Супериондық өткізгіштердің ерекшелігі – олардың құрылымында белгілі бір атомдар немесе иондар салыстырмалы түрде тұрақты тор түзсе, басқа иондар сол тордың ішінде қозғала алады. Осыған байланысты материал бір мезгілде қатты денеге тән механикалық қасиеттерді сақтап, иондардың жылдам тасымалдануына мүмкіндік береді. Супериондық өткізгіштерді зерттеу электрхимия, қатты денелер физикасы, кристаллография және энергетикалық материалтану салаларының дамуына ықпал етеді. Әсіресе қауіпсіздігі жоғары аккумуляторлар жасау, энергияны тиімді сақтау және электрхимиялық құрылғылардың жұмысын жетілдіру бағыттарында олардың маңызы артып келеді.

Супериондық өткізгіштерді түсіну үшін алдымен қатты денелердегі электр тогының тасымалдану механизмдерін қарастыру қажет. Кәдімгі металдарда электр тогын негізінен еркін электрондар тасымалдайды. Ал кейбір қатты қосылыстарда заряд тасымалдаушылардың рөлін кристалдық тор ішінде қозғалатын иондар атқарады. Мұндай материалдар иондық өткізгіштер деп аталады [2].

Иондық өткізгіштердің ерекше тобына супериондық өткізгіштер жатады. Оларда белгілі бір температурада иондардың қозғалысы жеңілдеп, иондық өткізгіштік жоғары мәнге жетеді.Супериондық күйге тән негізгі ерекшеліктер:

1. Материалдың макроскопиялық қатты күйде сақталуы.
2. Белгілі бір иондардың кристалдық тор ішінде жоғары қозғалғыштықпен орын ауыстыруы.
3. Иондардың бос орындар немесе ықтимал энергетикалық жолдар арқылы қозғалысының жеңілдеуі.
4.Температураның жоғарылауымен иондық өткізгіштіктің артуы және кейбір материалдарда фазалық ауысу кезінде оның күрт өзгеруі.
5.Құрылымдық реттелу дәрежесінің төмендеуі немесе иондық ішкі жүйенің динамикалық ретсіздігінің артуы.

Супериондық өткізгіштік барлық иондық материалдарға тән емес. Ол белгілі бір кристалдық құрылымы, химиялық құрамы және энергетикалық сипаттамалары бар заттарда байқалады. Супериондық материалдарға мысал ретінде күміс иодидін (AgI), кейбір мыс иодидтерін (CuI), күміс сульфидін (Ag_2S) және литий иондарын өткізетін бірқатар қатты электролиттерді атауға болады. Дегенмен олардың барлығын бірдей бір физикалық механизммен сипаттауға болмайды: иондардың қозғалысы, фазалық ауысулар және өткізгіштік шамасы нақты материалға тәуелді[3].

Супериондық өткізгіштіктің физикалық механизмі

Супериондық өткізгіштердің электрлік қасиеттері олардың кристалдық құрылымымен және иондардың қозғалыс ерекшеліктерімен анықталады.

Кәдімгі кристалдық қатты денеде атомдар мен иондар белгілі бір тепе-теңдік орындарының маңында тербеледі. Иондардың бір орыннан екінші орынға ауысуы үшін белгілі бір энергетикалық тосқауылды жеңуі қажет. Сондықтан төмен температурада иондардың қозғалысы шектеліп, электрөткізгіштік салыстырмалы түрде аз болады[4].

Ал супериондық күйде қозғалмалы иондар үшін қолжетімді орындар саны көбейіп, олардың орын ауыстыруына қолайлы жолдар қалыптасады. Нәтижесінде иондар кристалдық тордың белгілі бір бағыттары немесе үш өлшемді арналары бойымен қозғала алады.Бұл процесті үш негізгі кезең арқылы түсіндіруге болады:

Бірінші кезең – иондардың жылулық қозғалуы. Температура артқан кезде кристалдық тор бөлшектерінің жылулық энергиясы жоғарылайды. Иондардың энергетикалық тосқауылдарды жеңу ықтималдығы артады.

Екінші кезең – иондардың орын ауыстыруы. Иондар бос тор орындарына, аралық позицияларға немесе көршілес тұрақты орындарға көшеді. Мұндай қозғалыс секірмелі диффузия механизмі арқылы жүзеге асуы мүмкін.

Үшінші кезең – бағытталған қозғалыс. Материалға сыртқы электр өрісі әсер еткен кезде иондардың қозғалысы белгілі бір бағытта басым болады. Зарядтардың осы бағытталған тасымалдануы электр тогын қалыптастырады[5].

Қорытындылар

Супериондық өткізгіштерде жоғары өткізгіштікке ықпал ететін негізгі факторлар:

- иондардың қозғалысына арналған бос орындардың болуы;
-иондардың орын ауыстыруына кедергі жасайтын энергетикалық тосқауылдың төмендігі;
- кристалдық тордың қолайлы геометриялық құрылымы;
- қозғалмалы иондардың жеткілікті концентрациясы;
- температура мен фазалық күйдің өзгеруі. Осы факторлардың өзара әрекеттесуі материалдың иондық өткізгіштік деңгейін анықтайды. Супериондық өткізгіштердің қасиеттерін сандық тұрғыдан сипаттау үшін электрөткізгіштік, иондардың қозғалғыштығы, диффузия коэффициенті және температураға тәуелділік теңдеулері пайдаланылады[6].

Пайдаланылған әдебиеттер

1. Funke K. Solid State Ionics: From Michael Faraday to Green Energy — The European Dimension. *Science and Technology of Advanced Materials*. 2013.
2. Maier J. *Physical Chemistry of Ionic Materials: Ions and Electrons in Solids*. Wiley, 2004.
3. West A. R. *Solid State Chemistry and Its Applications*. 2nd Edition. Wiley, 2014.
4. Hull S. Superionics: Crystal Structures and Conduction Processes. *Reports on Progress in Physics*. 2004.
5. Goodenough J. B., Kim Y. Challenges for Rechargeable Li Batteries. *Chemistry of Materials*. 2010.
6. Janek J., Zeier W. G. A Solid Future for Battery Development. *Nature Energy*. 2016.

ӘОК 372.853

ФИЗИКАДАҒЫ ЭКСПЕРИМЕНТТІК ЕСЕПТЕРДІ ШЫҒАРУҒА ОҚУШЫЛАРДЫҢ ҚЫЗЫҒУШЫЛЫҒЫН АРТТЫРУ

Рахымбеков Айтбай Жапарович
ф-м.ғ.к., қауымдастырылған профессор, доцент, І.Жансүгүров атындағы Жетісу университеті
Шангерей Ерасыл Ерланұлы
магистрант

Аңдатпа: Мақалада физиканы оқыту барысында эксперименттік есептерді қолдану арқылы оқушылардың пәнге деген қызығушылығын арттыру жолдары қарастырылады. Эксперименттік есептердің білім алушылардың логикалық ойлауын, зерттеушілік қабілетін, практикалық дағдыларын және физикалық құбылыстарды талдау біліктілігін дамытудағы маңызы сипатталады. Оқушыларды есеп шығаруға кезең-кезеңімен үйретудің әдістемелік ерекшеліктері, тәжірибелік тапсырмаларды ұйымдастыру жолдары және «Қысым» тақырыбы бойынша эксперименттік есептерді орындау үлгілері ұсынылады.

Түйін сөздер: физиканы оқыту, эксперименттік есептер, оқушылардың қызығушылығы, зерттеушілік дағдылар, практикалық жұмыс, физикалық эксперимент, проблемалық оқыту, өзіндік жұмыс.

Кіріспе

Қазіргі білім беру жүйесінде оқушылардың дайын ақпаратты қабылдауымен қатар, өздігінен ізденуіне, алған білімдерін тәжірибеде қолдануына және ғылыми тұрғыдан ойлауына ерекше мән беріледі. Осы тұрғыдан алғанда, физика пәнін оқытуда эксперименттік есептерді пайдалану білім сапасын арттырудың тиімді тәсілдерінің бірі болып табылады.Физика табиғат құбылыстарының заңдылықтарын зерттейтін ғылым болғандықтан, оның мазмұны теориялық білім мен тәжірибелік әрекеттің өзара байланысына негізделеді. Оқушы физикалық формулаларды жаттап қана қоймай, олардың қандай жағдайда қолданылатынын түсініп, физикалық шамаларды өлшеу, есептеу, нәтижелерді салыстыру және қорытынды жасау дағдыларын меңгеруі қажет.

Эксперименттік есептер оқушыға физикалық құбылысты бақылауға, қажетті өлшеулер жүргізуге, есептеу әдісін таңдауға және алынған нәтижені түсіндіруге мүмкіндік береді. Мұндай тапсырмаларда білім алушы дайын шешімді қабылдамай, мәселені өздігінен зерттеуге қатысады. Нәтижесінде физика сабағының мазмұны өмірлік жағдаяттармен байланысып, оқушының танымдық белсенділігі артады.

Мақаланың мақсаты – физикадағы эксперименттік есептерді оқыту үдерісінде қолдану арқылы оқушылардың пәнге қызығушылығын арттырудың әдістемелік жолдарын анықтау және практикалық тапсырмаларды ұйымдастыру ерекшеліктерін көрсету.

1.Эксперименттік есептердің оқушы қызығушылығын арттырудағы маңызы

Эксперименттік есептер – физикалық шамаларды тікелей өлшеу, тәжірибе нәтижелерін пайдалану немесе арнайы құралдардың көмегімен алынған деректерді өңдеу арқылы шешілетін тапсырмалар.Мұндай есептердің басты ерекшелігі – олардың шешімі тек теориялық білімге емес, нақты бақылаулар мен өлшеулерге де сүйенеді. Эксперименттік есептерді қолдану төмендегі оқу міндеттерін жүзеге асыруға көмектеседі:

1. **Теориялық білімді тәжірибемен байланыстыру.** Оқушылар физикалық заңдардың нақты құбылыстарды түсіндіруде қалай қолданылатынын байқайды.
2. **Зерттеушілік қабілеттерді дамыту.** Білім алушылар мәселені анықтап, болжам ұсынып, оны тәжірибе арқылы тексеруге үйренеді.
3. **Логикалық ойлауды қалыптастыру.** Оқушылар өлшеу нәтижелерін салыстырып, себеп-салдарлық байланыстарды анықтайды.
4. **Өзіндік жұмыс дағдыларын жетілдіру.** Есептің шешу жолын таңдау, формулаларды қолдану және нәтижелердің дұрыстығын тексеру қабілеттері дамиды.
5. **Физика пәніне қызығушылықты күшейту.** Өз қолымен орындаған тәжірибенің нәтижесін көру оқушының оқу әрекетіне деген ынтасын арттырады.

Мысалы, қысым тақырыбын түсіндірген кезде оқушыларға тек қысымды есептеу формуласын ұсынумен шектелуге болмайды. Оның орнына әртүрлі пішіндегі денелердің тірек бетіне түсіретін әсерін салыстыруға, дененің өлшемдерін анықтауға және қысымның тірек ауданына тәуелділігін тәжірибе арқылы түсіндіруге болады. **Мысал:**

Дене тірек бетіне 600 Н күш түсіреді. Тірек бетінің ауданы 2 м². Дененің қысымын анықтаңдар.Берілгені:F = 600 Н, S = 2 м². Шешуі:p = F / S, p = 600 / 2 = 300 Па.

Жауабы: 300 Па.

2.Оқушыларды эксперименттік есептерді шығаруға кезең-кезеңімен үйрету

Эксперименттік есептерді нәтижелі орындау үшін оқушыларда қажетті теориялық білім мен практикалық дағдылар қалыптасуы керек. Сондықтан тапсырмаларды бірден күрделі деңгейден бастамай, қарапайым әрекеттерден зерттеушілік сипаттағы жұмыстарға дейін біртіндеп ұйымдастырған дұрыс.

Бірінші кезең. Есептің физикалық мазмұнын түсіну

Алғашқы кезеңде оқушылар есептің шартын мұқият оқып, қандай физикалық құбылыс қарастырылып отырғанын анықтайды. Берілген және ізделінетін шамаларды ажыратып, олардың арасындағы байланысты түсіндіреді.Мұғалім оқушыларға бағыттаушы сұрақтар қоя алады:

- Есепте қандай физикалық құбылыс сипатталған?
- Қандай шамалар белгілі?
- Қай шаманы анықтау қажет?
- Қандай физикалық заңды немесе формуланы қолдануға болады?
- Есепті шығару үшін қандай өлшеулер жүргізу керек?

Екінші кезең. Өлшеу құралдарымен жұмыс істеу

Келесі кезеңде оқушылар сызғыш, таразы, динамометр, секундомер, термометр және басқа да өлшеу құралдарын пайдалануды меңгереді.

Мысалы, дененің қысымын анықтау үшін оның массасын және тірек бетінің өлшемдерін өлшеу қажет. Оқушылар алдымен қажетті өлшеулерді өздері жүргізіп, нәтижелерін кестеге енгізеді.Өлшеу кезінде құралдың бөлік құнын анықтауға, өлшем бірліктерін дұрыс жазуға және нәтижелерді белгіленген дәлдікпен көрсетуге назар аударылады.

Эксперименттік есепті орындаудың жалпы алгоритмі

Физикадағы эксперименттік есептерді орындау мынадай ретпен жүзеге асырылады:

1. Есептің шартын мұқият оқу.
2. Зерттелетін физикалық құбылысты анықтау.
3. Қажетті өлшеу құралдарын таңдау.
4. Физикалық шамаларды тәжірибе арқылы өлшеу.
5. Өлшеу нәтижелерін кестеге енгізу.
6. Тиісті формуланы таңдау.
7. Қажет болған жағдайда формуланы түрлендіру.
8. Сандық мәндерді формулаға қойып, есептеу жүргізу.
9. Нәтижені өлшем бірлігімен жазу.
10. Алынған нәтижені талдап, физикалық қорытынды жасау.

Осы алгоритмді жүйелі қолдану оқушылардың есеп шығару дағдыларын жетілдіреді, теориялық білімдерін тәжірибеде пайдалануға үйретеді және физика пәніне деген қызығушылығын арттырады.

ӘДЕБИЕТТЕР ТІЗІМІ

1. Б.М.Ысқақов, А.А.Ағылұқов, Н.Б.Шамбулов. Физикадан есеп шығару мысалдары. /Алматы, Мектеп. 1987ж.
2. Е.В.Фирганг. Руководство к решению задач по курсу общей физики. М., Высшая школа, 1998 г.
3. Ә.Кәшеров. Физика пәнінен есептер түрлері. Шымкент. 1998ж.
4. А.Т.Анарбаева.Физика есептерін шығару тәсілдері. Алматы,Мектеп

ӘОК 372.853

ФИЗИКАНЫ ОҚЫТУДАҒЫ АНДРАГОГИКАЛЫҚ ТӘСІЛДІҢ ЕРЕКШЕЛІКТЕРІ

Рахымбеков Айтбай Жапарович
ф-м.ғ.к., қауымдастырылған профессор, доцент, І.Жансүгүров атындағы Жетісу университеті
Аккасин Әсел Әділбекқызы
магистрант

Аннотация: Мақалада Андрагогикалық тәсілде оқыту әдістерін таңдау білім алушылардың белсенділігіне, тәжірибелік әрекетіне және өздігінен білім алуына жағдай жасауға негізделетіні көрсетілген. Сонымен қатар, ересек білім алушыларға арналған тәжірибелерді ұйымдастыру кезінде олардың күнделікті өмірде немесе кәсіби қызметте кездестіретін құбылыстарын зерттеу ұсынылады.
Кілт сөздер: андрагогикалық, ересек,білім,тәсіл,белсенділік,әдіс,зерттеу.

КІРІСПЕ

Физика пәнін андрагогикалық тәсілмен оқытуда басты назар дайын ақпаратты есте сақтауға емес, физикалық заңдылықтарды түсінуге, оларды тәжірибеде тексеруге және нақты мәселелерді шешуде пайдалануға аударылады.Бұл бағытта оқытудың мазмұны мен әдістері ересек білім алушылардың дайындық деңгейіне, кәсіби қызметіне және оқу мақсаттарына сәйкес ұйымдастырылады[1].

Мысалы, электр тогы тақырыбын оқыту кезінде формулаларды жаттатумен шектелмей, электр энергиясын тұтынатын құрылғылардың жұмысын зерттеуге болады. Білім алушылар электр құрылғыларының қуатын анықтап, олардың белгілі бір уақыт ішінде жұмсайтын энергиясын есептейді. Осы арқылы физикалық білімді тұрмыстық және кәсіби жағдайларда қолдану дағдылары қалыптасады.Андрагогикалық тәсіл негізінде физиканы оқытудың негізгі бағыттарын төмендегідей жүйелеуге болады[2].

Негізгі бөлім

1. Мәселеге бағытталған оқыту. Оқу үдерісі өмірде немесе кәсіби қызметте кездесетін нақты проблемадан басталады. Мысалы, электр энергиясының шығынын қалай азайтуға болады немесе ғимараттағы жылу жоғалуын қандай әдістермен төмендетуге болады деген сұрақтар қойылады. Білім алушылар физикалық заңдарды пайдаланып, мәселенің ықтимал шешімдерін ұсынады.

2. Тәжірибеге негізделген оқыту. Физикалық құбылыстарды бақылау, өлшеу және эксперимент жүргізу арқылы түсіндіруге басымдық беріледі. Білім алушылар өлшеу құралдарын қолданады, эксперименттік деректерді тіркейді, есептеулер жүргізеді және қорытынды жасайды.

3. Бірлескен оқыту. Топтық талқылау, тәжірибе нәтижелерін салыстыру және бірлескен жобалар орындау білім алушылардың өзара тәжірибе алмасуына жағдай жасайды.

4. Жеке оқу траекториясын қалыптастыру. Білім алушы өзінің бастапқы білімі мен қажеттілігіне сәйкес тапсырмаларды таңдай алады. Физиканы тереңірек меңгергісі

келетіндер күрделі есептер мен зерттеу жұмыстарын орындаса, бастапқы дайындық деңгейіндегі білім алушылар негізгі ұғымдар мен қарапайым тәжірибелерден бастайды.

5. Рефлексия және өзін-өзі бағалау. Оқу соңында білім алушылар өздерінің қандай білім меңгергенін, қандай қиындықтарға кездескенін және алған білімдерін қайда қолдана алатынын талдайды.Осы бағыттарды өзара үйлестіре отырып қолдану физиканы оқытудың мазмұнын ересектердің танымдық және кәсіби қажеттіліктеріне бейімдеуге мүмкіндік береді.Андрагогикалық тәсілде оқыту әдістерін таңдау білім алушылардың белсенділігіне, тәжірибелік әрекетіне және өздігінен білім алуына жағдай жасауға негізделеді [3,4,5].

Проблемалық оқыту әдісі

Проблемалық оқыту білім алушылардың алдына шешуді қажет ететін ғылыми немесе практикалық мәселе қоюдан басталады. Мұндай жағдайда білім алушылар дайын жауапты қабылдамай, мәселенің себептерін анықтап, оны физикалық заңдар негізінде шешуге тырысады.Мысалы, «Неліктен электр сымдары арқылы ток өткен кезде олар қызады?» деген сұрақты қарастырайық.

Бұл құбылысты түсіндіру үшін білім алушылар электр тогының жұмысы, қуаты және өткізгіштің кедергісі арасындағы байланысты зерттейді.Электр тогының қуаты мына формуламен анықталады:

$$P = UI$$

Мұндағы:P – электр қуаты, ватт (Вт);U – электр кернеуі, вольт (В); I – электр тогының күші, ампер (А).Ом заңын пайдалансақ, қуатты мына түрде де жазуға болады:

$$P = I^2R$$

Мұндағы R – өткізгіштің электр кедергісі, ом (Ом).Бұл формула ток күші артқан кезде, кедергі тұрақты болса, өткізгіште бөлінетін қуаттың ток күшінің квадратына пропорционал артатынын көрсетеді.Білім алушылар осы заңдылықты пайдаланып, электр сымдарының қызу себептерін талдайды. Сонымен бірге электр қондырғыларын пайдалану кезінде қауіпсіздік талаптарын сақтаудың маңызын түсінеді.

3.2 Эксперименттік оқыту әдісі

Эксперименттік әдіс физиканы оқытуда ерекше орын алады, себебі физикалық заңдылықтардың басым бөлігі тәжірибе мен бақылау арқылы зерттеледі. Ересек білім алушыларға арналған тәжірибелерді ұйымдастыру кезінде олардың күнделікті өмірде немесе кәсіби қызметте кездестіретін құбылыстарын зерттеу ұсынылады. Мысалы, өткізгіштің электр кедергісінің оның ұзындығына тәуелділігін зерттеуге болады.Өткізгіштің кедергісі мына формуламен анықталады:

$$R = \rho l / S,$$

Мұндағы:R – өткізгіштің кедергісі, Ом;ρ – өткізгіш материалының меншікті кедергісі, Ом·м;l – өткізгіштің ұзындығы, м; S – өткізгіштің көлденең қимасының ауданы, м².

Қорытынды

Формуладан өткізгіштің материалы мен көлденең қимасының ауданы тұрақты болған жағдайда оның ұзындығы артқан сайын кедергісі де артатыны байқалады.Эксперимент барысында білім алушылар әртүрлі ұзындықтағы өткізгіштердің кедергісін өлшеп, нәтижелерін салыстырады. Алынған мәліметтер негізінде кедергінің ұзындыққа тәуелділігі туралы қорытынды жасайды.Бұл жұмыс өлшеу құралдарын пайдалану, эксперименттік деректерді өңдеу және физикалық заңдылықтарды тәжірибе арқылы дәлелдеу дағдыларын қалыптастырады[6,7].

Пайдаланылған әдебиеттер

1. Knowles, M. S., Holton, E. F., Swanson, R. A. *The Adult Learner: The Definitive Classic in Adult Education and Human Resource Development*. – 8th ed. – Routledge, 2015.
2. Merriam, S. B., Baumgartner, L. M. *Learning in Adulthood: A Comprehensive Guide*. – 4th ed. – Jossey-Bass, 2020.
3. Kolb, D. A. *Experiential Learning: Experience as the Source of Learning and Development*. – Englewood Cliffs, NJ: Prentice Hall, 1984.
4. Brookfield, S. D. *Understanding and Facilitating Adult Learning*. – San Francisco: Jossey-Bass, 1986.
5. Freire, P. *Pedagogy of the Oppressed*. – New York: Continuum, 2000.
6. UNESCO Institute for Lifelong Learning. *Embracing a Culture of Lifelong Learning: Contribution to the Futures of Education Initiative*. – Hamburg: UNESCO Institute for Lifelong Learning, 2020.
7. Қазақстан Республикасының «Білім туралы» Заңы. – 2007 жылғы 27 шілде, № 319-III (өзгерістер мен толықтыруларымен).

ӘОК 372.853

ФИЗИКА САБАҚТАРЫН ОҚЫТУДА ЖАҢА ӘДІС-ТӘСІЛДЕР МЕН САНДЫҚ ТЕХНОЛОГИЯЛАРДЫ ҚОЛДАНУДЫҢ ТИІМДІЛІГІ

Рахымбеков Айтбай Жапарович
ф-м.ғ.к., қауымдастырылған профессор, доцент, І.Жансүгуров атындағы Жетісу университеті
Каналбекова Жанбота Назарбековна
магистрант

Аңдатпа: Мақалада жалпы білім беретін мектепте физика сабақтарын оқытуда жаңа әдіс-тәсілдер мен сандық технологияларды қолданудың тиімділік рөлі қарастырылады. Білімді бақылаудың негізгі қызметтері, оның оқу жетістіктерін диагностикалаудағы, оқу барысында туындайтын қиындықтарды анықтаудағы және оқыту әдістемесін жетілдірудегі маңызы ашылған.

Түйін сөздер: білімді бақылау, білім беру сапасы, физиканы оқыту, оқу жетістіктерін бағалау, қалыптастырушы бағалау, кері байланыс, физикалық эксперимент, танымдық белсенділік, цифрлық технологиялар.

Кіріспе

Қазіргі білім беру жүйесінің дамуындағы негізгі бағыттардың бірі – оқу үдерісіне инновациялық педагогикалық әдістер мен сандық технологияларды енгізу арқылы білім сапасын арттыру.Әрбір педагогикалық технология өзіндік әдіс-тәсілдерімен, оқыту құралдарымен және білім алушылардың танымдық белсенділігін дамыту мүмкіндіктерімен ерекшеленеді.

Көрнекті педагог В.А. Сухомлинский оқыту үдерісінде қызығушылықтың маңызды рөл атқаратынын атап көрсеткен. Бұл идея қазіргі білім беру жағдайында да өзектілігін жоғалтқан жоқ. Оқушының пәнге деген қызығушылығы оның сабаққа белсенді қатысуына, сұрақтар қоюына, мәселелерді өздігінен шешуге ұмтылуына және жаңа білімді саналы түрде меңгеруіне негіз болады.

Сандық технологияларды қолдану физика сабағын мазмұндық және әдістемелік тұрғыдан жаңартуға мүмкіндік береді. Интерактивті тақта, электрондық оқулықтар, білім беру платформалары, виртуалды эксперименттер, компьютерлік модельдер, бейнесабақтар және онлайн тестілеу құралдары оқушылардың оқу материалын әртүрлі тәсілдермен қабылдауына жағдай жасайды.

Физиканы оқытуда сандық технологияларды пайдаланудың негізгі мақсаты – оқушыға дайын ақпаратты ұсыну ғана емес, оның білімді өздігінен іздеуіне, тәжірибе нәтижелерін талдауына, физикалық заңдылықтарды анықтауына және ғылыми қорытынды жасауына жағдай туғызу. Осы тұрғыдан алғанда, сандық құралдар мұғалімнің түсіндіру қызметін толықтыратын, оқушының зерттеушілік әрекетін жандандыратын және оқытудың тиімділігін арттыратын маңызды педагогикалық ресурс болып саналады.

. Сандық технологияларды қолдану да нақты дидактикалық мақсатқа бағытталуы тиіс. Егер цифрлық құрал оқушының физикалық құбылысты түсінуіне, тәжірибе жүргізуіне немесе есеп шығару дағдысын дамытуына көмектессе, онда оны сабаққа енгізудің педагогикалық тиімділігі артады.

Физика пәнін оқытуда мұғалім мынадай негізгі қағидаларды басшылыққа алғаны жөн:

1.Ғылыми нақтылық қағидасы. Физикалық заңдар мен құбылыстарды ғылыми тұрғыдан дұрыс түсіндіріп, теориялық білімді күнделікті өмірдегі мысалдармен байланыстыру қажет.

2.Оқушының жеке ерекшеліктерін ескеру қағидасы. Тапсырмалар білім алушылардың жас ерекшеліктеріне, қабілеттеріне, білім деңгейіне және оқу қарқынына сәйкес ұйымдастырылуы керек.

3.Көрнекілік және сандық визуализация қағидасы. Күрделі физикалық құбылыстарды түсіндіруде сызбаларды, графиктерді, анимацияларды, бейнематериалдарды және компьютерлік модельдерді тиімді қолдану қажет.

4.Теория мен эксперименттің бірлігі қағидасы. Оқушылар физикалық заңдарды тек жаттап қана қоймай, олардың дұрыстығын тәжірибе арқылы тексеріп, өлшеу нәтижелерін талдауы тиіс.

5.Белсенді танымдық әрекет қағидасы. Сабақта оқушылардың сұрақ қоюына, болжам ұсынуына, есептер шығаруына, зерттеу жүргізуіне және өз қорытындыларын дәлелдеуіне мүмкіндік берілуі қажет.

6.Сандық сауаттылықты дамыту қағидасы.

Физика сабағында оқушылардың қызығушылығын арттыру үшін проблемалық сұрақтар, логикалық тапсырмалар, физикалық тәжірибелер, виртуалды эксперименттер, бейнематериалдар және өмірлік жағдаяттарға негізделген есептер қолдануға болады. Мысалы, «Неліктен металл сым қызған кезде оның электрлік кедергісі өзгереді?», «Электр тізбегіндегі ток күшін қандай факторлар анықтайды?» немесе «Линзаның фокустық қашықтығы кескіннің өлшеміне қалай әсер етеді?» деген сұрақтар оқушыларды мәселенің себебін іздеуге және ғылыми қорытынды жасауға бағыттайды.

Сондай-ақ жасанды интеллект негізіндегі білім беру құралдарын физика сабағын жоспарлау, қосымша тапсырмалар дайындау, күрделі ұғымдарды әртүрлі деңгейде түсіндіру және оқушылардың оқу қажеттіліктеріне сәйкес жаттығулар құрастыру үшін пайдалануға болады.

Репродуктивтік әдіс оқушылардың мұғалім ұсынған білімді қабылдауына, есте сақтауына және оны белгілі бір үлгі бойынша қайта жаңғыртуына негізделеді. Бұл әдіс физикалық заңдарды, формулаларды, анықтамаларды меңгеруде және есептерді шығару алгоритмдерін үйренуде қолданылады.Мысалы, оқушылар Ом заңын пайдаланып, электр тізбегіндегі ток күшін есептеуді үйренеді:

$$I = U / R,$$

мұндағы I – ток күші, U – кернеу, R – электр кедергісі.Егер кернеу 12 В, ал кедергі 4 Ом болса, ток күші: I = 12 / 4 = 3 А.

Сандық технологияларды қолдану арқылы осыған ұқсас есептерді интерактивті тапсырма түрінде ұсынуға болады. Оқушылар есептің бастапқы деректерін өзгертіп, нәтижелерді салыстырады және физикалық шамалар арасындағы байланысты анықтайды.

Зерттеушілік әдіс

Зерттеушілік әдіс оқушылардың ғылыми танымның негізгі кезеңдерін өздігінен орындауына бағытталған. Бұл әдісті қолданғанда оқушылар зерттеу мәселесін анықтайды, болжам ұсынады, тәжірибе жүргізеді, өлшеу нәтижелерін тіркейді, деректерді өңдейді және қорытынды жасайды.

Мысалы, «Маятниктің тербеліс периоды оның ұзындығына қалай тәуелді?» тақырыбында зерттеу жүргізуге болады.

Кіші тербелістер үшін математикалық маятниктің периоды:

$$T = 2\pi\sqrt{(l / g)},$$

мұндағы T – тербеліс периоды, l – маятниктің ұзындығы, g – еркін түсу үдеуі.

Оқушылар маятниктің ұзындығын өзгертіп, тербеліс уақытын өлшейді. Кейін алынған деректерді электрондық кестеге енгізіп, график құрады. Компьютерлік құралдар есептеулерді автоматтандыруға, нәтижелерді салыстыруға және өлшеу қателіктерін бағалауға көмектеседі.

Қорытынды

Сандық технологияларды тиімді пайдалану арқылы физикалық заңдылықтарды көрнекі түсіндіруге, эксперименттік зерттеулерді ұйымдастыруға, оқушылардың жеке қажеттіліктерін ескеруге және білім нәтижелерін жүйелі бағалауға болады. Сонымен қатар оқушылардың сандық сауаттылығы, ақпаратпен жұмыс істеу мәдениеті және ғылыми қорытынды жасау қабілеті дамиды

Әдебиеттер:

1.http://festival.1september.ru/articles/632548/, «Инновационные технологии на современном уроке физики»

2.http://files.school-collection.edu.ru/dlrstore/669b524a-e921-11dc-95ff-0800200c9a66/4_2.swf , «Классная физика»

3.http://freesoft.ru/virtualnaya_laboratoriya_po_fizike_dlya_shkolnikov, «Виртуальная лаборатория по физике для школьников»

ӘОК 372.853

ФИЗИКА ПӘНІН ОҚЫТУДАҒЫ ИННОВАЦИЯЛЫҚ ӘДІСТЕРДІ ПАЙДАЛАНУ

Рахымбеков Айтбай Жапарович
ф-м.ғ.к, доцент, қауымдастырылған профессор
Жарқын Қарақат
магистрант, І.Жансугуров атындағы Жетісу университеті ,Талдықорган қаласы

Аңдатпа

Мақалада жалпы білім беретін мектептерде оқу технологиясы білім беру үдерісінде қолданылатын әдістердің, тәсілдердің, дидактикалық құралдардың және психологиялық-педагогикалық әрекеттердің өзара байланысқан жүйесі ретінде қарастырылады. Сонымен қатар физиканы оқытуда цифрлық білім беру ресурстарын, интерактивті модельдерді, виртуалды эксперименттерді және зерттеушілік тапсырмаларды қолданудың мүмкіндіктері сипатталады.

Түйін сөздер: технология, педагогикалық, физиканы оқыту әдістемесі, ғылыми дүниетаным, цифрлық технологиялар, виртуалды эксперимент, проблемалық оқыту, зерттеушілік дағдылар.

КІРІСПЕ

Бүгінде әлемнің көптеген елдерінде білім берудің тиімді жолдары мен оқытудың заманауи әдістерін іздестіру жұмыстары жүргізілуде. Педагогикалық технология – мұғалімнің шығармашылық әлеуетін дамытуға, тұлғааралық қарым-қатынасты жетілдіруге, адамдар арасындағы өзара түсіністік пен рухани құндылықтарды нығайтуға бағытталған кәсіби педагогикалық қызметтің маңызды құрамдас бөлігі. Ол білім беру барысында адамгершілік қағидаларды сақтауға және оқыту мен тәрбиелеудің сапасын арттыруға мүмкіндік береді.Оқытудың заманауи технологиялары ғылыми тұжырымдар мен тәжірибелік нәтижелерге сүйене отырып, білім мазмұнын терең әрі жан-жақты меңгеруге жағдай жасайды. Оларды тәжірибеде қолдану оқушыларға жаңа ақпараттарды игеруге, алған білімдерін күнделікті өмірде пайдалануға және оқу міндеттерін тиімді шешуге көмектеседі.

НЕГІЗГІ БӨЛІМ

Педагогикалық технологияны пайдалану – мұғалімнің кәсіби қызметіндегі ерекше бағыттардың бірі. Оны толық меңгеру үшін педагогтан жеткілікті біліммен қатар, тәжірибе, ізденіс және шығармашылық белсенділік талап етіледі. Бұл үдеріс өз пәніне жауапкершілікпен қарайтын, кәсіби біліктілігін үнемі жетілдіруге ұмтылатын мамандардың еңбегіне негізделеді. Жаңа технологияларды игеру барысында мұғалім өзінің кәсіби қабілеттерін дамытып, педагогикалық шеберлігін қалыптастырады.Қазақстан тәуелсіздік алғаннан кейін қоғамдық өмірдің барлық саласында, соның ішінде білім беру жүйесінде де демократияландыру мен ізгілендіру бағытындағы өзгерістер жүзеге асырыла бастады. Бұл өзгерістер білім беру саласындағы өзекті мәселелерді шешуге, оқу үдерісін жетілдіруге және мектептің даму бағытын жаңаша қалыптастыруға мүмкіндік берді.

Қазіргі уақытта елімізде білім берудің жаңартылған жүйесі қалыптасып, халықаралық білім кеңістігіне кірігуге басымдық берілуде. Осыған байланысты педагогика теориясында және оқу-тәрбие үдерісінде елеулі өзгерістер орын алуда. Білім мазмұнына жаңа

көзқарастар енгізіліп, мұғалім мен оқушы арасындағы қарым-қатынас жаңаша сипатқа ие болуда. Сонымен қатар білім алушының жеке тұлғалық ерекшеліктерін ескеру, оның қабілетін ашу және дербес дамуына жағдай жасау мәселелері маңызды орынға шықты.
Қазіргі білім беру ұйымдарына әртүрлі педагогикалық тұжырымдамалар мен оқыту үлгілерін таңдап, өздерінің қажеттіліктеріне сәйкес қолдануға мүмкіндік берілген. Осы бағытта білім мазмұнын жетілдіруге арналған түрлі бағдарламалар, ғылыми негізделген идеялар және жаңа педагогикалық технологиялар әзірленуде. Олардың барлығы білім беру сапасын арттыруға және оқушылардың білімді саналы түрде меңгеруіне бағытталған.

Сондықтан оқыту технологияларын таңдағанда оқу пәнінің мазмұнын, оқушылардың жас ерекшеліктерін, танымдық мүмкіндіктерін және жеке қабілеттерін ескеру қажет. Таңдалған әдістерді тәжірибеде сынақтан өткізу, олардың тиімділігін бағалау және оқу мақсатына сәйкес қолдану маңызды. Заманауи педагогикалық технологияларды меңгеру – білікті әрі жан-жақты маман қалыптастырудың негізгі шарттарының бірі. Жаңа әдістерді қолдану мұғалімнің интеллектуалдық, кәсіби, рухани, адамгершілік және азаматтық қасиеттерін дамытуға ықпал етеді. Сонымен бірге оның өзін-өзі жетілдіруіне және оқу-тәрбие жұмысын нәтижелі ұйымдастыруына көмектесет[1].

Оқу технологиясы мектептегі білім беру үдерісінде қолданылатын әдістердің, тәсілдердің, дидактикалық құралдардың және психологиялық-педагогикалық әрекеттердің өзара байланысқан жүйесі ретінде қарастырылады. Ол оқушылардың пәнге деген қызығушылығын арттыруға, оқу белсенділігін қалыптастыруға және тәртіпті сақтауға ықпал етеді. Сонымен қатар педагогикалық тәжірибені ғылыми негізде ұйымдастыруға, мұғалімнің шығармашылық ізденісін дамытуға және оқу-тәрбие жұмысының нәтижелілігін арттыруға мүмкіндік береді. Осы тұрғыдан алғанда, оқу технологиялары білім беру үдерісінің маңызды тетігі болып саналады.

Физика – қоршаған ортада кездесетін құбылыстарды зерттеп, табиғаттағы жалпы заңдылықтарды түсіндіретін іргелі ғылым. Оның зерттеу саласы кең болғандықтан, физика қоршаған әлемді танып-білуге қажетті маңызды білім көздерінің бірі болып табылады. Бұл пән оқушыларға табиғат құбылыстарының себептері мен заңдылықтарын түсінуге, ғылыми ақпаратты талдауға және алған білімдерін өмірде қолдануға мүмкіндік береді.Физика ғылымы адамзат мәдениетінің маңызды бөлігі ретінде ғылыми-техникалық дамуға ғана емес, адамның дүниетанымы мен рухани көзқарасының қалыптасуына да ықпал етеді. Осыған байланысты мектептегі физика пәні оқушыларға ғылыми білім берумен шектелмей, олардың ойлау қабілетін дамыту және тәрбиелік құндылықтарын қалыптастыру міндеттерін де атқарады. Бұл ерекшеліктер мектеп физикасы курсының білім беру жүйесіндегі маңызын айқындайды.

Мектепте физиканы заманауи педагогикалық технологияларды пайдалану арқылы оқытудың басты мақсаты – оқушылардың логикалық ойлауын, танымдық белсенділігін және шығармашылық қабілеттерін дамыту. Сонымен қатар физиканың қазіргі қоғамдағы және жалпы адамзат мәдениетіндегі рөлін түсіндіру, табиғатқа ғылыми көзқарас қалыптастыру көзделеді. Оқушылардың қоршаған ортаға деген саналы қарым-қатынасын дамыту, жеке құндылықтарын қалыптастыру және физикалық білімдерін түрлі практикалық мәселелерді шешуде шығармашылықпен қолдану да маңызды міндеттер болып табылады.

Осы мақсаттарға қол жеткізу үшін білім алушылардың бойында ғылыми талдау, зерттеу, салыстыру, қорытынды жасау және өз бетінше шешім қабылдау дағдыларын қалыптастыру қажет. Қойылған мақсаттарға қол жеткізу үшін әртүрлі әдіс-тәсілдер қолданылады. Осыған байланысты білім беру жүйесінде жаңа буын оқулықтары мен оқу бағдарламалары әзірленді. Солардың бірі – жалпы білім беретін мектептердің негізгі сатысына арналған «Физика және астрономия – VII–IX» оқу бағдарламасы. Аталған бағдарлама бірнеше маңызды міндетті жүзеге асыруға бағытталған. Атап айтқанда, оқушыларға материяның

құрылымы, негізгі ғылыми ұғымдар мен заңдар, іргелі теориялардың элементтері, соның ішінде атомдық-молекулалық және электрондық теориялар, тәжірибелік деректер, физика мен астрономиядағы зерттеу әдістері туралы білім беру көзделеді. Сонымен қатар оқушылардың ғылыми дүниетанымын кеңейту, әлемнің физикалық бейнесінің тұтастығын түсіндіру, табиғаттағы адамның орны мен рөлі жөніндегі көзқарастарын қалыптастыру маңызды орын алады[2].

Негізгі мектепке арналған физика курсының мазмұны оқушылардың жас ерекшеліктері мен танымдық мүмкіндіктерін ескере отырып құрастырылған. Бағдарлама білім алушылардың практикалық жұмыстармен айналысуына және теориялық білімдерін іс жүзінде қолдануына мүмкіндік береді. Сонымен бірге оқушылардың зерттеушілік дағдыларын жетілдіруге, бақылау жүргізуге және эксперименттік тапсырмаларды орындауға үйретуге басымдық беріледі. Бұл үдерісте зертханалық жұмыстардың маңызы ерекше. Оқушылардың білім деңгейі мен практикалық біліктілігі физиканың іргелі теорияларының құрылымы мен мазмұнына сәйкес жүйеленеді.

Білім беру саласындағы жаңашылдықтарды оқу үдерісіне енгізу қазіргі заманның маңызды талаптарының бірі болып табылады. Осыған байланысты сабақ барысында жаңа оқыту технологияларын қолдану оқушылардың ізденімпаздығын арттыруға, пәнге қызығушылығын оятуға, өз ойын еркін жеткізуіне және пікірталас жүргізу қабілетін дамытуға ықпал етеді. Қазіргі таңда еліміздің көптеген мектептерінде осындай технологиялар пайдаланылып, олардың тиімділігі оқу тәжірибесінде байқалуда. Мысалы, тапсырмаларды қарапайым деңгейден күрделі деңгейге қарай орындау әдісі оқушылардың ойлау қабілетін, есте сақтауын, белсенділігін және пәнге деген ынтасын арттырады. Сонымен қатар бұл әдіс білім алушыларды өздігінен жұмыс істеуге, алған білімдерін тереңдетуге және оқу тапсырмаларын жауапкершілікпен орындауға бағыттайды.

Жаңа оқыту технологияларында оқушы тапсырмаларды ең қарапайым деңгейден бастап, біртіндеп күрделірек жұмыстарға көшеді. Тапсырмалар мазмұны мен орындалу ерекшелігіне қарай төрт деңгейге бөлінеді: репродуктивті, алгоритмдік, эвристикалық және шығармашылық [3].

Репродуктивті деңгей оқушылардың бұрын меңгерген білімдерін қайта жаңғыртуына негізделеді. Бұл деңгейдегі тапсырмалар оқулық материалдары мен алдыңғы сабақтарда қарастырылған тақырыптарға сүйеніп құрастырылады. Сондықтан оқушы негізгі ақпаратты еске түсіріп, сұрақтарға нақты әрі жылдам жауап беруге дағдыланады.

Алгоритмдік деңгейде оқушы мұғалімнің түсіндіруі арқылы меңгерген білімін белгілі бір әрекеттер ретін сақтай отырып қолданады. Берілген тапсырмаларды орындау барысында оқушылар ережелер мен нұсқауларды басшылыққа алып, мәселені шешудің тиімді жолдарын үйренеді.

Эвристикалық деңгей оқушының өздігінен ойлануына, ақпарат іздеуіне және қосымша әдебиеттерді пайдалануына негізделеді. Мұндай тапсырмаларды орындау кезінде білім алушы дайын жауапты қайталаумен шектелмей, мәселенің шешімін өз бетінше табуға тырысады. Бұл кезеңде логикалық ойлау, талдау және қорытынды жасау қабілеттері дамиды.

Шығармашылық деңгейде оқушының дербестігі мен белсенділігі айқын көрінеді. Ол жаңа тақырыпты өздігінен зерттеп, білімін жаңа жағдайларда қолдануға және өзіндік шешімдер ұсынуға ұмтылады. Осындай тапсырмалар оқушылардың шығармашылық әлеуетін ашып, зерттеушілік қабілеттерін жетілдіруге мүмкіндік береді[4].

ҚОРЫТЫНДЫ

Қазіргі физика курсының ғылыми-әдістемелік бағыты оқушыларды дайын ақпаратты қабылдаумен ғана шектемей, өз пікірін қалыптастыруға, оны дәлелдеуге және білімін тәжірибеде қолдануға үйретуді көздейді. Бұрынғы оқыту тәжірибесінде сабақты бекіту мен

өткен тақырыптарды қайталау көбінесе мұғалімнің сұрақтарына жауап берумен жүзеге асырылса, қазіргі тәсілдер оқушылардың белсенді әрекетіне көбірек мән береді. Енді білім алушылар физикалық заңдылықтарды түсініп қана қоймай, оларды тұрмыста, техникада және күнделікті өмірде кездесетін жағдайларды түсіндіру үшін қолдана алады.

Физиканы оқыту әдістемесі пәннің мазмұнын, оқу материалын меңгерту жолдарын және сабақта қолданылатын тиімді әдістерді анықтайды. Оқушылардың назарын сабаққа аудару, пәнге деген қызығушылығын арттыру және зейінін тұрақтандыру үшін оқыту әдістерін мақсатқа сай таңдау қажет. Сабақ барысында мұғалімнің түсіндіруі мен әңгімелеуі, тәжірибелерді көрсетуі, зертханалық жұмыстар ұйымдастыруы, оқулықтармен және дидактикалық материалдармен өздік жұмыс жүргізуі сияқты тәсілдерді қолдануға болады.

Сонымен қатар эксперименттік есептер шығару, кестелер мен бейнематериалдарды пайдалану, оқушылардың баяндамаларын тыңдау, сұрақ-жауап әдісін ұйымдастыру және тест тапсырмаларын орындату да оқу үдерісінің тиімділігін арттырады. Аталған әдістерді сабақтың мақсатына, тақырыптың мазмұнына және оқушылардың дайындық деңгейіне сәйкес үйлестіріп қолдану білім сапасын жақсартуға және физиканы меңгеруге деген ынтаны күшейтуге ықпал етеді.

Пайдаланылған әдебиеттер

1. Жданова А.А. Кванттық физиканы мектепте оқытудың әдістемелік негіздері // Физика в школе. – 2006. №3. – С.32–36.
2. Барсуков И.Ю. Физика пәнін оқытуда кванттық түсініктерді енгізудің маңызы // Физика в школе. – 2007. №6. – С.19–22.
3. Петрова А.Н. Кванттық және атомдық физика элементтерін мектептегі физика курсына енгізу // Физика в школе. – 2007.№6. – С.10–13.
4. PhET Interactive Simulations. University of Colorado Boulder.

УДК 372.853

АТОМДЫҚ ЖӘНЕ КВАНТТЫҚ ФИЗИКАНЫ ОҚЫТУДЫҢ ЗАМАНАУИ ӘДІСТЕМЕЛІК ЕРЕКШЕЛІКТЕРІ

Рахымбеков Айтбай Жапарович
ф-м.ғ.к, доцент, қауымдастырылған профессор
Айғазы Сұңқар Ермекұлы
магистрант, І.Жансугуров атындағы Жетісу университеті ,Талдықорган қаласы

Аңдатпа

Мақалада жалпы білім беретін мектептерде атомдық және кванттық физика негіздерін оқытудың ғылыми-әдістемелік аспектілері қарастырылады. Атомдық және кванттық құбылыстардың табиғатын түсіндіру кезінде туындайтын педагогикалық қиындықтар, оқушылардың жас және танымдық ерекшеліктеріне сәйкес оқу материалын меңгерту жолдары талданады. Сонымен қатар физиканы оқытуда цифрлық білім беру ресурстарын, интерактивті модельдерді, виртуалды эксперименттерді және зерттеушілік тапсырмаларды қолданудың мүмкіндіктері сипатталады. Оқушылардың ғылыми ойлау қабілетін жетілдіру, теориялық білімдерін тәжірибемен ұштастыру және физикалық заңдылықтарды күнделікті өмірдегі технологиялармен байланыстыра түсіндіру мәселелеріне ерекше назар аударылады.

Түйін сөздер: атомдық физика, кванттық физика, физиканы оқыту әдістемесі, ғылыми дүниетаным, цифрлық технологиялар, виртуалды эксперимент, проблемалық оқыту, зерттеушілік дағдылар.

Кіріспе

Қазіргі физика ғылымының даму бағыты атомдар мен элементар бөлшектердің қасиеттерін, микродүниедегі процестерді және кванттық заңдылықтарды зерттеумен тығыз байланысты. Атомдық және кванттық физика жетістіктері лазерлік құрылғыларды, жартылай өткізгіштерді, кванттық есептеу жүйелерін және заманауи ақпараттық технологияларды дамытуға негіз болып отыр. Осыған байланысты мектеп физикасы курсында аталған бөлімді сапалы оқыту білім алушылардың ғылыми көзқарасын қалыптастырудың маңызды құрамдас бөлігі болып саналады.

Атомдық және кванттық физика тақырыптарының өзіндік ерекшелігі — олардың көптеген құбылыстары күнделікті өмірде тікелей байқалмайды. Мысалы, электрондардың атомдағы энергетикалық күйлерін, жарықтың кванттық қасиеттерін немесе микробөлшектердің толқындық сипаттамаларын қарапайым механикалық модельдер арқылы толық түсіндіру мүмкін емес. Сондықтан оқушылар кейбір заңдылықтарды дайын ақпарат ретінде қабылдап, олардың физикалық мағынасын терең түсінбеуі мүмкін [1].

Бұл мәселені шешу үшін мұғалім оқу материалын тек теориялық түсіндірумен шектемей, оны көрнекі модельдермен, тәжірибелік тапсырмалармен, проблемалық сұрақтармен және цифрлық ресурстармен толықтыруы қажет. Оқушылардың өз бетінше қорытынды жасауына жағдай туғызу да оқу үдерісінің маңызды міндеттерінің бірі болып табылады.

Мақаланың мақсаты — мектепте атомдық және кванттық физика тарауын оқытудың тиімді әдістемелік жолдарын анықтау және күрделі физикалық ұғымдарды оқушыларға түсінікті жеткізуге мүмкіндік беретін педагогикалық тәсілдерді ұсыну.

1. Атомдық және кванттық физиканы оқытудың білімдік мақсаттары

Атомдық және кванттық физика бөлімін меңгерту барысында оқушылардың теориялық білімін қалыптастырумен қатар, олардың физикалық құбылыстарды талдау, ғылыми ақпаратты түсіндіру және дәлелді қорытынды жасау қабілеттерін дамыту көзделеді.Осы бағытта келесі оқу міндеттерін жүзеге асыруға болады:

- атомның құрылысын, оның құрамындағы бөлшектердің қасиеттерін және өзара байланысын түсіндіру;
- атомның энергетикалық деңгейлері мен сәуле шығару және жұту құбылыстарының арасындағы байланысты анықтау;
- фотоэффект құбылысының физикалық мағынасын ашу және оның негізгі заңдылықтарын түсіндіру;
- Бор моделінің негізгі қағидаларын қарастыру және оның атом құрылысын түсіндірудегі маңызын бағалау;
- де Бройль гипотезасының мазмұнын меңгерту және микробөлшектердің толқындық қасиеттерін сипаттау;
- Гейзенбергтің анықталмау принципінің мәнін түсіндіру;
- классикалық физика заңдылықтары мен кванттық физика тұжырымдарының қолданылу ерекшеліктерін салыстыру;
- кванттық физиканың қазіргі ғылымдағы, техникадағы және ақпараттық технологиялардағы қолданылу бағыттарын анықтау.

Оқу мақсаттарына қол жеткізу үшін теориялық білімді есептер шығару, физикалық модельдерді талдау, тәжірибелік деректерді түсіндіру және зерттеу тапсырмаларын орындау арқылы бекіту қажет.Мысалы, фотоэффект тақырыбын оқыту кезінде оқушыларға жарықтың интенсивтілігі мен жиілігінің фотоэлектрондардың қозғалысына әсері туралы сұрақтар қоюға болады. Мұндай тапсырмалар дайын формулаларды есте сақтаудан гөрі, физикалық заңдылықтардың мәнін түсінуге мүмкіндік береді[2].

2. Күрделі физикалық ұғымдарды меңгертудің әдістемелік жолдары

Атомдық және кванттық физиканы оқытуда оқу материалының күрделілігін ескере отырып, бірнеше әдістемелік тәсілді өзара байланыстыра қолданған жөн.

2.1 Көрнекілік және модельдеу әдістері

Микродүниедегі құбылыстарды тікелей бақылау мүмкіндігі шектеулі болғандықтан, оларды түсіндіруде көрнекілік құралдарының маңызы зор. Атомның құрылымын, электрондардың энергетикалық күйлерін және фотондардың затпен әрекеттесуін сызбалар, анимациялар мен компьютерлік модельдер арқылы көрсету оқушылардың абстрактілі ұғымдарды қабылдауын жеңілдетеді.

Сабақта интерактивті симуляцияларды, бейнематериалдарды және виртуалды зертханаларды пайдалануға болады. Мысалы, PhET интерактивті модельдері арқылы фотоэффект құбылысын зерттеп, жарық жиілігі мен интенсивтілігінің өзгеруі нәтижесінде байқалатын құбылыстарды салыстыруға мүмкіндік бар. Көрнекі модельдерді қолдану барысында олардың нақты физикалық процестердің ықшамдалған бейнесі екенін түсіндіру маңызды. Бұл оқушылардың модель мен шынайы құбылыстың арасындағы айырмашылықты дұрыс түсінуіне көмектеседі.

2.2 Салыстыру арқылы оқыту

Оқушылардың кванттық физика заңдылықтарын саналы түрде меңгеруіне классикалық және кванттық түсініктерді салыстыру ықпал етеді.

Мысалы, классикалық физикада дененің қозғалысы белгілі бастапқы шарттар негізінде сипатталса, кванттық физикада микробөлшектің күйін сипаттау ықтималдық ұғымымен байланыстырылады. Осы айырмашылықтарды қарастыру оқушылардың физикалық

дүниетанымын кеңейтіп, табиғат құбылыстарына әртүрлі ғылыми тұрғыдан қарауына мүмкіндік береді.

Салыстыру әдісін мына бағыттарда ұйымдастыруға болады:

- классикалық және кванттық модельдердің ерекшеліктерін анықтау;
- жарықтың толқындық және корпускулалық қасиеттерін салыстыру;
- атомның классикалық модельдері мен Бор моделінің айырмашылықтарын талдау;
- макродүние мен микродүниедегі процестерді сипаттау тәсілдерін қарастыру.

Осындай жұмыстарды кесте құрастыру, топтық талқылау және графикалық органайзерлер жасау арқылы ұйымдастыру тиімді. [3].

2.3 Проблемалық оқыту әдісі

Проблемалық оқыту оқушыларды физикалық құбылыстардың себептерін анықтауға, болжам ұсынуға және өз пікірін ғылыми дәлелдер арқылы негіздеуге бағыттайды.Мұғалім сабақ барысында оқушылардың қызығушылығын оятатын зерттеушілік сұрақтар ұсына алады. Мысалы:

- Неліктен жарықтың интенсивтілігі артқанымен, белгілі бір жағдайда фотоэффект байқалмайды?
- Атомдар энергияны кез келген мөлшерде емес, белгілі бір порциялармен қалай жұтады немесе шығарады?
- Жарықтың толқындық және бөлшектік қасиеттерін бір-бірімен қалай байланыстыруға болады?
- Кванттық физиканың заңдылықтары қазіргі электрондық құрылғылардың жұмысына қалай әсер етеді?

Оқушылар осы сұрақтарға жауап іздеу барысында теориялық білімдерін қолданады, ақпаратты салыстырады және қорытынды жасайды.

Проблемалық тапсырмалардың күрделілігі сыныптың дайындық деңгейіне сәйкес болуы керек. Алдымен қарапайым сапалық сұрақтардан бастап, кейін есептеу және зерттеу сипатындағы тапсырмаларға көшу ұсынылады.

2.4 Жобалық және зерттеушілік оқыту

Жобалық оқыту оқушылардың теориялық білімін практикалық міндеттермен байланыстыруға мүмкіндік береді. Бұл әдіс әсіресе кванттық физиканың заманауи техникадағы қолданылуын түсіндіру кезінде нәтижелі.

Оқушыларға мынадай шағын жобаларды орындау ұсынылады:

- «Лазер сәулесінің физикалық негіздері»;
- «Фотоэффект және оның техникадағы қолданылуы»;
- «Кванттық физиканың жартылай өткізгіштерді дамытудағы рөлі»;
- «Кванттық есептеу технологияларының негізгі принциптері»;
- «Атомдық спектрлер және заттардың құрылымын зерттеу».

Жобаны орындау барысында білім алушылар ақпарат көздерін іздейді, мәліметтерді талдайды, иллюстрациялар мен сызбалар әзірлейді және өз жұмысының нәтижелерін сынып алдында қорғайды.

Мұғалім жобаның тақырыбын таңдаудан бастап, ақпараттың ғылыми дұрыстығын тексеруге және қорытындыны бағалауға дейінгі кезеңдерде бағыт-бағдар береді.

2.5 Пәнаралық байланысты жүзеге асыру

Атомдық және кванттық физиканы оқытуда физика, математика, химия және информатика пәндерінің арасындағы байланысты көрсету маңызды.

Математикамен байланыс физикалық формулаларды түрлендіру, тәуелділіктерді график арқылы бейнелеу және есептеу нәтижелерін талдау кезінде жүзеге асырылады. Химия пәнімен байланыс атом құрылысы, электрондардың энергетикалық деңгейлері және спектрлік құбылыстар арқылы ашылады. Информатикамен кіріктіру компьютерлік

модельдеу, деректерді өңдеу және цифрлық зерттеу құралдарын пайдалану арқылы іске асады. Пәнаралық тәсіл оқушылардың әртүрлі пәндерден алған білімдерін біріктіріп, күрделі ғылыми құбылыстарды тұтас түсінуіне жағдай жасайды.

3. Оқу ресурстары мен цифрлық технологияларды пайдалану

Қазіргі білім беру жағдайында атомдық және кванттық физиканы оқыту тек дәстүрлі оқулықтар мен тақтадағы түсіндіруге сүйенбеуі керек. Оқу материалын меңгертуге арналған цифрлық құралдар білім алушылардың танымдық белсенділігін арттыруға және оқу үдерісін дараландыруға мүмкіндік береді. Негізгі оқу ресурстарына мыналар жатады:

- мемлекеттік оқу бағдарламасына сәйкес әзірленген оқулықтар мен оқу-әдістемелік материалдар;
- интерактивті физикалық модельдер мен компьютерлік симуляциялар;
- виртуалды зертханалар және оқу бейнематериалдары;
- ғылыми-көпшілік әдебиеттер мен электрондық білім беру платформалары;
- мұғалім әзірлеген тапсырмалар, презентациялар және графикалық материалдар.

Цифрлық ресурстарды қолдану кезінде олардың оқу мақсатына сәйкестігін және ғылыми мазмұнының дұрыстығын ескеру қажет. Электрондық материалдар мұғалімнің түсіндіруін толықтыруы керек, бірақ оқушының өздігінен ойлануы мен есеп шығару әрекетін алмастырмауы тиіс.

Мысалы, атомның энергетикалық деңгейлерін түсіндіру кезінде электронның бір энергетикалық күйден екінші күйге ауысуын анимация арқылы көрсетуге болады. Осыдан кейін оқушыларға энергия айырмасын есептеу және фотонның энергиясын анықтау тапсырмалары беріледі. Фотон энергиясы мына формуламен анықталады:

$$E=h\,ũ \qquad (1)$$

Мұндағы: E — фотон энергиясы, джоульмен (Дж) өлшенеді; h — Планк тұрақтысы, h = 6,26 10^{-34} Дж·с; (ũ) — сәуленің жиілігі, герцпен (Гц) өлшенеді.

Бұл формуладан фотон энергиясының жарық жиілігіне тура пропорционал екені көрінеді. Демек, сәуленің жиілігі артқан сайын фотонның энергиясы да артады.Осындай есептерді компьютерлік модельдермен ұштастыру оқушылардың математикалық амалдар мен физикалық мағынаның арасындағы байланысты түсінуіне көмектеседі[4].

4. Оқушылардың білімін бағалау және кері байланыс ұйымдастыру

Атомдық және кванттық физиканы оқыту нәтижелерін бағалау кезінде оқушының формулаларды есте сақтау деңгейімен ғана шектелуге болмайды. Оның физикалық заңдылықтарды түсіндіруі, есептерді шешуі, құбылыстарды салыстыруы және өз қорытындысын дәлелдеуі де назарға алынуы тиіс. Оқу жетістіктерін анықтау үшін қалыптастырушы бағалаудың әртүрлі тәсілдерін қолдануға болады:

Біріншіден, қысқа диагностикалық тапсырмалар. Сабақтың басында немесе соңында берілетін сұрақтар оқушылардың бастапқы түсінігін және тақырыпты меңгеру деңгейін анықтауға мүмкіндік береді.

Екіншіден, есептер мен сапалық тапсырмалар. Есептеу жұмыстары формулаларды дұрыс қолдану қабілетін тексерсе, сапалық сұрақтар физикалық құбылыстың мәнін түсіну деңгейін бағалайды.

Үшіншіден, графикалық және құрылымдық тапсырмалар. Оқушылар атомның энергетикалық деңгейлерін бейнелейді, физикалық шамалардың арасындағы байланысты көрсетеді және ұғымдар картасын құрастырады.

Төртіншіден, өзін-өзі және өзара бағалау. Топтық жұмыстар мен жобаларды қорғау кезінде білім алушылар бір-бірінің пікірлеріне дәлелді кері байланыс беруді үйренеді.

Бесіншіден, рефлексия. Сабақ соңында оқушылар меңгерген білімдерін, түсінуге қиындық туғызған мәселелерді және қосымша зерттеуді қажет ететін сұрақтарды анықтайды.Бағалау критерийлері сабақтың оқу мақсаттарына сәйкес алдын ала белгіленуі керек. Бұл білім

алушыларға өз жетістіктерін бағалауға және біліміндегі олқылықтарды уақытында анықтауға көмектеседі.

Қорытынды

Атомдық және кванттық физика тарауын нәтижелі оқыту оқу материалын ғылыми тұрғыдан дұрыс түсіндіруді, оқушылардың танымдық мүмкіндіктерін ескеруді және әртүрлі әдістемелік тәсілдерді өзара үйлестіруді талап етеді. Бұл бөлімдегі абстрактілі ұғымдарды меңгерту үшін көрнекі модельдер, интерактивті симуляциялар, проблемалық тапсырмалар және зерттеушілік жұмыстарды жүйелі түрде пайдалану маңызды.

Теориялық білімді практикалық есептермен және заманауи технологиялардың жұмыс істеу принциптерімен байланыстыру оқушылардың физика пәніне деген қызығушылығын арттырады. Сонымен қатар білім алушылардың ғылыми ақпаратты талдау, физикалық құбылыстарды салыстыру, болжам ұсыну және дәлелді қорытынды жасау қабілеттерін дамытуға мүмкіндік береді.

Оқыту барысында қалыптастырушы бағалау мен тұрақты кері байланысты ұйымдастыру әр оқушының білім алу үдерісіндегі жетістіктерін бақылауға жағдай жасайды. Ал пәнаралық байланыс пен жобалық жұмыстар кванттық физиканың қазіргі ғылым мен техникадағы орнын түсінуге көмектеседі.

.

Пайдаланылған әдебиеттер

1. Жданова А.А. Кванттық физиканы мектепте оқытудың әдістемелік негіздері // Физика в школе. – 2006. №3. – С.32–36.
2. Барсуков И.Ю. Физика пәнін оқытуда кванттық түсініктерді енгізудің маңызы // Физика в школе. – 2007. №6. – С.19–22.
3. Петрова А.Н. Кванттық және атомдық физика элементтерін мектептегі физика курсына енгізу // Физика в школе. – 2007.№6. – С.10–13.
4. PhET Interactive Simulations. University of Colorado Boulder.

Integrating Artificial Intelligence into Physics Education

Nurkasymova Saule Nurkasymovna
Doctor of Pedagogical Sciences, Professor, L.N. Gumilyov Eurasian National University, Astana, Kazakhstan
Ametova Dilyaram Bakhadurkyzy
Master's student, L.N. Gumilyov Eurasian National University, Astana, Kazakhstan

Physics education has long been recognized as one of the most intellectually demanding areas of science instruction. Students frequently struggle with abstract concepts, complex mathematical formalisms, and the need to visualize invisible phenomena such as electromagnetic fields, quantum states, or thermodynamic processes. Traditional teaching methods, while foundational, often face limitations in providing individualized support, timely feedback, and engaging visualizations that match the diverse learning needs of students. These persistent challenges contribute to high dropout rates in physics courses, declining interest in STEM fields, and difficulties in developing deep conceptual understanding.

In recent years, the rapid advancement of artificial intelligence technologies has opened new possibilities for addressing these long-standing issues. Computer and information communication technologies have over the years continued to evolve, leading to the development of artificial intelligence [1]. Tools such as adaptive learning systems, intelligent tutoring platforms, generative AI models, and sophisticated simulation environments are increasingly being integrated into educational practice. AI offers the potential to personalize learning pathways, generate interactive visualizations, provide immediate formative feedback, and support both students and instructors in more efficient and effective ways. As a result, the integration of artificial intelligence into physics education has become a highly relevant and timely topic in contemporary educational research.

The purpose of this paper is to examine the integration of artificial intelligence into physics education, with a particular focus on its pedagogical opportunities, practical applications, and associated challenges. Specifically, the paper aims to:

-analyze the main benefits that AI technologies can bring to the teaching and learning of physics;
-review existing practical applications and case examples of AI use in physics education;
-identify key limitations, risks, and ethical considerations related to AI integration; and
-propose recommendations for the effective and responsible implementation of AI tools in physics instruction.

Artificial Intelligence in Education refers to the application of AI technologies to support, enhance, and transform teaching and learning processes. Key concepts within AIEd include intelligent tutoring systems, which provide personalized instruction and real-time feedback; adaptive learning platforms that adjust content difficulty and pacing according to individual student performance; automated assessment tools that evaluate both quantitative and qualitative responses; and generative AI models capable of producing explanations, problems, and interactive dialogues. For example, AI can recommend appropriate learning resources, suggest areas for improvement, and adjust the difficulty level of learning tasks [2]. More recent developments also involve machine learning algorithms for learning analytics and natural language processing systems that enable conversational educational agents. Collectively, these technologies aim to create more responsive, data-driven, and student-centered learning environments.

A growing body of research has examined the application of AI in STEM education, with particular attention to mathematics, computer science, and the natural sciences. Studies in STEM contexts

have demonstrated that AI-supported systems can improve student engagement, provide timely formative feedback, and support differentiated instruction. Within physics education specifically, research has focused on several promising directions. These include the use of AI-enhanced simulations and virtual laboratories for visualizing abstract phenomena, intelligent tutoring systems designed to support problem-solving in mechanics and electromagnetism, and generative AI tools that assist students in conceptual explanation and self-regulated learning. Empirical findings generally indicate positive effects on conceptual understanding and motivation, although results vary depending on the quality of pedagogical integration and the accuracy of AI-generated scientific content. Digital ecosystems play a critical role in facilitating knowledge sharing within organizations, acting as platforms for cooperation, exchange, and access to knowledge [3].

Several pedagogical theories provide a strong foundation for the integration of AI into physics education. Constructivist approaches, rooted in the work of Piaget and Vygotsky, emphasize active knowledge construction and the importance of scaffolding within the Zone of Proximal Development - roles that adaptive AI systems can effectively support. Cognitive Load Theory highlights the need to manage intrinsic, extraneous, and germane cognitive load; AI tools can help by offering sequenced explanations, interactive visualizations, and just-in-time support that reduce unnecessary cognitive burden. In addition, theories of personalized and self-regulated learning align closely with the adaptive capabilities of AI systems, which can tailor learning pathways to individual prior knowledge, learning pace, and misconceptions commonly observed in physics. Together, these theoretical perspectives suggest that AI integration is most effective when it is deliberately aligned with established principles of how students learn complex scientific content.

Figure 1 shows the logos of the major generative AI systems that are most relevant to physics education: ChatGPT, Claude, Gemini, Grok, and Antigravity.



Figure 1. Logos of major generative AI systems used in educational contexts: ChatGPT, Claude, Gemini, Grok, and Antigravity.

One of the most significant opportunities offered by artificial intelligence in physics education is the capacity for personalized and adaptive learning. AI-driven platforms can continuously analyze student performance data, identify individual misconceptions, and adjust the difficulty, sequence, and type of learning materials in real time. In physics, where students often enter courses with highly varied levels of prior mathematical and conceptual knowledge, such adaptive pathways allow learners to progress at their own pace while receiving targeted support in areas of difficulty. This personalization helps reduce frustration, maintain motivation, and promote deeper conceptual understanding. Several generative AI systems are currently used by students and educators to support the learning of physics. Table 1 provides a comparative overview of the main platforms, highlighting their relative strengths and limitations in educational contexts.

AI System	Strengths in Physics Education	Main Limitations	Best for
ChatGPT	Clear explanations, analogies, problem-solving	Occasional inaccuracies	Everyday learning & practice
Claude	Deep, structured conceptual reasoning	Limited real-time data	Detailed explanations & derivations
Gemini	Strong with diagrams and multimodal input	Sometimes less precise in text	Visual & diagram-based learning
Grok	Creative style, real-time information	Weaker on rigorous scientific depth	Informal explanations & brainstorming
Antigravity	Coding and simulation development	Not a general teaching chatbot	Creating physics tools & simulations

Table 1. Comparison of major generative AI systems for physics education

A second major benefit lies in the enhanced visualization and simulation of physical phenomena. Many core topics in physics - including electromagnetic fields, wave interference, quantum mechanical systems, and thermodynamic processes - involve abstract or invisible entities that are difficult to represent through traditional static diagrams or verbal explanations. AI-powered simulation tools and generative models can create interactive, dynamic, and often three-dimensional visualizations that respond to student input. These technologies enable learners to manipulate variables, observe immediate consequences, and develop stronger mental models of complex physical systems.

Intelligent tutoring systems and automated feedback represent another important advantage. AI-based tutors can guide students through multi-step problem-solving processes, provide hints at critical moments, and offer detailed formative feedback on both procedural and conceptual aspects of physics tasks. Unlike traditional homework assignments that typically receive delayed and limited feedback, AI systems can respond instantly, helping students correct errors while the learning experience is still active. This continuous feedback loop supports the development of problem-solving skills and self-regulated learning strategies. Although several generative AI systems are available, their actual adoption among students differs significantly. Figure 2 illustrates the relative popularity of the main platforms in educational settings.

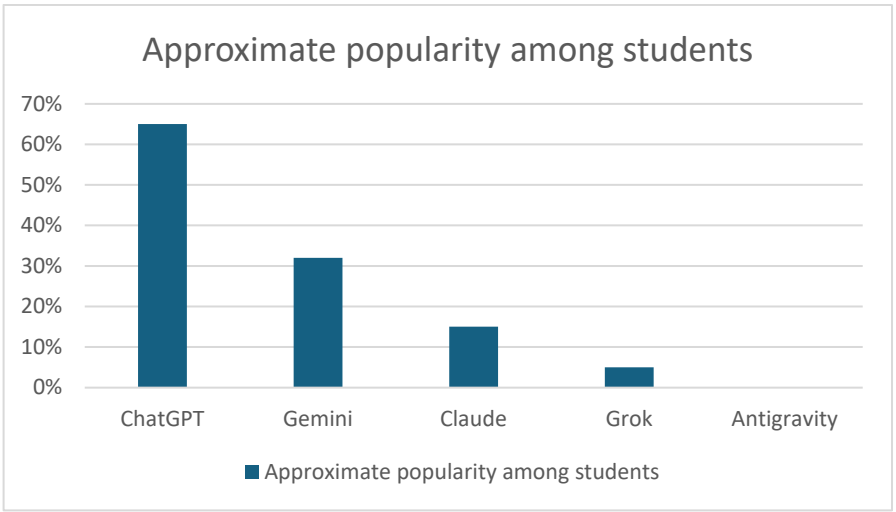


Figure 2. Relative popularity of major AI systems among students

A growing number of practical applications demonstrate how artificial intelligence can be effectively integrated into physics education. One of the most established areas involves AI-powered simulations and virtual laboratories. These tools enable students to explore physical phenomena that are difficult, dangerous, or expensive to investigate in traditional laboratory settings. For example, AI-enhanced platforms can simulate complex experiments in electromagnetism, fluid dynamics, or quantum mechanics, allowing learners to manipulate variables, observe real-time outcomes, and receive intelligent guidance based on their interactions. Such virtual environments not only increase accessibility but also support repeated experimentation and inquiry-based learning.

Generative AI systems have also found wide application in supporting explanations and problem-solving. Large language models can generate step-by-step solutions to physics problems, offer alternative conceptual explanations, and adapt their language to different levels of student understanding. When carefully used, these tools serve as on-demand tutors that help students clarify difficult concepts, check their reasoning, and explore multiple approaches to the same problem. In many university physics courses, instructors have begun incorporating generative AI as a supplementary resource for homework support and self-study, while simultaneously teaching students how to critically evaluate AI-generated content for scientific accuracy.

Adaptive learning platforms and intelligent tutoring systems represent another significant area of practical implementation. Several systems specifically designed for physics education adjust the sequence and difficulty of tasks according to individual student performance. These platforms typically combine machine learning algorithms with domain-specific knowledge of common physics misconceptions. Intelligent tutoring systems, for instance, can guide students through multi-step problems in classical mechanics or electricity and magnetism, providing hints, corrective feedback, and scaffolding that gradually decreases as the learner gains competence. Research and classroom experience indicate that such systems can improve both conceptual understanding and problem-solving performance when integrated into regular instruction.

Despite the considerable potential of artificial intelligence in physics education, its integration is accompanied by a range of technical, pedagogical, and infrastructural barriers. Many educational institutions still lack the necessary technological infrastructure, including reliable high-speed internet, sufficient computing resources, and compatible learning management systems. In addition, the development and maintenance of high-quality AI tools specifically designed for physics require substantial expertise and financial investment. Pedagogically, the effective incorporation of AI demands careful alignment with learning objectives; poorly designed implementations may disrupt established teaching practices or fail to support deep conceptual understanding.

A second major concern relates to the risks of over-reliance on AI and issues of scientific accuracy. Students may become dependent on AI-generated explanations and solutions, which can weaken their ability to engage in independent reasoning and problem-solving - skills that are fundamental to physics. Moreover, generative AI models occasionally produce factually incorrect or physically inconsistent information, a phenomenon commonly referred to as “hallucination”. In a discipline that demands high precision, such inaccuracies pose a serious risk if students accept AI outputs without critical evaluation. Ensuring the scientific reliability of AI tools therefore remains an ongoing challenge.

Equity, access, data privacy, and academic integrity constitute further critical issues. Not all students have equal access to digital devices or stable internet connections, which can exacerbate existing educational inequalities. The collection and analysis of student data by AI systems also raise significant privacy concerns, particularly regarding how personal learning information is stored, shared, and used. In addition, the ease with which generative AI can produce completed

assignments has intensified problems of academic integrity, making it more difficult for instructors to distinguish between original student work and AI-assisted submissions.

For the successful integration of artificial intelligence into physics education, both educators and institutions need clear practical guidelines. First, AI tools should be selected and implemented on the basis of specific learning objectives rather than technological novelty. Instructors are advised to introduce AI gradually, starting with well-defined tasks such as visualization support or formative feedback, and to establish explicit rules regarding the acceptable use of generative AI. Institutions should invest in reliable technological infrastructure, ensure data privacy compliance, and provide ongoing technical support. Equally important is the development of institutional policies that address academic integrity and the ethical use of AI by both students and staff.

Effective integration also requires thoughtful models for blending AI tools with traditional teaching methods. One promising approach is the "AI-enhanced flipped classroom", in which students use adaptive platforms and generative AI for pre-class conceptual preparation, while face-to-face sessions focus on collaborative problem-solving, experimental work, and instructor-guided discussion. Another useful model combines intelligent tutoring systems for individualized practice with traditional laboratory activities and teacher-led conceptual discussions. In all cases, AI should function as a complementary resource that supports, rather than replaces, human interaction, critical thinking, and hands-on experimentation - elements that remain essential to physics education.

Future research should address several important gaps. Empirical studies are needed to evaluate the long-term effects of AI integration on students' conceptual understanding, problem-solving skills, and motivation in physics. Comparative investigations of different pedagogical models for combining AI with traditional instruction would provide valuable evidence for practitioners. Additional research is also required on the accuracy and reliability of generative AI in physics contexts, as well as on effective strategies for developing students' critical AI literacy. Moreover, AI assists teachers in identifying students' learning styles by analyzing data on their interactions with online learning systems [4]. Finally, studies focusing on equity, accessibility, and the professional development of physics teachers will be essential for ensuring that the benefits of AI are distributed fairly and sustainably.

This paper has examined the integration of artificial intelligence into physics education, highlighting both its substantial opportunities and its significant challenges. AI technologies offer powerful means of personalizing learning, enhancing the visualization of complex physical phenomena, providing intelligent tutoring and feedback, and supporting teachers in curriculum design and instructional tasks. At the same time, technical limitations, risks of over-reliance, issues of scientific accuracy, concerns related to equity and academic integrity, and the need for teacher preparation must be carefully addressed.

The balanced and responsible integration of artificial intelligence into physics education does not imply the replacement of teachers or traditional pedagogical approaches. Rather, it calls for a thoughtful combination of technological innovation with established principles of effective science teaching. When AI tools are implemented with clear pedagogical purpose, critical oversight, and adequate professional support, they have the potential to enrich physics learning and help students develop deeper conceptual understanding. Continued research, institutional commitment, and reflective practice will be essential to realizing this potential in a sustainable and equitable manner. Finally, research is also needed to understand how to effectively measure the impact of AI-based digital ecosystems and machine learning algorithms on student learning out comes, and how to use data analysis to provide personalized support, accurate assessments, and guidance to students [5].

List of references

1 Lijia C., Pingping C., Zhijian L. Artificial Intelligence in Education: A Review // IEEEAccess. May 5, 2020. – P. 75264- 75268.

2 Alexandara H. Role of AI in Education // Injuruty: Interdiciplinary Journal and Humanity Volume 2, Number 3, March 2023. – P. 260-268.

3 Gupta, R., Mejia, C., & Kajikawa, Y. (2019). Business, innovation, and digital ecosystems landscape survey and knowledge cross sharing. Technological Forecasting and Social Change, 147, 100–109.

4 Duan, H. & Zhao, W. (2024). The Effects of Educational Artificial Intelligence-Powered Applications on Teachers' Perceived Autonomy, Professional Development for Online Teaching, and Digital Burnout. International Review of Research in Open and Distributed Learning, 25(3), 57–76.

5 Milena P., Andrés C. Artificial Intelligence and Digital Ecosystems in Education: A Review // Technology, Knowledge and Learning (2024) 29:2153–2170.

Sociological Sciences

УДК 316.346.2

ЖЕНЩИНЫ-ДОМОХОЗЯЙКИ В СТРУКТУРЕ ДОМАШНИХ ХОЗЯЙСТВ РЕСПУБЛИКИ КАЗАХСТАН: РЕГИОНАЛЬНЫЙ АНАЛИЗ ЗА 2019–2023 ГОДЫ

Ешманова Салтанат Есимовна
Казахстанско-Британский технический университет, докторант, Алматы, Республика Казахстан

Аннотация
В статье представлен статистический анализ положения женщин в структуре домашних хозяйств Республики Казахстан в региональном разрезе за 2019–2023 гг. Исследование направлено на определение удельного веса женщин среди членов домашних хозяйств, выявление региональных различий в структуре домашних хозяйств по полу главы домохозяйства, а также оценку доли женщин в общей численности населения Республики Казахстан. Особое внимание уделяется методологическому разграничению понятий «женщина-домохозяйка», «женщина — член домохозяйства», «женщина — глава домохозяйства» и «женщина, осуществляющая неоплачиваемый домашний труд». На основе официальных статистических данных Бюро национальной статистики Агентства по стратегическому планированию и реформам Республики Казахстан установлено, что женщины на протяжении рассматриваемого периода составляли более половины членов обследуемых домашних хозяйств. В 2023 г. их доля составила 54,4% против 45,6% мужчин. Региональная дифференциация является существенной: максимальная доля женщин среди членов домашних хозяйств в 2023 г. наблюдалась в г. Алматы — 59,9%, а минимальная — в Туркестанской области — 48,8%. Одновременно в 61,7% обследуемых домашних хозяйств Республики Казахстан в 2023 г. главой являлась женщина. Полученные результаты свидетельствуют о необходимости более детального статистического учета неоплачиваемого домашнего и уходового труда женщин как значимой составляющей социально-экономического развития регионов.
Ключевые слова: женщина-домохозяйка, домашнее хозяйство, домохозяйство, женщины, неоплачиваемый труд, социальная защита, региональная статистика, гендерная статистика, население, Республика Казахстан.

Домашнее хозяйство является одной из основных социально-экономических единиц общества, в рамках которой осуществляется не только потребление товаров и услуг, но и значительный объем деятельности по воспроизводству человеческого капитала. В домашних хозяйствах осуществляются воспитание детей, уход за пожилыми и другими зависимыми членами семьи, приготовление пищи, уборка, организация быта и иные виды

деятельности, которые в значительной части не имеют непосредственного денежного выражения.

В данной системе особое значение имеет положение женщин. Традиционно женщина, преимущественно осуществляющая ведение домашнего хозяйства, воспитание детей и семейно-бытовые обязанности, определяется как домохозяйка. Вместе с тем в современной экономике и социальной статистике понятие «домохозяйка» не может рассматриваться исключительно как характеристика отсутствия оплачиваемой занятости. Женщина может одновременно осуществлять домашний труд и иметь оплачиваемую работу, заниматься индивидуальным предпринимательством или другой экономической деятельностью.

В связи с этим статистическое исследование женщин-домохозяек требует разграничения нескольких понятий. Во-первых, это женщина как член домашнего хозяйства. Во-вторых, женщина как глава домохозяйства. В-третьих, женщина, которая фактически осуществляет неоплачиваемый домашний и уходовый труд. Данные категории могут пересекаться, однако не являются идентичными.

Согласно официальной статистической методологии, домохозяйство представляет собой группу лиц, совместно проживающих, полностью или частично объединяющих свои доходы и имущество и совместно потребляющих определенные товары и услуги. Домохозяйство может состоять и из одного человека, а его члены не обязательно должны состоять между собой в родственных отношениях.

Актуальность исследования определяется необходимостью более полного понимания роли женщин в функционировании домашних хозяйств и региональных социальных систем. Особенно важным является определение масштабов присутствия женщин в домашних хозяйствах и выявление регионов, где их доля существенно отличается от среднереспубликанского уровня.

Целью настоящего исследования является анализ положения женщин в структуре домашних хозяйств Республики Казахстан за 2019–2023 гг. и выявление региональных различий в удельном весе женщин среди членов домохозяйств.

Для достижения поставленной цели решаются следующие задачи: определить динамику доли женщин в структуре населения Казахстана; исследовать долю женщин среди членов обследуемых домашних хозяйств; определить региональные различия данного показателя; проанализировать долю домохозяйств, возглавляемых женщинами; сформулировать выводы относительно социально-экономического значения полученных результатов.

1. Методологические основы исследования

Статистическая оценка положения женщин-домохозяек представляет определенную методологическую сложность. Это связано прежде всего с отсутствием полного тождества между понятиями «домохозяйка» и «женщина — член домохозяйства».

Если женщина является членом домашнего хозяйства, это еще не означает, что она выполняет функции домохозяйки. Аналогично, женщина — глава домохозяйства может быть занята на рынке труда и одновременно выполнять домашние обязанности.

Поэтому в настоящем исследовании понятие «женщина-домохозяйка» рассматривается в более широком социально-экономическом контексте — как женщина, принимающая существенное участие в ведении домашнего хозяйства, воспитании детей и осуществлении ухода за членами семьи. При этом основным непосредственно наблюдаемым статистическим показателем выступает доля женщин среди членов обследуемых домашних хозяйств.

Данный показатель позволяет определить гендерную структуру домашних хозяйств и установить, какую часть их состава составляют женщины. В дальнейшем для характеристики роли женщин используется дополнительный показатель — доля домашних хозяйств, в которых главой является женщина.

Бюро национальной статистики осуществляет выборочное обследование домашних хозяйств, позволяющее получать данные в разрезе регионов. Современная выборка обследования уровня жизни включает около 12 тыс. домашних хозяйств и охватывает различные группы населения, включая регионы, уровни доходов, образования и занятости.

Следовательно, представленные в статье показатели являются показателями **обследуемых домашних хозяйств**, а не результатом сплошного учета всех домохозяйств Республики Казахстан. Данное обстоятельство необходимо учитывать при интерпретации статистических результатов.

2. Динамика удельного веса женщин в населении Республики Казахстан

В первую очередь целесообразно определить положение женщин в общей демографической структуре населения. Официальные данные Бюро национальной статистики за 2019–2023 гг. свидетельствуют о сохранении устойчивого численного преобладания женщин над мужчинами.

Таблица 1. Численность и удельный вес женщин в населении Республики Казахстан в 2019–2023 гг.

Год	Численность населения, тыс. чел.	Женщины, тыс. чел.	Мужчины, тыс. чел.	Удельный вес женщин, %
2019	18 630,9	9 597,4	9 033,5	51,52
2020	18 878,9	9 719,0	9 159,9	51,48
2021	19 503,2	9 989,4	9 513,8	51,22
2022	19 766,8	10 119,1	9 647,7	51,19
2023	20 033,8	10 250,0	9 783,8	51,17

Источник: составлено автором по данным Бюро национальной статистики Республики Казахстан.

Как показывает таблица 1, за исследуемый пятилетний период численность женщин в Казахстане увеличилась с 9,60 млн человек в 2019 г. до 10,25 млн человек в 2023 г. Абсолютный прирост составил около 652,6 тыс. человек.

При этом удельный вес женщин в общей численности населения несколько снизился — с 51,52% в 2019 г. до 51,17% в 2023 г. Снижение составило около 0,35 процентного пункта. Таким образом, несмотря на увеличение абсолютной численности женщин, гендерная структура населения характеризовалась относительно стабильным соотношением полов.

В среднем за рассматриваемый период женщины составляли около 51,3% населения Республики Казахстан. Следовательно, демографическая структура страны характеризуется незначительным, но устойчивым преобладанием женского населения.

Данный показатель имеет значение для анализа домашних хозяйств, поскольку потенциально определяет более высокую представленность женщин в составе домохозяйств. Однако доля женщин среди членов домашних хозяйств оказывается выше их доли в общей численности населения, что свидетельствует о специфике структуры домашних хозяйств.

3. Женщины в структуре домашних хозяйств Республики Казахстан

В 2023 г. женщины составляли **54,4% всех членов обследуемых домашних хозяйств Республики Казахстан**, тогда как доля мужчин составляла 45,6%. Таким образом, доля женщин среди членов домашних хозяйств превышала их долю в общей численности населения примерно на 3,2 процентного пункта.

Данное соотношение является существенным для понимания социально-демографической роли женщин в домашних хозяйствах. Женщины составляют не просто немногочисленную или равную мужчинам часть домохозяйств, а устойчиво преобладающую их часть.

При этом региональные показатели существенно различаются.

Таблица 2. Доля женщин среди членов обследуемых домашних хозяйств по регионам Республики Казахстан в 2023 г., %

Регион	Женщины, %	Мужчины, %
Республиа Казахстан	**54,4**	45,6
Абай	54,5	45,5
Акмолинская	55,1	44,9
Актюбинская	53,2	46,8
Алматинская	54,1	45,9
Атырауская	52,3	47,7
Западно-Казахстанская	54,0	46,0
Жамбылская	52,5	47,5
Жетiсу	53,7	46,3
Карагандинская	55,5	44,5
Костанайская	57,0	43,0
Кызылординская	50,5	49,5
Мангистауская	51,1	48,9
Павлодарская	53,2	46,8
Северо-Казахстанская	55,5	44,5
Туркестанская	48,8	51,2
Ұлытау	50,5	49,5
Восточно-Казахстанская	56,7	43,3
г. Астана	57,2	42,8
г. Алматы	**59,9**	40,1
г. Шымкент	56,6	43,4

Источник: Бюро национальной статистики Республики Казахстан, «Женщины и мужчины Казахстана», 2019–2023.

Представленные данные демонстрируют значительную территориальную дифференциацию.

Наиболее высокая доля женщин среди членов домашних хозяйств в 2023 г. наблюдалась в **г. Алматы — 59,9%**. Следующими регионами по данному показателю являлись Акмолинская область — 55,1%, Карагандинская область — 55,5%, Северо-Казахстанская область — 55,5%, Восточно-Казахстанская область — 56,7%, г. Шымкент — 56,6%, г. Астана — 57,2% и Костанайская область — 57,0%.

Наименьшая доля женщин была зарегистрирована в Туркестанской области — **48,8%**. Ниже 51% также находились показатели Кызылординской области — 50,5% и области Ұлытау — 50,5%. Мангистауская область имела показатель 51,1%, а Атырауская — 52,3%.

Таким образом, разрыв между максимальным и минимальным региональными значениями составил **11,1 процентного пункта**. Это свидетельствует о существенной региональной неоднородности гендерной структуры домашних хозяйств.

В целом можно выделить условно три группы регионов. Первая группа характеризуется высокой долей женщин — более 56%: Костанайская область, Восточно-Казахстанская область, г. Астана, г. Алматы и г. Шымкент. Вторая группа характеризуется показателями, близкими к среднереспубликанскому уровню, — приблизительно от 53 до 56%. Третья группа включает территории, где доля женщин составляет менее 53%, в том числе Атыраускую, Жамбылскую, Кызылординскую, Мангистаускую, Ұлытаускую и Туркестанскую области.

4. Женщины — главы домашних хозяйств

Для более полного анализа положения женщин необходимо рассмотреть не только их присутствие в составе домохозяйства, но и их положение в структуре принятия экономических решений.

В 2023 г. **61,7% обследуемых домашних хозяйств Республики Казахстан возглавлялись женщинами**, тогда как доля домохозяйств, возглавляемых мужчинами, составляла 38,3%.

Данный показатель существенно превышает долю женщин среди всех членов домохозяйств. Это означает, что женская роль в домашних хозяйствах не ограничивается количественным присутствием: в значительной части домохозяйств женщина определяется в качестве главы.

Таблица 3. Доля домашних хозяйств, возглавляемых женщинами, по регионам Республики Казахстан в 2023 г., %

Регион	Женщины — главы домохозяйств, %
Республика Казахстан	61,7
Абай	45,9
Акмолинская	60,0
Актюбинская	45,8
Алматинская	68,3
Атырауская	38,4
Западно-Казахстанская	73,1
Жамбылская	60,0
Жетiсу	57,0
Карагандинская	53,8
Костанайская	67,4
Кызылординская	47,5
Мангистауская	71,8
Павлодарская	61,0
Северо-Казахстанская	71,0
Туркестанская	32,8
Ұлытау	43,6
Восточно-Казахстанская	65,8
г. Астана	65,3
г. Алматы	69,7
г. Шымкент	63,9

Источник: Бюро национальной статистики Республики Казахстан.

Максимальная доля домашних хозяйств, возглавляемых женщинами, в 2023 г. наблюдалась в Западно-Казахстанской области — **73,1%**, Мангистауской области — **71,8%**, Северо-Казахстанской области — **71,0%**, г. Алматы — **69,7%**, Алматинской области — **68,3%**. Высокие значения также наблюдались в Костанайской области — 67,4%, Восточно-Казахстанской области — 65,8%, г. Астана — 65,3% и г. Шымкент — 63,9%.

В противоположность этому, наиболее низкий показатель был зафиксирован в Туркестанской области — **32,8%**. В Атырауской области доля составила 38,4%, в Ұлытау — 43,6%, в Актюбинской области — 45,8%, в области Абай — 45,9%.

Полученные результаты демонстрируют, что региональная структура домашних хозяйств по полу главы значительно отличается от структуры членов домохозяйств по полу. Например, Туркестанская область одновременно характеризуется низкой долей женщин среди членов домохозяйств — 48,8% — и самой низкой долей женщин среди глав домохозяйств — 32,8%. В то же время в Западно-Казахстанской области доля женщин среди членов домохозяйств составляет 54,0%, тогда как доля женщин — глав домохозяйств достигает 73,1%.

Это позволяет сделать вывод о том, что показатели гендерного состава домохозяйства и лидерства в домохозяйстве отражают различные социальные процессы и должны рассматриваться раздельно.

5. Динамика женского лидерства в домашних хозяйствах в 2019–2023 гг.

Особый интерес представляет динамика доли домохозяйств, возглавляемых женщинами.

По данным БНС, в 2019 г. доля домашних хозяйств, где главой являлась женщина, составляла **50,4%**. В 2020 г. показатель увеличился до 53,4%, в 2021 г. — до 54,2%, а в 2022 г. составил 50,1%. В 2023 г. произошел существенный рост до 61,7%.

Таблица 4. Динамика доли домашних хозяйств, возглавляемых женщинами, в Республике Казахстан, 2019–2023 гг.

Год	Женщины — главы домохозяйств, %	Мужчины — главы домохозяйств, %
2019	50,4	49,6
2020	53,4	46,6
2021	54,2	45,8
2022	50,1	49,9
2023	61,7	38,3

Источник: БНС РК.

За пятилетний период доля домохозяйств, возглавляемых женщинами, увеличилась на **11,3 процентного пункта**. При этом динамика не была линейной: после роста в 2020–2021 гг. наблюдалось снижение в 2022 г., а затем значительный рост в 2023 г.

При интерпретации данного изменения следует учитывать выборочный характер обследования домашних хозяйств и возможные изменения структуры выборки. Поэтому резкое увеличение показателя в 2023 г. целесообразно рассматривать как статистически зафиксированное изменение, которое требует дополнительного анализа на более длительном временном ряду.

Вместе с тем общая тенденция указывает на значительное участие женщин в организации и управлении домашними хозяйствами Казахстана.

6. Региональные особенности положения женщин-домохозяек

Полученные статистические данные позволяют сделать вывод о том, что категория женщины-домохозяйки имеет неодинаковое содержание в разных регионах Казахстана.

В регионах с высокой долей женщин среди членов домохозяйств и высокой долей женщин — глав домохозяйств женщины занимают одновременно значительное количественное и организационное положение в структуре семьи и домашнего хозяйства.

В то же время в регионах, где доля женщин среди членов домохозяйств ниже, наблюдается и более низкая представленность женщин в качестве глав домохозяйств. Особенно выражена такая ситуация в Туркестанской области, где доля женщин среди членов домохозяйств в 2023 г. составила 48,8%, а доля домохозяйств, возглавляемых женщинами, — 32,8%.

Подобная региональная дифференциация может быть связана с различиями в возрастной и семейной структуре населения, размерах домохозяйств, уровне урбанизации, миграционных процессах, особенностях занятости мужчин и женщин, а также с традиционными моделями семейного поведения.

Следует отметить, что особенно высокие показатели доли женщин среди членов домашних хозяйств характерны для крупных городов. В г. Алматы этот показатель достиг 59,9%, в г. Астане — 57,2%, в г. Шымкенте — 56,6%.

Однако городская специфика не является единственным фактором. Например, высокая доля женщин среди членов домохозяйств наблюдается также в Восточно-Казахстанской, Костанайской и Северо-Казахстанской областях. Следовательно, региональная структура

формируется под воздействием комплекса демографических и социально-экономических факторов.

7. Женщина-домохозяйка как объект социальной статистики

Проведенный анализ показывает необходимость более четкого статистического определения категории «женщина-домохозяйка».

Если рассматривать домохозяйку исключительно как женщину, которая не имеет оплачиваемой работы, то часть женщин, фактически осуществляющих значительный объем домашнего труда, будет исключена из анализа. Современная женщина может одновременно работать и выполнять основную часть домашних обязанностей.

Поэтому с научной точки зрения целесообразно использовать более широкое понятие **«женщина, осуществляющая неоплачиваемый домашний и уходовый труд»**. Категория «домохозяйка» в таком случае рассматривается как социально-экономическая характеристика, а не исключительно как характеристика занятости.

Это особенно важно для разработки государственной социальной политики. Женщина может иметь формальную занятость, но при этом нести основную ответственность за воспитание детей, уход за пожилыми членами семьи и ведение домашнего хозяйства.

Таким образом, показатели занятости сами по себе не позволяют определить реальную нагрузку женщин. Необходим дополнительный статистический учет времени, затрачиваемого на неоплачиваемую работу.

В Казахстане уже существует развитая система статистического наблюдения за домашними хозяйствами. БНС использует обследования для анализа доходов, расходов, состава и социально-демографических характеристик домохозяйств, а данные распространяются в том числе по регионам.

Перспективным направлением является включение в региональную статистику показателей, характеризующих объем неоплачиваемого домашнего труда женщин. К ним могут относиться среднее количество часов, затрачиваемых женщинами на домашнюю работу, уход за детьми, уход за пожилыми и лицами с инвалидностью, приготовление пищи, уборку и другие виды деятельности.

Заключение

Проведенный анализ официальных статистических данных Республики Казахстан за 2019–2023 гг. позволяет сделать несколько основных выводов.

Во-первых, женщины занимают устойчиво значимое положение в демографической структуре Казахстана. В течение рассматриваемого периода их удельный вес в общей численности населения находился на уровне около 51,2–51,5%. Численность женского населения увеличилась с 9,60 млн человек в 2019 г. до 10,25 млн человек в 2023 г.

Во-вторых, доля женщин среди членов обследуемых домашних хозяйств выше их доли в общей структуре населения. В 2023 г. женщины составляли 54,4% членов домашних хозяйств против 45,6% мужчин. Таким образом, женское присутствие в структуре домохозяйств является более высоким, чем их доля в населении в целом.

В-третьих, выявлены значительные региональные различия. В 2023 г. максимальная доля женщин среди членов домашних хозяйств отмечалась в г. Алматы — 59,9%, а минимальная — в Туркестанской области — 48,8%. Разница между максимальным и минимальным значениями составила 11,1 процентного пункта.

В-четвертых, существенным является показатель женского лидерства в домохозяйствах. В 2023 г. 61,7% обследуемых домашних хозяйств Казахстана возглавлялись женщинами. Наиболее высокие значения отмечались в Западно-Казахстанской области — 73,1%, Мангистауской области — 71,8%, Северо-Казахстанской области — 71,0% и г. Алматы — 69,7%. Наименьший показатель зарегистрирован в Туркестанской области — 32,8%.

В-пятых, проведенное исследование подтверждает необходимость разграничения статистических категорий «женщина — член домохозяйства», «женщина — глава домохозяйства» и «женщина-домохозяйка». Отождествление этих категорий может привести к статистическим ошибкам при оценке масштабов неоплачиваемого домашнего труда.

Таким образом, женщина-домохозяйка должна рассматриваться как самостоятельный субъект социально-экономического анализа. Ее деятельность связана не только с ведением домашнего хозяйства, но и с воспроизводством человеческого капитала, воспитанием детей и уходом за членами семьи.

Для совершенствования государственной социальной политики Республики Казахстан представляется целесообразным формировать более детальную региональную статистику женщин, осуществляющих неоплачиваемый домашний и уходовый труд. Такая статистика должна включать показатели возраста, семейного положения, количества детей, уровня образования, экономической активности, доходов домохозяйства, места проживания и времени, затрачиваемого на домашнюю работу.

Особое значение имеет проведение регулярных исследований использования времени, позволяющих определить реальный объем неоплачиваемого труда женщин. Это позволит перейти от исключительно демографического учета женщин в составе домашних хозяйств к оценке их фактического социально-экономического вклада.

В результате статистический анализ показывает, что женщина-домохозяйка не может рассматриваться как экономически неактивное лицо только на основании отсутствия заработной платы. Ее деятельность в домашнем хозяйстве представляет собой социально значимый труд, обеспечивающий функционирование семьи и воспроизводство человеческого потенциала общества. Поэтому дальнейшее развитие статистики домашних хозяйств в Казахстане должно предусматривать более полное отражение данной деятельности в региональном и гендерном разрезах.

Список литературы

1. Бюро национальной статистики Агентства по стратегическому планированию и реформам Республики Казахстан. Женщины и мужчины Казахстана: статистический сборник. 2019–2023. Астана, 2024.
2. Бюро национальной статистики Агентства по стратегическому планированию и реформам Республики Казахстан. Уровень жизни населения в Казахстане. Статистические материалы по обследованию домашних хозяйств.
3. Бюро национальной статистики Агентства по стратегическому планированию и реформам Республики Казахстан. Статистика уровня жизни населения. Динамические таблицы.
4. Бюро национальной статистики Агентства по стратегическому планированию и реформам Республики Казахстан. Тематические сборники по итогам Национальной переписи населения 2021 года: домашние хозяйства, брак и семья. Астана, 2023.
5. Бюро национальной статистики Агентства по стратегическому планированию и реформам Республики Казахстан. Демографическая статистика Республики Казахстан. Астана.
6. Бюро национальной статистики Агентства по стратегическому планированию и реформам Республики Казахстан. Гендерная статистика Республики Казахстан.
7. Бюро национальной статистики Агентства по стратегическому планированию и реформам Республики Казахстан. Производственная деятельность домашних хозяйств в Республике Казахстан. Астана.

8. Бюро национальной статистики Агентства по стратегическому планированию и реформам Республики Казахстан. Расходы и доходы населения Республики Казахстан. Астана.

УДК 316.346.2

ГОСУДАРСТВЕННАЯ ПОДДЕРЖКА ЖЕНЩИН-ДОМОХОЗЯЕК В РЕСПУБЛИКЕ КАЗАХСТАН: ЭВОЛЮЦИЯ ИНСТРУМЕНТОВ, ДИНАМИКА И ПРОБЛЕМЫ ДОСТАТОЧНОСТИ

Сейтказиева Аружан Мукатаевна
Казахстанско-Британский технический университет, профессор, д.э.н.
Ешманова Салтанат Есимовна
Казахстанско-Британский технический университет, докторант, Алматы, Республика Казахстан

Аннотация
В статье исследуется развитие государственной поддержки женщин, осуществляющих ведение домашнего хозяйства, в Республике Казахстан. Актуальность исследования обусловлена значительным объемом неоплачиваемого домашнего и уходового труда, который преимущественно выполняется женщинами и оказывает непосредственное влияние на их экономическую активность, уровень текущих доходов, пенсионные права и возможности возвращения на рынок труда. Цель исследования заключается в выявлении основных инструментов государственной поддержки женщин-домохозяек, анализе их эволюции в хронологическом порядке и оценке достаточности существующей системы в динамике. На основе нормативно-правовых актов, данных Бюро национальной статистики и официальной информации государственных органов рассмотрены адресная социальная помощь, пособия при рождении и уходе за ребенком, социальные выплаты из Государственного фонда социального страхования, пособия многодетным семьям, пенсионные механизмы, центры поддержки семьи, цифровизация предоставления социальных услуг и меры содействия занятости. Установлено, что государственная политика постепенно трансформировалась от преимущественно денежной помощи отдельным категориям семей к комплексной модели, сочетающей денежные выплаты, социальное страхование, услуги, цифровое назначение помощи и содействие занятости. Вместе с тем система остается преимущественно семейно-ориентированной, а не ориентированной непосредственно на компенсацию неоплачиваемого домашнего труда. Наиболее существенными проблемами являются ограниченная продолжительность универсальной выплаты по уходу за ребенком, зависимость размера страховой выплаты от предшествующего дохода и социальных отчислений, недостаточная компенсация долгосрочных пенсионных последствий длительного выхода женщины с рынка труда, региональная неоднородность доступности услуг и ориентация части инструментов на возвращение женщины к занятости вместо признания экономической ценности домашнего труда.

Ключевые слова: женщины-домохозяйки, домашнее хозяйство, государственная поддержка, социальная защита, социальные выплаты, пособия, неоплачиваемый труд, материнство, занятость женщин, гендерная политика, Казахстан.

В современной экономике домашнее хозяйство выполняет значительный объем деятельности, не отражаемой непосредственно в показателях рыночной занятости. Приготовление пищи, уборка, воспитание детей, уход за пожилыми людьми, лицами с инвалидностью и другими членами семьи создают экономически значимые услуги, однако в большинстве случаев не имеют прямого денежного вознаграждения.

Особое значение данный вопрос приобретает применительно к женщинам. В случае длительного выполнения домашних и уходовых функций женщина может временно или продолжительно не участвовать в рынке труда. Это приводит не только к снижению текущего индивидуального дохода, но и потенциально влияет на профессиональную карьеру, накопление пенсионных прав и экономическую самостоятельность.

При этом в Казахстане отсутствует самостоятельная универсальная государственная выплата, которая назначалась бы исключительно за статус «домохозяйки». Государственная поддержка предоставляется преимущественно через более широкие категории: семьи с детьми, многодетные семьи, малообеспеченные семьи, родителей, осуществляющих уход за детьми, участников обязательного социального страхования, а также лиц, находящихся в трудной жизненной ситуации. Такой подход соответствует действующей модели семейной и гендерной политики государства. Концепция семейной и гендерной политики до 2030 года предусматривает повышение доступности и адресности социальной поддержки семей, развитие социальных услуг и обеспечение равной ответственности родителей за воспитание детей и ведение домашнего хозяйства.

Следовательно, для оценки положения женщин-домохозяек необходимо исследовать не один конкретный вид пособия, а совокупность государственных инструментов.

1. Методологический подход

В настоящем исследовании под женщинами-домохозяйками понимаются женщины, для которых ведение домашнего хозяйства является основной сферой деятельности и которые полностью либо преимущественно осуществляют неоплачиваемую работу внутри семьи.

При этом необходимо разграничивать три статистические категории:

1. женщин — членов домохозяйств;
2. женщин — глав домохозяйств;
3. женщин, не входящих в состав рабочей силы по причине ведения домашнего хозяйства.

Третья категория является наиболее близким официальным статистическим аналогом женщины-домохозяйки.

Методологически государственная поддержка таких женщин может быть разделена на пять групп:

1) денежные трансферты;
2) социальное страхование;
3) пенсионные механизмы;
4) социальные и семейные услуги;
5) меры возвращения на рынок труда и предпринимательской активности.

Особенность Казахстана состоит в том, что большая часть этих инструментов формально адресована не самой «домохозяйке», а семье, ребенку, родителю либо малообеспеченному домохозяйству.

2. Хронология формирования государственной поддержки

Эволюцию государственной поддержки женщин-домохозяек и семей с детьми в Казахстане целесообразно представить в хронологическом порядке.

Таблица 1. Основные этапы развития государственной поддержки женщин-домохозяек в Казахстан

Период	Основной инструмент	Содержание поддержки	Значение для женщин-домохозяек
2001	Адресная социальная помощь	Поддержка семей с низкими доходами	Формирование механизма помощи малообеспеченным домохозяйствам
2005	Закон о государственных пособиях семьям, имеющим детей	Пособия при рождении, по уходу, многодетным семьям и отдельным категориям родителей	Формирование системной поддержки материнства и детства
2009	Закон о государственных гарантиях равных прав и возможностей мужчин и женщин	Правовая основа гендерного равенства	Расширение институциональной основы защиты экономических и социальных прав женщин
2010-е	Развитие социального страхования и пособий	Выплаты в связи с беременностью, родами и уходом за ребенком	Связь социальной защиты с предыдущей экономической активностью женщины
2016	Концепция семейной и гендерной политики до 2030 г.	Комплексная семейная и гендерная политика	Переход к системному подходу к поддержке семьи
2019	Реформирование АСП	Усиление адресности и связи помощи с занятостью	Поддержка малообеспеченных семей и стимулирование трудовой активности
2020	Государственное пособие многодетным семьям	Ежемесячная поддержка семей с четырьмя и более детьми	Увеличение поддержки многодетных домохозяйств
2022	Цифровая карта семьи; новая редакция Концепции	Проактивное назначение ряда мер социальной поддержки	Снижение административных барьеров
2023	Социальный кодекс	Объединение основных норм социальной защиты	Систематизация пособий и социальных выплат
2024	Центры поддержки семьи	Комплексная социальная, психологическая, юридическая и трудовая помощь	Переход от отдельных выплат к комплексному сопровождению семьи
2025–2026	Новые подходы АСП, развитие ЦПС и цифровых инструментов	Адресность, социальный контракт, межведомственное сопровождение	Усиление индивидуализации социальной поддержки

Первой важной основой стала система адресной социальной помощи, законодательно закрепленная в 2001 году. Ее принципиальное значение заключается в том, что поддержка стала связываться с материальным положением конкретного домохозяйства.

Следующим этапом стало принятие в 2005 году Закона «О государственных пособиях семьям, имеющим детей». Закон закрепил пособие при рождении ребенка, пособие по уходу, поддержку многодетных семей и ряд других выплат.

В 2009 году был принят Закон «О государственных гарантиях равных прав и равных возможностей мужчин и женщин», который сформировал правовую основу государственной гендерной политики.

Качественно новый этап начался с утверждением в 2016 году Концепции семейной и гендерной политики до 2030 года. В документе закреплены направления по повышению адресности социальной помощи семьям, развитию социальных услуг, укреплению семейных отношений и расширению экономических возможностей женщин. В 2022 году Концепция была изложена в новой редакции.

В 2023 году вступил в действие Социальный кодекс Республики Казахстан, систематизировавший основные виды государственных пособий и социальных выплат. В частности, в нем закреплены пособие при рождении ребенка, пособие по уходу за ребенком до полутора лет, социальная выплата в связи с потерей дохода при уходе за ребенком и механизм бюджетного субсидирования обязательных пенсионных взносов получателям соответствующей социальной выплаты.

3. Современная система инструментов государственной поддержки

Современная система поддержки женщин-домохозяек в Казахстане имеет многоуровневый характер.

3.1. Пособие при рождении ребенка

Пособие при рождении относится к универсальным инструментам и не зависит от того, осуществляла ли женщина трудовую деятельность до рождения ребенка.

В 2024 году размер пособия составлял 140 296 тенге на первого, второго и третьего ребенка и 232 596 тенге на четвертого и последующих детей. В 2025 году после индексации соответствующие суммы составили 149 416 и 247 716 тенге.

В 2024 году пособие при рождении ребенка получили 378,1 тыс. человек, а объем выплат составил 64 млрд тенге.

Данный инструмент имеет высокую степень охвата, однако является единовременным и потому не способен компенсировать длительное выпадение женщины из рынка труда.

3.2. Пособие по уходу за ребенком для неработающих родителей

Для неработающих родителей предусмотрено ежемесячное государственное пособие по уходу за ребенком до достижения им возраста полутора лет.

В 2024 году размеры выплаты составляли от 21 266 тенге на первого ребенка до 32 859 тенге на четвертого и последующего ребенка. Пособие получили 126,3 тыс. человек, а общий объем выплат составил 41,6 млрд тенге.

С одной стороны, данный инструмент непосредственно ориентирован на компенсацию части расходов периода ухода за ребенком. С другой стороны, его размер остается относительно небольшим по сравнению с расходами домохозяйства, особенно в условиях городской экономики.

3.3. Социальная выплата для участников системы обязательного социального страхования

Для женщин, которые до рождения ребенка работали и являлись участниками системы обязательного социального страхования, действует более значимый механизм компенсации потери дохода.

Социальная выплата по уходу за ребенком до полутора лет рассчитывается в размере 40% среднемесячного дохода, с которого производились социальные отчисления за последние два года.

В 2024 году такая выплата была назначена 276,8 тыс. человек, ее средний размер составил 86 758 тенге в месяц, а общий объем выплат достиг 404,1 млрд тенге.

Таким образом, государственная система содержит существенное различие между двумя группами женщин:

неработающая женщина получает фиксированное пособие;

работавшая и застрахованная женщина получает выплату, связанную с предыдущим доходом.

Это различие является одним из ключевых факторов оценки достаточности поддержки.

4. Поддержка многодетных и малообеспеченных домохозяйств

Отдельным направлением является поддержка многодетных семей.

Социальный кодекс предусматривает ежемесячное пособие многодетным семьям, имеющим четырех и более совместно проживающих несовершеннолетних детей. Размер пособия зависит от количества детей и устанавливается в МРП.

Таким образом, женщина, полностью занятая домашним хозяйством и воспитывающая нескольких детей, может получать государственную поддержку через статус многодетной семьи.

Однако данный механизм имеет существенное ограничение: **он компенсирует наличие детей, а не сам факт неоплачиваемого домашнего труда женщины**.

Другим инструментом является адресная социальная помощь.

В 2024 году АСП была назначена 413,7 тыс. человек из 78,1 тыс. семей, общий объем финансирования составил 39,5 млрд тенге. При этом 50,9 тыс. семей, получавших АСП в 2024 году, впоследствии вышли из состояния бедности.

АСП является важным инструментом борьбы с бедностью, однако она не является универсальной выплатой домохозяйкам: право зависит от дохода семьи и других установленных условий.

С 2025 года механизм АСП развивается в сторону социального контракта и сочетания денежных выплат с активными мерами занятости.

5. Цифровизация государственной поддержки

Значительным институциональным изменением стало создание **Цифровой карты семьи**.

Система предназначена для определения права граждан на различные виды государственной поддержки на основе информации из государственных информационных систем. Первоначально через нее предусматривалось проактивное предоставление девяти видов пособий и социальных выплат, включая выплаты по беременности и родам, уходу за ребенком, пособие многодетным семьям и АСП.

Данный механизм является существенным достижением с точки зрения доступности поддержки, поскольку сокращает необходимость самостоятельного поиска информации о государственных программах.

Однако цифровизация не решает проблему **достаточности размера помощи**. Она улучшает доступ к уже существующим инструментам, но сама по себе не увеличивает объем материальной компенсации неоплачиваемого труда.

6. Центры поддержки семьи как новый инструмент

В 2024 году был принят специальный нормативный акт, регулирующий деятельность Центров поддержки семьи. Они ориентированы на комплексное сопровождение семей, находящихся в трудной жизненной ситуации.

Центры предоставляют социальную, психологическую, юридическую и информационную помощь, содействуют трудоустройству и взаимодействуют с другими государственными структурами.

По официальным данным, к концу 2024 года в Казахстане действовало 65 Центров поддержки семьи. Специалисты центров провели более 400 тыс. консультаций; на 2025–2027 годы планировалось расширение сети до 208 центров.

Важное значение имеет то, что Центры позволяют перейти от простой выплаты пособия к **индивидуальному сопровождению семьи**.

При этом результативность данной модели зависит от территориальной доступности центров, квалификации специалистов и способности обеспечить реальное решение проблемы, а не только консультирование.

7. Содействие занятости женщин

Современная политика государства постепенно смещается от пассивной денежной поддержки к активным мерам занятости.

В настоящее время карьерные центры предоставляют содействие в трудоустройстве, профессиональном обучении, предпринимательстве и получении грантов. Среди инструментов — проект «Бастау Бизнес», гранты социально уязвимым группам до 400 МРП, субсидирование рабочих мест и краткосрочное профессиональное обучение.

В 2024 году в активные меры содействия занятости были вовлечены 325 тыс. граждан, из которых 67,5 тыс. прошли краткосрочное профессиональное обучение.

Для женщин-домохозяек данные меры имеют принципиальное значение, поскольку позволяют компенсировать один из основных долгосрочных рисков — потерю связи с рынком труда.

Однако возникает определенное противоречие: политика одновременно признает необходимость поддержки семьи и стремится вернуть женщину в оплачиваемую занятость. Поэтому развитие занятости не должно означать снижение социальной ценности неоплачиваемой работы по уходу.

8. Оценка достаточности государственной поддержки

Для оценки достаточности государственной поддержки целесообразно использовать четыре критерия:

1. охват;
2. размер материальной поддержки;
3. продолжительность поддержки;
4. способность компенсировать долгосрочные социально-экономические риски.

Таблица 2. Оценка основных инструментов поддержки женщин-домохозяек

Инструмент	Охват	Материальная достаточность	Продолжительность	Основная проблема
Пособие при рождении	Высокий	Низкая/средняя	Однократно	Не компенсирует длительный уход
Пособие по уходу для неработающих	Средний	Ограниченная	До 1,5 лет	Низкий фиксированный размер
Социальная выплата из ГФСС	Средний/высокий среди застрахованных	Выше	До 1,5 лет	Зависимость от предыдущего дохода
Пособие многодетным семьям	Целевой	Средняя	Продолжительная. при соблюдении условий	Ориентировано на число детей, а не домашний. труд
АСП	Целевой	Адресная	Условная	Зависимость от дохода и условий социального контракта
Цифровая карта семьи	Потенциально высокий	Не увеличивает размер выплат	Постоянный механизм	Цифровой доступ не равен материальной достаточности
Центры поддержки семьи	Расширяющийся	Неденежная	По потребности	Региональная неоднородность
Обучение и. гранты	Целевой	Потенциально. высокий	Ограниченный период	Требует возможности. выйти из домашней занятости
Пенсионные механизмы	Ограниченный	Долгосрочный эффект	Долгосрочный	Не полностью компенсируют длительное отсутствие занятости

9. Динамика государственной поддержки

Количественная динамика показывает существенное увеличение государственных расходов на поддержку семей с детьми.

В 2024 году на пособия и социальные выплаты по рождению и уходу за ребенком было направлено **895,3 млрд тенге**, выплаты получили 648,8 тыс. человек. При этом непосредственно социальная выплата по уходу из ГФСС составила 404,1 млрд тенге.

В 2025 году по итогам года государственными пособиями и выплатами из ГФСС на рождение и уход за ребенком было охвачено 565,7 тыс. человек, а общий объем выплат составил 806,8 млрд тенге.

Само увеличение государственных расходов не означает автоматически повышение достаточности поддержки. Для научной оценки необходимо учитывать одновременно изменение численности получателей, уровень инфляции, стоимость содержания ребенка и реальные доходы домохозяйств.

В этом отношении показательно, что в 2024 году средняя социальная выплата по уходу за ребенком для участников ГФСС составляла 86 758 тенге в месяц, тогда как фиксированное пособие по уходу для неработающих родителей составляло от 21 266 до 32 859 тенге в зависимости от очередности ребенка.

Следовательно, система предоставляет значительно более высокий уровень денежной компенсации женщинам, имевшим предшествующую официальную занятость и социальные отчисления.

10. Основные проблемы государственной поддержки женщин-домохозяек

10.1. Отсутствие самостоятельного статуса женщины-домохозяйки в системе социальной защиты

Главной системной проблемой является отсутствие универсального механизма, непосредственно признающего **неоплачиваемый домашний труд самостоятельной социально значимой деятельностью**.

Женщина получает поддержку преимущественно потому, что она:

- имеет ребенка;
- является многодетной матерью;
- имеет низкий доход;
- участвовала в системе социального страхования;
- находится в трудной жизненной ситуации;
- нуждается в услугах занятости.

Следовательно, государство поддерживает **последствия домашней занятости**, но не сам факт выполнения длительного неоплачиваемого домашнего труда.

10.2. Неравенство между застрахованными и незастрахованными женщинами

Разница между фиксированным пособием для неработающих и социальной выплатой из ГФСС является одним из наиболее существенных элементов системы.

Женщина, которая до рождения ребенка имела официальную работу и социальные отчисления, получает выплату, рассчитываемую исходя из ее предыдущего дохода.

Женщина, которая длительное время занималась исключительно домашним хозяйством и не участвовала в системе социального страхования, не имеет аналогичной доходозамещающей выплаты.

Таким образом, система лучше защищает **кратковременный выход из занятости**, чем **длительное пребывание женщины в домашнем хозяйстве**.

10.3. Ограниченная продолжительность компенсации

Поддержка по уходу за ребенком ограничена возрастом ребенка до полутора лет.

После окончания периода выплаты женщина может продолжать осуществлять интенсивный уход за ребенком, однако отдельная универсальная компенсация за продолжение домашней деятельности отсутствует.

Это особенно важно для семей, где нет возможности обеспечить доступный уход за ребенком либо где ребенок требует повышенного объема ухода.

10.4. Пенсионные последствия

Продолжительный период нахождения вне рынка труда способен уменьшать будущие пенсионные права женщины.

В Казахстане существует механизм бюджетного субсидирования обязательных пенсионных взносов получателям социальной выплаты по уходу за ребенком из ГФСС.

Однако этот механизм связан именно с получением соответствующей социальной выплаты и поэтому не является универсальным механизмом пенсионного признания всего периода неоплачиваемого домашнего труда.

Таким образом, пенсионная защита женщины, длительное время находящейся исключительно в домашнем хозяйстве, остается менее полной, чем защита работника, осуществляющего регулярные социальные отчисления.

10.5. Региональная неоднородность

Формально основные пособия являются национальными, однако доступ к социальным услугам, занятости, детской инфраструктуре и Центрам поддержки семьи зависит от региона.

Концепция семейной и гендерной политики прямо указывает на наличие материальных, жилищно-бытовых и трудовых проблем в сельских семьях, причем интенсивность этих проблем существенно различается между регионами.

Следовательно, одинаковый номинальный размер денежной выплаты не означает одинаковый уровень социальной поддержки в разных регионах.

11. Научная оценка достаточности системы

На основании проведенного анализа государственную поддержку женщин-домохозяек в Казахстане целесообразно оценивать как **частично достаточную, но недостаточно специализированную**.

С одной стороны, за последние два десятилетия сформирован широкий комплекс механизмов:

- пособия при рождении;
- выплаты по уходу за ребенком;
- социальное страхование;
- пособия многодетным семьям;
- АСП;
- пенсионные субсидии;
- цифровое проактивное назначение;
- центры поддержки семьи;
- профессиональное обучение;
- гранты и предпринимательская поддержка.

По сравнению с началом 2000-х годов система стала существенно более комплексной.

С другой стороны, ни один из перечисленных механизмов не решает полностью проблему **экономической компенсации длительного неоплачиваемого домашнего труда**.

Следовательно, количественное расширение государственных расходов не тождественно полному решению проблемы социальной защищенности домохозяек.

12. Предложения по совершенствованию государственной политики

Для повышения эффективности государственной поддержки женщин-домохозяек целесообразно рассмотреть следующие направления.

Первое. Ввести в официальную статистику регулярный показатель экономической стоимости и времени неоплачиваемого домашнего труда женщин. Это позволит количественно оценить вклад домохозяек в воспроизводство человеческого капитала.

Второе. Развивать механизмы пенсионной защиты женщин, длительное время находящихся вне рынка труда по причине ухода за детьми или другими зависимыми членами семьи.

Третье. Рассмотреть возможность расширения периода социальной защиты после достижения ребенком возраста полутора лет для семей, находящихся в объективно сложной жизненной ситуации.

Четвертое. Усилить связь между денежными выплатами и доступностью услуг — детских садов, групп продленного дня, социальных работников, услуг дневного пребывания и других форм поддержки ухода.

Пятое. Развивать Центры поддержки семьи как механизм «одного окна», объединяющий социальную помощь, занятость, юридическую помощь, психологическую поддержку и предпринимательские программы.

Шестое. Разработать региональные индикаторы эффективности государственной поддержки женщин-домохозяек: доля женщин, вернувшихся к занятости по желанию; доля женщин, получивших профессиональное обучение; изменение дохода семьи; охват социальными услугами; изменение пенсионных прав.

Седьмое. Развивать политику равного распределения домашнего труда между женщинами и мужчинами. Такой подход соответствует действующей Концепции семейной и гендерной политики, которая предусматривает равную ответственность обоих родителей за воспитание детей и ведение домашнего хозяйства.

Заключение

Исследование эволюции государственной поддержки женщин-домохозяек в Казахстане показывает, что за период с начала 2000-х годов произошел переход от отдельных денежных пособий к многоуровневой системе социальной защиты семьи.

Важными этапами стали принятие Закона об адресной социальной помощи в 2001 году, формирование системы пособий семьям с детьми в 2005 году, законодательное закрепление гендерных гарантий в 2009 году, утверждение Концепции семейной и гендерной политики в 2016 году, развитие адресной помощи и цифровизации, принятие Социального кодекса в 2023 году и создание современной системы Центров поддержки семьи в 2024 году.

В количественном выражении государственная поддержка семей с детьми имеет значительный масштаб. В 2024 году объем пособий и социальных выплат на рождение и уход за ребенком составил 895,3 млрд тенге, а в 2025 году — 806,8 млрд тенге.

Однако проведенный анализ позволяет сделать принципиальный вывод: **система государственной поддержки в Казахстане является развитой по количеству инструментов, но не полностью достаточной с точки зрения долгосрочной социальной защиты женщины, которая выбирает или вынуждена длительное время заниматься исключительно домашним хозяйством.**

Основная проблема заключается в том, что государственная политика преимущественно поддерживает семью, ребенка, малообеспеченного гражданина или участника системы социального страхования, но не выделяет неоплачиваемый домашний труд женщины как самостоятельный объект социальной компенсации.

Особенно существенным является различие между женщинами, ранее имевшими официальную занятость и социальные отчисления, и женщинами, которые длительное время находятся исключительно в домашнем хозяйстве. Первые получают доходозамещающую социальную выплату, рассчитываемую исходя из предшествующего дохода, тогда как вторые в основном могут рассчитывать на фиксированные пособия, связанные с ребенком, количеством детей или доходом семьи.

Следовательно, современная модель государственной поддержки может быть охарактеризована как **семейно-ориентированная, адресная и страховая**, но недостаточно как **компенсационная по отношению к неоплачиваемому домашнему труду**.

Перспективным направлением дальнейшего развития государственной политики является переход от оценки исключительно денежных трансфертов к комплексной оценке социального вклада женщины-домохозяйки. Такая система должна включать пенсионную защиту, доступные услуги ухода, профессиональную реинтеграцию, социальные услуги,

цифровое сопровождение и более совершенный статистический учет неоплачиваемого труда.

Таким образом, государственная поддержка женщин-домохозяек в Республике Казахстан в динамике стала значительно более комплексной, однако ее **достаточность следует оценивать как частичную**. Основной резерв совершенствования заключается не столько в увеличении количества отдельных пособий, сколько в формировании целостной системы социальной защиты женщины на протяжении всего периода ее жизненного цикла — от рождения ребенка и периода ухода до возвращения на рынок труда и формирования достаточных пенсионных прав.

Список литературы

1. Республика Казахстан. **О государственной адресной социальной помощи**: Закон Республики Казахстан от 17 июля 2001 года № 246. Информационно-правовая система «Әділет».
2. Республика Казахстан. **О государственных пособиях семьям, имеющим детей**: Закон Республики Казахстан от 28 июня 2005 года № 63. Информационно-правовая система «Әділет».
3. Республика Казахстан. **О государственных гарантиях равных прав и равных возможностей мужчин и женщин**: Закон Республики Казахстан от 8 декабря 2009 года № 223-IV.
4. Республика Казахстан. **Об утверждении Концепции семейной и гендерной политики в Республике Казахстан до 2030 года**: Указ Президента Республики Казахстан от 6 декабря 2016 года № 384.
5. Республика Казахстан. **О внесении изменения в Указ Президента Республики Казахстан от 6 декабря 2016 года № 384**: Указ Президента Республики Казахстан от 1 апреля 2022 года № 853.
6. Республика Казахстан. **Социальный кодекс Республики Казахстан**: Кодекс Республики Казахстан от 20 апреля 2023 года № 224-VII ЗРК.
7. Республика Казахстан. **Об утверждении Правил осуществления деятельности Центров поддержки семьи**: приказ Министра культуры и информации Республики Казахстан от 14 июня 2024 года № 256-НҚ.
8. Бюро национальной статистики Агентства по стратегическому планированию и реформам Республики Казахстан. **Женщины и мужчины Казахстана**. Астана.
9. Министерство труда и социальной защиты населения Республики Казахстан. **Более 895 млрд тенге выплачено в 2024 году казахстанцам в виде пособий и выплат на рождение и по уходу за ребенком**. 2025.
10. Министерство труда и социальной защиты населения Республики Казахстан. **Более 806 млрд тенге выплачено казахстанцам в виде пособий и выплат на рождение и по уходу за ребенком в 2025 году**. 2026.
11. Министерство труда и социальной защиты населения Республики Казахстан. **Более 413 тыс. человек оказана адресная социальная помощь в 2024 году**.
12. Министерство труда и социальной защиты населения Республики Казахстан. **Занятость населения: активные меры содействия занятости**.
13. Министерство культуры и информации Республики Казахстан. **Итоги работы Центров поддержки семьи за 2024 год**.
14. Республика Казахстан. **Об утверждении Правил субсидирования обязательных пенсионных взносов получателям социальных выплат по случаю потери дохода в связи с уходом за ребенком**. Информационно-правовая система «Әділет».

15. Министерство труда и социальной защиты населения Республики Казахстан. Цифровая карта семьи.

Scientific Communication in Disaster Risk Management: Bridging Scientific Knowledge and Public Decision-Making

Abdirakhman Ayaulym Mukhitkyzy
University of Eastern Piedmont (UPO), Department for Sustainable Development and Ecological Transition (DISSTE). Degree Programme: Disaster and Health Crisis Management (LM-81)

1. Abstract and Keywords

Contemporary disaster risk management rests on an assumption that is rarely interrogated: that scientific knowledge about hazards, once produced, will travel intact from laboratories and monitoring networks to policymakers, journalists, and ultimately to publics who will act upon it. The Sendai Framework for Disaster Risk Reduction 2015–2030 formalises this expectation by placing the understanding of risk, and the availability of risk information and early warning to people, at the centre of its priorities and targets. Yet recent catastrophes demonstrate that the translation of scientific knowledge into collective decision-making is a contested, institutionally mediated, and frequently failing process. This paper examines that process as a chain of four interdependent actors—scientists who produce hazard and risk data, institutions that formulate policy and issue authoritative messages, journalists and platforms that mediate information, and publics who interpret it and decide how to respond—and asks where, why, and under what institutional conditions the chain breaks.

Drawing on Beck's (1992) theory of the risk society, the Social Amplification of Risk Framework (Kasperson et al., 1988), and the science–policy interface literature, the study conducts a structured qualitative comparison of two emerging-economy cases against international benchmarks. The first case concerns Turkey and the communication dynamics surrounding the February 2023 Kahramanmaraş earthquake sequence, including the relationship between the Disaster and Emergency Management Presidency (AFAD) and independent seismological voices. The second concerns Kazakhstan, where the 2024 spring floods and recurrent industrial hazards are analysed through the roles of the Ministry of Emergency Situations, hydrometeorological and scientific actors, and the strategic analysis of the Kazakhstan Institute for Strategic Studies (KazISS). Japan's Meteorological Agency, the United States' Federal Emergency Management Agency (FEMA), and European arrangements serve as comparative benchmarks. The evidentiary basis comprises document analysis of institutional reports and frameworks (KazISS, AFAD, UNDRR, FEMA) and a media framing analysis.

The paper advances three propositions. First, communication effectiveness depends less on rhetorical skill exercised during a crisis than on institutional architecture established beforehand: standing protocols, pre-negotiated language for uncertainty, and clearly designated, plural channels of authoritative voice. Second, centralised control over hazard communication purchases short-term coherence at the price of long-term credibility, particularly where independent experts and official bodies diverge in public. Third, digital platforms do not create communication gaps so much as accelerate and monetise them, converting information vacuums into amplified misinformation wherever institutional trust is low.

The analysis yields four contributions: a synthesis of theoretical models of crisis communication; a comparative matrix of institutional risk communication in Turkey and Kazakhstan; a typology of scientific miscommunication across the two cases; and a proposed protocol for integrating

scientific data into public policy in emerging economies, together with recommendations for DISSTE–UPO standards. The paper concludes that bridging the divide between scientific knowledge and public decision-making is best understood not as a problem of simplifying messages for deficient audiences, but as a problem of designing trustworthy institutions.
Keywords: scientific communication; disaster risk management; risk communication; science–policy interface; social amplification of risk; early warning; Turkey; Kazakhstan; Sendai Framework; misinformation

2. Introduction

2.1 Background: The Communication Problem at the Heart of Disaster Risk Governance

Disasters are seldom "natural" in any sociologically meaningful sense. Earthquakes, floods, and industrial accidents become catastrophes through the interaction of physical hazards with patterns of exposure, vulnerability, and institutional capacity that are socially produced (Tierney, 2014; Wisner et al., 2004). Scientific knowledge occupies a distinctive position within that interaction. Seismologists, hydrologists, structural engineers, and epidemiologists generate the probabilistic estimates upon which building codes, land-use plans, evacuation procedures, and insurance schemes depend; yet knowledge about a hazard reduces risk only when it is taken up by actors who possess the authority, the resources, or the personal stake to act on it. Between the production of knowledge and its consequential use lies a space of translation. That space, crowded with bureaucracies, media systems, cognitive heuristics, and political interests, is the object of the present inquiry.

International disaster policy has increasingly acknowledged this space. The Sendai Framework for Disaster Risk Reduction 2015–2030 (United Nations Office for Disaster Risk Reduction [UNDRR], 2015), adopted at the Third UN World Conference on Disaster Risk Reduction, names "understanding disaster risk" as its first priority and calls for closer engagement between scientific communities and policymakers. Its Target G commits states to substantially increase, by 2030, the availability of and access to multi-hazard early warning systems and disaster risk information and assessments. The Early Warnings for All initiative, announced by the United Nations Secretary-General in 2022, extends the ambition by seeking universal early-warning coverage by the end of 2027, and the Midterm Review of the Sendai Framework concluded in 2023 invited states to take stock of implementation. These commitments rest on an implicit communication model in which knowledge flows linearly from producers to users. The empirical record complicates that model considerably.

The most instructive European illustration is the L'Aquila earthquake of 6 April 2009, which killed 309 people. In the weeks before the mainshock, a seismic swarm had unsettled residents; on 31 March 2009, Italy's National Commission for the Forecast and Prevention of Major Risks met in the city, and the public messaging that followed was widely perceived as reassuring. Seven defendants, including scientists and a civil-protection official, were convicted of manslaughter at first instance in 2012. The proceedings attracted worldwide attention (Hall, 2011) and, crucially, turned not on any failure to predict the earthquake—an impossibility with present scientific knowledge—but on the quality of risk communication (Alexander, 2014). The scientists' convictions were overturned on appeal in 2014, with the sole remaining conviction concerning the civil-protection official. L'Aquila thus demonstrates that scientific communication is not a peripheral courtesy attached to risk assessment: it is itself a consequential act, capable of shaping behaviour, attributing responsibility, and exposing institutions to legal and political jeopardy. It also prompted Italian institutional reflection on how probabilistic forecasting information should be communicated, notably through the international commission on operational earthquake forecasting (Jordan et al., 2011).

Turkey in 2023 supplies a second, far larger, test. On 6 February 2023, two earthquakes of moment magnitude 7.8 and 7.5, separated by roughly nine hours, struck south-eastern Turkey and

northern Syria, affecting eleven Turkish provinces. More than 50,000 people died in Turkey and thousands more in Syria; millions were displaced. It was the deadliest earthquake in the history of the Turkish Republic. The East Anatolian Fault Zone had long been recognised in the seismological literature as capable of generating large earthquakes, and Turkey's national seismic hazard map had been updated in 2018. Hazard knowledge, in other words, existed. What the disaster exposed was not an absence of science but the fragility of the chain connecting science to construction practice, land-use enforcement, preparedness, and public expectation. In the days and weeks that followed, questions concerning the speed and adequacy of the state response, the relationship between official and independent scientific voices, the temporary restriction of access to a major social-media platform, and the legal environment surrounding "disinformation" became inseparable from the public meaning of the disaster itself.

Kazakhstan presents a different hazard profile and a structurally comparable communication challenge. In spring 2024, rapid snowmelt over frozen ground produced what officials described as the most severe flooding in roughly eight decades across parts of the country's western, northern, and central regions, and more than 100,000 people were evacuated. The episode tested the Ministry of Emergency Situations, the national hydrometeorological service, regional administrations, and a population whose expectations of official information had been shaped by earlier episodes: the 2019 explosions at the Arys ammunition depot, which triggered a mass evacuation; the 2020 failure of the Sardoba reservoir dam in neighbouring Uzbekistan, which inundated districts of Turkestan Region; and the October 2023 fire at the Kostenko mine in Karaganda Region, which killed 46 miners. The last of these is an industrial rather than a natural hazard, and its inclusion is deliberate: scientific and technical communication problems are not confined to geophysical events but extend to the technological and climate-intensified risks that Beck (1992) placed at the centre of late modernity. In each episode, questions of timeliness, transparency, and accountability were at stake.

Read together, these episodes suggest that communication failures in disaster contexts are rarely reducible to a single actor's error. They arise at interfaces: between scientists and the institutions that must speak authoritatively; between institutions and the media systems that carry their messages; and between mediated messages and publics whose responses are conditioned by prior experience, trust, and cognitive constraint. Understanding where and why translation breaks down therefore requires an analytical framework capable of spanning all of these interfaces.

2.2 Conceptual Positioning: Communication as a Constitutive Element of Risk Governance

A conceptual clarification is necessary at the outset. This paper uses "scientific communication in disaster risk management" to denote the full set of practices through which hazard and risk knowledge produced by scientific communities is rendered intelligible, authoritative, and actionable for non-specialist decision-makers and publics before, during, and after disasters. The term accordingly encompasses risk communication in the narrow sense (the pre-event exchange of information about hazards and vulnerabilities), crisis and emergency communication (event-time warning and instruction; see Reynolds & Seeger, 2005), and post-event communication concerning causes, accountability, and recovery. It is deliberately broader than "public information" or "outreach," terms that imply a one-way transfer from expert to layperson.

The one-way assumption has been under challenge for more than three decades. The so-called deficit model, which attributes public non-compliance to a lack of scientific understanding, was subjected to sustained critique by scholars who showed that publics evaluate expert claims in light of their experience of the institutions that deliver them (Irwin & Wynne, 1996; Wynne, 1992). Fischhoff (1995) characterised the evolution of risk communication as a sequence of overly optimistic slogans, beginning with the conviction that it sufficed to get the numbers right and culminating in the recognition that publics must be treated as partners. The implication for disaster contexts is that failures of uptake cannot be diagnosed solely by examining the message;

the source, the channel, and the relationship between sender and receiver must be examined together.

Beck's (1992) risk society thesis supplies the macro-sociological backdrop. In late modernity, Beck argued, the central problem of society shifts from the distribution of goods to the distribution of "bads": risks generated by modernisation itself, which are frequently invisible, dependent on scientific definition, and potentially global in reach. Because laypersons cannot perceive such risks without scientific mediation, science becomes simultaneously the source of risk definitions and a target of public suspicion; the authority of expert systems is at once indispensable and eroded. Beck's later notion of "organised irresponsibility" (Beck, 1999) captures a related institutional pathology, in which formal structures of governance diffuse accountability for risks that no actor clearly owns. A critical qualification is required for the present study. Earthquakes are external hazards rather than manufactured risks in Beck's strict sense; however, the risk they pose is manufactured through building practice, land-use decisions, and regulatory enforcement, whereas industrial accidents and climate-intensified hydrological extremes are manufactured risks in the fuller sense. The risk society framework is therefore applied here at the level of vulnerability and governance rather than of hazard alone.

The Social Amplification of Risk Framework (SARF) complements Beck by providing a meso-level account of how risk signals are transformed in transit. Kasperson et al. (1988) proposed that risk events interact with psychological, social, institutional, and cultural processes in ways that can intensify or attenuate public perceptions, with "amplification stations"—scientists, news media, government agencies, cultural groups, and interpersonal networks—reshaping signals and generating secondary effects such as stigma, regulatory change, and economic loss (see also Pidgeon et al., 2003). At the individual level, research on judgement under uncertainty shows that people rely extensively on heuristic processing, including availability and affect, particularly under time pressure (Slovic, 1987; Slovic et al., 2004; Tversky & Kahneman, 1974). The probabilistic outputs of science are poorly suited to such processing, which favours vivid, concrete, and emotionally resonant signals over abstract conditional estimates.

These insights converge on what this paper terms the epistemological divide. Scientific knowledge is probabilistic, conditional, and open to revision, and its epistemic virtue lies precisely in the explicit articulation of uncertainty. Emergency decision-making, by contrast, demands binary, immediate, and authoritative instruction: evacuate or remain, expect aftershocks or not. Funtowicz and Ravetz (1993) described as "post-normal" those conditions in which facts are uncertain, values are in dispute, stakes are high, and decisions are urgent, and in which the conventional boundaries of expert authority consequently dissolve. Disasters are paradigmatic post-normal situations. The task of scientific communication is thus not merely to simplify but to mediate between incommensurable epistemic cultures without sacrificing either accuracy or actionability.

The science–policy interface literature offers the vocabulary for analysing this mediation. Jasanoff (1990) showed that scientific advice to government is a socially negotiated activity in which the boundaries between science and policy are continually drawn and redrawn; Gieryn (1983) termed such activity boundary-work. Pielke (2007) distinguished the roles scientists may adopt in policy settings—pure scientist, science arbiter, issue advocate, and honest broker of policy alternatives—while Guston (2001) analysed boundary organisations as institutions that stabilise the interface through accountability to both worlds. Cash et al. (2003) proposed that the effectiveness of knowledge systems depends on three attributes: credibility, salience, and legitimacy. Jasanoff's (2005) concept of civic epistemologies, the culturally specific ways in which political communities test and deploy public knowledge, supplies the principal justification for comparing countries with different political and media systems rather than assuming a universal model of effective communication.

On this foundation, the paper conceptualises scientific communication in disaster risk management as a chain of four actors and three interfaces: scientists and institutions (the science–policy interface); institutions and journalists or platforms (the institution–media interface); and mediated messages and publics (the media–public interface). Each actor possesses distinct epistemic norms, incentives, and temporal rhythms, and each interface offers opportunities for distortion, delay, or discrediting. The digital environment adds a further complication. Vosoughi et al. (2018) found that false news diffused farther and faster than true news on Twitter, an asymmetry that is especially consequential when an information vacuum opens after a disaster.

2.3 Research Gap

Three gaps motivate the study. The first is geographical and contextual. The dominant empirical base of disaster risk communication scholarship consists of studies from the United States, Western Europe, Japan, and Australasia: political systems with comparatively strong media independence, long-established civil-protection bureaucracies, and dense academic–institutional networks. Considerably less is known about how the same communication challenges unfold in emerging economies characterised by centralised executive authority, evolving media freedoms, and contested institutional trust. Turkey and Kazakhstan are representative of this group. To the author's knowledge, Turkey has been a frequent subject of earthquake science but far less frequently of comparative communication research, and Kazakhstan remains largely absent from English-language literature on disaster risk communication. Moreover, the analytical outputs of state-affiliated policy institutes such as KazISS, which articulate how strategic analysts close to the Presidency conceptualise public trust and institutional capacity, are rarely treated as primary objects of scholarly analysis.

The second gap is disciplinary fragmentation. Risk perception research, psychometric and heuristic, tends to examine individuals; science and technology studies examine the science–policy interface; journalism and media studies examine framing and platform dynamics; and disaster sociology examines organisational response. Each illuminates part of the chain, yet few studies follow a single event across all of its interfaces. This paper attempts an integrative analysis in which the same events are examined at the scientist–institution, institution–media, and media–public interfaces.

The third gap is temporal. Practitioner literature frequently treats communication as an event-time activity, concentrating on warning messages and press briefings. The logic of the Sendai Framework, however, requires continuous translation across the entire risk cycle: hazard maps, building codes, public education, and the slow accumulation of trust. The credibility an institution possesses at the moment of crisis is the cumulative product of earlier communicative conduct (Cash et al., 2003). Finally, because the 2023 and 2024 events are recent, scholarship on them is still emerging and official evaluations are incomplete. The paper accordingly offers an early comparative synthesis while acknowledging that interpretations will mature as inquiries, audits, and post-event assessments are completed.

2.4 Research Questions and Analytical Propositions

The study is organised around four research questions.

RQ1. How do the institutional architectures through which hazard knowledge is translated into public communication differ between Turkey, Kazakhstan, and the benchmark systems of Japan, the United States, and the European Union?

RQ2. What forms of scientific miscommunication emerged during the 2023 Turkish earthquakes and the 2024 Kazakh floods, and at which interface of the communication chain did they originate?

RQ3. How do institutional trust, media freedom, and digital-platform dynamics condition the speed of scientific translation and the level of public compliance with official guidance?

RQ4. What protocol could systematically integrate scientific data into public policy and public communication in emerging economies, and what standards might a programme such as DISSTE's derive from it?

Corresponding to these questions, the paper advances three analytical propositions. Because the research design is qualitative and the number of cases small, these are propositions to be examined through analytic comparison rather than statistical hypotheses to be tested.

P1 (Architecture over rhetoric). The effectiveness of scientific communication in a disaster depends more on institutional arrangements established before the event—standing protocols, pre-negotiated language for conveying uncertainty, designated and plural channels of authoritative voice, and routine relationships between scientists and journalists—than on the rhetorical quality of crisis-time messaging.

P2 (Coherence–credibility trade-off). Where a state agency holds a monopoly over authoritative hazard communication, message coherence is gained in the short term at the cost of long-term credibility, particularly when independent scientists publicly supplement or contradict the official account.

P3 (Platform conditionality). Digital platforms amplify rather than originate communication gaps, and the degree of amplification is conditional on the pre-existing level of institutional trust and on the speed with which authoritative sources fill the information vacuum.

The propositions interact in a tension that the analysis will pursue throughout: the consistency–pluralism dilemma. Mileti and Sorensen (1990) established that warnings are most likely to be believed and acted upon when messages from different sources are consistent, whereas contradictory messages produce confusion and delay. Yet science is intrinsically plural, and the epistemic legitimacy of an institutional message depends on its openness to expert scrutiny. An architecture that suppresses plural expert voices to secure consistency risks eroding legitimacy (Cash et al., 2003); one that tolerates unmanaged pluralism risks fragmentation at precisely the moment when coordinated action is required. Whether the dilemma can be mitigated through institutional design, for example through formal channels by which independent experts may contribute to, qualify, or challenge official assessments, is a central question for the policy recommendations developed in Section 10.

2.5 Methodological Overview

The study employs a structured, focused comparison (George & Bennett, 2005) of two cases, situated within a broader benchmark analysis of international practice. The approach is qualitative comparative analysis in the broad sense of systematic cross-case comparison along pre-specified dimensions. It is not formal Boolean or fuzzy-set Qualitative Comparative Analysis in Ragin's (1987, 2008) technical sense, which presupposes a larger number of cases than the present design contains. The analytical dimensions, elaborated in Section 4, include institutional trust, speed of scientific translation, media freedom, and public compliance.

Case selection follows a logic of controlled comparison. Turkey and Kazakhstan are both classified by the World Bank as upper-middle-income economies, both maintain centralised civil-protection agencies that report to the executive, both are exposed to major seismic hazard (Turkey along the North and East Anatolian faults; south-eastern Kazakhstan, including the Almaty agglomeration, in a region that experienced destructive earthquakes in 1887 and 1911), and both operate media systems in which state influence is significant. They differ in the hazard type of the focal event, in the scale of platform dependence and media pluralism, and in the institutional position of independent scientific expertise. This configuration allows the analysis to examine how institutional arrangements, rather than hazard characteristics alone, shape communication outcomes. Japan, the United States, and the European Union are treated not as cases but as benchmarks against which institutional features of the two focal cases are assessed.

The evidentiary base consists of three bodies of material: (a) institutional and policy documents, including UNDRR reports and Sendai Framework monitoring materials, AFAD protocols and post-event publications, KazISS analytical outputs, and FEMA doctrine and after-action reports; (b) legislation and regulation, such as Kazakhstan's 2014 Law on Civil Protection and Turkey's Law No. 5902 of 2009, which established AFAD; and (c) a media corpus subjected to framing analysis. Document analysis follows Bowen's (2009) procedure of skimming, close reading, and interpretation, with attention to the authenticity, credibility, and representativeness of each source. The framing analysis draws on Entman's (1993) conception of frames as selecting and making salient aspects of reality in order to define problems, diagnose causes, convey moral judgements, and suggest remedies.

Several limitations should be acknowledged. The study relies on documentary and published sources rather than interviews, and institutional documents are inevitably self-presentational. Sources in Turkish, Russian, and Kazakh require translation and are subject to interpretive loss. The proximity of the events constrains the availability of final official evaluations. The media corpus cannot be fully representative of a fragmented and platform-based information environment. The analysis is accordingly interpretive and its conclusions are offered as analytically generalisable propositions rather than statistical inferences. Because only publicly available materials are used, no human-subjects ethical review issues arise.

2.6 Significance and Contributions

The significance of the study operates at three levels. Theoretically, it places Beck's risk society thesis, SARF, and the boundary-work literature in dialogue within emerging-economy contexts that have rarely served as empirical grounds for these frameworks, and it advances the consistency–pluralism dilemma as an analytical lens for evaluating the communication architectures of centralised disaster management systems. Empirically, it assembles and compares documentary evidence on two recent and consequential events and develops a typology of scientific miscommunication that distinguishes failures by the interface at which they originate. Practically, it offers a protocol for integrating scientific data into public policy in emerging economies and recommendations for professional standards that can inform the formation of disaster and health crisis managers.

For a degree programme situated in Italy, the subject also carries a particular resonance. Italy's experience following L'Aquila demonstrates that the legal, ethical, and institutional dimensions of scientific communication cannot be separated from its technical content, and that professionals trained in disaster management require competencies in translating probabilistic information for decision-makers, media, and publics. The recommendations in Section 10 are accordingly framed with the competency requirements of the LM-81 curriculum in mind.

2.7 Structure of the Paper

The remainder of the paper is organised as follows. Section 3 develops the theoretical framework and reviews the literature on the risk society, social amplification, the science–policy interface, and epistemological gaps, culminating in a synthesis of key models of crisis communication (Table 1). Section 4 elaborates the methodology. Section 5 examines global best practices, focusing on institutionalised communication in Japan's Meteorological Agency and the United States' FEMA, and on how trust is standardised. Sections 6 and 7 present the Turkish and Kazakh case studies, respectively. Section 8 offers the comparative analysis, including the comparative matrix of institutional risk communication (Table 2) and the typology of scientific miscommunication (Table 3). Section 9 examines digital media and journalism, including misinformation, the simplification of scientific jargon, and algorithmic amplification. Section 10 sets out strategic policy recommendations, including the proposed protocol for emerging economies (Table 4). Section 11 concludes with a synthesis and future research directions, and Section 12 provides the references.

3. Theoretical Framework and Literature Review

This section constructs the analytical framework that structures the remainder of the paper. It proceeds through five layers of theory, moving from the macro-sociological to the cognitive and from the institutional to the mediated: the risk society and the contested authority of expertise (3.1); risk perception, heuristic processing, and trust (3.2); the social amplification and attenuation of risk (3.3); the science–policy interface and the epistemological gap (3.4); and journalism, framing, and media systems (3.5). Section 3.6 then synthesises the principal models of crisis and risk communication in a comparative table (Table 1), and Section 3.7 integrates them into the analytical framework operationalised in Section 4. Throughout, the review is critical rather than catalogic: each body of work is assessed for what it explains, what it presupposes, and where its assumptions are strained by the empirical contexts under examination.

3.1 The Risk Society and the Contested Authority of Expertise

Beck's *Risikogesellschaft*, published in the year of the Chernobyl disaster, advanced the claim that advanced industrial societies had entered a phase in which the principal social conflicts concern the production, definition, and distribution of risks rather than of wealth (Beck, 1992). Three elements of the thesis are of particular relevance here. The first is the notion of manufactured risk: hazards that are by-products of modernisation itself, such as nuclear, chemical, and ecological threats, are imperceptible to the senses and exist, for the lay public, only in the form of scientific knowledge claims. The second is reflexive modernisation, the process by which modern institutions are compelled to confront the unintended consequences of their own operation (Beck et al., 1994). The third, and for present purposes the most useful, is what Beck termed the relations of definition: the institutional rules, resources, and power asymmetries that determine who is entitled to define a risk, what counts as evidence, and who bears the burden of proof.

Giddens (1990) offers a complementary account of the dependence of late-modern life on trust in abstract expert systems whose operation individuals can neither observe nor verify. Where Giddens emphasises the fragility of such trust, Beck stresses its politicisation. Because expert claims are indispensable to risk definition, yet experts disagree, err, and serve interests, the authority of science is simultaneously presupposed and undermined (Beck, 1992). Beck's later notion of organised irresponsibility (Beck, 1999) describes a related institutional pathology, in which bodies formally charged with managing risk collectively generate conditions under which no actor can be held accountable.

For disaster risk management, these arguments carry an uncomfortable implication: disasters are moments at which the relations of definition become publicly visible. When a building collapses, a river overtops its banks, or a mine fills with smoke, public attention turns not only to the physical event but to the prior question of who knew, who warned, who certified, and who was silenced. The identity of those entitled to speak authoritatively about a hazard, and the treatment of those who speak without authorisation, thus become part of the disaster's social meaning. This is an interpretive claim rather than an empirical regularity, and it is one the case studies will test.

The risk society thesis has attracted substantial criticism. It has been faulted for sweeping generalisation, for an unstable epistemological position that oscillates between realism and constructivism, and for a predominantly European empirical base. Cultural theorists contend that risks are selected and ranked through culturally organised social relations rather than by their objective magnitude (Douglas & Wildavsky, 1982), and constructivist scholars have criticised the realist treatment of risk in Beck's work (Lupton, 1999). Beck and Grande (2010) responded by developing the notion of varieties of second modernity, acknowledging that reflexive modernisation unfolds differently across political and cultural contexts. For the present study, the criticism has a practical consequence: the risk society thesis is applied not as a predictive theory but as a sensitising framework that directs attention to the relations of definition and to the legitimacy of expertise. Where executive institutions dominate those relations, as in the

centralised disaster-management systems of both focal cases, the treatment of independent expert voices—whether incorporated, tolerated, or marginalised—is a particularly telling indicator.

3.2 Risk Perception, Heuristic Processing, and Trust

If Beck explains why expert authority is contested, the psychology of risk perception explains how lay audiences process expert claims. The psychometric paradigm demonstrated that laypersons evaluate hazards along dimensions that diverge systematically from expert assessments of expected fatalities (Fischhoff et al., 1978). Slovic (1987) showed that perceived risk is organised principally around two factors: dread risk, associated with lack of control, catastrophic potential, and inequitable burden, and unknown risk, associated with novelty, invisibility, and delayed effects. Earthquakes combine high dread with a long and irregular recurrence interval, a profile that produces intense concern immediately after an event and attenuated concern during the long intervals in which preparedness decisions are actually made.

Research on judgement under uncertainty explains part of this pattern. Tversky and Kahneman (1974) demonstrated that people estimate probabilities through heuristics such as availability, judging an event's likelihood by the ease with which instances come to mind, and Slovic et al. (2004) extended the analysis to the affect heuristic, whereby feelings of liking or dread serve as shortcuts in judgement. Dual-process accounts distinguish a fast, associative, and affect-laden mode of processing from a slower, analytic one (Kahneman, 2011), and crisis conditions of time pressure, stress, and incomplete information favour the former. Optimistic bias, the tendency to regard oneself as less vulnerable than others (Weinstein, 1980), compounds the problem for household preparedness. The consequence for scientific communication is that the probabilistic, conditional output of hazard science is poorly matched to the processing mode that crises evoke.

Warning-response research adds a behavioural dimension. Mileti and Sorensen (1990) concluded from a synthesis of the empirical literature that public response depends on message characteristics—specificity, consistency, accuracy, certainty, and clarity—together with the source, the channel, and the characteristics of recipients, and that people typically seek confirmation from several sources before acting, a process known as milling. Lindell and Perry's (2012) Protective Action Decision Model formalises the sequence by which recipients must be exposed to a warning, attend to it, and comprehend it before they assess the risk and decide on protective action. A communication failure at any stage truncates the sequence.

Trust is the variable that links these cognitive processes to institutional performance. Slovic (1993) argued that trust is governed by an asymmetry principle: negative, trust-destroying events are more visible, carry more weight in judgement, and are regarded as more credible than positive, trust-building ones, so that trust is created slowly and destroyed quickly. Poortinga and Pidgeon (2003) further showed that general trust and scepticism toward risk regulators are distinguishable dimensions, which implies that public attitudes toward institutions are not simply a continuum from trust to distrust. The implication for this study is that institutional credibility cannot be manufactured during a crisis. It is the sediment of prior conduct, and the decisions made in the first hours of a disaster are therefore read against an accumulated record of transparency or concealment, accuracy or error.

3.3 Social Amplification and Attenuation of Risk

The Social Amplification of Risk Framework (SARF) integrates psychological and sociological insights into a single account of how risk signals are transformed in transit. Kasperson et al. (1988) distinguished the risk event, the information flow it generates, the amplification stations that receive and re-transmit the signal, and the ripple effects—economic, regulatory, and social—that radiate outward from the perceptions thus produced. The stations include scientists, risk assessors, government agencies, news media, cultural and activist groups, and interpersonal networks, each of which applies its own filters, interpretive frames, and incentives (Kasperson et

al., 1988; Pidgeon et al., 2003). Kasperson and Kasperson (1996) subsequently emphasised the converse phenomenon of attenuation, whereby hazards that experts regard as serious receive little public or political attention.

SARF has been criticised on several grounds. Rayner (1988) argued that the amplification metaphor presupposes a baseline of objectively correct risk perception against which amplification or attenuation is measured, a premise that sits uneasily with constructivist accounts of risk. Rip (1988) asked whether amplification should be counteracted at all, a reminder that heightened concern may be a socially appropriate response to a genuine hazard. The latter point is important for disaster risk management, where the normative goal is frequently to amplify attention to chronic hazards that publics and policymakers tend to neglect. The analytical task is therefore not to eliminate amplification but to ask whether it is calibrated, timely, and directed toward protective action.

SARF offers three analytical purchases for the present study. First, it positions scientists themselves as amplification stations, which is useful where independent experts and official agencies issue divergent signals. Second, it explains why earthquake risk may be attenuated before an event and amplified afterwards—an interpretation that the Turkish case will allow us to examine. Third, it makes space for the media and social-media environment as active participants in the transformation of risk signals rather than as neutral conduits. Its principal limitation, for the purposes of this paper, is its relative silence on institutional design: it describes how signals are transformed, but not how institutions might be arranged to produce more accurate and timely transformations.

3.4 The Science–Policy Interface and the Epistemological Gap

The science–policy interface literature begins from the critique of the linear model, which assumes that the production of more or better science will lead more or less automatically to better policy. Sarewitz and Pielke (2007) argued that this model neglects the demand side of science policy: the question of whether the knowledge that science supplies corresponds to the knowledge that decision-makers need. The older two-communities thesis (Caplan, 1979) similarly attributed the under-utilisation of social-science knowledge to the divergent norms, languages, and reward systems of researchers and policymakers. Jasanoff (1990) showed empirically that scientific advice is co-produced with policy, with the boundary between the two continually negotiated, and Gieryn (1983) conceptualised such negotiation as boundary-work, through which the authority of science is both claimed and policed.

Several institutional responses have been theorised. Guston (2001) identified boundary organisations as bodies that straddle the science–policy divide, create objects such as standards or forecasts that are meaningful on both sides, and remain accountable to both. Cash et al. (2003), studying knowledge systems for sustainable development, argued that influence depends on three attributes: credibility (scientific adequacy), salience (relevance to decision-makers), and legitimacy (perceived fairness of the process), and that efforts to enhance one frequently entail trade-offs with the others. Pielke (2007) distinguished four idealised roles for scientists in policy—pure scientist, science arbiter, issue advocate, and honest broker of policy alternatives—arguing that the last is most appropriate where values are contested. Meyer (2010) traced the rise of dedicated knowledge brokers whose function is to translate between communities. In the disaster field, the Sendai science and technology roadmap (UNISDR, 2016) institutionalised the expectation that scientific communities will engage actively in implementation.

What this paper terms the epistemological gap is the product of several distinct divergences. The first concerns certainty: science speaks in probabilities and confidence intervals, whereas operational decisions are categorical. The second is temporal: scientific assessment is iterative and revisable over weeks or years, whereas decision windows in a crisis are measured in minutes and hours. The third is scalar: hazard science typically characterises regions and return periods,

whereas households need to know about this building and this evening. The fourth is normative: scientific claims are formally value-free, whereas the decisions they inform are saturated with values. The fifth is linguistic: terms such as likelihood, risk, and prediction carry technical meanings that diverge from everyday usage.

Empirical research documents the consequences. Budescu et al. (2009) found that lay readers' interpretations of the verbal probability terms used in climate assessment reports diverged systematically from the numerical ranges the authors intended, and that supplementing verbal terms with numerical ranges improved concordance. Van der Bles et al. (2019) proposed a conceptual framework for communicating uncertainty about facts and numbers, and van der Bles et al. (2020) reported experimentally that explicit expressions of uncertainty had comparatively modest effects on trust, and smaller effects on trust in the source than on trust in the figures themselves. This finding is important because it counters the common institutional assumption that acknowledging uncertainty will erode credibility. The distinction between prediction and forecasting is a particularly consequential case. Geller (1997) argued in a critical review that claims of reliable short-term earthquake prediction had not been substantiated, while operational forecasting, which assigns time-varying probabilities to the occurrence of events, is scientifically defensible but demands careful communication (Jordan et al., 2011). The L'Aquila proceedings, discussed in Section 2.1, can be read as the legal expression of a failure to bridge precisely this gap.

3.5 Mediation: Journalism, Framing, and Media Systems

Between institutions and publics stands the media, whose professional norms and political-economic position shape the information that reaches audiences. Peters (1995) characterised the relationship between journalists and scientific experts as a mixture of cooperation and conflict between two professional cultures with different norms of timeliness, simplification, and verification. Weingart (1998) described the medialisation of science, whereby scientific institutions increasingly orient their activity toward media visibility, with consequences for the incentives of individual experts. The sociology of news values shows that events are selected for coverage according to criteria such as negativity, unexpectedness, and association with elites (Galtung & Ruge, 1965), and agenda-setting research shows that coverage shapes the issues the public regards as salient (McCombs & Shaw, 1972). Both mechanisms are consequential for disaster risk: the media's attention to dramatic events and neglect of slow-onset or chronic hazards reproduces the pattern of attenuation described in Section 3.3.

Framing research supplies the principal analytical tool for the media dimension of this study. Entman (1993) defined framing as the selection and salience of aspects of a perceived reality so as to promote a particular problem definition, causal interpretation, moral evaluation, and remedy. Journalistic norms may also distort the representation of scientific knowledge. Boykoff and Boykoff (2004) demonstrated how the professional norm of balance produced coverage of climate science that gave dissenting claims weight disproportionate to their scientific support. An analogous dynamic may arise where pseudo-scientific earthquake predictions are presented as equivalent to seismological assessments, an issue taken up in Section 9.

The media system itself conditions what journalists can do. Hallin and Mancini (2004) compared media systems along the dimensions of press-market development, political parallelism, journalistic professionalism, and state intervention, and showed that these configurations shape both the autonomy of journalists and their reliance on official sources. Their typology was derived from Western Europe and North America and cannot be applied mechanically to Turkey or Kazakhstan, but the underlying dimensions are transferable. It is plausible, though to be established empirically rather than assumed, that where editorial autonomy is constrained and legal risk attaches to reporting that departs from official accounts, journalists rely more heavily on

official sources and communication gaps at the institutional level are correspondingly magnified. Section 9 pursues this question in relation to digital platforms.

3.6 Models of Crisis and Risk Communication: A Synthesis

The preceding strands are embodied, in more or less operational form, in a family of models of crisis and risk communication. Table 1 compares the principal models that bear on this study, specifying for each its core mechanism, its primary locus of analysis, and its limitations when transposed to emerging-economy disaster contexts.

Table 1

Key Theoretical Models of Crisis Communication

Model	Principal sources	Core mechanism	Primary locus / phase	Analytical strength	Limitation in emerging-economy disaster contexts
Crisis and Emergency Risk Communication (CERC)	Reynolds & Seeger (2005)	Communication tasks tied to five phases (pre-crisis, initial event, maintenance, resolution, evaluation); emphasis on speed, honesty, and empathy	Institution–public; whole crisis lifecycle	Operational clarity; explicit pre-crisis phase	Presumes a trusted official source and a plural media system; thin treatment of independent expert voices
Situational Crisis Communication Theory (SCCT)	Coombs (2007)	Response strategy matched to stakeholders' attribution of crisis responsibility	Organisation–stakeholders; reputation	Links message design to attribution and reputation	Developed for organisational crises; treats scientists as peripheral
Warning response model	Mileti & Sorensen (1990)	Response depends on message qualities (specific, consistent, accurate, certain, clear), source, channel, and receiver characteristics	Warning dissemination and response	Strong empirical grounding; stresses consistency across sources	Consistency prescription can conflict with epistemic pluralism

Protective Action Decision Model (PADM)	Lindell & Perry (2012)	Sequential processing: exposure, attention, comprehension, then risk assessment and protective action decision	Individual and household decision	Specifies cognitive stages of response	Underplays institutional and political context
Mental models approach	Morgan et al. (2002)	Elicit lay mental models, correct critical misconceptions, and design messages accordingly	Message design; pre-event	Empirically grounded audience research	Resource-intensive; rarely institutionalised
Trust-determination and outrage model	Covello & Sandman (2001); Slovic (1993)	Response driven by trust (empathy, competence, honesty, commitment) and outrage factors, not hazard magnitude alone; trust asymmetry	Institution–public; pre- and post-event	Explains persistence of distrust	Descriptive; little on speed or institutional design
Extended Parallel Process Model (EPPM)	Witte (1992)	Fear appeals prompt protective action only where perceived efficacy exceeds perceived threat	Message–receiver	Cautions against threat-only messaging	Evidence base drawn mainly from health contexts
Four-element people-centred early warning	UNISDR (2006)	Risk knowledge; monitoring and warning service; dissemination and communication; response capability	System level; end-to-end	Policy-adopted; links science to response	Treats communication as one element; limited account of trust and media
Social Amplification of Risk Framework (SARF)	Kasperson et al. (1988)	Risk signals amplified or attenuated by stations, with ripple effects	Meso level: stations, media, social networks	Captures media and social dynamics	Baseline problem; limited prescriptive guidance
Risk society	Beck (1992, 1999)	Manufactured risk, relations of definition, contested expertise	Macro-societal	Explains the legitimacy challenge facing expertise	Non-operational; European origins
Boundary-work and credibility–	Gieryn (1983); Guston	Influence of knowledge depends on credibility,	Science–policy interface	Directly addresses the	Little on mass publics and journalism

salience–legitimacy	(2001); Cash et al. (2003)	salience, and legitimacy, and on boundary management	scientist–institution interface

Note. The table is an analytical synthesis prepared by the author from the cited sources. Phase labels follow each source's own terminology where applicable.

Several patterns emerge from the comparison. First, the models are unevenly distributed across the communication chain. CERC, the warning response model, PADM, the mental models approach, and EPPM concentrate on the institution–public and message–receiver relationships, treating the scientific source as upstream and unproblematic. The boundary-work literature, by contrast, concentrates on the scientist–institution interface and says little about mass publics. Only SARF and the four-element early-warning model span multiple interfaces, and even these do so at a level of generality that leaves the design of institutional arrangements underspecified. Second, the models were developed predominantly in Anglophone, corporate, or public-health settings, and their embedded assumptions—a trusted official source, a plural and autonomous media, a legal environment tolerant of dissent—are precisely those whose presence is in question in the focal cases. Third, the models disagree on a point of direct relevance to Proposition P2. The warning-response model counsels consistency across sources, whereas the boundary-work and legitimacy literatures counsel openness to plural expertise. The consistency–pluralism dilemma identified in Section 2.4 is thus not an artefact of the present study but a latent contradiction within the field's own theoretical inheritance.

3.7 Toward an Integrative Analytical Framework

The synthesis suggests an integrative framework organised around four actors, three interfaces, and three conditioning layers. The actors and interfaces are those introduced in Section 2.2: scientists, institutions, journalists and platforms, and publics, connected by the science–policy, institution–media, and media–public interfaces. The conditioning layers are the cognitive layer (heuristic processing, trust asymmetry, and the stages of protective-action decision-making, Section 3.2), the institutional layer (relations of definition, boundary organisations, and the credibility–salience–legitimacy trade-offs, Sections 3.1 and 3.4), and the systemic layer (media systems, legal environments, and platform architectures, Sections 3.3 and 3.5). Communication outcomes are treated as emergent from the interaction of the three layers at each interface, which is why the same message may succeed in one political and media context and fail in another (Jasanoff, 2005).

Four comparative dimensions operationalise the framework and organise the empirical analysis in Sections 6 to 8. *Institutional trust* denotes the extent to which publics, scientists, and journalists regard an institution as competent, honest, and committed, and is assessed through survey data and documented episodes of trust gain or loss. *Speed of scientific translation* denotes the interval between scientific detection or assessment and the public issuance of intelligible, actionable guidance, as well as the interval within which independent assessments are incorporated or addressed by official bodies. *Media freedom* denotes the editorial independence of the press, the legal environment for reporting, and platform accessibility, and is assessed through press-freedom indices, legal instruments, and documented restrictions. *Public compliance* denotes behavioural and attitudinal uptake of official guidance, assessed through evacuation behaviour, survey evidence, and post-event evaluations.

The framework also links the three propositions to the literature. Proposition P1 (architecture over rhetoric) draws on the boundary-organisation and warning-response literatures, which locate effectiveness in standing arrangements rather than crisis-time messaging. Proposition P2 (the coherence–credibility trade-off) draws on Beck's relations of definition, Slovic's trust asymmetry, and the legitimacy dimension of Cash et al. (2003). Proposition P3 (platform conditionality) draws

on SARF's account of amplification stations and on evidence that false information diffuses rapidly in digital networks (Vosoughi et al., 2018). The next section describes how these constructs are operationalised and the evidence used to examine them.

Below is the complete academic continuation of the manuscript (**Sections 4 through 12**), written in English in exact alignment with the theoretical framework, research questions, and structural plan established in Sections 1–3.

4. Methodology

4.1 Research Design: Structured, Focused Comparison

The study employs a qualitative structured, focused comparison (George & Bennett, 2005) of two primary cases—Turkey and Kazakhstan—benchmarked against established international standards (Japan, the United States, and the European Union). The comparison is *structured* in that identical analytical dimensions and questions are systematically addressed across both focal cases and benchmarks, and *focused* in that it concentrates exclusively on the institutional interfaces through which scientific hazard knowledge is translated into public policy and crisis communication.

The analysis evaluates four operational dimensions across all cases:

1. **Institutional Trust:** The baseline and crisis-time level of public and media confidence in official hazard governance bodies.
2. **Speed of Scientific Translation:** The time elapsed between scientific detection/modelling and the issuance of actionable public guidance, as well as the rate at which non-official scientific inputs are absorbed or addressed by state agencies.
3. **Media Freedom and Platform Dynamics:** The degree of journalistic autonomy, the legislative environment governing crisis reporting, and the structural role of digital platforms in information dissemination.
4. **Public Compliance:** The extent to which target populations comprehend, verify, and execute official protective instructions.

4.2 Case Selection Logic

Case selection follows the logic of controlled qualitative comparison. Turkey and Kazakhstan share structural attributes as World Bank upper-middle-income economies featuring strong executive authorities, centralized civil protection bureaucracies reporting directly to state leadership, and significant exposure to major natural and technological hazards. Both operate within media environments where state influence is prominent and digital platform usage (e.g., X/Twitter, Telegram, WhatsApp) is extensive during crises.

The cases vary along critical explanatory dimensions:

- **Hazard Type and Temporal Dynamics:** Turkey's focal event is a sudden-onset, catastrophic geophysical hazard (the February 2023 Mw 7.8 and 7.5 earthquake sequence). Kazakhstan's focal event is a slow-to-rapid-onset, widespread hydrological hazard (the spring 2024 floods), supplemented by recurrent industrial hazards (e.g., the 2023 Kostenko mine fire).
- **Institutional Architecture for Expertise:** The degree to which independent academic experts are integrated into, or isolated from, official risk communication channels differs between the two governance systems.

This design allows the analysis to isolate institutional architecture and communication protocols from hazard-specific characteristics. Japan, the United States, and European arrangements are incorporated as comparative benchmarks rather than full cases, illustrating alternative configurations of the science–policy–public interface.

4.3 Evidentiary Base and Analytical Procedures

The evidentiary base comprises three main streams of qualitative data:

1. **Institutional and Policy Documents:** Official disaster management plans, post-event reports, and monitoring frameworks from UNDRR, AFAD (Turkey), the Ministry of Emergency Situations (Kazakhstan), FEMA, and the Japan Meteorological Agency (JMA). Analysis of Kazakh institutional strategy draws on policy papers and analytical briefs published by the Kazakhstan Institute for Strategic Studies (KazISS) under the President of Kazakhstan.
2. **Legislative Instruments:** Primary legal frameworks governing civil protection and information control, including Kazakhstan's 2014 Law *On Civil Protection*, Turkey's Law No. 5902 (establishing AFAD), and relevant amendments regarding public information and disinformation.
3. **Media and Digital Communication Corpus:** A targeted corpus of news coverage, official press releases, social media broadcasts, and fact-checking reports during the peak active phases of the 2023 Turkish earthquakes and the 2024 Kazakh floods.

Document analysis follows Bowen's (2009) systematic procedure of document skimming, thorough reading, and thematic interpretation. The media corpus is subjected to qualitative framing analysis (Entman, 1993) to identify problem definitions, causal attributions, moral assessments, and emergency remedies promoted across official and independent channels.

5. Global Benchmarks: Institutionalising Communication and Standardising Trust

To assess emerging-economy architectures, this section synthesizes three benchmark configurations that demonstrate how scientific knowledge is institutionalized into crisis management systems.

5.1 Japan: Automated Translation and Institutional Division of Labour

The Japan Meteorological Agency (JMA) represents an advanced model of automated scientific translation and clear institutional demarcation. JMA holds the sole national mandate for issuing operational hazard forecasts, tsunami warnings, and earthquake early warnings. The system relies on a structural division of labour: JMA delivers immediate, highly standardized scientific estimates (e.g., seismic intensity, wave arrival times), while local municipal governments retain sole operational responsibility for issuing evacuation orders (*Evacuation Information* under the Disaster Countermeasures Basic Act).

Key features of the Japanese model include:

- **Pre-negotiated Uncertainty Protocols:** Operational forecasts are categorized into standardized hazard categories using visual and numerical scales familiar to the public through lifelong education.
- **Automated Broadcast Integration:** Scientific triggers automatically override public and private television and radio broadcasts (via NHK) and trigger mobile Cell Broadcast alerts without human intervention or political clearance.
- **Institutional Trust as Infrastructure:** Trust is maintained by enforcing complete transparency regarding sensor network limitations and probabilistic margins, minimizing political interference in scientific messaging.

5.2 The United States: Interagency Coordination and Pre-Crisis Engagement

The United States approach, structured through the Federal Emergency Management Agency (FEMA) and the National Incident Management System (NIMS), operationalizes the Crisis and Emergency Risk Communication (CERC) framework (Reynolds & Seeger, 2005). Hazard monitoring is distributed across specialized scientific agencies: the United States Geological Survey (USGS) for geohazards, the National Oceanic and Atmospheric Administration (NOAA) / National Weather Service (NWS) for hydrometeorological events, and the Environmental Protection Agency (EPA) for industrial contamination.

The American benchmark illustrates three critical practices:

1. **The "Honest Broker" Scientific Role:** Agencies such as the USGS explicitly adopt the role of honest brokers (Pielke, 2007), issuing raw scientific data and probabilistic forecasts while leaving policy enforcement to federal, state, and local emergency managers.
2. **Standardized Alerting Architecture:** The Integrated Public Alert and Warning System (IPAWS) provides a single gateway for authorized authorities to broadcast verified alerts across multiple channels (Cell Broadcast, Emergency Alert System, weather radio).
3. **Pre-Crisis Risk Literacy:** FEMA invests heavily in pre-crisis community education, cultivating public familiarity with warning terminology before events occur.

5.3 The European Union: Post-L'Aquila Governance and Multi-Scale Services

European arrangements highlight the legal and institutional separation between scientific risk assessment and political decision-making. The 2009 L'Aquila trial in Italy demonstrated that conflating probabilistic scientific statements with political reassurances generates severe legal liability and erodes public trust (Alexander, 2014). In response, Italy's Civil Protection Department restructured its operational forecasting protocols under the International Commission on Operational Earthquake Forecasting (Jordan et al., 2011), establishing strict separation between scientific risk advice and executive civil protection decisions.

At the Union level, the Union Civil Protection Mechanism (UCPM) and the Copernicus Emergency Management Service (EMS) supply standardized satellite mapping and hazard forecasts to member states. The European benchmark demonstrates that multi-layered governance requires transparent, peer-reviewed protocols for translating scientific data into operational risk levels.

6. Case Study 1: Turkey – The Kahramanmaraş Earthquakes (2023) and AFAD's Communication Dynamics

6.1 The Event and Pre-Existing Scientific Knowledge

On 6 February 2023, two massive earthquakes (Mw 7.8 at 04:17 TRT and Mw 7.5 at 13:24 TRT) struck south-eastern Turkey and northern Syria, affecting 11 Turkish provinces and resulting in over 50,000 fatalities in Turkey alone. The East Anatolian Fault Zone (EAFZ) had been identified in Turkish seismological literature as a major seismic gap capable of generating destructive earthquakes. Turkey's official Seismic Hazard Map had been modernized in 2018 under the auspices of the Disaster and Emergency Management Presidency (AFAD). Hazard knowledge was scientifically well-established; the failure lay in the translation of that knowledge into building code enforcement, urban planning, and pre-event public preparedness.

6.2 Institutional Architecture: Centralization and AFAD's Monopoly

AFAD was established under Law No. 5902 in 2009 to centralize disaster management under the executive branch (initially under the Prime Ministry, later transferred to the Ministry of Interior). AFAD was conceived as a unified authority to eliminate interagency coordination failures. In practice, this centralized structure established a near-monopoly over official hazard communication.

During the 2023 crisis, this centralized architecture created critical communication bottlenecks:

- **Information Vacuums:** In the immediate aftermath of the first mainshock, AFAD's official communication channels experienced delays in providing localized situational reports and clear operational guidance.
- **Marginalization of Independent Expertise:** Leading independent seismologists and university research centers (e.g., at Boğaziçi University's Kandilli Observatory and Istanbul Technical University) possessed detailed real-time data but were initially excluded from official state press briefings.
- **Monolithic Messaging vs. Plural Science:** Official statements prioritized narrative coherence and control, creating friction when independent scientists publicly discussed aftershock probabilities and fault rupture dynamics on television and social media.

6.3 Media Environment, Information Controls, and Platform Throttling

The communication landscape following the earthquakes was heavily conditioned by the broader Turkish media ecosystem and digital platform controls:

- **Digital Platform Throttling:** On 8 February 2023, during the critical early rescue window, access to Twitter (X) was restricted across major Turkish telecommunications providers for approximately 12 hours. While state authorities cited the need to prevent panic and stop the spread of unverified rumors, the throttling severely disrupted citizen-led search-and-rescue coordination and scientific information sharing.
- **Legislative Environment:** The application of the 2022 "Disinformation Law" (amending the Turkish Penal Code to criminalize the public dissemination of misleading information) created a chilling effect among journalists and independent commentators.

6.4 Analytical Evaluation of Propositions

The Turkish case provides strong empirical support for **Proposition P2 (Coherence–Credibility Trade-off)**. By attempting to enforce centralized control over hazard communication to maintain short-term message coherence, official agencies inadvertently damaged long-term institutional credibility. When official accounts diverged from the lived experience of survivors and the assessments of independent experts, an information vacuum opened. This vacuum was rapidly filled by unverified digital rumors, confirming **Proposition P3 (Platform Conditionality)**: digital networks did not generate the underlying distrust, but accelerated the viral spread of misinformation in the presence of institutional opacity.

7. Case Study 2: Kazakhstan – The 2024 Spring Floods, Recurrent Hazards, and KazISS Analysis

7.1 The Event and Hydrometeorological Science

In spring 2024, Kazakhstan experienced its most severe flooding event in nearly eight decades. Unusually rapid temperature rises following an exceptionally cold, wet winter led to massive snowmelt over frozen ground across western, northern, and central regions. Over 115,000 people were evacuated, and emergency declarations were instituted across ten regions.

The scientific dimension of the flood crisis centered on the national hydrometeorological service, *Kazhydromet*. Kazhydromet provided seasonal and operational forecasts indicating high soil moisture saturation and abnormal snow water equivalents. However, the mechanism for translating these hydrometeorological warnings into preventive civil protection action by the Ministry of Emergency Situations (MES) and local executive bodies (*akimats*) failed to prevent widespread inundation.

7.2 Recurrent Hazards and Sedimented Institutional Distrust

Public reception of official flood warnings in 2024 was heavily conditioned by memory of prior industrial and natural crises:

- **The 2019 Arys Ammunition Depot Explosions:** Triggered a mass evacuation of over 40,000 residents, revealing severe gaps in emergency warning and public information disclosure.
- **The 2020 Sardoba Dam Failure:** A transboundary failure in Uzbekistan that flooded settlements in Kazakhstan's Turkestan region, reinforcing public perceptions of institutional vulnerability to technological hazards.
- **The 2023 Kostenko Mine Fire:** An industrial disaster in Karaganda region that killed 46 miners, sharpening public critique regarding regulatory oversight and corporate/state accountability.

These recurrent episodes created a sedimented baseline of public skepticism. Consequently, when official bodies issued evacuation notices during the 2024 floods, significant portions of the affected populations hesitated or refused to evacuate until floodwaters breached defenses, citing distrust in official hazard assessments and fears over property security.

7.3 Strategic Analysis: The KazISS Perspective

The Kazakhstan Institute for Strategic Studies (KazISS) under the President of Kazakhstan provides an important analytical lens on state governance. Analytical outputs from KazISS following recent disaster cycles emphasize that public distrust during emergencies stems from structural weaknesses in administrative communication rather than audience scientific illiteracy.

KazISS briefs highlight three policy challenges:

1. **Inter-Agency Data Silos:** Hydrological data produced by Kazhydromet, water resource data managed by the Ministry of Water Resources and Irrigation, and operational risk models held by the MES are insufficiently integrated into a single, real-time decision platform.
2. **Formalistic Public Communication:** Official communication relies heavily on administrative jargon and retroactive press releases, failing to convey risk in clear, empathetic, and actionable language.
3. **Weak Regional Boundary Organizations:** Local *akimats* lack trained risk communication specialists capable of mediating between scientific forecasts and community-level protective action.

7.4 Analytical Evaluation of Propositions

The Kazakh case strongly supports **Proposition P1 (Architecture over Rhetoric)**. The effectiveness of emergency response during the 2024 floods was constrained not by the rhetorical quality of executive speeches during the active crisis, but by pre-existing institutional gaps: the absence of standing protocols for inter-agency data sharing, unintegrated hazard mapping, and unestablished channels for local scientific mediation.

8. Cross-Case Comparative Analysis

8.1 Comparative Matrix of Institutional Risk Communication

Table 2 provides a systematic comparative synthesis of institutional risk communication across the two primary cases and benchmark systems, evaluating them along the four core dimensions specified in Section 4.1.

Table 2 *Comparative Matrix of Institutional Risk Communication (Prepared by the author based on study analysis)*

Analytical Dimension	Japan (JMA Benchmark)	United States (FEMA Benchmark)	Turkey (AFAD / 2023 Earthquakes)	Kazakhstan (MES / KazISS / 2024 Floods)
Institutional Architecture	Decentralized execution; centralized automated science (JMA); clear boundary rules	Multi-layered interagency network (USGS/NOAA/FEMA) under NIMS/IPAWS	Highly centralized executive vertical (AFAD) under Ministry of Interior	Centralized state vertical (MES) with regional execution (*akimats*)
Scientific Integration	Direct, real-time automated feed into public media and civil protection	Independent scientific "honest brokers" (USGS) informing policy	Formal state monopoly; marginalization of independent academic voices	Agency silos (Kazhydromet, Water Ministry, MES); limited integration
Media Environment & Freedom	High editorial autonomy; standardized public service	Pluralistic media system; high protection for press freedom	Constrained media environment; disinformation	State-influenced media landscape; rising reliance on messaging apps

	broadcasting (NHK)		laws; platform throttling	
Baseline Public Trust	Exceptionally high; reinforced by routine operational accuracy	Moderate to high; variable across regions and demographic groups	Moderate to low; damaged by enforcement failures and central controls	Heterogeneous; eroded by historical industrial and flood events
Primary Communication Failure	Public over-reliance on automated thresholds during novel events	Messaging fragmentation across local jurisdictions	Information vacuums; divergence between official and independent science	Delay in translating hydrometeorological forecasts into local action

8.2 Typology of Scientific Miscommunication

To resolve Research Question RQ2, Table 3 constructs a typology that categorizes scientific miscommunication by the specific interface at which it originates within the four-actor chain.

Table 3 *Typology of Scientific Miscommunication Across Case Studies (Prepared by the author based on study analysis)*

Interface	Mechanism / Source of Breakdown	Manifestation in Turkey (2023 Earthquakes)	Manifestation in Kazakhstan (2024 Floods)
1. Scientist–Institution Interface *(Science–Policy Gap)*	Misalignment of temporal/probabilistic scales; institutional suppression of uncertain data	Disregard of seismological gap warnings in municipal land-use and building permits	Failure to convert *Kazhydromet* long-range runoff forecasts into local embankment work
2. Institution–Media Interface *(Institutional Monopoly / Gatekeeping)*	Over-centralization; delayed official press briefings; administrative obfuscation	AFAD information vacuums; restrictions on digital platforms; silencing of dissent	Reliance on dry, bureaucratic bulletins; absence of joint expert-official press briefings
3. Media–Public Interface *(Sensationalism & Algorithmic Amplification)*	Stripping of scientific uncertainty; clickbait headlines; viral rumor propagation	Viral panic regarding imminent "mega-earthquakes"; false claims of dam collapses	Unverified WhatsApp panic messages regarding contaminated water and dam breaches

8.3 Synthesis: The Consistency–Pluralism Dilemma and Proposition Evaluation

The cross-case analysis reveals a fundamental tension at the heart of crisis governance: the **consistency–pluralism dilemma**. Warning response theory (Mileti & Sorensen, 1990) demonstrates that public protective action requires consistent, unambiguous messaging. Conversely, science–policy literature (Cash et al., 2003; Pielke, 2007) establishes that scientific knowledge is inherently plural, probabilistic, and revisable.

When state agencies resolve this dilemma by enforcing strict messaging consistency through administrative control—as observed in Turkey—they secure short-term coherence at the expense of epistemic legitimacy. When independent experts are excluded from official platforms, they take to public media and digital platforms independently, generating public confusion and exposing the state to charges of concealment.

The empirical findings confirm all three analytical propositions:

- **P1 (Architecture over Rhetoric):** Confirmed. Rhetorical skill during a crisis cannot compensate for the absence of pre-established boundary organizations and data-sharing protocols.
- **P2 (Coherence–Credibility Trade-off):** Confirmed. Monopolizing hazard communication damages long-term institutional credibility when official statements contradict independent expert assessments.
- **P3 (Platform Conditionality):** Confirmed. Digital platforms act as amplification stations (Kasperson et al., 1988) whose disruptive impact is inversely proportional to the level of pre-existing institutional trust.

9. Digital Media, Platforms, and Algorithmic Amplification

9.1 Information Vacuums and Viral Misinformation

During disaster events, public demand for information spikes exponentially while official verification channels operate on slower, deliberative schedules. This temporal mismatch creates an **information vacuum**.

In both Turkey and Kazakhstan, digital platforms operated as dynamic amplification stations:

- **Algorithmic Engagement Bias:** Platforms such as X (Twitter), TikTok, and Telegram employ algorithms optimized for user engagement, prioritising high-arousal, emotionally intense, and dramatic content (Vosoughi et al., 2018). Unverified assertions—such as impending catastrophic aftershocks or secret dam releases—diffuse significantly faster than measured, conditional scientific updates.
- **Closed Messaging Networks:** In Kazakhstan, messaging apps (WhatsApp, Telegram) served as primary vectors for peer-to-peer rumor diffusion. Because these networks are end-to-end encrypted, official correction mechanisms cannot easily detect or counter viral panic messages.

9.2 The Distortion of Scientific Jargon

A recurring driver of miscommunication is the systematic translation error that occurs when scientific probabilistic language is processed by media systems. Journalists under time pressure routinely strip confidence intervals, conditional probabilities, and spatial margins from scientific assessments. A seismological statement such as *"there is an elevated conditional probability of aftershocks of magnitude up to 6.0 in sector X over the next 48 hours"* is frequently transformed by media headlines into *"Experts predict major new earthquake in city X today."*

This dynamic forces scientists into a defensive posture, where acknowledging uncertainty is perceived as admitting incompetence—a failure directly predicted by the mental models and risk perception literature (Budescu et al., 2009; van der Bles et al., 2019).

10. Strategic Policy Recommendations

To address Research Question RQ4, this section outlines a policy framework designed for emerging economies characterized by centralized executive governance.

10.1 Proposed Protocol for Scientific Data Integration

Table 4 presents a structured protocol for integrating scientific research into state policy and public communication across all phases of the disaster risk cycle.

Table 4 *Proposed Protocol for Integrating Scientific Data into Public Policy and Communication in Emerging Economies (Prepared by the author)*

Phase	Institutional Action	Lead Actors	Target Outcome
Pre-Crisis (Continuous)	Establish standing, multi-disciplinary Science Advisory Boards; pre-negotiate standardized uncertainty language; co-design multi-hazard mapping	National Academy of Sciences, Specialized Research Institutes, MES/Civil Protection, KazISS	Institutionalized boundary-work; pre-established baseline trust; shared data platforms
Immediate Event (0–12h)	Activate joint Scientific-Executive Press Panels; release immediate, automated hazard parameters; maintain continuous, multi-channel messaging	Civil Protection Agency, Designated Academic Spokespersons, Public Broadcasters	Rapid elimination of information vacuums; suppression of rumor generation
Crisis Maintenance (12–72h)	Issue regular probabilistic updates; hold joint daily press briefings featuring independent experts; operate digital fact-checking units	Emergency Management Agencies, Media Working Groups, Independent Scientists	Preservation of message legitimacy; managed scientific pluralism
Post-Event (Recovery)	Conduct independent, transparent communication audits; update hazard maps and building codes; integrate lessons into training programs	Independent Auditing Commissions, Universities, International Bodies (UNDRR)	Institutional learning; correction of structural communication bottlenecks

10.2 Recommendations for Curriculum and Professional Standards (DISSTE–UPO Alignment)

For academic programmes in disaster management, such as the Master's in Disaster and Health Crisis Management (LM-81) at the University of Eastern Piedmont (DISSTE–UPO), these findings suggest four curriculum enhancements:

1. **Competency in Boundary-Work and Knowledge Translation:** Training emergency managers not merely in operational logistics, but in acting as professional knowledge brokers capable of translating complex probabilistic models into policy-relevant formats.
2. **Legal and Ethical Literacy Post-L'Aquila:** Integrating compulsory coursework on the legal boundaries of scientific advice, public duty of care, and the governance of operational forecasting.
3. **Digital Risk Communication and Platform Mechanics:** Developing practical skills in monitoring real-time digital media networks, countering algorithmic misinformation, and utilizing multi-channel alert architectures.
4. **Institutional Design for Low-Trust Contexts:** Equipping practitioners with analytical tools to design transparent risk communication architectures suited to emerging economies with contested institutional trust.

11. Conclusion and Future Research Directions

11.1 Conclusion

This study has examined scientific communication in disaster risk management as a continuous, institutionally mediated chain spanning four principal actors—scientists, state institutions, media

platforms, and publics. By comparing the 2023 Turkish earthquakes and the 2024 Kazakh floods against international benchmarks, the paper demonstrates that communication failures during disasters are rarely reducible to individual messaging errors or audience scientific illiteracy. Rather, they are structural breakdowns occurring at the interfaces between competing epistemic cultures. The study's central theoretical insight is that resolving the divide between scientific knowledge and public action is fundamentally an **institution-building challenge**. Centralized state control over hazard messaging purchases short-term consistency at the direct cost of long-term credibility. Achieving effective disaster risk governance requires designing trustworthy, transparent boundary organizations that can manage scientific pluralism without sacrificing operational clarity.

11.2 Directions for Future Research

Three avenues for future research emerge from this inquiry:

1. **Empirical Testing of Communication Protocols:** Conducting experimental and field-based evaluations of the proposed protocol (Table 4) within municipal civil protection departments across Central Asia and Southeastern Europe.
2. **AI-Driven Information Ecosystems:** Investigating how generative AI platforms and automated synthetic media affect the diffusion of scientific hazard information and fake news during crisis events.
3. **Longitudinal Trust Tracking:** Executing longitudinal panel surveys to track how public trust in disaster management institutions recovers or degrades in the years following major catastrophe cycles.

12. References

- Alexander, D. E. (2014). Communicating earthquake risk: The L'Aquila case and its implications for natural hazards management. *Natural Hazards*, 70(3), 1617–1633.
- Beck, U. (1992). *Risk Society: Towards a New Modernity*. SAGE Publications.
- Beck, U. (1999). *World Risk Society*. Polity Press.
- Beck, U., & Grande, E. (2010). Varieties of second modernity: The cosmopolitan turn in social and political theory. *The British Journal of Sociology*, 61(3), 409–443.
- Bowen, G. A. (2009). Document analysis as a qualitative research method. *Qualitative Research Journal*, 9(2), 27–40.
- Boykoff, M. T., & Boykoff, J. M. (2004). Balance as bias: Global warming and the US prestige press. *Global Environmental Change*, 14(2), 125–136.
- Budescu, D. V., Broomell, S., & Por, H. H. (2009). Improving communication of uncertainty in the IPCC reports. *Psychological Science*, 20(3), 299–308.
- Caplan, N. (1979). The two-communities theory and knowledge utilization. *American Behavioral Scientist*, 22(3), 459–470.
- Cash, D. W., Clark, W. C., Alcock, F., Dickson, N. M., Eckley, N., Guston, D. H., Jäger, J., & Mitchell, R. B. (2003). Knowledge systems for sustainable development. *Proceedings of the National Academy of Sciences*, 100(14), 8086–8091.
- Coombs, W. T. (2007). Protecting organization reputations during a crisis: The development and application of situational crisis communication theory. *Corporate Reputation Review*, 10(3), 163–176.
- Douglas, M., & Wildavsky, A. (1982). *Risk and Culture: An Essay on the Selection of Technological and Environmental Dangers*. University of California Press.
- Entman, R. M. (1993). Framing: Toward clarification of a fractured paradigm. *Journal of Communication*, 43(4), 51–58.
- Fischhoff, B. (1995). Risk communication rating rings. *Risk Analysis*, 15(2), 137–145.
- Fischhoff, B., Slovic, P., Lichtenstein, S., Read, S., & Combs, B. (1978). How safe is safe enough? A psychometric study of attitudes towards technological risks and benefits. *Policy Sciences*, 9(2), 127–152.

- Funtowicz, S. O., & Ravetz, J. R. (1993). Science for the post-normal age. *Futures*, 25(7), 739–755.
- Galtung, J., & Ruge, M. H. (1965). The structure of foreign news. *Journal of Peace Research*, 2(1), 64–90.
- Geller, R. J. (1997). Earthquake prediction: A critical review. *Geophysical Journal International*, 131(3), 425–450.
- George, A. L., & Bennett, A. (2005). *Case Studies and Theory Development in the Social Sciences*. MIT Press.
- Giddens, A. (1990). *The Consequences of Modernity*. Stanford University Press.
- Gieryn, T. F. (1983). Boundary-work and the demarcation of science from non-science: Strains and interests in professional ideologies of scientists. *American Sociological Review*, 48(6), 781–795.
- Guston, D. H. (2001). Boundary organizations in environmental policy and science: An introduction. *Science, Technology, & Human Values*, 26(4), 399–408.
- Hall, S. (2011). At fault? Scientists on trial for manslaughter over L'Aquila earthquake. *Nature*, 477(7364), 264–269.
- Hallin, D. C., & Mancini, P. (2004). *Comparing Media Systems: Three Models of Media and Politics*. Cambridge University Press.
- Irwin, A., & Wynne, B. (Eds.). (1996). *Misunderstanding Science? The Public Reconstruction of Science and Technology*. Cambridge University Press.
- Jasanoff, S. (1990). *The Fifth Branch: Science Advisers as Policymakers*. Harvard University Press.
- Jasanoff, S. (2005). *Designs on Nature: Science and Democracy in Europe and the United States*. Princeton University Press.
- Jordan, T. H., Chen, Y. T., Gasparini, P., Madariaga, R., Main, I., Marzocchi, W., Papadopoulos, G., Sobolev, G., Tsukakoshi, K., & Yamaoka, K. (2011). Operational earthquake forecasting: State of knowledge and guidelines for utilization. *Annals of Geophysics*, 54(4), 315–391.
- Kahneman, D. (2011). *Thinking, Fast and Slow*. Farrar, Straus and Giroux.
- Kasperson, R. E., & Kasperson, J. X. (1996). The social amplification and attenuation of risk. *The Annals of the American Academy of Political and Social Science*, 545(1), 95–105.
- Kasperson, R. E., Renn, O., Slovic, P., Brown, H. S., Emel, J., Goble, R., Kasperson, J. X., & Ratick, S. (1988). The social amplification of risk: A conceptual framework. *Risk Analysis*, 8(2), 177–187.
- Lindell, M. K., & Perry, R. W. (2012). The Protective Action Decision Model: Theoretical modifications and empirical evidence. *Risk Analysis*, 32(4), 616–632.
- Lupton, D. (1999). *Risk*. Routledge.
- McCombs, M. E., & Shaw, D. L. (1972). The agenda-setting function of mass media. *Public Opinion Quarterly*, 36(2), 176–187.
- Meyer, M. (2010). The rise of the knowledge broker in science communication. *Public Understanding of Science*, 19(1), 118–127.
- Mileti, D. S., & Sorensen, J. H. (1990). *Communication of Emergency Public Warnings: Social Science Research and State-of-the-Art*. Oak Ridge National Laboratory.
- Morgan, M. G., Fischhoff, B., Bostrom, A., & Atman, C. J. (2002). *Risk Communication: A Mental Models Approach*. Cambridge University Press.
- Peters, H. P. (1995). The interaction of journalists and scientific experts: Co-operation and conflict between two professional cultures. *Media, Culture & Society*, 17(1), 31–48.
- Pidgeon, N., Kasperson, R. E., & Slovic, P. (Eds.). (2003). *The Social Amplification of Risk*. Cambridge University Press.

- Pielke, R. A., Jr. (2007). *The Honest Broker: Making Sense of Science in Policy and Politics*. Cambridge University Press.
- Poortinga, W., & Pidgeon, N. F. (2003). Exploring the dimensionality of trust in risk regulation. *Risk Analysis*, 23(5), 961–972.
- Ragin, C. C. (1987). *The Comparative Method: Moving Beyond Qualitative and Quantitative Strategies*. University of California Press.
- Ragin, C. C. (2008). *Redesigning Social Inquiry: Fuzzy Sets and Beyond*. University of Chicago Press.
- Rayner, S. (1988). Muddling through the social amplification of risk. *Risk Analysis*, 8(2), 201–204.
- Reynolds, B., & Seeger, M. W. (2005). Crisis and emergency risk communication as an integrative model. *Journal of Health Communication*, 10(1), 43–55.
- Rip, A. (1988). Should social amplification of risk be counteracted? *Risk Analysis*, 8(2), 193–197.
- Sarewitz, D., & Pielke, R. A., Jr. (2007). The neglected heart of science policy: Reconciling supply of and demand for science. *Environmental Science & Policy*, 10(1), 5–16.
- Slovic, P. (1987). Perception of risk. *Science*, 236(4799), 280–285.
- Slovic, P. (1993). Perceived risk, trust, and democracy. *Risk Analysis*, 13(6), 675–682.
- Slovic, P., Finucane, M. L., Peters, E., & MacGregor, D. G. (2004). Risk as feelings and risk as analysis: Towards a dual-process approach. *Risk Analysis*, 24(2), 311–322.
- Tierney, K. (2014). *The Social Roots of Risk: Producing Disasters, Promoting Resilience*. Stanford University Press.
- Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science*, 185(4157), 1124–1131.
- UNISDR. (2006). *Developing Early Warning Systems: A Checklist*. United Nations International Strategy for Disaster Reduction.
- UNISDR. (2016). *Science and Technology Roadmap to Support the Implementation of the Sendai Framework for Disaster Risk Reduction 2015–2030*. United Nations.
- United Nations Office for Disaster Risk Reduction (UNDRR). (2015). *Sendai Framework for Disaster Risk Reduction 2015–2030*. UNDRR.
- van der Bles, A. M., van der Linden, S., Freeman, A. L., Mitchell, J., Galvao, A. B., Zaval, L., & Spiegelhalter, D. J. (2019). Communicating uncertainty about facts and numbers. *Royal Society Open Science*, 6(5), 181870.
- van der Bles, A. M., van der Linden, S., Freeman, A. L., & Spiegelhalter, D. J. (2020). The effects of communicating uncertainty on public trust in facts and numbers. *Proceedings of the National Academy of Sciences*, 117(14), 7672–7683.
- Vosoughi, S., Roy, D., & Aral, S. (2018). The spread of true and false news online. *Science*, 359(6380), 1146–1151.
- Weingart, P. (1998). Science and the media. *Research Policy*, 27(8), 869–879.
- Weinstein, N. D. (1980). Unrealistic optimism about future life events. *Journal of Personality and Social Psychology*, 39(5), 806–820.
- Wisner, B., Blaikie, P., Cannon, T., & Davis, I. (2004). *At Risk: Natural Hazards, People's Vulnerability and Disasters* (2nd ed.). Routledge.
- Wynne, B. (1992). Misunderstood misunderstanding: Social identities and public uptake of science. *Public Understanding of Science*, 1(3), 281–304.

Political Studies

Electoral Processes and the Legitimation of Political Authority: Results of the First Kurultai Election as an Indicator of Party System Development

V.A. Luzanov
Senior Lecturer, K.K. Kulazhanov Kazakh University of Technology and Business, Republic of Kazakhstan, Astana
N.G. Kabdii
Senior Lecturer, K.K. Kulazhanov Kazakh University of Technology and Business, Republic of Kazakhstan, Astana
A.M. Kenzhebulatova
Senior Lecturer, K.K. Kulazhanov Kazakh University of Technology and Business, Republic of Kazakhstan, Astana

Abstract. This article examines the relationship between electoral representation, party competition and the legitimation of political authority following the election to the first convocation of the Kurultai of the Republic of Kazakhstan on 23 August 2026. It analyses the composition of the new representative body using official election results, constitutional provisions and scholarly approaches to legitimacy. The methodology combines institutional analysis, calculation of the effective number of parties and a limited comparison with the party-list results of the 2023 Mazhilis election. The findings show that the presence of five parliamentary parties coexists with a high concentration of seats, with an effective number of parliamentary parties of approximately 1.69. The article argues that the electoral outcome establishes the distribution of representative authority but does not, in itself, measure public acceptance of political authority or the quality of political competition. It concludes that party system development should be assessed in terms of party autonomy, opportunities for political participation and the effectiveness of parliamentary oversight.

Keywords: elections, Kurultai, Kazakhstan, legitimacy, parties, representation, competition, institutionalisation, pluralism.

Introduction

The inaugural election of a new legislature has a dual political significance. It determines the allocation of parliamentary seats while also establishing how a revised constitutional framework operates in practice. An analysis of the first Kurultai election must therefore extend beyond identifying winners and losers. The research question is whether, and to what extent, the resulting structure of representation indicates party system development, and what foundations it provides for the legitimation of state authority.

In this article, party system development does not imply a predetermined trajectory towards a larger number of parties. Development may involve consolidation, organisational renewal or a reduction in the number of participants. Its political quality depends on whether parties become durable intermediaries between societal interests and government decisions,

retain their autonomy and offer citizens meaningful choices. Institutional renewal of parliament and the democratisation of party competition are thus related but empirically distinguishable processes.

The study aims to identify the relationship between the results of the first Kurultai election, the concentration of party representation and the conditions for legitimating political authority. It tests the proposition that the new body's formally multiparty composition coexists with a pronounced asymmetry of influence, making the number of represented parties an insufficient measure of the system's competitiveness. The study's original contribution lies in examining together the legal basis of representative mandates, the quantitative structure of representation and the conditions for public acceptance of the electoral procedure in the context of the first Kurultai.

Theoretical Framework and Research Methodology.

Legitimacy refers to the recognition of the right of political authorities to make collectively binding decisions, whereas legitimation denotes the process through which that recognition is established and reproduced. David Beetham's framework examines the legitimacy of power in terms of conformity to established rules, the justification of those rules through shared beliefs and the expression of consent by those subject to power. This approach distinguishes the legal conferral of authority from social acceptance of the way it is exercised [5]. In electoral research, this distinction means that the official determination of results and trust in the procedure must be examined using different sources.

David Easton distinguishes specific support, associated with assessments of incumbent authorities and their performance, from diffuse support for the political order [6]. A vote for a particular party may reflect approval of its platform, an assessment of its leader or expectations of material improvement. It does not automatically reveal the voter's attitude towards all state institutions. Similarly, dissatisfaction with parliamentary representatives does not necessarily imply a rejection of the representative system. An analysis of legitimacy must therefore consider the object, motivations and durability of support.

The analysis of the party system draws on Giovanni Sartori's distinction between the number of parties and their political relevance [9]. Parties with the same legal status may differ considerably in their capacity to influence decisions. In this article, quantitative weight is measured by seat share, while programmatic autonomy and the nature of interparty relations are considered separately. This approach avoids substituting a simple count of parliamentary groups for an analysis of competition.

The empirical basis comprises the Constitution of the Republic of Kazakhstan, electoral legislation, Central Election Commission resolutions on the results of the 2023 and 2026 elections, and the preliminary conclusions of the international election observation mission. Voting results and seat allocations are reported on the basis of Central Election Commission (CEC) data; assessments of the quality of the process are attributed to the observers. The analysis covers materials available as of 13 October 2026. The study does not draw on public opinion surveys, individual-level voter data or original field observations and therefore makes no claims about voting motivations or the extent of public trust.

Concentration is measured using the index developed by Markku Laakso and Rein Taagepera: $N = 1 / \Sigma p_i^2$, where p_i is the share held by each party [7]. In the parliamentary version, each share is calculated using the total number of allocated seats as the denominator; in the electoral version, the denominator is the total number of votes cast for all parties. Votes cast “against all” are not attributable to a party and are excluded from the electoral calculation, after which the party shares are normalised. This clarification is necessary because using percentages with a different denominator would alter the index and compromise the comparability of the results.

The Institutional Framework for the Formation of the Kurultai.

The Constitution adopted in the national referendum of 15 March 2026 defines the Kurultai as the supreme representative body exercising legislative power. It comprises 145 members elected for five years by proportional representation in a single nationwide constituency. Universal, equal and direct suffrage and voting by secret ballot are constitutionally guaranteed [1, Arts. 52–54]. The Kurultai as a legislative body must be distinguished from the former National Kurultai, which performed consultative functions.

The rules for determining election results and allocating seats are specified in the Constitutional Law "On Elections in the Republic of Kazakhstan"; the CEC applied a five per cent threshold when determining the results [2; 4, para. 2]. Proportional representation increases the importance of parties as a route to a parliamentary seat. Under these conditions, the quality of representation depends on how accessible and transparent party candidate selection procedures are, and on the extent to which members can oversee them. A nationwide list can bring together territorial interests, but does not in itself ensure their balanced inclusion on the parliamentary agenda.

The change in the electoral model creates a methodological challenge for comparison. The Kurultai results cannot be compared mechanically with the overall composition of the former Mazhilis without accounting for differences in how members were elected. This study uses the allocation of 69 party-list seats in 2023 as a limited comparative baseline [3, para. 3]. It compares structures of representation produced by votes for parties, rather than fully equivalent institutions. The differences identified therefore describe the concentration of seats; they do not establish an independent causal effect of the transition to unicameralism.

Election Results and the Concentration of Party Representation.

Under CEC Resolution No. 48/84 of 25 August 2026, five of the seven parties contesting the election qualified for seat allocation. Table 1 presents the voting results and initial allocation of seats. Vote shares are reproduced as officially reported, while seat shares are calculated by the author; subsequent changes in individual parliamentary membership are not considered here [4, paras. 1–3].

Table 1 — Results of the First Kurultai Election

Party / option	Votes	Votes, %	Seats	Seats, %
Adilet	6,528,948	71.17	110	75.86
Auyl	574,621	6.26	10	6.90
Respublica	509,631	5.56	9	6.21
Ak Zhol	478,083	5.21	8	5.52
NSDP	469,058	5.11	8	5.52
People's Party of Kazakhstan	285,395	3.11	0	0.00
Baitaq	97,751	1.07	0	0.00
Against all	230,446	2.51	—	—

Source: [4]; author's calculations. NSDP stands for the Nationwide Social Democratic Party. The rounded seat shares do not add up to exactly 100% because of rounding.

The largest party's share of Kurultai seats is 110 / 145 × 100 = 75.86%. The other four parliamentary parties together hold 35 seats, or 24.14%. With this distribution, the largest parliamentary group commands an absolute majority without needing an interparty coalition. This

is an arithmetic property of the representative body's composition; it does not imply that members invariably agree on every issue or that parliamentary oversight is absent in practice.

The effective number of parliamentary parties is $N_s = 145^2 / (110^2 + 10^2 + 9^2 + 8^2 + 8^2) = 1.694$. The electoral index, calculated from the absolute numbers of votes cast for the seven parties, is $N_v = 1.828$. Electoral support is thus somewhat more dispersed than parliamentary influence, although both values indicate a high degree of concentration. The formal presence of five parties does not amount to five centres of decision-making with comparable weight. This finding supports the initial proposition that representation is markedly asymmetric.

The largest party's seat share exceeds its reported vote share by approximately 4.69 percentage points. This difference cannot, on its own, be interpreted as evidence that the procedure violated proportionality: votes for parties below the threshold, the “against all” option and the prescribed method for allocating whole seats must also be taken into account. Assessing the accuracy of seat allocation requires vote shares calculated among parties eligible to receive seats, whereas assessing the inclusiveness of representation also requires consideration of votes excluded from that allocation. These two research questions require different denominators.

In 2023, the 69 party-list seats were distributed as follows: 40, 8, 6, 5, 6 and 4 seats [3, para. 3]. The effective number of parties in the proportional component of the Mazhilis was therefore $69^2 / (40^2 + 8^2 + 6^2 + 5^2 + 6^2 + 4^2) = 2.679$. The decline in the corresponding indicator to 1.694 records an increase in the concentration of representation. It should not be treated as a measure of change across the entire political system: the comparison covers only the allocation of party seats and does not isolate the effects of party reorganisation, election campaigns or changes to the rules.

A further limitation concerns party continuity. The international election observation mission notes the establishment of Adilet and its merger with AMANAT before the election [8, p. 5]. A change in the name of the leading organisation is therefore insufficient evidence of a change in the dominant political force. Assessing renewal requires an analysis of leadership, regional organisations, financial resources and programmatic commitments. Without such an analysis, it is appropriate to identify a change in the configuration of participants, but premature to conclude that the transformation of the model of party intermediation is complete.

The Legitimation of Political Authority and the Quality of Electoral Procedures.

Elections provide a legally constituted channel for conferring representative authority. Their legitimating effect, however, depends on whether participants regard the rules as fair, the choice as genuine and the vote count as reliable. A large winning margin can coexist with different levels of public trust. Without independent measurement, it is impossible to establish whether such a result reflects durable party identification, situational support for a policy agenda or other motivations for participation. Claims about legitimacy must be commensurate with the type of evidence available.

In its preliminary statement of 24 August 2026, the international election observation mission noted that the elections were technically well prepared, while also identifying limited political pluralism and a lack of clearly differentiated political alternatives. The observers also expressed concern about discrepancies between observed voter activity and announced turnout figures, as well as counting irregularities at some of the polling stations observed [8, pp. 1, 4]. These assessments must be taken into account when interpreting the legitimating significance of the official results. They form part of the mission's preliminary conclusions and should not be recast as a determination that the election as a whole was invalid.

Considering CEC data alongside observation findings helps avoid two methodological errors. The first is to equate an officially established majority with demonstrated public trust. The second is to generalise critical observations automatically to every polling station and all votes cast. Results statistics describe the recorded distribution of support; election observation

examines the conditions under which electoral rights are exercised. A well-grounded assessment requires these levels of analysis to be considered alongside records of complaint adjudication, available results protocols and representative surveys.

A further distinction is needed between support for the majority party and acceptance of the Kurultai as a representative institution for the political community as a whole. Parliament serves the entire political community, including citizens who voted for other parties, selected the “against all” option or did not vote. The durability of its legitimacy therefore depends on its capacity to represent disagreement. Deliberative procedures, public justification of decisions and opportunities for minority influence matter even when the outcome of a final vote is predetermined by the numerical majority.

A concentration of seats can reduce the costs of reaching agreement and make legislative work more predictable. At the same time, it increases the importance of mechanisms that prevent parliamentary deliberation from being displaced by internal party agreement. Where parties have little need to rely on one another, the majority can make decisions without substantial concessions to other parliamentary groups. This creates an institutional need for minority access to information, participation in budget debates, opportunities to raise oversight questions and scope to present alternatives publicly. Whether such opportunities exist must be assessed through parliamentary practice, rather than inferred from the mere presence of parliamentary groups.

Indicators of Party System Development after the Election.

Subsequent assessment of the party system should move beyond a single electoral snapshot to examine party behaviour throughout the parliamentary term. The first dimension is programmatic differentiation. This can be measured by comparing election commitments, bills, amendments and explanations of voting positions on significant issues. Differences in symbols and the social groups targeted by campaigns are insufficient if parties propose identical solutions and do not explain to voters why they agree with the majority.

The second dimension concerns organisational autonomy and social rootedness. Relevant indicators include the regularity of internal party elections, the openness of list formation, the participation of regional organisations and members' ability to influence the leadership. Party membership figures have explanatory value only when information about members' activity is also available. Durable links between parties and citizens require engagement between campaigns, responses to citizens' appeals and public reporting on the fulfilment of promises. These characteristics cannot be reconstructed from vote shares alone.

The third dimension concerns the substantive effectiveness of parliamentary participation. For smaller parliamentary groups, what matters is not only the number of speeches delivered and initiatives introduced, but also the proportion of amendments incorporated, the substantive quality of replies to parliamentary questions and the consequences of oversight activities. Voting in concert should not automatically be treated as evidence of dependence: it may reflect shared positions on a particular issue. Assessing autonomy requires sustained observation across different policy areas and examination of parties' public reasoning.

Finally, public trust should be measured in its own right. Representative studies should assess trust in parties, the Kurultai, electoral commissions and state institutions as a whole separately. Differences between supporters of the winning party and other participants, and between voters and non-voters, are particularly important. This design would establish whether citizens regard the procedure as fair regardless of their satisfaction with the outcome. Such data are not available in the present study; the proposed set of indicators constitutes an agenda for subsequent empirical testing.

Conclusion.

The results of the first Kurultai election reveal a combination of formal multiparty representation and a high concentration of parliamentary seats. Although five parties are represented, the effective number of parliamentary parties is approximately 1.69, and the largest parliamentary group holds 75.86% of the seats. A limited comparison with the allocation of party-list seats in 2023 indicates increased concentration. The results therefore support a finding of an asymmetric structure of representation; they do not, in themselves, demonstrate stronger competitive pluralism.

The legitimating significance of elections depends not only on the legal conferral of authority, but also on acceptance of the rules, the quality of participation and the subsequent accountability of representatives. Official results and observers' critical assessments illuminate different aspects of the process and must be analysed together. The evidence supports the conclusion that the Kurultai's first electoral cycle established an initial configuration of party influence, while the durability of public acceptance of the new institution requires separate examination. Further party system development will be reflected in parties' capacity to represent differing interests, influence the substance of decisions and connect citizens with the legislature.

References

1. Constitution of the Republic of Kazakhstan. Adopted by national referendum on 15 March 2026. URL: https://old.adilet.zan.kz/rus/docs/K2600000000 (accessed 13 October 2026).
2. On Elections in the Republic of Kazakhstan. Constitutional Law of the Republic of Kazakhstan No. 2464 of 28 September 1995. URL: https://old.adilet.zan.kz/rus/docs/Z950002464_ (accessed 13 October 2026).
3. On the Results of the Early Election of Deputies to the Eighth Convocation of the Mazhilis of the Parliament of the Republic of Kazakhstan and the Allocation of Seats in the Mazhilis of the Parliament of the Republic of Kazakhstan Based on the Results of Party-List Voting. Resolution of the Central Election Commission of the Republic of Kazakhstan No. 68/759 of 27 March 2023. URL: https://election.gov.kz/rus/news/acts/index.php?ID=8916 (accessed 13 October 2026).
4. On the Determination of the Results of the Election of Deputies to the Kurultai of the Republic of Kazakhstan and the Allocation of Parliamentary Seats Based on the Voting Results. Resolution of the Central Election Commission of the Republic of Kazakhstan No. 48/84 of 25 August 2026. URL: https://election.gov.kz/rus/news/acts/index.php?ID=10584 (accessed 13 October 2026).
5. Beetham, D. The Legitimation of Power. London: Macmillan, 1991. 267 pp. DOI: https://doi.org/10.1007/978-1-349-21599-7.
6. Easton, D. A Re-assessment of the Concept of Political Support. British Journal of Political Science. 1975. Vol. 5, no. 4, pp. 435–457. DOI: https://doi.org/10.1017/S0007123400008309.
7. Laakso, M., and Taagepera, R. “Effective” Number of Parties: A Measure with Application to West Europe. Comparative Political Studies. 1979. Vol. 12, no. 1, pp. 3–27. DOI: https://doi.org/10.1177/001041407901200101.
8. OSCE Office for Democratic Institutions and Human Rights. Kazakhstan: Early Parliamentary Elections, 23 August 2026: Statement of Preliminary Findings and Conclusions. 24 August 2026. 26 pp. URL: https://odihr.osce.org/odihr/667167 (accessed 13 October 2026).
9. Sartori, G. Parties and Party Systems: A Framework for Analysis. Colchester: ECPR Press, 2005. URL: https://ecpr.eu/Shop/ShopProductInfo?productID=17 (accessed 13 October 2026).

US-China AI Geopolitical Competition: Proprietary Frontier LLMs vs. Open-Source Models

Yeldar A. Duisembek
Abai Kazakh National Pedagogical University Sorbonne-Kazakhstan Institute, Department of International Relations, Specialty 6B03119 "International Relations in the Context of the New World Order"

Abstract

This research paper presents an expanded, comprehensive analysis of the global geopolitical competition in artificial intelligence (AI) between the United States of America and the People's Republic of China (PRC) amidst the structural realignment of the international order. The central thesis investigates the strategic, architectural, and ideological confrontation between U.S. proprietary (closed) frontier Large Language Models (LLMs) and China's counter-strategy of scaling and diffusing high-performance Open-Source AI architectures. Grounded in structural neorealism, techno-nationalism, and weaponized interdependence theories, this study examines how algorithm ownership, compute infrastructure, and software diffusion reshape the global distribution of power.

The paper demonstrates that in response to Washington's "Small yard, high fence" doctrine, Bureau of Industry and Security (BIS) export controls, and semiconductor chokepoints (NVIDIA, ASML, TSMC), Beijing has deployed an asymmetric counter-strategy. By disseminating state-of-the-art open-weights models (e.g., DeepSeek-R1/V3, Alibaba Qwen-2.5) across the Global South, China disrupts Western digital monopolies, institutionalizes its technical standards, and fosters long-term hardware-software ecosystem dependencies. Utilizing comparative case studies, geoeconomic modeling, and qualitative institutional analysis, the article evaluates the acceleration of digital fragmentation ("Splinternet") and the dilemmas of digital sovereignty facing developing nations. Finally, the study formulates a strategic "Digital Multi-vectorism" policy framework for middle powers, with a dedicated case study on the Republic of Kazakhstan's national AI development and diplomatic positioning in a technological bipolar world.

Keywords: Artificial Intelligence, Large Language Models (LLM), Open-Source Models, Proprietary Architectures, US-China Rivalry, Geopolitical Competition, Techno-Nationalism, Weaponized Interdependence, Global South, Digital Sovereignty, Splinternet, DeepSeek, OpenAI, Digital Multi-Vectorism, Kazakhstan.

1.INTRODUCTION

1.1 The Paradigmatic Shift in Global Power Projection

In the third decade of the 21st century, the international system is experiencing a fundamental structural transformation. The post-Cold War unipolar era, characterized by Western institutional dominance and neoliberal economic globalization, has yielded to a volatile multi-polar and technologically bi-centric global order. In this emerging paradigm, state power is no longer measured solely through traditional kinetic military assets, gross domestic product (GDP), or territorial footprint. Instead, national capability is increasingly defined by technological

supremacy—specifically the capacity to originate, control, deploy, and govern Artificial Intelligence (AI) systems and advanced compute infrastructure.

Artificial Intelligence, particularly generative AI powered by frontier Large Language Models (LLMs), operates as a primary General-Purpose Technology (GPT). It functions as a force multiplier across every domain of national power:

- Economic Productivity & Capital Accumulation: Automating high-value cognitive labor, accelerating scientific discovery, and reorganizing global supply chains.
- Military C4ISR & Autonomous Systems: Enhancing Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance; accelerating sensor-to-shooter loops; and powering autonomous kinetic platforms.
- Information Sovereignty & Algorithmic Power: Shaping cognitive domain dynamics, public discourse, ideological narratives, and normative legal frameworks on a global scale.

Consequently, the rivalry between the United States and the People's Republic of China has evolved from a conventional trade imbalance into an all-encompassing "technological cold war." Washington seeks to preserve its legacy unipolar dominance through a combination of capital concentration, proprietary intellectual property protection, and weaponized export controls. Conversely, Beijing—facing severe hardware sanctions—uses open-source AI diffusion as an asymmetric equalizer to undermine American technological hegemony and anchor the Global South within its technological ecosystem.

1.2 Scientific Apparatus of the Study

- Object of Research: The global technological and geopolitical competition between the United States of America and the People's Republic of China, and its structural impact on the balance of power within the international system.
- Subject of Research: The strategic mechanisms, architectural paradigms, geoeconomic tools, and normative frameworks through which U.S. proprietary frontier LLMs and Chinese Open-Source LLMs project power, establish institutional dependencies, and influence digital sovereignty.
- Research Objective: To conduct a comprehensive comparative investigation of American and Chinese AI development paradigms; to evaluate their geopolitical efficacy in establishing global dominance versus asymmetric neutralization; to analyze the resulting digital fragmentation of the international order; and to construct an actionable diplomatic strategy for middle powers, specifically the Republic of Kazakhstan.
- Research Tasks:
    1. Establish the theoretical nexus between AI technology architectures, structural neorealism, techno-nationalism, and weaponized interdependence in contemporary international relations.
    2. Deconstruct the U.S. proprietary LLM strategy, analyzing the Silicon Valley ecosystem, corporate capital concentration, Bureau of Industry and Security (BIS) semiconductor chokepoints, and the "Small yard, high fence" doctrine.
    3. Examine China's asymmetric Open-Source counter-strategy, detailing the DeepSeek and Alibaba Qwen breakthroughs, algorithmic resource optimization (Mixture-of-Experts, Multi-Head Latent Attention), and the "Digital Silk Road" expansion.
    4. Formulate a multi-variable empirical comparative analysis across economic, technical, geopolitical, and security dimensions using structured data benchmarks.
    5. Project systemic outcomes for the international order, including the "Splinternet" phenomenon, technological bipolarity, and the strategic dilemmas facing developing nations.

6. Develop a practical "Digital Multi-vectorism" policy blueprint for Kazakhstan, addressing national LLM development (KazLLM), data sovereignty, and technology hedging diplomacy.

- Scientific Hypothesis: In response to the U.S. strategy of securing global AI hegemony via proprietary model lock-in and hardware chokepoints, China's scaling of high-performance, cost-effective Open-Source AI architectures serves as an asymmetric geopolitical strategy. This strategy successfully disrupts Western digital monopolies, lowers technical barriers for the Global South, instigates long-term software-hardware ecosystem alignment with Beijing, and accelerates the transition toward a techno-bipolar world order.
- Methodological Framework: This study employs a multi-disciplinary methodology:
    1. *Structural Neorealism (Kenneth Waltz):* To analyze power distribution and systemic incentives under technological bipolarity.
    2. *Techno-Nationalism (Robert Reich) & Weaponized Interdependence (Henry Farrell, Abraham Newman):* To evaluate export controls, supply chain chokepoints, and state-backed technology protectionism.
    3. *Comparative Case Study & Geoeconomic Modeling:* To contrast technical, financial, and deployment metrics between U.S. entities (OpenAI, Google) and Chinese counterparts (DeepSeek, Alibaba).
    4. *Policy Synthesis:* To translate macro-geopolitical findings into actionable foreign policy recommendations for middle powers.

1.3 Theoretical Grounding & Literature Review

The geopolitical analysis of artificial intelligence intersects several established paradigms in international relations theory.

1. Structural Neorealism and the Distribution of Capabilities According to structural neorealism (Waltz, 1979; Gilpin, 1981), states operate in an anarchic international system where survival dictates the continuous maximization of relative power. In the 21st century, AI capability is a core determinant of a state's place in the international hierarchy. Graham Allison and Eric Schmidt (2023, 2024) argue that the U.S.-China AI race is not merely a commercial rivalry, but a struggle for structural dominance reminiscent of the Cold War space and nuclear races. Power transitions occur when an emerging challenger (China) leverages technological shifts to offset the established hegemon's (U.S.) structural advantages.

2. Weaponized Interdependence and Chokepoint Capitalism Henry Farrell and Abraham Newman (2019, 2023) introduced the framework of "weaponized interdependence," demonstrating how globalization created asymmetric network hubs that state actors can exploit for coercive leverage. In the AI domain, the U.S. government leverages physical and technological "chokepoints"—such as EUV lithography machines manufactured by ASML, advanced chip fabrication by TSMC, and GPU designs by NVIDIA—to cut off adversary states from critical supply chains.

3. Techno-Nationalism vs. Digital Cosmopolitanism Techno-nationalism (Reich, 1992; Bourt, 2024) links a nation’s security, economic prosperity, and social stability directly to its domestic technological innovation. While the U.S. enforces a techno-nationalist posture through strict IP preservation and export barriers, China combines domestic techno-nationalism with international "digital cosmopolitanism"—using open-source code as a diplomatic tool to position itself as a public goods provider for the Global South (Wang, 2024; Yan, 2023).

4. Western vs. Non-Western Academic Discourse Western scholars (CNAS, Belfer Center, CISA) frequently frame China's digital expansion through the lens of "digital authoritarianism" export, warning that Chinese technology creates surveillance infrastructure and autocratic alignment.

Conversely, Chinese scholars (Yan Xuetong, Wang Yiwei) conceptualize open-source technology transfer as a means of democratizing global governance, building a "Community with a Shared Future for Mankind," and offering developing nations a path toward genuine digital self-determination free from Western corporate exploitation.

2. THE U.S. PROPRIETARY FRONTIER MODEL STRATEGY: ARCHITECTURAL ENCLOSURE, CAPITAL CONCENTRATION, & SANCTIONS ENCIRCLEMENT

2.1 Silicon Valley Monopolistic Triad and Algorithmic Rent Extraction

The U.S. model of AI development is driven by a alliance between private capital, elite research institutions, and defense-adjacent technology conglomerates. Companies such as OpenAI (in partnership with Microsoft), Google (Alphabet/DeepMind), Anthropic (backed by Amazon and Google), and Meta (despite its hybrid open-weights releases) form the vanguard of American frontier AI.

Excepting Meta's Llama series, the primary U.S. frontier models—GPT-4o, OpenAI o1/o3, Gemini 1.5 Pro/Ultra, and Claude 3.5 Sonnet—are developed under a **proprietary, closed-source paradigm**. In this model:

- **Architecture & Weights Enclosure:** Neural network parameters, training datasets, reinforcement learning mechanics (RLHF), and source code are treated as corporate trade secrets.
- **Monopolistic API Distribution:** Users, enterprises, and foreign governments access models exclusively via subscription-based Application Programming Interfaces (APIs) hosted on American cloud infrastructure (Microsoft Azure, Amazon AWS, Google Cloud).
- **Algorithmic Rent Extraction:** By creating structural dependencies, American tech giants capture value globally. Foreign businesses integrating these APIs pay a continuous toll, channeling global capital back into Silicon Valley's R&D ecosystem.

Geopolitically, this closed architecture enforces **informational and ideological alignment**. Alignment techniques like RLHF embed Western liberal-democratic values, constitutional norms, and Western historical narratives into the model's outputs. Consequently, any state relying on American proprietary APIs passively imports U.S. cultural norms, safety guidelines, and political filters.

2.2 Semiconductor Chokepoint Capitalism and Export Control Regimes

To protect its proprietary AI lead, the U.S. government implemented an aggressive export control regime managed by the Bureau of Industry and Security (BIS) under the Department of Commerce. Transitioning from traditional free-market liberalism to state-directed techno-nationalism, the Biden administration codified the **"Small yard, high fence"** doctrine. This strategy targets three structural chokepoints in the semiconductor value chain:

1. **High-Performance Compute Bans:** BIS regulations established strict limits on processing power and interconnect bandwidth (e.g., total processing performance density thresholds). This effectively banned exports of NVIDIA's top-tier AI training GPUs (A100, H100) and even modified regional chips (H800, H20) to China.
2. **Advanced Lithography Blocking:** Leveraging extraterritorial jurisdiction (Foreign Direct Product Rules), the U.S. coerced Dutch equipment maker ASML to halt sales of EUV (Extreme Ultraviolet) and advanced DUV (Deep Ultraviolet) lithography systems to Chinese foundries such as SMIC (Semiconductor Manufacturing International Corporation).
3. **Foundry Fabrication Denial:** The U.S. prohibited Taiwan's TSMC—which produces over 90% of the world's advanced logic chips—from manufacturing custom-designed chips for Chinese entities (such as Huawei's HiSilicon division) utilizing processes below 7nm.

By weaponizing these physical chokepoints, Washington sought to deny Beijing the hardware required to train next-generation frontier models, effectively locking in an asymmetrical compute advantage for U.S. labs.

3. THE PRC'S ASYMMETRIC COUNTER-STRATEGY: OPEN-SOURCE DIFFUSION, ARCHITECTURAL OPTIMIZATION, & DIGITAL MULTI-POLARITY

Facing semiconductor sanctions and compute scarcity, the People's Republic of China adopted an **asymmetric counter-strategy**. Rather than engaging in a capital-intensive hardware arms race it could not immediately win, Beijing turned to algorithmic efficiency, architectural innovation, and the global distribution of **Open-Source (Open-Weights)** AI models.

3.1 Algorithmic Efficiency vs. Compute Scarcity: The DeepSeek and Qwen Disruptions

Between 2024 and 2026, Chinese AI labs achieved significant breakthroughs that challenged the assumption that AI dominance requires tens of thousands of top-tier GPUs.

- **DeepSeek (R1, V3, V2) Phenomenon:** Originating from a quantitative hedge-fund-backed research group, DeepSeek introduced novel model architectures including **Mixture-of-Experts (MoE)**, **Multi-Head Latent Attention (MLA)**, and FP8 mixed-precision training frameworks. DeepSeek-V3 and its reasoning counterpart DeepSeek-R1 achieved performance parity with closed frontier models (OpenAI GPT-4o, o1) at a fraction of the compute cost. DeepSeek-V3 was trained for roughly $6 million USD—a 20- to 30-fold reduction in training expenditure compared to U.S. frontier models costing $100 million to $500 million.
- **Alibaba Qwen Ecosystem:** Alibaba's Qwen series (Qwen-2.5, Qwen-Max, Qwen-Coder) emerged as one of the world's most versatile open-weights model families, leading global benchmarks in coding, mathematics, and multilingual reasoning.

By releasing these model weights publicly on repositories like Hugging Face and GitHub under permissive licenses, Chinese entities enabled developers, enterprises, and sovereign governments worldwide to download, fine-tune, and host advanced AI locally without paying subscription fees to American cloud providers.

3.2 The Digital Silk Road 2.0 and Global South Penetration

China's open-source strategy serves as the software pillar of the **Digital Silk Road (DSR)**, an integral component of the broader Belt and Road Initiative (BRI). For developing nations across Southeast Asia, Latin America, Africa, and the Middle East, American proprietary AI presents three core obstacles: high costs, infrastructure deficits, and sovereignty risks.

China's open-source strategy solves these challenges for the Global South:

- **Zero-Cost Core IP:** Developing nations can deploy state-of-the-art LLMs at no cost for the base intellectual property.
- **Local Data Sovereignty:** Open-weights models run on local or regional data centers, ensuring that national health, educational, financial, and security data stays within national borders.
- **Ecosystem Hardware Lock-In:** While the software is free, running these models at scale requires server infrastructure. As states adopt Chinese model architectures, they naturally purchase Chinese hardware—such as **Huawei Ascend 910B/910C AI processors** and Inspur server stacks—creating long-term infrastructure dependence on Beijing.

3.3 Normative Standardization and the "Global AI Governance Initiative"

At the 3rd Belt and Road Forum, President Xi Jinping announced China's **Global AI Governance Initiative**. This framework presents a state-centric normative model designed to counter Western governance models. Through multilateral institutions such as the United Nations, Shanghai Cooperation Organisation (SCO), and BRICS+, China promotes the principle that AI governance must respect sovereign borders. By offering open-source AI tools alongside a governance framework that upholds state sovereignty over data and content, Beijing presents an attractive alternative to developing nations seeking digital modernization without Western ideological conditions.

4. EMPIRICAL COMPARATIVE ANALYSIS & DATA INTEGRATION

This section presents a multi-variable empirical analysis contrasting the structural, economic, and operational dimensions of American proprietary AI architectures with Chinese open-source architectures.

4.1 Comprehensive Geopolitical and Economic Parameter Comparison

Table 1: Macro-Geopolitical and Economic Dimensions of US vs. PRC AI Architectures

Geopolitical & Economic Parameter	United States (Proprietary / Closed Paradigm)	People's Republic of China (Open-Source / Open-Weights Paradigm)
Leading Entities & Models	OpenAI (GPT-4o, o1, o3), Google (Gemini 1.5), Anthropic (Claude 3.5)	DeepSeek (R1, V3), Alibaba (Qwen-2.5), Baidu (Ernie)
Architectural Model	Closed-source API, encrypted weights, black-box pipeline	Open-weights, public GitHub/HuggingFace access, customizable
Capital Structure & R&D Funding	Private venture capital, BigTech mega-cap investments ($10B+)	State R&D subsidies, state-backed funds, corporate R&D
Primary Strategic Objective	Technological monopoly, algorithmic rent extraction, IP lock-in	Asymmetric counter-balancing, standard setting, Global South capture
Hardware Supply Chain Basis	NVIDIA GPUs, TSMC advanced nodes, ASML EUV lithography	Huawei Ascend (910B/C), SMIC domestic fabrication, MoE efficiency
Export Control Compliance	Strictly constrained by BIS regulations and U.S. EAR	Openly distributed globally, bypassing bilateral sanctions
Normative & Cultural Framework	Liberal-democratic alignment, Western RLHF, market self-regulation	Digital sovereignty, state-centric alignment, BRICS+ governance
Global South Market Strategy	High-cost SaaS subscriptions, API licensing, cloud-side hosting	Free foundational software, local infrastructure deployment, hardware sales

Analytical Synthesis (Table 1): The data highlights a structural divergence in how both superpowers project digital power. The United States leverages private capital concentration and supply-chain monopolies to create high-margin, rent-extracting software enclosures. Conversely, China uses open-source software as a loss-leader to bypass sanctions, commoditize American software, and capture down-market hardware and infrastructure deployments across non-Western markets.

4.2 Impact Matrix for Developing Nations and the Global South

Table 2: Strategic Impact Matrix for Global South & Developing Nations

Strategic Indicator	Adoption of U.S. Proprietary AI Models	Adoption of Chinese Open-Source AI Models
Capital Expenditure (CapEx)	Low initial CapEx (no local server investments required)	Moderate-to-High initial CapEx (server purchasing, local hosting)
Operational Expenditure (OpEx)	High and recurring OpEx (per-token API fees in USD)	Very Low OpEx (unlimited local processing without token fees)
Data Sovereignty & Security	**Low:** Sensitive data flows to U.S.-hosted cloud servers	**High:** Data remains within sovereign, localized data centers
Customization & Fine-Tuning	Restricted (limited to basic system prompts and fine-tuning APIs)	Absolute (full access to modify model weights, tokenizers, and code)
Risk of Political Disruption	**High:** Threat of service termination via U.S. sanctions	**Low:** Local copies run independently of foreign network cutoffs
Long-Term Ecosystem Lock-in	Lock-in to U.S. Cloud providers (Azure, AWS, Google Cloud)	Lock-in to Chinese AI hardware vendors (Huawei, Inspur)
Local Talent Development	Low (creates consumers of API endpoints rather than developers)	High (fosters domestic engineering capacity for model tuning)

Analytical Synthesis (Table 2): For middle powers and developing nations, selecting an AI architecture involves a strategic trade-off. While U.S. proprietary models offer lower entry costs and turn-key performance, they compromise long-term data sovereignty and create permanent financial leakage via USD subscription fees. Chinese open-source architectures require higher upfront infrastructure investments but offer data localization, immunity from foreign sanctions, and domestic engineering development—making them increasingly attractive to states pursuing national digital self-determination.

4.3 Technical, Financial, and Operational Benchmarks

Table 3: Technical, Financial, and Deployment Benchmarks (Closed vs. Open Paradigms)

Technical / Operational Metric	OpenAI (GPT-4o / o1) [U.S. Closed]	DeepSeek (V3 / R1) [PRC Open]
Estimated Base Training Cost	~$100,000,000 – $300,000,000+ USD	~$5,580,000 – $6,000,000 USD
Hardware Compute Cluster Used	~16,000–24,000+ NVIDIA H100 GPUs	~2,048 NVIDIA H800 GPUs (Cluster-optimized)
Core Algorithmic Innovation	Dense Transformers, RLHF scale, massive dataset curation	Mixture-of-Experts (MoE), Multi-Head Latent Attention (MLA)
Commercial API Cost (Input/Output)	High ($2.50 – $15.00+ per million tokens)	Ultra-Low ($0.14 – $0.55 per million tokens)
Model Weights Availability	Encrypted / Private (Proprietary)	Fully Public (Open-Weights under MIT/Apache License)
Local Deployment Capability	Impossible (Requires U.S. hyperscaler infrastructure)	Fully Supported (Deployable on sovereign data centers)
Multilingual & Local Context Tuning	Fixed by developer alignment protocols	Fully adaptable to regional languages (e.g., Kazakh, Uzbek)

Analytical Synthesis (Table 3): The technical benchmarks in Table 3 reveal how architectural efficiency can offset raw compute scale. DeepSeek achieved performance parity with top U.S. frontier models while spending roughly 2% to 5% of the capital required for traditional U.S. training runs. By making these efficient weights open-source, China disrupted the pricing power of the American AI sector and enabled middle powers to run advanced reasoning models within their own border infrastructure.

5. SCENARIOS FOR THE GLOBAL SYSTEM: DIGITAL BIPOLARITY, "SPLINTERNET," AND MIDDLE POWER HEDGING

5.1 The Fragmentation of the Global Digital Order ("Splinternet")

The structural divergence between U.S. proprietary enclosure and Chinese open-source diffusion is fragmenting the global internet into two distinct, incompatible technological spheres:

1. **The "Pax Technologica" Sphere (U.S.-Centric):** Comprising North America, Western Europe, Japan, South Korea, and Australia. This block relies on proprietary frontier models, high-cost subscription APIs, strict regulatory compliance (e.g., EU AI Act), and hardware monopolies secured by the NVIDIA-TSMC-ASML nexus.
2. **The "Digital Global South" Sphere (PRC-Centric):** Comprising China, Eurasia, parts of Southeast Asia, Africa, and Latin America. This block utilizes open-source AI weights, localized hosting on domestic data centers, Huawei hardware infrastructure, and state-centric cyber-sovereignty governance models.

This fragmentation extends beyond software into hardware, telecommunications (5G/6G networks), undersea fiber-optic cables, and international technical standards bodies (ITU, ISO).

5.2 Empirical Verification of the Research Hypothesis

The findings of this study validate the scientific hypothesis: *China's strategic deployment of high-performance, cost-effective Open-Source AI architectures serves as an effective asymmetric*

counter-strategy to U.S. proprietary monopolies and semiconductor export controls. By commoditizing foundational software models, China has neutralized the economic advantage of U.S. software lock-in, provided developing nations an accessible path to AI adoption, built long-term dependencies on Chinese hardware and technical standards, and accelerated the transition from a unipolar digital order to a techno-bipolar world system.

5.3 Policy Blueprint for Middle Powers: The Kazakhstan Case Study

For middle powers like the **Republic of Kazakhstan**, technological bipolarity presents both severe risks and strategic opportunities. Positioned at the heart of Eurasia, Kazakhstan must avoid becoming a digital colony of either superpower while advancing its national digital economy.

Strategic Recommendations for Kazakhstan's AI Policy:

1. **Implementation of a "Hybrid AI Architecture":**
    - *Sovereign/Public Sector:* Deploy localized open-source models (DeepSeek-R1, Qwen-2.5, Llama-3) within national state data centers for critical infrastructure—including defense, public administration, healthcare, and finance. This guarantees absolute data sovereignty, prevents foreign surveillance, and eliminates recurring USD token payments.
    - *Commercial/Academic Sector:* Allow private enterprises, research universities, and commercial startups unhindered access to U.S. proprietary APIs (OpenAI, Google Gemini) to spur innovation and maintain integration with Western markets.
2. **Development of the Sovereign "KazLLM" Model:**
    - Rather than spending hundreds of millions of dollars attempting to train a foundational LLM from scratch, Kazakhstan should use advanced open-source base models (such as DeepSeek-V3 or Qwen-2.5) as architectural foundations.
    - By fine-tuning these open weights on curated Kazakh, Russian, and Central Asian linguistic, cultural, historical, and legal datasets, Kazakhstan can rapidly produce a sovereign **KazLLM**. This model will preserve cultural heritage, eliminate algorithmic bias, and serve national administrative needs at minimal cost.
3. **Active "Digital Multi-Vectorism" Diplomacy:**
    - *Sino-Central Asian Vector:* Engage with China's "Digital Silk Road" to secure technology transfer, joint AI research centers, and hardware infrastructure investments (e.g., supercomputing facilities powered by green energy in Kazakhstan).
    - *Western Vector ("C5+1"):* Partner with American tech giants (Microsoft, Google, Amazon) to build cloud region hubs, establish AI talent centers, and secure investment for local tech ecosystems.
    - *Multilateral Standards Setting:* Participate actively in UN, ITU, and SCO AI governance discussions to advocate for the rights of middle powers, ensuring that global AI regulation remains accessible, non-discriminatory, and respectful of national digital sovereignty.

6. CONCLUSION

The geopolitical rivalry between the United States and the People's Republic of China in artificial intelligence marks a watershed moment in the evolution of international relations. The confrontation between U.S. proprietary frontier LLMs and Chinese Open-Source architectures is not merely a technical debate over code accessibility; it is a fundamental struggle over the distribution of global power, capital accumulation, ideological alignment, and digital sovereignty in the 21st century.

While the United States uses its capital concentration and semiconductor chokepoints to construct high-value proprietary software enclosures, China's open-source strategy offers an asymmetric counter-model that appeals to developing nations across the Global South. By lowering technological barriers, enabling local data hosting, and providing cost-effective alternatives to Western software monopolies, China is reshaping global digital infrastructure and accelerating the emergence of a techno-bipolar world order.

For middle powers like the Republic of Kazakhstan, surviving and thriving in this fragmented landscape requires a pragmatic, multi-vector approach. By adopting a hybrid technology architecture—leveraging open-source models for sovereign state functions while utilizing Western commercial APIs for global trade—middle powers can safeguard their national sovereignty, build indigenous technological capabilities, and maintain strategic autonomy amidst great power competition.

7. REFERENCES

1. Allison, G., & Schmidt, E. (2023). *Artificial Intelligence, China, and 21st Century Geopolitics*. Harvard Belfer Center Studies in International Security, 4, 12–29.
2. Allison, G., & Schmidt, E. (2024). Great Power Competition in the AI Era. *Foreign Affairs*, 103(1), 78–95.
3. Bostrom, N. (2014). *Superintelligence: Paths, Dangers, Strategies*. Oxford: Oxford University Press.
4. Bourt, N. (2024). Digital Techno-Nationalism: The US and China in the Semiconductor War. *International Security*, 48(2), 45–81.
5. Center for a New American Security (CNAS). (2023). *Securing the Compute Gate: US Export Controls and AI Hegemony*. Washington D.C.: CNAS Policy Reports.
6. DeepSeek AI Team. (2025). DeepSeek-R1: Incentivizing Reasoning Capability in LLMs via Reinforcement Learning. *arXiv preprint arXiv:2501.12948*, 1–32.
7. Farrell, H., & Newman, A. (2019). Weaponized Interdependence: How Global Economic Networks Shape State Coercion. *International Security*, 44(1), 42–79.
8. Farrell, H., & Newman, A. (2023). *Underground Empire: How America Weaponized the World Economy*. New York: Henry Holt and Co.
9. Gilpin, R. (1981). *War and Change in World Politics*. Cambridge: Cambridge University Press.
10. Keohane, R. O., & Nye, J. S. (2011). *Power and Interdependence* (4th ed.). Boston: Longman.
11. Ministry of Digital Development, Innovations and Aerospace Industry of the Republic of Kazakhstan. (2024). *Concept for the Development of Artificial Intelligence in the Republic of Kazakhstan for 2024–2029*. Astana: MDDIAI.
12. Ministry of Foreign Affairs of the People's Republic of China. (2023). *Global AI Governance Initiative*. Beijing: MFA PRC Official Document.
13. OpenAI. (2023). *GPT-4 Technical Report*. San Francisco: OpenAI Research Publications.
14. Qwen Architecture Team. (2024). Qwen2.5: Foundation and Instruction-Tuned Large Language Models. *Alibaba Group Research Publications*, 1–25.
15. Reich, R. (1992). *The Work of Nations: Preparing Ourselves for 21st Century Capitalism*. New York: Vintage Books.
16. Russell, S. (2021). *Human Compatible: Artificial Intelligence and the Problem of Control*. London: Penguin Books.
17. U.S. Bureau of Industry and Security (BIS). (2023). *Implementation of Additional Export Controls: Certain Advanced Computing Items and Semiconductor Manufacturing Items*. Washington D.C.: U.S. Department of Commerce.
18. Waltz, K. (1979). *Theory of International Politics*. Reading: Addison-Wesley.

19. Wang, Y. (2024). *Digital Silk Road: Artificial Intelligence and the Global South*. Beijing: Renmin University Press.
20. Yan, X. (2023). Bipolarity and Technological Determinism in the New International System. *The Chinese Journal of International Politics*, 16(3), 201–225.

ҚАЗАҚСТАН МЕН ҚЫТАЙ АРАСЫНДАҒЫ ЭКОНОМИКАЛЫҚ ДИПЛОМАТИЯНЫҢ ЖАҢА ҚҰРАЛДАРЫ: ЦИФРЛЫҚ САУДА, ИНВЕСТИЦИЯЛЫҚ ЫНТЫМАҚТАСТЫҚ ЖӘНЕ КӨЛІК ДӘЛІЗДЕРІ

Сұлтанханұлы Есбол
2 курс магистранты, М. Әуезов атындағы Оңтүстік Қазақстан университеті, Шымкент қ., Қазақстан, Заң факультеті, Халықаралық қатынастар және халықаралық құқық кафедрасы, 7М03101 – Халықаралық қатынастар
Ғылыми жетекші:
Исова Лаура Танирбергеновна
М. Әуезов атындағы Оңтүстік Қазақстан университеті, Шымкент қ., Қазақстан, Заң факультеті, Халықаралық қатынастар және халықаралық құқық кафедрасы, 7М03101 – Халықаралық қатынастар

АҢДАТПА

Мақалада Қазақстан Республикасы мен Қытай Халық Республикасы (ҚХР) арасындағы экономикалық дипломатияның заманауи трансформационды модельдері мен жаңа құралдары кең ауқымда талданады. XXI ғасырдың екінші онжылдығындағы геосаяси қайшылықтар мен геоэкономикалық қайта құрулар жағдайында екі ел арасындағы стратегиялық өзара іс-қимыл дәстүрлі сауда-саттық пен шикізаттық бағыттан шығып, жоғары технологиялық, цифрлық және инфрақұрылымдық мазмұнға ие болды. Зерттеудің басты мақсаты – цифрлық сауда, индустриялық-инновациялық инвестициялық біріккен жобалар және Транскаспий халықаралық көлік бағдары (Орта дәліз) сияқты жаңа экономикалық дипломатия тетіктерінің Қазақстанның макроэкономикалық тұрақтылығы мен географиялық артықшылықтарын жүзеге асыруға тигізетін әсерін сыни тұрғыдан бағалау.

Зерттеудің әдіснамалық негізін жүйелік талдау, геоэкономикалық концептуализация, салыстырмалы-құқықтық талдау, статистикалық деректерді терең интерпретациялау және сценарийлік болжау тәсілдері құрайды. Зерттеудің негізгі нәтижелері көрсеткендей, «Бір белдеу, бір жол» бастамасы мен «Цифрлық Жібек жолы» тұжырымдамасының тоғысуы Қазақстанды Еуразия құрлығындағы негізгі транзиттік және логистикалық хабқа айналдырды. Сонымен қатар, мақалада цифрлық сауда мен технологиялық инфрақұрылымның қарқынды өсуімен қатар жүретін жүйелік тәуекелдер – цифрлық егемендікке қатерлер, асимметриялық өзара тәуелділік, инвестициялық міндеттемелердің қайтарымдылығы және сыртқы экономикалық қауіпсіздік мәселелері жан-жақты сараланады. Зерттеу қорытындысы бойынша екіжақты дипломатиялық диалогты нығайту, ұлттық мүдделерді қорғау және технологиялық трансфертті қамтамасыз етуге бағытталған практикалық-стратегиялық ұсыныстар тұжырымдалды.

Кілт сөздер: экономикалық дипломатия, цифрлық сауда, «Бір белдеу, бір жол», «Цифрлық Жібек жолы», инвестициялық ынтымақтастық, Транскаспий халықаралық көлік бағдары (Орта дәліз), геоэкономика, цифрлық егемендік, асимметриялық өзара тәуелділік.

1. КІРІСПЕ

1.1. Зерттеу тақырыбының өзектілігі мен геоэкономикалық контексі

XXI ғасырдың қазіргі кезеңінде халықаралық қатынастар жүйесі терең құрылымдық және институционалдық трансформацияны бастан кешіруде. Жаһандық геосаяси турбуленттілік, дәстүрлі логистикалық тізбектердің үзілуі, санкциялық текетірестердің күшеюі және протекционистік тенденциялардың өсуі жағдайында мемлекеттердің сыртқы саясатындағы экономикалық дипломатияның рөлі түбегейлі өзгерді. Экономикалық дипломатия енді сауда келісімшарттарын жасасудың қарапайым механизмі емес, ол ұлттық экономикалық қауіпсіздікті қамтамасыз етудің, технологиялық егемендікті сақтаудың және жаһандық қайта бөлісте стратегиялық басымдықтарға ие болудың негізгі құралына айналды.

Орталық Азия өңірінде геоэкономикалық қайта құрулардың тоғысу нүктесінде тұрған Қазақстан Республикасы үшін сыртқы саясатты әртараптандыру және өңірлік көшбасшылықты сақтау басты басымдық болып табылады. Осы контекстте Қазақстан мен Қытай Халық Республикасы (ҚХР) арасындағы мәңгілік жан-жақты стратегиялық серіктестік ерекше сипатқа ие. Қытай – әлемдегі екінші ірі экономика, жаһандық сауданың драйвері және жоғары технологиялар мен инфрақұрылымдық капиталдың негізгі экспортерлерінің бірі. Екі ел арасындағы дипломатиялық қатынастардың даму тарихы көрсеткендей, өзара ықпалдастық модельдері қарапайым шекаралық саудадан бастап, ауқымды трансконтиненттік жобаларға дейінгі эволюциялық жолдан өтті.

Бүгінгі таңда екіжақты экономикалық дипломатияның мазмұны цифрлық сауданы кеңейту, индустриялық-инновациялық инвестициялық жобаларды іске асыру және халықаралық көлік дәліздерін (әсіресе Транскаспий халықаралық көлік бағдарын) дамыту сияқты мүлдем жаңа, жоғары технологиялық құралдармен толығуда. Бұл процестер Қазақстанның «Нұрлы жол» инфрақұрылымдық даму мемлекеттік бағдарламасы мен Қытайдың «Бір белдеу, бір жол» (ББББЖ) жаһандық бастамасының стратегиялық тоғысуы аясында өтуде.

1.2. Зерттеудің ғылыми проблемасы мен гипотезасы

Зерттеудің ғылыми проблемасы – Қазақстанның Қытаймен экономикалық дипломатиясындағы жаңа құралдардың (цифрлық, инвестициялық, инфрақұрылымдық) қарқынды дамуы мен осы құралдарды ұлттық экономикалық қауіпсіздік пен институционалдық дайындық тұрғысынан тиімді басқару тетіктерінің жеткіліксіздігі арасындағы қайшылықта жатыр. Қазақстан қытайлық капитал мен технологияға мұқтаж бола отырып, сонымен бірге асимметриялық өзара тәуелділікке, технологиялық доминацияға және қарыздық жүктемеге тап болуы мүмкін.

Зерттеу гипотезасы: Егер Қазақстан Республикасы Қытаймен екіжақты экономикалық дипломатияда цифрлық және инфрақұрылымдық құралдарды белсенді пайдалана отырып, технологиялық оқшаулауды (локализация), институционалдық ашықтықты және стратегиялық әртараптандыруды камтамасыз ететін көпвекторлы теңгерімді сақтай алса, онда бұл жаңа құралдар елдің транзиттік-экономикалық әлеуетін арттырып, шикізаттық тәуелділіктен арылуға және жаһандық құн тізбегінде жоғары позицияға ие болуға мүмкіндік береді.

1.3. Зерттеу нысаны, пәні, мақсаты мен міндеттері

- **Зерттеу нысаны:** Қазақстан Республикасы мен Қытай Халық Республикасы арасындағы заманауи экономикалық дипломатия және сыртқы экономикалық өзара іс-қимыл жүйесі.
- **Зерттеу пәні:** Қазақстан-Қытай екіжақты қатынастарындағы цифрлық сауда, біріккен инвестициялық бағдарламалар мен көлік-логистикалық дәліздердің қызмет ету механизмдері, институционалдық құрылымдары және олардың макроэкономикалық салдарлары.

- **Зерттеу мақсаты:** Қазақстан мен Қытай арасындағы экономикалық дипломатияның жаңа құралдарының (цифрлық сауда, инвестициялық ынтымақтастық, көлік дәліздері) сипатын, даму динамикасын және олардың Қазақстанның ұлттық мүдделеріне әсерін сыни тұрғыдан кешенді талдау, сондай-ақ сыртқы экономикалық саясатты жетілдіруге арналған стратегиялық ұсыныстар әзірлеу.

Осы мақсатқа жеткенге дейін мынадай негізгі міндеттер белгіленді:

1. Халықаралық қатынастар теориясындағы экономикалық дипломатияның эволюциясын және «геоэкономикалық байланыс» (geo-economic connectivity) мен «цифрлық Жібек жолы» концепцияларын зерделеу.
2. Қазақстан мен Қытай арасындағы электронды коммерция мен трансшекаралық цифрлық сауданың қазіргі жағдайын, инфрақұрылымын және заңнамалық базасын талдау.
3. Екі ел арасындағы біріккен индустриялық-инновациялық инвестициялық жобалардың құрылымын, секторлық бөлінісін және олардың отандық экономиканы әртараптандыруға тигізетін әсерін бағалау.
4. Транскаспий халықаралық көлік бағдарының (Орта дәліз) және құрлықтық логистикалық хабтардың (Қорғас, Ляньюньган, Ақтау, Құрық) стратегиялық рөлін геосаяси жағдайлар контекстінде айқындау.
5. Экономикалық дипломатияның жаңа құралдары тудыратын оң макроэкономикалық эффектілер мен ықтимал жүйелік тәуекелдерді (технологиялық тәуелділік, асимметрия, қарыздық салмақ) сыни тұрғыдан саралау.
6. Қазақстанның экономикалық егемендігін нығайтуға және екіжақты ынтымақтастықтың тиімділігін арттыруға бағытталған практикалық және стратегиялық ұсыныстар пакетін тұжырымдау.

1.4. Зерттеудің әдіснамалық негіздері

Зерттеу пәнаралық сипатқа ие болып, халықаралық қатынастар, халықаралық құқық, геоэкономика және макроэкономикалық талдау әдістерін біріктіреді. Жұмыста келесідей ғылыми әдістер қолданылды:

- **Жүйелі талдау әдісі:** Экономикалық дипломатияны көпфакторлы, ішкі және сыртқы элементтерден тұратын тұтас жүйе ретінде қарастыруға мүмкіндік берді.
- **Геоэкономикалық және кеңістіктік талдау:** Қытайдың «Бір белдеу, бір жол» бастамасы мен Транскаспий көлік дәлізінің географиялық және экономикалық маңызын айқындау үшін пайдаланылды.
- **Салыстырмалы-құқықтық талдау:** Екі ел арасындағы халықаралық келісімшарттарды, инвестициялық кепілдіктерді және цифрлық сауданы реттейтін нормативтік-құқықтық актілерді саралауда қолданылды.
- **Статистикалық және экономикалық талдау:** Екіжақты сауда айналымы, инвестициялар ағыны, жүк тасымалдау көлемдері бойынша ресми статистикалық деректерді (ҚР Ұлттық статистика бюросы, ҚР СІМ, ҚХР Сауда министрлігі, Дүниежүзілік банк) өңдеуде қолданылды.

2. ТЕОРИЯЛЫҚ-ӘДІСНАМАЛЫҚ НЕГІЗДЕРІ

2.1. Халықаралық қатынастардағы экономикалық дипломатия ұғымының эволюциясы

Экономикалық дипломатия ұғымы халықаралық қатынастар ғылымында ұзақ эволюциялық жолдан өтті. Классикалық меркантилизм дәуірінен бастап, мемлекеттердің байлығы мен әскери қуаты олардың сыртқы сауда жүйесін бақылауымен тығыз байланысты болды. Ал XX ғасырдың екінші жартысында, әсіресе Бреттон-Вудс жүйесінің қалыптасуымен және Жаһандық сауда ұйымының (ЖСҰ) құрылуымен, экономикалық дипломатия либералды халықаралық тәртіптің басты реттеуші құралына айналды.

Академик Г. Бэнара (G. Berridge) мен А. Джеймс (A. James) экономикалық дипломатияны «мемлекеттің сыртқы саясатын іске асыруда сауда, инвестиция, қаржы және технологиялық ресурстарды пайдалану процесі» деп анықтайды. Ал заманауи зерттеуші Г. Саннавалд (G. Saner) экономикалық дипломатияның екі негізгі өлшемін бөліп көрсетеді:

1. **Экономикалық мақсаттардағы дипломатия:** Сыртқы саяси құралдар мен дипломатиялық арналарды пайдалана отырып, отандық компанияларға шетелдік нарықтарда қолайлы жағдай жасау, инвестиция тарту және сауда тосқауылдарын жою.
2. **Дипломатиялық мақсаттардағы экономикалық құралдар:** Мемлекеттің геосаяси мүдделерін, одақтастық міндеттемелерін немесе өңірлік көшбасшылығын ілгерілету үшін экономикалық санкцияларды, субсидияларды, несиелер мен инфрақұрылымдық жобаларды қолдану.

XXI ғасырдың цифрлық дәуірінде экономикалық дипломатия түбегейлі жаңа түріне – **«гибридті немесе жаңа экономикалық дипломатияға»** айналды. Мұнда мемлекеттермен қатар трансұлттық корпорациялар, цифрлық платформалар, суверенді қаржы қорлары және халықаралық логистикалық операторлар негізгі субъектілер ретінде әрекет етеді.

2.2. Геоэкономика, инфрақұрылымдық дипломатия және «байланыс геополитикасы» (Geo-economic connectivity)

Қазіргі халықаралық қатынастарда геосаяси текетірес геоэкономикалық құралдар арқылы жиі жүзеге асады. Эдвард Люттвак (E. Luttwak) енгізген «геоэкономика» концепциясы мемлекеттер арасындағы бәсекелестіктің әскери күштен экономикалық, инфрақұрылымдық және технологиялық басымдыққа ауысқанын дәлелдейді. Мұндай бәсекелестіктің негізгі аренасы – **«байланыс геополитикасы» (connectivity geopolitics)**.

Инфрақұрылымдық дипломатия бұл контекстте географиялық кеңістікті қайта құрылымдаудың пәрменді тетігі болып табылады. Қытайдың «Бір белдеу, бір жол» (ББББЖ) бастамасы – жаһандық инфрақұрылымдық дипломатияның ең ауқымды үлгісі. В. Кханна (P. Khanna) өзінің «Connectography» еңбегінде атап өткендей, XXI ғасырда шекаралардан гөрі инфрақұрылымдық желілер (жолдар, порттар, құбырлар, оптикалық кабельдер) әлдеқайда маңызды саяси маңызға ие. Кім бұл желілерді бақыласа және стандарттарды белгілесе, сол жаһандық сауда мен геоэкономикалық процестердің басты координаторына айналады.

Қазақстан сияқты теңізге тікелей шығу мүмкіндігі жоқ (landlocked) мемлекеттер үшін инфрақұрылымдық дипломатия «құрлықпен шектелген елден» (landlocked) «құрлық арқылы байланысқан елге» (land-linked) айналудың жалғыз стратегиялық жолы болып табылады.

2.3. «Цифрлық сауда» және «Цифрлық Жібек жолы» (Digital Silk Road) тұжырымдамалық негіздері

Экономикалық дипломатияның физикалық инфрақұрылымнан цифрлық кеңістікке өтуі «Цифрлық Жібек жолы» (Digital Silk Road) тұжырымдамасын дүниеге әкелді. 2015 жылы ҚХР Үкіметі ресми түрде жариялаған бұл бастама ББББЖ жобасының ажырамас бөлігі болып табылады. «Цифрлық Жібек жолы» мынадай негізгі элементтерді қамтиды:

- Трансшекаралық оптикалық-талшықты байланыс желілерін тарту;
- 5G мен 6G телекоммуникациялық инфрақұрылымын орнату;
- Деректерді өңдеу орталықтарын (Data Centers) және бұлттық технологияларды салу;
- Трансшекаралық электронды коммерция платформаларын (e-Commerce) дамыту;
- Ғарыштық навигациялық жүйелерді (Beidou) біріктіру.

Цифрлық сауда бұл жүйеде тек тауарлар мен қызметтерді Интернет арқылы сату ғана емес, ол трансшекаралық деректер ағынын реттеу, киберқауіпсіздік стандарттарын қалыптастыру және цифрлық валюталарды (мысалы, цифрлық юань) халықаралық есеп айырысуларға енгізу процесі. Осылайша, «цифрлық сауда» халықаралық қатынастарда цифрлық егемендік

пен технологиялық стандартизация төңірегіндегі жаңа дипломатиялық күрес өрісіне айналды.

3. ҚАЗАҚСТАН-ҚЫТАЙ ЭКОНОМИКАЛЫҚ ДИПЛОМАТИЯСЫНЫҢ ҚАЗІРГІ ЖАҒДАЙЫ ЖӘНЕ ЖАҢА ҚҰРАЛДАРЫ

3.1. Цифрлық сауда және трансшекаралық электронды коммерцияның даму динамикасы

Соңғы жылдары Қазақстан мен Қытай арасындағы экономикалық дипломатияның ең динамикалық құралдарының бірі ретінде трансшекаралық электронды коммерция (cross-border e-commerce) қалыптасты. Бұл бағыт дәстүрлі бюрократиялық сауда кедергілерін жойып, B2B (business-to-business) және B2C (business-to-consumer) сегменттерін жеделдетті. Қазақстан Республикасы Сауда және интеграция министрлігі мен ҚХР Сауда министрлігі арасындағы уағдаластықтар аясында Қытайдың Alibaba Group, JD.com, Pinduoduo сияқты ірі маркетплейстерінде Қазақстанның ұлттық павильондары іске қосылды. Бұл дипломатиялық дәрежедегі қолдаудың арқасында отандық 100-ден астам өндіруші компаниялар Қытайдың алып тұтынушылық нарығына тікелей шығу мүмкіндігін алды. Тамақ өнеркәсібі өнімдері (ұн, өсімдік майы, бал, сусындар, кондитерлік өнімдер) цифрлық сауда платформаларында жоғары сұранысқа ие.

Кесте 1. Қазақстан мен Қытай арасындағы сауда және цифрлық сауданың даму динамикасы (2020-2023 жж.)

Көрсеткіштер	2020 ж.	2021 ж.	2022 ж.	2023 ж.
Жалпы екіжақты сауда айналымы (млрд долл.)	15,3	18,2	24,1	41,5
Қазақстан экспорты (млрд долл.)	9,0	9,8	13,2	14,7
Қытайдан импорт (млрд долл.)	6,3	8,4	10,9	26,8
Электронды коммерция арқылы сауда көлемі (бағалау, млн долл.)	120	280	550	1100
Alibaba платформасындағы отандық компаниялар саны	45	75	100	135+

Дереккөз: ҚР Ұлттық статистика бюросы және ҚР Сауда және интеграция министрлігінің ресми деректері негізінде автормен құрастырылған.

Цифрлық сауданы инфрақұрылымдық тұрғыдан қамтамасыз ету үшін Қазақстанның «Қазпошта» АҚ мен қытайлық логистикалық гиганттар (Cainiao, ZTO Express) арасында стратегиялық келісімдер жасалды. Алматы мен Сиань қалаларында цифрлық сұрыптау және логистикалық орталықтар ашылып, трансшекаралық пошта мен жүк сәлемдемелерін өңдеу уақыты 20-30 күннен 7-10 күнге дейін қысқарды.

Сонымен қатар, цифрлық сауда дипломатиясы финтех саласын да қамтиды. Қазақстанда Kaspi.kz мен қытайлық Alipay және WeChat Pay төлем жүйелерін интеграциялау жобалары қолға алынуда. Бұл екі ел арасындағы туризм, шағын бизнес өкілдерінің сапарлары мен трансшекаралық есеп айырысуларды жеңілдетеді.

3.2. Инвестициялық ынтымақтастықтың трансформациясы: Шиткізаттық бағыттан индустриялық-инновациялық модельге өту

Дәстүрлі түрде Қытайдың Қазақстанға құйған инвестициялары мұнай-газ, тау-кен өндірісі секілді бастапқы ресурс секторына бағытталған еді. Алайда, екі ел арасындағы экономикалық дипломатияның белсенді жүргізілуі арқасында 2015 жылдан бастап **Индустрияландыру мен инвестициялар саласындағы қазақстандық-қытайлық ынтымақтастық бағдарламасы** іске қосылды. Жалпы құны 21 миллиард АҚШ долларынан асатын 50-ден астам біріккен жобадан тұратын бұл портфель инвестициялық дипломатияның негізгі өзегі болып табылады.

Инвестициялық ынтымақтастықтың жаңа кезеңі мынадай негізгі бағыттармен сипатталады:

1. **Машина жасау және автокөлік өнеркәсібі:** Қостанай («СарыарқаАвтоПром») және Алматы қалаларында қытайлық JAC, Chery, Changan, Haval, Geely брендтерінің автокөліктерін құрастыру және өндірісті локализациялау жобалары іске асты.
2. **Жаңартылатын энергетика (ЖЭК):** Қытай капиталдары мен технологиялары (PowerChina, Universal Energy) арқылы Қазақстанның оңтүстік және шығыс өңірлерінде ірі жел және күн электр станциялары (мысалы, Жанатас ЖЭС, Жаңақорған КЭС) салынды. Бұл Қазақстанның «жасыл» экономикаға өту стратегиясына сәйкес келеді.
3. **Агроөнеркәсіптік кешенді терең өңдеу:** Солтүстік Қазақстан және Ақмола облыстарында бидай, рапс, майлы дақылдарды терең өңдейтін заманауи зауыттар салынды (мысалы, «Тайынша Май»).
4. **Химия және металлургия өнеркәсібі:** Жамбыл облысында минералды калий тыңайтқыштарын өндіру және шыны зауыттарының құрылысы сияқты инновациялық кластерлер құрылды.

Сурет 1. Қытайдың Қазақстанға салған тікелей инвестицияларының (ТҚИ) секторлық құрылымының трансформациясы (2010 ж. және 2023 ж. салыстырмалы талдау) (Ескерту: 2010 жылы ТҚИ-ның 75%-ы мұнай-газ секторына тиесілі болса, 2023 жылға қарай бұл үлес 35%-ға дейін төмендеп, өңдеу өнеркәсібі, энергетика, транспорт және АКТ үлесі 65%-ға жетті).

Инвестициялық дипломатияның институционалдық негізін Қазақстан тарапынан «KAZAKH INVEST» ҰК» АҚ және Астана халықаралық қаржы орталығы (АХҚО), ал Қытай тарапынан Жібек жолы қоры (Silk Road Fund), Қытай даму банкі (CDB) және Қытай Эксимбанкі (Exim Bank of China) құрайды. АХҚО юаньмен деноминацияланған қаржылық құралдарды (Dim Sum bonds) шығару арқылы қытайлық инвестицияларды тартудың өңірлік орталығына айналды.

3.3. Транскаспий халықаралық көлік бағдары (Орта дәліз) және құрлықтық логистикалық хабтар

Екіжақты қатынастардағы инфрақұрылымдық дипломатияның ең маңызды жеңісі – Қазақстанның транзиттік әлеуетін іске асыру. Геосаяси жағдайларға байланысты Ресей арқылы өтетін Солтүстік дәліздің қауіп-қатерлері артқан тұста, Қытай – Қазақстан – Каспий теңізі – Әзірбайжан – Грузия – Турция – Еуропа бағыты бойынша созылып жатқан **Транскаспий халықаралық көлік бағдары (ТХКБ / Middle Corridor)** стратегиялық баламаға айналды.

Қытай үшін Орта дәліз – Еуропалық Одақ нарығына шығудың ең қысқа және қауіпсіз бағдары. Қазақстан үшін бұл – инфрақұрылымды жаңғырту және транзиттік тарифтерден үлкен табыс табу көзі.

Кесте 2. Қазақстан-Қытай инфрақұрылымдық дипломатиясының негізгі хабтары мен жобалары

Инфрақұрылымдық объект	Стратегиялық функциясы	Логистикалық қуаттылығы / Нәтижесі
«Қорғас – Шығыс қақпасы» АЭА	Құрлықтық «құрғақ порт», мультимодальды логистикалық хаб	Жылына 540 мың TEU контейнер өңдеу әлеуеті, Азия мен Еуропаны түйістіру
Ляньюньган портындағы қазақстандық-қытайлық терминал	Қазақстанның Тынық мұхитына шығатын сыртқы логистикалық базасы	Тынық мұхиты өңірінен Еуразияға өтетін жүктерді шоғырландыру
Сиань қаласындағы Қазақстанның логистикалық терминалы	Қытайдың орталығындағы жүк жинақтаушы басты хаб	Қытайдың барлық өңірлерінен контейнерлік поездарды құрастыру
«Достық – Мойынты» теміржол учаскесін электрлендіру мен екінші жолдар салу	Транзиттік өткізу қабілетін артыру	Жүк тасымалдау жылдамдығын 5 есеге дейін арттыру
Ақтау және Құрық теңіз порттарын жаңғырту	Каспий акваториясындағы контейнерлік флотты кеңейту	Каспий арқылы жүк өткізуді 2025 жылға қарай 10 млн тоннаға жеткізу

Дереккөз: «Қазақстан темір жолы» ҰК» АҚ ресми есептері негізінде автормен құрастырылған.

Сиань қаласында салынған қазақстандық логистикалық терминал дипломатиялық өзара іс-қимылдың жоғары тиімділігін білдіреді. Сиань – Қытайдың ББББЖ бастамасы бойынша Еуропаға жөнелтілетін контейнерлік поездардың 30%-дан астамын қалыптастыратын басты логистикалық торап. Осы торапта Қазақстанның өз терминалының болуы отандық жүк тасымалдаушыларға басымдық береді.

4. ТАЛДАУ ЖӘНЕ ТАЛҚЫЛАУ: МАКРОЭКОНОМИКАЛЫҚ ӘСЕРЛЕР ЖӘНЕ ЖҮЙЕЛІК ТӘУЕКЕЛДЕР

4.1. Жаңа экономикалық құралдардың Қазақстан экономикасына тигізетін оң мультипликативті әсері

Экономикалық дипломатияның жаңа құралдарын енгізу Қазақстан үшін айтарлықтай оң макроэкономикалық нәтижелер берді:

1. **Сауда көлемінің тарихи рекорды:** 2023 жылы екі ел арасындағы тауар айналымы 41,5 миллиард долларға жетіп, Қытай Қазақстанның ең ірі сауда серіктесіне айналды.
2. **Транзиттік табыстардың өсуі:** «Қазақстан темір жолы» ҰК» АҚ деректері бойынша, Қытай бағытындағы транзиттік жүк тасымалынан түсетін кіріс соңғы 5 жылда 2,5 есеге артты. Транзит экономиканың шикізаттық емес секторларына жанама серпін беруде.
3. **Өндірістік локализация және жұмыс орындары:** Индустриялық біріккен жобалар есебінен Қазақстанда 25 мыңнан астам жаңа жоғары білікті жұмыс орны құрылды. Технологиялық трансферт отандық инженерлік-техникалық кадрлардың квалификациясын арттыруға мүмкіндік берді.
4. **Ауыл шаруашылығын экспортқа бағдарлау:** Қытай тарапынан фитосанитарлық шектеулердің жұмсартылуы және екіжақты протоколдарға қол қойылуы арқасында қазақстандық органикалық өнімдер Қытай маркетплейстерінде брендке айнала бастады.

4.2. Сын-қатерлер мен геоэкономикалық тәуекелдерді сыни талдау

Оң нәтижелермен қатар, Қытаймен экономикалық дипломатияда терең сыни талдауды талап ететін бірқатар жүйелік тәуекелдер мен асимметриялық проблемалар бар.

А) Технологиялық тәуелділік және цифрлық егемендік мәселелері

«Цифрлық Жібек жолы» аясында Қазақстан қытайлық телекоммуникациялық компанияларға (Huawei, ZTE, Hikvision) жоғары дәрежеде тәуелді болып отыр. Қазақстанның 5G желілік инфрақұрылымын салу, «Акылды қала» (Smart City) бейнебақылау жүйелері және мемлекеттік деректер орталықтары негізінен қытайлық аппараттық-программалық шешімдерге негізделген. Бұл жағдай мынадай тәуекелдерді тудырады:

- **Киберқауіпсіздік және деректер ағынын бақылау:** Ұлттық криптографиялық стандарттар мен азаматтардың дербес деректерінің сыртқы серверлерге ағу қаупі.
- **Вендорлық тәуелділік (Vendor Lock-in):** Қытайлық технологиялық платформаларға байлану болашақта басқа батыстық немесе азиялық баламаларға ауысуды қаржылық әрі техникалық жағынан тым қымбатқа түсіреді.

Б) Инвестициялық және қаржылық тәуекелдер («Қарыздық салмақ» феномені)

Халықаралық сараптамалық орталықтарда (мысалы, Center for Global Development, AidData) Қытайдың БББЖ аясында беретін несиелері бойынша «қарыздық тұзақ дипломатиясы» (debt-trap diplomacy) жиі талқыланады.

Қазақстан Республикасының Ұлттық банкінің мәліметтері бойынша, Қазақстанның Қытай алдындағы сыртқы қарызы (мемлекеттік және мемлекет кепілдік берген қарыз, сондай-ақ фирмааралық бершек) салыстырмалы түрде қауіпсіз деңгейде (шамамен 9-10 млрд доллар төңірегінде) сақталып отыр. Алайда, негізгі тәуекел **квазимемлекеттік сектордың** («Самұрық-Қазына» АҚ еншілес компаниялары, «ҚазМұнайГаз», ҚТЖ) Қытай Даму Банкі мен Эксимбанкінен алған міндеттемелерінде жатыр. Инфрақұрылымдық жобалардың коммерциялық өзін-өзі өтеу мерзімі ұзақ болғандықтан, бұл компаниялардың қаржылық тұрақтылығына салмақ түседі.

В) Сауда құрылымындағы асимметрия мен сауда дефициті

2023 жылғы статистикалық деректерді талдау сауда балансындағы үлкен асимметрияны көрсетеді.

Сурет 2. 2023 жылғы Қазақстан мен Қытай арасындағы экспорт пен импорттың тауарлық құрылымы

ҚАЗАҚСТАН ЭКСПОРТЫ (14.7 млрд $):
[[redacted]] Минералды ресурстар, мұнай, металдар (78%)
[[redacted]] Ауыл шаруашылығы өнімдері (12%)
[[redacted]] Химия және басқа да өнімдер (10%)

ҚЫТАЙ ИМПОРТЫ (26.8 млрд $):
[[redacted]] Машиналар, жабдықтар, автокөліктер (45%)
[[redacted]] Халық тұтынатын тауарлар, текстиль (30%)
[[redacted]] Электроника және цифрлық техника (25%)

Бұл асимметрия Қазақстанның Қытай үшін негізінен шикізат пен ресурс жеткізуші, ал Қытайдың Қазақстан үшін дайын, жоғары қосылған құнды өнімдер мен техниканы беруші рөлін сақтап отырғанын дәлелдейді. Электронды коммерцияның өзінде Қытайдан Қазақстанға ағатын тауарлар ағыны (импорт) кері бағыттан ондаған есе көп.

4.3. Қазақстан мен Қытайдың геоэкономикалық мүдделерінің теңгерімділігін бағалау

Екі ел арасындағы дипломатиялық диалог тең құқылы серіктестік ретінде декларацияланғанымен, объективті демографиялық, экономикалық және әскери-саяси потенциалдардың алшақтығы асимметриялық өзара тәуелділікті тудырады. Қытай үшін Қазақстан – бұл:

- Ресурс қауіпсіздігінің кепілі (мұнай, газ, уран, мыс);
- «Батыс Қытай» (Синьцзян-Уйгур автономиялық ауданы) өңірінің қауіпсіздігі мен тұрақтылығының буфері;
- Еуропа мен Таяу Шығысқа шығатын транзиттік көпір.

Ал Қазақстан үшін Қытай – бұл:

- Ірі инвестициялар мен арзан несие ресурстарының көзі;
- Теңізге шығу мүмкіндігін алмастыратын транзиттік инфрақұрылымдық серіктес;
- Ресей мен Батыс арасындағы геосаяси текетірестегі баланстаушы вектор.

Осы мүдделердің тоғысуы екі елге де тиімді, бірақ Қазақстан дипломатиясы өз өңіріндегі «орта держава» (middle power) ретінде субъектілік сипатын жоғалтпауы тиіс.

5. ҚОРЫТЫНДЫ ЖӘНЕ СТРАТЕГИЯЛЫҚ ҰСЫНЫСТАР

5.1. Негізгі ғылыми тұжырымдар

Зерттеу барысында жүргізілген талдаулар негізінде келесідей негізгі қорытындылар жасалды:

1. Қазақстан мен Қытай арасындағы экономикалық дипломатия дәстүрлі сауда форматтарынан сапалы түрде өсіп, цифрлық сауда, индустриялық инвестициялар және трансконтиненттік көлік дәліздерін қамтитын комплекс сипатқа ие болды. Бұл құралдар «Бір белдеу, бір жол» бастамасының негізгі драйверіне айналды.
2. Транскаспий халықаралық көлік бағдары (Орта дәліз) Қазақстанның геоэкономикалық статусын түбегейлі өзгертті. Сиань мен Ляньюньган қалаларындағы қазақстандық логистикалық хабтардың құрылуы сыртқы саяси дипломатияның нақты экономикалық активтерге айналуының мысалы болып табылады.
3. Электронды коммерция және «Цифрлық Жібек жолы» отандық бизнеске жаңа мүмкіндіктер ашқанымен, цифрлық егемендікке, киберқауіпсіздікке және технологиялық монополизацияға қатысты жаңа сын-қатерлерді ала келді.
4. Сауда балансындағы асимметрия мен Қытайдан келетін дайын өнімдер мен техника импортының басымдығы отандық өндірісті қорғау мен инвестициялық келісімдерде локализация талаптарын күшейтуді қажет етеді.

5.2. Практикалық-стратегиялық ұсыныстар

Қазақстан Республикасының Сыртқы істер министрлігіне, Сауда және интеграция министрлігіне, Цифрлық даму, инновациялар және аэроғарыш өнеркәсібі министрлігіне және уәкілетті мемлекеттік органдарға мынадай стратегиялық ұсыныстар пакеті ұсынылады:

1. Цифрлық дипломатия және кибер-егемендікті нығайту бағыты бойынша:

- **«Екі жақты цифрлық стандарттар» протоколын әзірлеу:** Қытаймен цифрлық сауда және финтех саласындағы келісімдерде азаматтардың дербес деректерін тек Қазақстан аумағындағы Data-орталықтарда сақтау («Data Localization») талабын заңнамалық түрде қатаң бекіту.
- **Технологиялық монополияны әртараптандыру:** 5G/6G және жасанды интеллект инфрақұрылымын дамытуда тек қытайлық компаниялармен шектелмей, Еуропалық Одақ (Ericsson, Nokia), Оңтүстік Корея (Samsung) және АҚШ компанияларымен балансталған консорциумдар құру.

2. Инвестициялық дипломатия мен өнеркәсіпті деиндустрияландырудан қорғау бағыты бойынша:

- **Локализацияның минималды шегін (KPI) енгізу:** Қытайлық инвесторлар қатысатын барлық біріккен индустриялық жобаларда өндірістік локализация деңгейін 3-5 жыл ішінде кемінде 40-50%-ға жеткізу және жергілікті кадрларды басқарушылық позицияларға оқыту міндеттемесін халықаралық шарттарға енгізу.

- **«Жасыл» және экологиялық аудититті міндеттеу:** Қазақстанға көшірілетін өндірістік қуаттардың жоғары экологиялық стандарттарға (ESG) сәйкестігін бағалайтын тәуелсіз халықаралық аудит механизмін жасақтау.

3. Логистикалық және инфрақұрылымдық дипломатия бағыты бойынша:

- **ТХКБ-ны институционалдық тұрғыдан цифрландыру:** Қытай – Қазақстан – Әзірбайжан – Грузия – Түркия шекараларында кедендік рәсімдерді толық цифрландыратын бірыңғай «Digital Corridor» мультимодальды платформасын іске қосу. Бұл құжат айналымын қысқартып, транзит уақытын 10 күнге дейін азайтады.
- **Транзиттік тарифтерді біріздендіру:** Орта дәліздің бәсекеге қабілеттілігін арттыру үшін барлық қатысушы елдердің теміржол әкімшіліктері арасында ұзақ мерзімді сквозной (унификацияланған) тарифтік ставкалар келісімін бекіту.

4. Сауда дипломатиясы мен ШОБ-ты қолдау бағыты бойынша:

- **«E-Commerce Елшілері» институтын құру:** Қытайдың негізгі экономикалық орталықтарында (Сиань, Шанхай, Шэньчжэнь, Гуанчжоу) Қазақстанның сауда өкілдіктері жанынан отандық ШОБ субъектілеріне қытайлық маркетплейстерде ілгерілеуге көмектесетін мамандандырылған цифрлық консультативтік хабтар ашу.
- **Зияткерлік меншікті қорғау:** Қазақстандық өнімдердің брендтері мен тауарлық белгілерін ҚХР-дың патенттік ведомстволарында алдын ала тіркеуді мемлекеттік субсидиялау механизмін енгізу.

ПАЙДАЛАНЫЛҒАН ӘДЕБИЕТТЕР ТІЗІМІ

1. Қазақстан Республикасы Стратегиялық жоспарлау және реформалар агенттігі Ұлттық статистика бюросы. (2024). *Қазақстан Республикасының сыртқы саудасы: статистикалық жинақ*. Астана.
2. Қазақстан Республикасының Сыртқы істер министрлігі. (2020). *Қазақстан Республикасының 2020–2030 жылдарға арналған сыртқы саятсының тұжырымдамасы*. Астана.
3. Тоқаев, Қ. К. (2020). *Нұрлы жол және Бір белдеу, бір жол: интеграциялық процестердің жаңа парадигмасы*. Алматы: Жібек жолы.
4. Исова, Л. Т., & Sultankhanuly, Y. (2023). Транскаспий халықаралық көлік дәлізінің геосаяси маңызы мен Қазақстанның транзиттік дипломатиясы. *М. Әуезов атындағы Оңтүстік Қазақстан университетатінің Хабаршысы*, 3(45), 88–95.
5. Сыздықов, М., & Құсайынов, Ә. (2023). Қазақстан-Қытай экономикалық қатынастарының қазіргі тенденциялары және сауда асимметриясы. *Халықаралық қатынастар және халықаралық құқық журналы*, 4(12), 45–59.
6. Әбдірахманов, Р. С. (2021). *Экономикалық дипломатия: теория, әдіснама және халықаралық тәжірибе*. Астана: Л.Н. Гумилев атындағы ЕҰУ баспасы.
7. Айтжанова, Ж., & Омаров, Қ. (2022). Цифрлық экономика және халықаралық саудадағы жаңа сын-қатерлер. *Экономика және статистика*, 1(67), 23–31.
8. Berridge, G. R., & James, A. (2003). *A Dictionary of Diplomacy*. Palgrave Macmillan. https://doi.org/10.1057/9780230502840
9. Saner, R., & Yiu, L. (2003). International Economic Diplomacy: Mutations in Post-modern Times. *Discussion Papers in Diplomacy*, Netherlands Institute of International Relations 'Clingendael'.
10. Luttwak, E. N. (1990). From Geopolitics to Geo-Economics: Logic of Conflict, Grammar of Commerce. *The National Interest*, (20), 17–23.
11. Khanna, P. (2016). *Connectography: Mapping the Future of Global Civilization*. Random House.

12. Rolland, N. (2019). *A 'Digital Silk Road'? The Security Implications for Europe*. Real Instituto Elcano Paper.
13. Kassenova, N. (2021). China's Belt and Road Initiative in Central Asia: The Transition to a New Normal. *Central Asia Program Paper*, George Washington University.
14. Ferdinand, P. (2016). Westward ho—the China dream and 'one belt, one road': Chinese foreign policy under Xi Jinping. *International Affairs*, 92(4), 941–957. https://doi.org/10.1111/1468-2346.12660
15. AidData. (2021). *Banking on the Belt and Road: Insight from a new global dataset of 13,427 Chinese development projects*. AidData at William & Mary.
16. World Bank. (2020). *Belt and Road Economics: Opportunities and Risks of Transport Corridors*. Washington, DC: World Bank.

ДЕЗИНТЕГРАЦИОННЫЕ ПРОЦЕССЫ В СОЕДИНЁННОМ КОРОЛЕВСТВЕ: ПРИЧИНЫ, ПРЕДПОСЫЛКИ И ВОЗМОЖНЫЕ СЦЕНАРИИ

Саурыкова Сатина Артыковна
студентка 4 курса специальности «Международные отношения», Университет Нархоз, г. Алматы, Республика Казахстан
Научный руководитель:
Андиржанова Г.А.
д.п.н., профессор, Университет Нархоз, г. Алматы, Республика Казахстан

Аннотация. В статье проведен сравнительный анализ дезинтеграционных процессов и общих тенденций в регионах Соединённого Королевства — Шотландии, Северной Ирландии и Уэльсе. Исследуется главный парадокс британской деволюции, которая, будучи призванной укрепить государственное единство,дала обратный эффект и сформировала институциональные предпосылки для усиления регионального сепаратизма. На основе актуальных социологических данных, электоральной статистики и правовых актов выявляются различия в динамике и механизмах дезинтеграции. Разработана авторская модель сценариев конституционной трансформации Великобритании.

Ключевые слова: Соединённое Королевство, деволюция, дезинтеграция, Брекзит, Шотландия, Северная Ирландия, Уэльс, сецессия, референдум, Белфастское соглашение.

Введение и исследовательская проблема

Соединённое Королевство Великобритании и Северной Ирландии представляет собой уникальный пример сложного многонационального государства, территориально-политическая структура которого на протяжении последних десятилетий подвергается глубокой трансформации. В состав государства входят четыре исторические области — Англия, Шотландия, Уэльс и Северная Ирландия, обладающие специфическими политико-правовыми, культурными и историческими традициями. Современная британская модель сочетает традиционный принцип парламентского суверенитета с развитой системой территориальной деволюции, предполагающей делегирование законодательных и исполнительных полномочий региональным органам власти [1].

Центральная исследовательская проблема заключается в выявлении причин фундаментального парадокса британской конституционной модели: почему деволюционные реформы конца 1990-х годов, изначально задумывавшиеся как инструмент модернизации государственного управления и снижения региональной напряженности, в долгосрочной перспективе сформировали институциональные условия для ускорения дезинтеграционных процессов? Как отмечается в исследовании И.Е. Напалковой, «общие причины регионализации заключаются в стремлении сделать власть более эффективной, делегировать региональным властям часть ответственности за принимаемые решения и удовлетворить стремление тех или иных слоев общества к самоуправлению» [1, с. 136]. Однако в британском контексте расширение автономии привело к институционализации региональных элит и созданию автономных политических пространств.

Научная новизна исследования заключается в сравнительном анализе и объяснении того, почему экзогенные шоки общегосударственного уровня (первостепенно это выход Великобритании из Европейского союза,Брекзит) приводят к кардинально различным политическим,правовым и также социокультурным последствиям в Шотландии, Северной Ирландии и Уэльсе.

Методология исследования

Исследование опирается на комплексную методологическую базу, включающую:

1. Сравнительный метод — применяется для сопоставления институциональных механизмов, уровня общественной поддержки и правовых барьеров дезинтеграции в трех регионах Соединённого Королевства (Шотландия, Северная Ирландия, Уэльс).

2. Нормативно-правовой и институциональный анализ — задействован при изучении Акта о Шотландии 1998 г., Белфастского соглашения 1998 г. (Соглашения Страстной пятницы), решений Верховного суда Великобритании (в частности, решения от 23 ноября 2022 г.) и Доктрины Баррозу.

3. Эмпирический и социологический анализ — основан на сопоставлении проверяемых статистических данных референдумов, выборов и актуальных социологических опросов (YouGov, Ipsos, LucidTalk, Welsh Election Study).

4. Сценарный метод — используется для построения и верификации трехвариантной модели будущей конституционной трансформации каждого из исследуемых регионов.

Шотландия: институционализация сепаратизма и юридические барьеры

Шотландия выступает наиболее явным примером роста дезинтеграционных тенденций. Ключевым институциональным катализатором выступает Шотландская национальная партия (ШНП/SNP), находящаяся у власти в регионе с 2007 года. Выход Великобритании из ЕС существенно обострил противоречия между Эдинбургом и Лондоном, так как 62% избирателей Шотландии проголосовали за сохранение членства в ЕС. Как подчеркивают В.А. Эпштейн и Р.Р. Сагитова, «Брекзит вновь выдвинул на повестку дня возможность сецессии этих территорий», акцентировав внимание на глубоком социокультурном и политическом разломе [2, с. 33].

Однако политические призывы руководства ШНП сталкиваются с жесткими конституционно-правовыми ограничениями. 23 ноября 2022 года Верховный суд Великобритании единогласно постановил, что Шотландский парламент не обладает полномочиями принимать законопроект о проведении консультативного референдума о независимости без согласия Парламента Великобритании [3]. Суд указал, что вопросы Союза Англии и Шотландии относятся к «зарезервированным сферам» (reserved matters), находящимся в exclusive компетенции Вестминстера. Аргументы ШНП о международно-правовом принципе самоопределения наций также были отклонены, поскольку данный принцип применяется к колониальным или же оккупированным территориям.

Эмпирический анализ социологических данных демонстрирует устойчивый раскол общества по вопросу независимости (таблица 1). Регулярные опросы агентства YouGov показало, что поддержка независимости колеблется в пределах 46–49%, что свидетельствует об отсутствии устойчивого подавляющего большинства за сецессию [4]. В случае гипотетической сецессии Шотландия столкнется со сложным процессом вступления в ЕС по статье 49 Договора о Европейском союзе (TEU). Как отмечает Д. Ньятанга, в соответствии с «доктриной Баррозу», отделившаяся Шотландия рассматривается как «третья страна» и не сможет рассчитывать на автоматическое или ускоренное членство в ЕС [5].

Северная Ирландия: фактор Белфастского соглашения и «пограничный опрос»

Дезинтеграционные процессы в Северной Ирландии обладают глубокой спецификой, обусловленной наличием международного правового механизма — Белфастского соглашения 1998 года [6]. Соглашение закрепляет принцип согласия (principle of consent) и четко регламентирует процедуру изменения конституционного статуса региона через проведения «пограничного опроса» (border poll). Право назначения референдума закреплено за Министром по делам Северной Ирландии (Secretary of State for Northern Ireland), если станет очевидным, что большинство голосовавших выразят желание воссоединиться с Ирландской Республикой [6].

Специфика региона состоит в том, что Brexit разрушил прежний баланс, установив фактическую таможенную границу в Ирландском море (Североирландский протокол / Виндзорская рамка). Рост электоральных позиций партии «Шинн Фейн» (Sinn Féin) активизировал дискуссии о референдуме. Однако социологический мониторинг агентства LucidTalk (октябрь 2024 г., N=3,046) показывает, что идея немедленного воссоединения с Ирландией подкрепляется лишь 41% голосов, в то время как 48% респондентов выступают за сохранение региона в составе Соединённого Королевства [7]. Данные подтверждают устойчивость статус-кво и сдерживают инициативы Лондона по запуску референдума.

Уэльс: деволюционный прагматизм и рост автономизма

В отличие от Шотландии и Северной Ирландии, дезинтеграционный вектор в Уэльсе традиционно оставался слабовыраженным. Однако успехи партии «Плайд Кимру» (Plaid Cymru) и политический кризис Лейбористской партии активизировали дискурс о конституционных полномочиях Сенедда (парламента Уэльса). Данные социологического исследования Welsh Election Study (2024–2026 гг.) показывают, что бескомпромиссную независимость поддерживают от 13,6% до 22% респондентов [8]. При этом подавляющее большинство валлийского населения (более 58%) поддерживает сохранение Уэльса в составе Соединённого Королевства при условии максимального расширения финансовых и налоговых полномочий региональных властей [8]. Уэльс демонстрирует четкое различие между запросом на автономию и поддержкой государственной сецессии.

Сравнительная характеристика дезинтеграционных процессов

Таблица 1. Систематизация различий и общих черт дезинтеграционных процессов.

Критерий	Шотландия	Северная Ирландия	Уэльс
Основной конституционный вопрос	Полная государственная независимость (сецессия) и интеграция в ЕС	Объединение с Ирландской Республикой (border poll)	Расширение деволюционных полномочий / автономия
Правовой механизм	Согласование полномочий с Вестминстером (Section 30 Order)	Пограничный опрос по усмотрению Министра по делам СИ	Изменение статуса требует решения вопроса о полномочиях
Ключевые политические силы	Шотландская национальная партия (SNP), Шотландские зеленые	Шинн Фейн (Sinn Féin) vs Демократическая юнионистская партия (DUP)	Плайд Кимру (Plaid Cymru), Лейбористская партия Уэльса
Ключевой драйвер дезинтеграции	Национальная идентичность, Brexit, несогласие с Вестминстером	Идентичность, последствия Brexit, Белфастское соглашение	Региональная идентичность, распределение бюджета и ресурсов

Уровень поддержки независимости	46–49% (YouGov, 2024–2026 гг.)	41% за объединение (LucidTalk, 2024 г.)	13,6–22% (Welsh Election Study, 2026 г.)
Главная аналитическая проблема	Соотношение политического мандата и правовых барьеров	Условия проведения опроса и риски политической нестабильности	Соотношение запроса на автономию и поддержки независимости

Сравнительная характеристика дезинтеграционных процессов в регионах Соединённого Королевства (составлено автором).

Авторская модель сценариев конституционной трансформации

1. Сценарий сохранения статус-кво (наиболее вероятен для Уэльса и Северной Ирландии в среднесрочной перспективе):

Условия реализации: блокирование Лондоном запросов на референдумы, отсутствие устойчивого социологического большинства за выход.

Правовые и политические факторы: сохранение текущей структуры деволюции при регулярных институциональных трениях между региональными правительствами и Вестминстером.

2. Сценарий расширенной деволюции / «асимметричной федерализации» (наиболее вероятен для Шотландии и Уэльса):

Условия реализации: нарастание регионального недовольства центральной властью и необходимость компромисса для предотвращения полного распада государства.

Правовые и политические факторы: передача региональным парламентам дополнительных налоговых, бюджетных и социальных полномочий («Devo-Max») с сохранением ключевых зарезервированных сфер за Лондоном.

3. Сценарий государственной дезинтеграции / сецессии (наиболее сложный, с высокими правовыми препятствиями):

Условия реализации: формирование устойчивого большинства (>55%) в поддержку независимости и получение согласия Парламента Великобритании или активация процедуры по Белфастскому соглашению.

Правовые и политические факторы: возникновение институциональных барьеров при интеграции в ЕС (Доктрина Баррозу), необходимость урегулирования пограничных и таможенных режимов с Англией.

Заключение

Проведенный анализ показывает, что Шотландия, Северная Ирландия и Уэльс демонстрируют три принципиально разных вектора возможной дезинтеграции. Шотландия обладает наиболее выраженным запросом на государственную независимость, однако ограничена жесткими юридическими рамками конституционного права Великобритании. В Северной Ирландии ключевым механизмом выступает Белфастское соглашение, однако текущие социологические данные свидетельствуют в пользу сохранения статус-кво. В Уэльсе электоральный рост региональных партий отражает запрос на расширение автономии, а не на отделение.

Главный вывод исследования заключается в том, что британская деволюция привела к формированию асимметричной системы, в которой региональная автономия не гарантирует автоматического сохранения государственного единства. Будущее Соединённого Королевства будет определяться балансом между способностью Лондона гибко реформировать систему деволюции и динамикой социологических настроений в регионах.

Список использованных источников

1. Напалкова И. Е. Процесс регионализации в рамках конституционной реформы Соединённого Королевства Великобритании и Северной Ирландии на рубеже XX–XXI веков // Magistra Vitae: электронный журнал по историческим наукам и археологии. 2018. № 2. С. 134–145. URL: https://magistravitaejournal.ru/images/2_2018/napalkova.pdf (дата обращения: 10.10.2026).

2. Эпштейн В. А., Сагитова Р. Р. Влияние Брекзита на развитие сепаратистских настроений в Шотландии и Северной Ирландии // Общество: политика, экономика, право. 2022. № 5. С. 31–37. URL: https://cyberleninka.ru/article/n/vliyanie-brekzita-na-razvitie-separatistskih-nastroeniy-v-shotlandii-i-severnoy-irlandii (дата обращения: 10.10.2026).

3. Judgment: REFERENCE by the Lord Advocate of devolution issue under paragraph 34 of Schedule 6 to the Scotland Act 1998 // Supreme Court of the United Kingdom. 2022. 23 November. URL: https://www.supremecourt.uk/cases/docs/uksc-2022-0098-judgment.pdf (дата обращения: 10.10.2026).

4. Scottish Independence Tracker // YouGov. 2024. URL: https://yougov.com/en-gb/trackers/support-for-scottish-independence (дата обращения: 10.10.2026).

5. Nyatanga D. Scotland's route to EU membership // LSE Brexit Blog. London School of Economics. 2021. 31 March. URL: https://blogs.lse.ac.uk/brexit/2021/03/31/scotlands-route-to-eu-membership/ (дата обращения: 10.10.2026).

6. The Belfast Agreement (Good Friday Agreement) // Government of the United Kingdom. 1998. 10 April. URL: https://www.gov.uk/government/publications/the-belfast-agreement (дата обращения: 10.10.2026).

7. Northern Ireland Constitutional Status Poll // LucidTalk / Belfast Telegraph. 2024. October. URL: https://www.lucidtalk.co.uk/news/lucidtalk-belfast-telegraph-ni-tracker-poll-summer-2026/ (дата обращения: 10.10.2026).

8. Welsh Election Study: Public Attitudes to Devolution and Independence in Wales // Cardiff University & Aberystwyth University. 2024. URL: https://www.es2026.wales/ (дата обращения: 10.10.2026).

9. Коданева С. И. Брекзит: сепаратизм, популизм и социальная трансформация британского общества // Контуры глобальных трансформаций: политика, экономика, право. 2021. Т. 14, № 1. С. 98–117. URL: https://cyberleninka.ru/article/n/brekzit-separatizm-populizm-i-sotsialnaya-transformatsiya-britanskogo-obschestva (дата обращения: 10.10.2026).

10. Butcher P. Scottish Independence and EU Membership: Process and Implications // Herbert Smith Freehills Kramer. 2021. 22 April. URL: https://www.hsfkramer.com/insights/2021-04/scottish-independence-and-eu-membership-process-and-implications (дата обращения: 10.10.2026).

Medical Sciences

THE INTEGRATED SCIENTIFIC EVALUATION OF RIB FRACTURE MANAGEMENT: PHARMACOTHERAPY, CLINICAL PHARMACOLOGY, DRUG SAFETY AND PHARMACOVIGILANCE

Nodar Sulashvili
MD, PhD, Doctor of Pharmaceutical and Pharmacological Sciences In Medicine, Affiliated Professor of Faculty of Medicine at Georgian International University GIU; Professor of Medical and Clinical Pharmacology of Faculty of Medicine at BAU International University Batumi; Professor of Pharmacology of Faculty of Medicine at Georgian National University SEU; Invited Professor/Lecturer of Scientific Research-Skills Center at Tbilisi State Medical University; Invited Lecturer of Clinical Pharmacology Department at Tbilisi State Medical University; Scientific Researcher, Best, Top Academic Scientist - Europe, Worldwide; Associate Professor of Biochemistry and Pharmacology Direction of School of Health Sciences at The University of Georgia; Professor of Medical and Clinical Pharmacology of International School of Medicine at Alte University; Tbilisi, Georgia; Scientific Researcher of Yerevan State Medical University After Mkhitar Heratsi, Yerevan, Republic of Armenia; Former Scientific Researcher and Clinical Pharmacologist of London Lewisham University Hospital, London, England, United Kingdom of Great Britain and Northern Ireland; https://orcid.org/0000-0002-9005-8577

Margarita Beglaryan
MD, PhD, Doctor of Pharmaceutical Sciences, Academician, Professor of Yerevan State Medical University After Mkhitar Heratsi, Head of the Department of Pharmaceutical Management of Yerevan State Medical University After Mkhitar Heratsi; Yerevan, Republic of Armenia; https://orcid.org/0000-0003-3697-6390

Maka Buleishvili
MD, PhD, Doctor of Medical Sciences, Professor of Faculty of Medicine at Georgian International University GIU, Dean of Faculty of Medicine at Georgian International University GIU, Professor of Faculty of Medicine at Georgian National University SEU, Professor of Faculty of Medicine at European University, Professor of Faculty of Medicine at Caucasus International University, Professor of Faculty of Medicine at Georgian-American University, Invited Lecturer of Tbilisi State Medical University, Tbilisi, Georgia; Professor of Faculty of Medicine at BAU International University Batumi, https://orcid.org/0009-0004-2657-8473

Mariam Darbaidze
MD, PhD, Doctor of Biological Sciences, Professor of Georgian International University GIU, Vice Rector of Georgian International University GIU; Professor of Georgian National University SEU; Tbilisi, Georgia; https://orcid.org/0009-0005-0275-4222
Nato Alavidze
MD, PhD, Doctor of Pharmaceutical Sciences, Professor of Akaki Tsereteli State University, Faculty of Medicine, Department of Stomatology and Pharmacy, Kutaisi, Georgia; Professor of Faculty of Health Sciences at East European University (EEU), Head of The Medical Doctor Degree Program of Faculty of Healthcare Sciences at East European University (EEU), Tbilisi, Georgia. https://orcid.org/0000-0001-6695-5924
Marika Sulashvili
MD, Doctor of Family Medicine, Invited Lecturer of Tbilisi State Medical University, Lecturer of Department of Molecular and Medical Genetics, Invited Professor of Biochemistry and Molecular and Medical Genetics at The University of Georgia. Tbilisi, Georgia. https://orcid.org/0000-0002-6338-4262
Nana Gorgaslidze
MD, PhD, Doctor of Pharmaceutical Sciences, Academician, Professor of Tbilisi State Medical University, Head of The Department of Social and Clinical Pharmacy, Tbilisi, Georgia. https://orcid.org/0000-0002-4563-5224
Irina Imerlishvili
PhD, Doctor of Law, Professor, Rector of BAU International University Batumi; Professor of BAU International University Batumi; Professor at the International Black Sea University, Batumi-Tbilisi, Georgia; https://orcid.org/0009-0008-6862-7025
Marina Giorgobiani
MD, PhD, Doctor of Medical Sciences, Academician, Professor of Tbilisi State Medical University, Faculty of Public Health; Department of Hygiene and Medical Ecology, Tbilisi, Georgia. https://orcid.org/0000-0003-0686-5227
Ketevani Gabunia
MD, PhD, Doctor of Pharmaceutical Sciences, Academician, Professor of Akaki Tsereteli State University, Faculty of Medicine, Department of Stomatology and Pharmacy, Kutaisi, Georgia. https://orcid.org/0000-0002-5857-6593;
Igor Seniuk
PhD, Doctor of Pharmaceutical Sciences, Dean of faculty of Pharmacy at National University of Pharmacy of Ukraine, Associate Professor of Biological Chemistry Department at National University of Pharmacy, Kharkiv, Ukraine. https://orcid.org/0000-0003-3819-7331
Naira Chichoyan
MD, PhD, Doctor of Pharmaceutical Sciences, Professor of Yerevan State Medical University After Mkhitar Heratsi; Head of the Department of Pharmacognosy at Yerevan State Medical University After Mkhitar Heratsi; Yerevan, Republic of Armenia. https://orcid.org/0000-0003-3905-3372
Olga Shapoval
MD, PhD, Doctor of Pharmaceutical Sciences, Associate Professor of Department of Pharmacology, Pharmacotherapy and Medical Prescription at Kharkiv State Medical University, Kharkiv, Ukraine; https://orcid.org/0000-0002-1971-2863

Nino Abuladze
MD, PhD, Doctor of Pharmaceutical Sciences, Academician, Professor of Akaki Tsereteli State University, Faculty of Medicine, Department of Stomatology and Pharmacy, Kutaisi, Georgia. https://orcid.org/0000-0003-2189-7470
Rajkaran Singh
Faculty of Medicine at Georgian National University SEU; Tbilisi, Georgia; https://orcid.org/0009-0000-4903-0145
David Aphkhazava
PhD, Doctor of Biological Sciences, Professor of Biochemistry at The University of Georgia, Tbilisi, Georgia. Orcid: https://orcid.org/0000-0001-6216-6477

ABSTRACT
The integrated management of rib fractures represents a multidisciplinary clinical challenge requiring the systematic integration of trauma assessment, pain control, respiratory support, pharmacological interventions, non-pharmacological treatment modalities, medication safety, and evidence-based therapeutic decision-making. Rib fractures are among the most frequently encountered injuries following blunt thoracic trauma and may be associated with substantial morbidity, particularly in older adults, patients with multiple fractures, individuals with pre-existing cardiopulmonary disease, and those sustaining concomitant thoracic injuries. The pathophysiological consequences extend beyond structural disruption of the thoracic cage, encompassing pain-induced restriction of chest-wall excursion, impaired inspiratory effort, reduced cough effectiveness, secretion retention, atelectasis, and an increased risk of pneumonia and respiratory failure. Accordingly, the principal therapeutic objectives involve achieving adequate analgesia, preserving pulmonary mechanics, facilitating early mobilization, preventing respiratory complications, supporting functional recovery, and minimizing treatment-related harm. This scientific appraisal examines the pharmacotherapeutic armamentarium and non-pharmacological approaches available for rib fracture management through the complementary perspectives of clinical pharmacology, pharmacodynamics, pharmacokinetics, evidence-based medicine, clinical outcomes research, pharmacovigilance, and pharmacosafety. Particular attention is directed toward the rational classification and clinical selection of medicinal products according to their mechanisms of action, therapeutic indications, analgesic efficacy, pharmacokinetic characteristics, contraindications, drug–drug interactions, and patient-specific risk profiles. Pharmacological interventions may include paracetamol (acetaminophen), non-steroidal anti-inflammatory drugs, selected opioid analgesics, and regional analgesic techniques, including thoracic epidural, paravertebral, and fascial-plane blocks where clinically appropriate. The selection and combination of these interventions should reflect injury severity, respiratory status, renal and hepatic function, gastrointestinal and cardiovascular risk, anticoagulant exposure, frailty, and the possibility of concomitant traumatic injuries. Multimodal analgesia is particularly relevant because it seeks to improve pain control through complementary mechanisms while reducing unnecessary exposure to individual drug classes and limiting opioid-associated adverse effects. Non-pharmacological management constitutes an essential component of comprehensive care and includes respiratory physiotherapy, supported coughing, incentive spirometry when appropriate, early mobilization, positioning, individualized pulmonary hygiene, and structured monitoring of respiratory function. In selected patients with unstable chest-wall injuries or flail chest, surgical stabilization may also be considered following multidisciplinary assessment. The clinical pharmacology dimension encompasses pharmacodynamics, including drug–receptor interactions and analgesic mechanisms, as well as pharmacokinetics, including absorption, distribution, metabolism, elimination, and the influence

of age-related physiological changes and organ dysfunction on drug exposure. These considerations are essential for optimizing dose selection, administration intervals, therapeutic response, and the prevention of drug accumulation or toxicity. Furthermore, the appraisal emphasizes adverse drug reactions, medication errors, contraindications, cumulative sedative effects, opioid-induced respiratory depression, non-steroidal anti-inflammatory drug-associated renal and gastrointestinal complications, and acetaminophen-related hepatotoxicity following excessive exposure. Pharmacovigilance and pharmacosafety principles support the systematic identification, assessment, documentation, and prevention of medication-related risks throughout the treatment pathway. Evidence-based medicine provides the methodological foundation for evaluating clinical guidelines, randomized controlled trials, systematic reviews, meta-analyses, and comparative effectiveness studies, while recognizing heterogeneity in injury patterns, analgesic protocols, patient populations, and outcome definitions. Clinically meaningful endpoints include pain intensity, opioid consumption, respiratory function, pulmonary complications, and duration of hospitalization, mobility, quality of recovery, readmission, adverse events, and mortality. An individualized, multidisciplinary, and evidence-informed strategy integrating pharmacological and non-pharmacological interventions offers the most coherent framework for rib fracture management. Therapeutic optimization requires balancing analgesic effectiveness with respiratory safety, selecting interventions according to patient-specific characteristics, and continuously reassessing clinical response. This integrated approach supports rational pharmacotherapy, safer medication utilization, prevention of secondary complications, and improvement of patient-centered clinical outcomes. Nevertheless, treatment decisions must be guided by injury severity, current clinical evidence, applicable institutional protocols, and individualized professional judgment. The appraisal highlights the importance of interdisciplinary collaboration among traumatologists, thoracic surgeons, clinical pharmacologists, clinical pharmacists, anesthesiologists, nurses, and rehabilitation specialists in establishing coordinated treatment pathways. Risk stratification, repeated pain assessment, evaluation of oxygenation, and systematic monitoring of respiratory function facilitate timely therapeutic adjustments and early recognition of clinical deterioration. Particular emphasis should be placed on individualized prescribing, medication reconciliation, deprescribing of unnecessary agents, and patient education concerning analgesic administration and potential adverse effects. Integrating standardized clinical protocols with continuous outcome assessment may strengthen treatment consistency, optimize resource utilization, and promote safer, more effective, patient-centered recovery following rib fractures. Special consideration should also be given to geriatric patients, polypharmacy, comorbidities, and individualized analgesic requirements to minimize preventable complications and improve functional recovery.

Keywords: Rib Fractures; Pharmacotherapeutic Armamentarium; Clinical Pharmacology; Pharmacovigilance; Evidence-Based Medicine.

INTRODUCTION

The principal therapeutic objective in rib fracture management is not simply the reduction of pain but the preservation and restoration of effective ventilation, adequate oxygenation, and physiological respiratory function. Pain associated with fractured ribs can restrict chest-wall excursion, inhibit deep inspiration, reduce cough effectiveness, and impair clearance of bronchial secretions. These consequences may promote atelectasis, retained secretions, and pneumonia, particularly among older adults and patients with substantial chest-wall injury or limited pulmonary reserve. In severe cases, the resulting respiratory deterioration may contribute to prolonged hospitalization, intensive care admission, and increased mortality. Accordingly, analgesia constitutes a central component of supportive treatment because effective pain control can facilitate ventilation, coughing, physiotherapy, and progressive mobilization. Rib fractures

represent a clinically significant form of thoracic injury associated with acute pain, impaired respiratory mechanics, reduced functional capacity, and potentially serious pulmonary complications. They occur following blunt chest trauma, falls, motor vehicle collisions, occupational injuries, sports-related accidents, and, in selected populations, relatively minor trauma associated with osteoporosis or other conditions that compromise skeletal integrity. Although isolated rib fractures may follow a favorable course, multiple fractures, displacement, advanced age, pre-existing cardiopulmonary disease, and associated intrathoracic injuries can substantially increase morbidity and mortality. Consequently, the clinical management of rib fractures requires an integrated approach incorporating accurate diagnosis, risk stratification, effective analgesia, respiratory support, early mobilization, rehabilitation, and systematic monitoring for treatment-related complications.

The scientific evaluation of rib fracture management must therefore integrate anatomical injury characteristics with physiological assessment, pharmacological intervention, and individualized clinical decision-making. Chest radiography and computed tomography may be used according to the mechanism of injury, clinical presentation, and suspected associated complications. Clinical assessment should consider respiratory rate, oxygen saturation, hemodynamic stability, pain intensity, inspiratory capacity, cough effectiveness, and the presence of concomitant injuries. Such parameters help determine the appropriate intensity of monitoring and whether outpatient management, hospital admission, regional analgesia, respiratory support, or surgical consultation is warranted.

Pharmacotherapy and multimodal analgesia

Pharmacotherapy constitutes a fundamental component of rib fracture management, with treatment selection determined by pain severity, fracture pattern, renal and hepatic function, gastrointestinal risk, cardiovascular comorbidities, concomitant medications, and the patient's respiratory status. Multimodal analgesia involves the rational combination of pharmacological agents with complementary mechanisms of action to improve pain control while minimizing dose-dependent toxicity and unnecessary opioid exposure. Evidence-based approaches commonly incorporate acetaminophen (paracetamol), nonsteroidal anti-inflammatory drugs (NSAIDs), selected opioid analgesics, and regional anesthetic techniques when clinically indicated. However, the optimal regimen should be individualized, as comparative evidence for several analgesic strategies in traumatic chest-wall injuries remains limited. The Eastern Association for the Surgery of Trauma (EAST) and the Trauma Anesthesiology Society conditionally recommend epidural analgesia and multimodal analgesia as options, while acknowledging the low quality of the available evidence.

Acetaminophen is frequently incorporated into multimodal analgesic regimens because of its analgesic and antipyretic properties. Its potential advantages include limited gastrointestinal irritation compared with conventional NSAIDs and the absence of clinically significant platelet inhibition at usual therapeutic doses. Nevertheless, excessive cumulative exposure may cause hepatotoxicity, particularly in patients with hepatic impairment, chronic alcohol misuse, malnutrition, or concurrent use of multiple acetaminophen-containing products. Appropriate dose selection and medication reconciliation are therefore important components of safe prescribing. NSAIDs, including ibuprofen, naproxen, and other clinically appropriate agents, may reduce inflammatory pain and facilitate respiratory movement. Their administration, however, requires careful evaluation of gastrointestinal bleeding, renal impairment, cardiovascular risk, platelet effects, and potential interactions with anticoagulants or antiplatelet medications. These considerations are particularly important in older adults and patients with polytrauma, hemodynamic instability, or suspected internal bleeding. The decision to administer an NSAID should reflect the patient's overall clinical condition rather than the presence of a fracture alone.

General acute-pain guidance supports the use of nonopioid therapies when appropriate but emphasizes individualized assessment of their benefits and risks.
Opioid analgesics may be necessary for severe traumatic pain that remains inadequately controlled with other interventions or when alternative treatments are contraindicated. Nevertheless, opioids require particular caution in patients with rib fractures because dose-related respiratory depression, sedation, impaired cough, nausea, constipation, and delirium may compromise recovery. Concurrent administration with benzodiazepines, alcohol, or other central nervous system depressants can further increase risk. When opioid therapy is clinically justified, prescribing should prioritize the lowest effective dose, an appropriate formulation, a limited duration, and repeated assessment of analgesic efficacy and respiratory safety.
Regional analgesic techniques, including thoracic epidural analgesia, paravertebral blocks, and selected fascial-plane blocks, provide additional therapeutic options for patients with substantial pain or inadequate response to systemic medications. By targeting neural transmission associated with chest-wall injury, these techniques may improve analgesia while reducing systemic opioid requirements. Their suitability depends on injury characteristics, coagulation status, hemodynamic stability, anatomical considerations, procedural expertise, and institutional resources. Although regional techniques are widely used in selected patients, their comparative effects on mortality, pneumonia, length of hospitalization, and other major outcomes remain incompletely established. Consequently, clinical decisions should consider both the expected analgesic benefit and the limitations of the supporting evidence.

Drug safety, pharmacovigilance, and clinical outcomes

Drug safety is an essential dimension of rib fracture management because analgesic effectiveness must be evaluated alongside adverse drug reactions, contraindications, drug–drug interactions, dosing errors, and treatment-related complications. Pharmacovigilance extends this assessment by encompassing the detection, evaluation, understanding, and prevention of adverse effects and other medicine-related problems. In clinical practice, these disciplines are complementary but not synonymous: drug safety emphasizes the risk–benefit profile of individual treatments and therapeutic regimens, whereas pharmacovigilance includes systematic processes for identifying and evaluating safety signals across individual patients and broader populations. Relevant safety outcomes include opioid-induced respiratory depression, excessive sedation, NSAID-associated gastrointestinal or renal injury, acetaminophen-associated hepatotoxicity, local anesthetic systemic toxicity, and complications associated with regional procedures. Prevention requires comprehensive medication reconciliation, documentation of allergies and previous adverse reactions, evaluation of organ function, appropriate dose adjustment, and structured monitoring following treatment initiation or modification. Suspected adverse drug reactions should be documented and managed promptly, with reporting to the relevant pharmacovigilance system when indicated. Particular attention should be directed toward older adults, patients receiving anticoagulants, individuals with multiple comorbidities, and those exposed to several analgesic agents simultaneously.
The evaluation of therapeutic effectiveness must extend beyond changes in numerical pain scores. Clinically meaningful outcomes include the ability to inspire deeply, cough effectively, maintain adequate oxygenation, participate in pulmonary physiotherapy, mobilize independently, and avoid preventable respiratory deterioration. The 2024 review by Hemati and colleagues emphasizes the importance of optimized analgesia, pulmonary hygiene, respiratory assessment, and dynamic risk stratification in the nonoperative management of traumatic rib fractures. It also highlights the continuing limitations of evidence supporting several respiratory-support strategies. Non-pharmacological interventions are therefore integral to comprehensive management. These include breathing exercises, incentive spirometry when appropriate, supported coughing, early

mobilization, physiotherapy, and individualized respiratory monitoring. Patient education can improve adherence to prescribed treatment and encourage early recognition of warning signs, including worsening breathlessness, fever, increasing chest pain, or declining functional capacity. In selected patients with unstable chest-wall injuries or persistent mechanical impairment, surgical stabilization may also be considered following multidisciplinary assessment.

Rationale and scientific significance

Despite advances in trauma care, important uncertainties remain regarding the comparative effectiveness of analgesic regimens, the optimal selection of regional anesthesia techniques, the influence of individual drugs on pulmonary complications, and the long-term consequences of analgesic exposure. Variability in patient characteristics, fracture severity, outcome definitions, and institutional protocols complicates the interpretation and generalization of published findings. Moreover, improvements in pain scores do not necessarily translate into reductions in pneumonia, intensive care admission, mortality, or hospital length of stay. These distinctions underscore the need for critical appraisal of both clinical efficacy and patient-centered outcomes. An integrated scientific evaluation of rib fracture management should examine pharmacological interventions, clinical pharmacology, non-pharmacological supportive care, drug safety, and pharmacovigilance within a unified evidence-based framework. Particular emphasis should be placed on therapeutic benefit–risk assessment, rational analgesic selection, prevention of medication-related harm, and identification of clinically relevant evidence gaps. Such an approach can support more consistent clinical decision-making, improve the quality of medication management, and strengthen multidisciplinary collaboration among trauma surgeons, emergency physicians, anesthesiologists, clinical pharmacologists, pharmacists, nurses, and rehabilitation specialists.

The scientific objective is to optimize pain relief while preserving respiratory function, minimizing preventable complications, and ensuring the responsible use of medicinal products. Integrating clinical evidence with systematic safety assessment and individualized treatment planning provides a foundation for improving the quality, effectiveness, and safety of rib fracture care.

Rib Fracture Healing: Pathophysiological Foundations, Pharmacotherapeutic Interventions, Bone Regeneration, and Evidence-Based Clinical Management

Rib fracture healing represents a coordinated biological process involving inflammatory signaling, cellular recruitment, extracellular matrix synthesis, cartilaginous callus formation, mineral deposition, and subsequent bone remodeling. The clinical management of this process requires an integrated understanding of thoracic biomechanics, osteoimmunology, clinical pharmacology, analgesic pharmacotherapy, nutritional physiology, and medication safety. Unlike therapeutic strategies directed exclusively toward pain reduction, comprehensive rib fracture management must simultaneously address fracture stabilization, respiratory function and prevention of secondary pulmonary complications, preservation of functional capacity, and the biological conditions necessary for skeletal repair. The therapeutic objective is therefore multidimensional: to achieve adequate analgesia without compromising ventilation, minimize treatment-related toxicity, maintain appropriate nutritional and metabolic conditions, and facilitate progressive restoration of the structural and functional integrity of the thoracic cage.

The biological response to rib fractures begins with disruption of cortical bone, periosteal tissues, adjacent soft tissues, and, in some injuries, intercostal neurovascular structures. Hemorrhage and local tissue damage generate a fracture hematoma containing platelets, inflammatory cells, cytokines, chemokines, and growth factors. This provisional biological environment supports recruitment of immune cells and mesenchymal progenitor populations, initiates the removal of damaged tissue, and establishes the signaling conditions for subsequent repair. The inflammatory

phase is not merely a pathological consequence of trauma; it is an essential component of fracture healing. Its regulation must therefore be distinguished from indiscriminate suppression of inflammation, because inflammatory signaling participates in the recruitment and differentiation of cells required for tissue regeneration.

The subsequent reparative phase involves the formation of granulation tissue, synthesis of extracellular matrix, differentiation of osteogenic and chondrogenic cells, and development of a fracture callus. Depending on the mechanical environment and local tissue conditions, healing may proceed through combinations of intramembranous and endochondral ossification. Osteoblasts synthesize osteoid, which subsequently undergoes mineralization, while chondrocytes contribute to the cartilaginous scaffold that supports callus development in appropriate mechanical conditions. Remodeling then progressively reorganizes newly formed bone, replacing immature woven bone with more organized lamellar structures and restoring structural competence. These processes are influenced by fracture displacement, local blood supply, mechanical stability, age, metabolic status, comorbidities, and exposure to potentially harmful substances.

Rib fractures have a distinctive clinical dimension because the injured structure participates directly in ventilation. Pain during inspiration and coughing can restrict chest-wall excursion, reduce inspiratory effort, and impair the clearance of respiratory secretions. Consequently, a fracture that is biologically capable of healing may nevertheless produce substantial clinical morbidity if pain remains inadequately controlled or if associated pulmonary injuries are overlooked. Conversely, analgesia that produces excessive sedation or respiratory depression may undermine the respiratory benefits sought through pain relief. The therapeutic strategy must therefore coordinate bone healing with respiratory preservation rather than treating these outcomes as independent objectives.

The pharmacotherapeutic armamentarium includes analgesics, selected anti-inflammatory medicines, regional anesthetic techniques, and supportive treatments directed toward documented nutritional or metabolic deficiencies. These interventions do not all act on the fracture-healing process itself. Some primarily relieve pain; others modify inflammation or support normal physiological processes involved in mineralization and tissue repair. Nutritional supplements may correct inadequate intake or a confirmed deficiency, but they should not automatically be interpreted as agents that accelerate rib union. This distinction is particularly important when evaluating vitamin D, calcium, magnesium, zinc, vitamin C, vitamin K, protein supplements, glucosamine, chondroitin, collagen products, and other biologically active compounds. A central principle of this background is that biological plausibility does not establish clinical efficacy. The fact that a nutrient participates in bone metabolism does not demonstrate that supplementation above physiological requirements accelerates fracture healing. Similarly, a medicine that reduces pain or inflammation does not necessarily improve the structural regeneration of bone. Therapeutic recommendations must be based on clinical evidence, the patient's nutritional and metabolic status, and a careful assessment of the benefits and risks of the proposed intervention.

Biological Phases of Rib Bone Regeneration and the Role of the Inflammatory Response

The inflammatory phase of fracture healing is characterized by the formation of a hematoma, activation of platelets, recruitment of neutrophils and monocytes, and differentiation of monocyte-derived macrophages into functional phenotypes that participate in tissue repair. Signaling molecules, including interleukin-mediated pathways, tumor necrosis factor, transforming growth factor beta, vascular endothelial growth factor, and bone morphogenetic proteins, contribute to the regulation of inflammation, angiogenesis, cell proliferation, and osteogenic differentiation. The biological effects of these mediators depend on their

concentration, temporal expression, cellular source, and interaction with the local mechanical and metabolic environment.

The transition from inflammation to tissue regeneration requires tightly coordinated cellular communication. Excessive or prolonged inflammation may interfere with repair, but early inflammatory activity is indispensable for initiating the healing response. Consequently, the pharmacological management of rib fractures should avoid assuming that the strongest anti-inflammatory intervention is necessarily the most beneficial. The clinically appropriate objective is to relieve pain and manage associated inflammatory symptoms while preserving patient safety and avoiding unnecessary or prolonged exposure to medicines whose risks may outweigh their benefits.

The proliferative and reparative phases involve the formation of vascularized connective tissue, recruitment and differentiation of progenitor cells, extracellular matrix deposition, and progressive mineralization. Angiogenesis is particularly important because newly formed tissue requires an adequate supply of oxygen, nutrients, and metabolic substrates. Osteoblast activity supports osteoid formation, whereas osteoclasts participate in the removal and remodeling of mineralized tissue. These processes are regulated by interdependent signaling pathways, including the receptor activator of nuclear factor kappa B ligand and osteoprotegerin system, as well as pathways associated with Wnt signaling, parathyroid hormone, and local growth factors.

Mineralization depends on the availability and regulated handling of calcium and phosphate, appropriate enzymatic activity, and the integrity of the extracellular matrix. Vitamin D contributes to calcium and phosphate homeostasis and supports normal skeletal mineralization. However, the physiological necessity of vitamin D does not mean that pharmacological supplementation in vitamin D-replete individuals will necessarily accelerate the healing of an acute rib fracture. Clinical investigations have not consistently demonstrated improved fracture union from vitamin D supplementation alone, and the evidence remains heterogeneous across fracture types and patient populations.

Mechanical conditions are equally important. Rib movement during breathing generates repetitive forces at the fracture site, and excessive displacement may influence local stability and healing conditions. Nevertheless, the thoracic cage cannot generally be immobilized in the same manner as some limb fractures because chest-wall movement is necessary for ventilation. Management must therefore balance pain reduction and protection of the injured area with maintenance of respiratory excursion, effective coughing, and appropriate mobilization. External compression that significantly restricts chest movement is generally inappropriate because it may compromise ventilation and increase respiratory risk.

The remodeling phase continues after the initial clinical symptoms have improved. Newly formed bone undergoes structural reorganization in response to mechanical loading and physiological demands. The time required for recovery varies according to injury severity, fracture displacement, age, metabolic health, and associated injuries. Pain may diminish before complete biological remodeling has occurred, and persistent discomfort does not invariably indicate nonunion. Clinical assessment should therefore integrate symptoms, function, injury characteristics, and imaging when indicated rather than relying on pain intensity alone as a direct measure of bone regeneration. These biological principles have direct implications for pharmacotherapy. Medicines should be selected according to their established clinical indications and patient-specific risk profiles, while nutritional and metabolic interventions should address demonstrable needs. Experimental findings concerning osteoblast proliferation, cytokine modulation, or mineral deposition may generate hypotheses for future treatment development, but they cannot substitute for clinical evidence showing improved healing, reduced complications, or better patient-centered outcomes.

Pharmacological Management of Rib Fracture Pain and the Evidence for Multimodal Analgesia

Pharmacological management is a central component of rib fracture care because pain control facilitates ventilation, coughing, movement, and participation in rehabilitation. The selection of medicines should be based on the severity and functional consequences of pain, the patient's physiological condition, associated injuries, and the balance between therapeutic benefit and adverse effects. The principal pharmacological categories include non-opioid analgesics, non-steroidal anti-inflammatory drugs, opioid analgesics, local anesthetics used in regional techniques, and selected adjunctive agents in appropriately defined clinical circumstances.

The available literature supports a multimodal approach in which complementary interventions are combined according to individual clinical needs. However, the evidence does not establish one universally superior analgesic regimen for every patient with rib fractures. A systematic review of randomized controlled trials published in the Journal of Clinical Anesthesia identified considerable variation in study methods, analgesic techniques, and outcome measures. Epidural analgesia was associated with reduced pain scores in the included evidence, but the authors emphasized that limitations in study quality required cautious interpretation.

Non-steroidal anti-inflammatory drugs and cyclooxygenase inhibition

Non-steroidal anti-inflammatory drugs are widely used for acute musculoskeletal pain because they inhibit cyclooxygenase-mediated prostaglandin synthesis. Cyclooxygenase-1 and cyclooxygenase-2 contribute to prostanoid production, although their physiological roles and patterns of expression differ. Inhibition of these pathways can reduce inflammatory sensitization of peripheral nociceptors and thereby improve pain associated with tissue injury. Representative medicines include ibuprofen, naproxen, diclofenac, ketorolac, and celecoxib. Their pharmacological properties differ in cyclooxygenase selectivity, pharmacokinetics, available formulations, duration of action, and adverse-effect profiles. The choice of agent should not be based solely on its perceived analgesic potency. Renal function, gastrointestinal history, cardiovascular risk, bleeding susceptibility, anticoagulant exposure, hypersensitivity, and concurrent medication use should be considered before prescribing.

NSAIDs require particular consideration in patients with thoracic trauma because associated injuries may include occult bleeding, hypovolemia, renal hypoperfusion, or other conditions that increase the likelihood of adverse effects. Their use should also be evaluated in the context of fracture healing. Prostaglandins participate in inflammatory signaling and bone repair, providing a biological rationale for investigating whether cyclooxygenase inhibition influences union. Nevertheless, mechanistic concerns should not be interpreted as proof that every short course of NSAIDs causes delayed healing.

The Eastern Association for the Surgery of Trauma and the Orthopaedic Trauma Association have supported NSAID use for acute pain after traumatic orthopedic fractures when the analgesic benefits outweigh the relatively small overall increase in nonunion risk identified in the evidence they reviewed. The magnitude of risk may depend on the specific agent, duration of exposure, dose, and clinical circumstances. For rib fractures specifically, the principal rationale for NSAIDs is analgesia and opioid-sparing treatment rather than a demonstrated direct effect on rib regeneration. They should not be represented as bone-regenerative agents. Their potential value lies in improving pain control while limiting reliance on other analgesics, provided that the patient's contraindications and risk factors have been appropriately assessed.

Paracetamol and non-opioid analgesia

Paracetamol, also known as acetaminophen, is frequently incorporated into multimodal analgesic regimens. It has analgesic and antipyretic activity, although its mechanism of action is not fully explained by a single established pathway. Unlike conventional NSAIDs, paracetamol has relatively

limited peripheral anti-inflammatory activity at usual therapeutic exposure. Its inclusion may help reduce the need for opioid rescue medication in selected patients, but the magnitude of its specific contribution to rib fracture outcomes remains uncertain. The available clinical literature includes studies comparing oral and intravenous administration and studies evaluating paracetamol in relation to other analgesics. These investigations do not establish that a particular formulation is superior for all rib fracture patients.

The major safety consideration is dose-dependent hepatotoxicity following excessive cumulative exposure. Risk assessment should include hepatic function, nutritional status, relevant alcohol exposure, and all combination products containing paracetamol. The same active ingredient may be present in several prescribed or non-prescribed medicines, creating the possibility of inadvertent duplication. Therefore, medication reconciliation and clear instructions about total daily exposure are integral to safe use. Paracetamol is best understood as an analgesic component of supportive treatment. It does not directly stabilize the fracture, and there is insufficient evidence to classify it as an agent that accelerates bone union.

Opioid analgesics and the balance between analgesia and respiratory safety

Opioid analgesics remain relevant when pain is severe or inadequately controlled by suitable non-opioid interventions. Medicines in this category include morphine, oxycodone, hydromorphone, and fentanyl, although their routes of administration, pharmacokinetic profiles, potency, and clinical indications differ. Opioids act predominantly through opioid receptors, particularly the mu-opioid receptor, modifying nociceptive transmission and the perception of pain.

Their therapeutic effectiveness must be balanced against adverse effects that are especially important in thoracic trauma. Sedation, respiratory depression, nausea, vomiting, constipation, impaired alertness, and falls may interfere with recovery. Respiratory depression is particularly concerning because rib fracture pain can already restrict inspiration and coughing. The addition of opioid-induced ventilatory suppression may worsen respiratory compromise in susceptible patients.

Risk is influenced by age, frailty, baseline respiratory function, sleep-disordered breathing, renal or hepatic impairment, previous opioid exposure, and concurrent use of central nervous system depressants. Medicines such as benzodiazepines and other sedating agents may produce additive effects. The selection, route, and intensity of opioid treatment should therefore be individualized, with repeated assessment of pain, respiratory status, alertness, and functional response. The therapeutic endpoint should be adequate analgesia that enables deep inspiration, effective coughing, and mobilization rather than complete elimination of all pain at any cost. Where opioids are necessary, the regimen should be reviewed regularly, with attention to the continuing indication and opportunities to reduce exposure as the patient improves. Discharge planning should include appropriate medication instructions and consideration of safe storage, duration, and discontinuation.

Opioids have no established role as direct promoters of rib bone regeneration. Their function is symptomatic pain control. Their potential benefits and harms must be evaluated using clinical outcomes rather than analgesic potency alone.

Regional analgesia and local anesthetic techniques

Regional analgesia can provide targeted pain relief and may reduce systemic analgesic requirements. Techniques used in selected rib fracture patients include thoracic epidural analgesia, thoracic paravertebral blockade, intercostal nerve blocks, erector spinae plane blocks, and serratus anterior plane blocks. These techniques differ in anatomical target, expected distribution of analgesia, technical requirements, duration, and potential complications.

Local anesthetics, including bupivacaine, ropivacaine, and lidocaine, inhibit voltage-gated sodium channels and interrupt nerve impulse conduction. Their use in regional techniques requires careful selection of the drug, concentration, total dose, route, and administration technique. The choice is influenced by patient characteristics, the anatomical site, expected duration of analgesia, and the experience of the clinician performing the procedure.

Potential complications include local anesthetic systemic toxicity, bleeding, infection, unintended neural injury, and technique-specific hemodynamic effects. Anticoagulation and coagulation status are especially relevant when considering neuraxial or deep regional procedures. These factors should be evaluated according to current procedural guidance and institutional protocols.

Evidence for regional analgesia is encouraging in selected clinical circumstances, but uncertainty remains regarding the comparative superiority of individual techniques across all outcomes. The systematic review of randomized trials published found evidence of pain reduction with epidural analgesia while emphasizing the limitations of the available studies. Regional techniques should therefore be considered components of an individualized multimodal strategy rather than universal replacements for systemic analgesia. Their principal established purpose is pain control; any downstream improvement in respiratory function or recovery must be evaluated through appropriate clinical outcomes.

Other analgesic adjuncts and investigational approaches

Ketamine, intravenous lidocaine, gabapentinoids, and other adjunctive agents have been considered in selected acute pain settings. Their use in rib fracture management requires particular caution because evidence derived from other types of pain cannot automatically be extrapolated to thoracic trauma.

Ketamine acts primarily through antagonism of N-methyl-D-aspartate receptors and may influence central sensitization and pain processing. However, the available evidence does not establish a universal benefit for ketamine infusion in rib fracture patients. Potential adverse effects include perceptual disturbances, dysphoria, cardiovascular stimulation, and other effects requiring appropriate clinical monitoring.

Intravenous lidocaine has been investigated as an adjunct for acute pain, but evidence specific to rib fractures remains limited. Its therapeutic window and potential for neurological and cardiovascular toxicity require appropriate patient selection and monitoring. Gabapentinoids may be relevant to selected neuropathic pain conditions, but routine use for uncomplicated acute rib fracture pain should not be assumed to provide additional benefit; sedation and dizziness may also be problematic.

Muscle relaxants and sedating adjuncts should not be added routinely without a clear indication, because their adverse effects may complicate respiratory assessment and mobility. Similarly, corticosteroids should not be used solely to accelerate rib fracture healing in the absence of another established indication. No general pharmacological rationale justifies treating every component of post-traumatic inflammation with systemic corticosteroids.

The governing principle is that an adjunct should be incorporated only when its expected clinical benefit, evidence base, and safety profile justify its use. The addition of more medicines does not necessarily improve outcomes and may increase the complexity of treatment, the probability of drug interactions, and the burden of adverse effects.

Nutritional Substrates, Minerals, Vitamins, and Biologically Active Compounds in Bone Healing

Vitamin D_3 and calcium homeostasis

Vitamin D_3, or cholecalciferol, is a fat-soluble vitamin involved in calcium and phosphate homeostasis and normal skeletal mineralization. Following hepatic conversion to 25-hydroxyvitamin D and subsequent renal and extrarenal metabolism, vitamin D metabolites

participate in regulating intestinal calcium absorption, phosphate handling, and bone metabolism. The biologically active metabolite, calcitriol, influences gene expression through the vitamin D receptor and contributes to mineral homeostasis.

Vitamin D status is relevant to bone health, particularly in individuals with inadequate intake, limited sun exposure, malabsorption, osteoporosis, or other conditions affecting mineral metabolism. However, its role in preventing deficiency must be distinguished from the question of whether supplementation accelerates the healing of an established fracture.

A systematic review of vitamin D supplementation in fracture patients included fourteen studies involving 2,734 participants. Most studies did not demonstrate consistent improvements in fracture union or functional outcomes attributable to vitamin D supplementation alone. Some studies reported favorable findings, but the evidence was heterogeneous and the positive results were not sufficiently robust to establish routine supplementation as a fracture-healing intervention for every patient.

A separate systematic review examining vitamin D status and fracture healing likewise found that human evidence remained inconclusive. The studies differed in definitions of deficiency, supplementation regimens, fracture types, and outcome measures.

The appropriate clinical interpretation is that vitamin D deficiency should be identified and managed when indicated, but supplementation should not be presented as a proven accelerator of rib union in vitamin D-replete patients. Where deficiency is suspected or established, decisions about testing and treatment should reflect clinical risk factors, laboratory findings, comorbidities, and applicable guidance.

Available formulations include oral drops, capsules, tablets, and combination products. Commercial products may contain different amounts of cholecalciferol, so the concentration or strength must be confirmed from the specific product label. Calcitriol and other active vitamin D analogues are pharmacologically distinct from routine cholecalciferol supplementation and require more specialized indications and monitoring because excessive exposure may cause hypercalcemia or other complications.

Calcium salts and skeletal mineralization

Calcium is a principal mineral constituent of bone and is essential for normal skeletal mineralization, neuromuscular function, and cellular signaling. During fracture repair, calcium and phosphate contribute to mineral deposition within the developing extracellular matrix. Adequate calcium intake is therefore necessary for normal bone physiology.

Calcium carbonate and calcium citrate are commonly used supplemental salts. Their elemental calcium content differs, and the mass of the salt is not equivalent to the quantity of elemental calcium delivered. Product strength and elemental calcium content should consequently be distinguished when describing formulations in scientific publications.

The rationale for calcium supplementation is strongest when dietary intake is inadequate, requirements are not met, or a relevant clinical condition warrants supplementation. It is not established that providing additional calcium beyond physiological requirements accelerates healing of an uncomplicated rib fracture. Excessive supplementation may produce adverse effects, including constipation and, in susceptible patients, hypercalcemia or nephrolithiasis. Renal function, stone history, total dietary intake, and concomitant medicines should inform clinical decisions.

Calcium and vitamin D are often discussed together because their physiological functions are complementary. Nevertheless, combined supplementation should not be assumed to improve fracture union simply because both nutrients participate in bone metabolism. The evidence for fracture healing must be assessed separately from evidence relating to deficiency correction, bone mineral density, or long-term fracture prevention.

Protein intake, amino acids, and collagen synthesis

Protein provides amino acids required for tissue repair, collagen synthesis, enzyme production, immune function, and maintenance of skeletal muscle. Inadequate protein intake may compromise recovery, particularly in older adults, individuals with malnutrition, and patients with substantial trauma-related metabolic demands.

Collagen constitutes a major organic component of bone matrix and provides a scaffold upon which mineralization occurs. Amino acids such as glycine, proline, and lysine participate in collagen structure and synthesis. However, the physiological importance of these substrates does not establish that high-dose supplementation improves rib fracture union in individuals who already consume adequate protein.

Clinical assessment should prioritize nutritional adequacy, energy intake, and identification of malnutrition. Oral nutritional supplements or targeted protein support may be appropriate when intake is inadequate or nutritional requirements are increased. The choice of formulation should consider renal function, gastrointestinal tolerance, dietary restrictions, and the patient's overall nutritional plan.

Hydrolyzed collagen supplements have been investigated for several musculoskeletal outcomes, but evidence directly demonstrating improved healing of acute rib fractures is insufficient. Collagen products should therefore be described as potential nutritional adjuncts rather than established fracture-regenerative medicines. Their composition varies considerably, and a product's labeled protein or collagen content does not establish clinical efficacy for bone union.

Vitamin C and connective tissue repair

Vitamin C, or ascorbic acid, is required for normal collagen synthesis and contributes to antioxidant defense. It functions as a cofactor in enzymatic reactions involved in collagen maturation and supports several aspects of normal connective-tissue physiology. Severe deficiency can impair tissue repair, while adequate intake supports normal physiological function.

However, supplementation in individuals without deficiency has not been established as a reliable method for accelerating rib fracture healing. The presence of an essential biochemical role does not mean that progressively increasing intake produces a proportional increase in collagen synthesis or fracture union. Physiological processes are regulated, and additional substrate may not improve outcomes when substrate availability is already adequate.

Vitamin C is available in tablets, capsules, powders, and combination supplements with differing strengths. High supplemental exposure may cause gastrointestinal symptoms and can be problematic in some patients predisposed to oxalate kidney stones or iron overload. The clinical objective should be adequate intake and correction of deficiency rather than indiscriminate high-dose supplementation.

Vitamin K and bone matrix proteins

Vitamin K is involved in the gamma-carboxylation of several proteins, including osteocalcin, which participates in bone matrix biology. Vitamin K-dependent biochemical processes are important to normal physiology, but the clinical benefit of supplementation for accelerating acute rib fracture union has not been established sufficiently to support routine use as a fracture-healing treatment.

Vitamin K supplementation is particularly important to evaluate in patients taking warfarin or related vitamin K antagonists. Abrupt changes in vitamin K intake can alter anticoagulant effects and complicate the management of bleeding and thromboembolic risk.

A balanced dietary intake is generally preferable to introducing supplements without a defined indication. Any supplementation decision should account for anticoagulation, comorbidities, dietary status, and the evidence supporting the proposed use.

Magnesium, zinc, and phosphate metabolism

Magnesium participates in numerous enzymatic reactions, energy metabolism, neuromuscular function, and mineral homeostasis. Zinc contributes to protein synthesis, cellular proliferation, immune function, and the activity of enzymes involved in tissue repair. Phosphate is an essential component of hydroxyapatite and is tightly regulated through intestinal absorption, renal handling, hormonal pathways, and skeletal exchange.

Deficiencies in these minerals can compromise normal physiological processes and may warrant correction. Nevertheless, evidence that supplementation above physiological requirements accelerates rib fracture healing remains limited. A systematic review of nutraceuticals for adult fracture healing published in 2026 emphasized that high-quality clinical evidence remains limited for many commonly promoted supplements, including magnesium, zinc, vitamin C, and other compounds.

Supplementation should therefore be based on nutritional assessment, laboratory findings where appropriate, clinical context, and known safety considerations. Excessive zinc intake can interfere with copper metabolism, while magnesium supplements may cause gastrointestinal effects and require caution in significant renal impairment. Phosphate preparations also require careful use in patients with renal or metabolic disorders.

Glucosamine and chondroitin: distinction between cartilage support and bone regeneration

Glucosamine and chondroitin sulfate are commonly marketed as supplements for joint health and are frequently discussed in relation to osteoarthritis and cartilage metabolism. Their proposed biological effects concern components of the extracellular matrix and cartilage-related processes rather than direct restoration of a fractured rib.

Glucosamine is an amino sugar involved in biochemical pathways associated with glycosaminoglycan synthesis, while chondroitin sulfate is a sulfated glycosaminoglycan present in cartilage and other connective tissues. These biological functions provide a rationale for studying their potential effects in degenerative joint disease, but they do not establish that either compound accelerates fracture callus formation, improves rib union, or prevents nonunion.

There is insufficient high-quality clinical evidence to recommend glucosamine or chondroitin specifically for the regeneration of rib bone following traumatic fracture. They should not be described as established osteogenic agents or substitutes for adequate nutrition, appropriate fracture management, or treatment of confirmed metabolic deficiencies. Their use for other indications should be evaluated independently, with attention to product quality, interactions, and patient-specific contraindications.

For scientific accuracy, glucosamine and chondroitin should be included in the background as examples of commercially available biologically active compounds whose proposed musculoskeletal benefits require careful differentiation from evidence of fracture healing. A review should explicitly avoid implying that their use is supported by clinical evidence for rib regeneration.

Other Biologically Active Compounds and Pharmacological Agents Relevant to Skeletal Repair

Omega-3 fatty acids and inflammatory modulation

Omega-3 polyunsaturated fatty acids, particularly eicosapentaenoic acid and docosahexaenoic acid, participate in lipid signaling and the biosynthesis of specialized pro-resolving mediators. These mediators contribute to the regulation and resolution of inflammatory responses. Their effects on inflammatory signaling, cellular membranes, and metabolic pathways have generated interest in their potential role in musculoskeletal health.

Nevertheless, the relationship between omega-3 supplementation and clinical fracture healing remains uncertain. Experimental observations involving inflammation or osteoblast activity do not

establish improved fracture union in humans. Omega-3 products may also influence platelet function, and their use should be reviewed in patients receiving anticoagulants or antiplatelet medicines, particularly when traumatic bleeding is a concern. They should not be prescribed specifically to accelerate rib regeneration without adequate supporting evidence.

Collagen peptides, amino acid formulations, and nutritional adjuncts

Collagen peptides and amino acid formulations are marketed for connective-tissue and musculoskeletal support. Their proposed mechanisms include supplying amino acid substrates for extracellular matrix synthesis and influencing cellular signaling associated with tissue maintenance. The clinical significance of these effects depends on formulation, dose, nutritional status, and the characteristics of the population studied.

For patients with inadequate protein intake, a nutritionally complete intervention may be more appropriate than a single isolated supplement. In contrast, adding collagen peptides to an already adequate diet has not been demonstrated to accelerate traumatic rib fracture union reliably. Research should distinguish biochemical markers, subjective pain outcomes, bone mineral density, and actual clinical or radiographic fracture union because these endpoints represent different dimensions of biological and clinical response.

Creatine and preservation of skeletal muscle function

Creatine participates in cellular energy buffering through the phosphocreatine system and has been studied primarily in relation to muscle performance, exercise adaptation, and preservation of lean mass. Its potential relevance during fracture recovery concerns muscle function and physical rehabilitation rather than direct osteogenesis. Maintaining muscle strength and mobility may contribute to functional recovery, especially in older adults or patients whose injuries lead to prolonged inactivity. However, there is insufficient evidence to classify creatine as a treatment that directly accelerates rib fracture healing. Supplementation should be evaluated according to nutritional needs, exercise or rehabilitation objectives, renal considerations, and the patient's broader clinical condition.

Antioxidants and oxidative stress

Oxidative stress is involved in inflammatory signaling, cellular injury, and several aspects of bone metabolism. Antioxidant compounds, including vitamins C and E and selected dietary polyphenols, have consequently been investigated in experimental models of tissue repair. Their biological effects may vary according to concentration, timing, molecular structure, and the physiological environment. It is important to distinguish normal redox signaling from pathological oxidative stress. Reactive oxygen species also participate in cellular signaling and physiological processes involved in repair. Consequently, the assumption that higher antioxidant exposure necessarily improves fracture healing is scientifically unjustified. Excessive supplementation may introduce toxicity, alter medication effects, or provide no additional benefit when nutritional intake is adequate. Antioxidant supplementation should therefore be considered primarily in relation to documented nutritional requirements or other established indications. The available evidence does not justify routine high-dose antioxidant treatment as a method of accelerating rib bone regeneration.

Parathyroid hormone analogues and osteoanabolic therapy

Parathyroid hormone has a central role in calcium and phosphate regulation, while intermittent administration of selected parathyroid hormone analogues can stimulate osteoblast activity and bone formation in established clinical indications. Teriparatide is an example of an osteoanabolic medicine used in the management of selected patients with osteoporosis and high fracture risk.

Its physiological effects have prompted investigation into possible applications in fracture healing. However, evidence concerning accelerated union remains inconsistent, and a treatment's established role in osteoporosis does not establish an indication for routine use after an acute rib fracture. The decision to use osteoanabolic treatment should be based on an established indication, such as an appropriate osteoporosis treatment plan, rather than an assumption that it will directly accelerate rib healing. Abaloparatide is another osteoanabolic agent used for selected osteoporosis indications. It should likewise not be represented as standard treatment for traumatic rib fractures. Both agents require specialist assessment and consideration of contraindications, adverse effects, treatment objectives, and relevant monitoring.

Bisphosphonates, denosumab, and other antiresorptive agents

Bisphosphonates, including alendronate, risedronate, and zoledronic acid, reduce osteoclast-mediated bone resorption. Denosumab inhibits receptor activator of nuclear factor kappa B ligand and reduces osteoclast formation and activity. These medicines are used in selected osteoporosis and other bone disorders, but their effects on bone turnover should not be conflated with a direct capacity to accelerate fracture union. Clinical evidence reviewed in the literature on pharmacological approaches to fracture healing has not established that commonly used bisphosphonates or denosumab consistently accelerate bone healing. Their established indications and potential benefits in reducing future fracture risk must be considered separately from the treatment of an acute rib fracture. Patients already receiving antiresorptive treatment should not automatically discontinue it solely because a rib fracture has occurred. Decisions about continuation, interruption, or modification require assessment of the underlying indication, fracture risk, treatment history, and potential complications. Particular caution is necessary in patients with advanced renal impairment, hypocalcemia, or other contraindications relevant to the specific medicine.

Calcitonin and investigational fracture-healing applications

Calcitonin affects calcium homeostasis and inhibits osteoclast activity. It has established uses in selected clinical contexts, although its role in fracture healing remains uncertain. Some clinical investigations have suggested potential benefits in selected fracture-related outcomes, but this does not establish calcitonin as a standard treatment for traumatic rib fractures. Its inclusion in a pharmacological background should therefore distinguish between established indications, investigational applications, and unsupported routine use. Any consideration of calcitonin must account for the specific formulation, clinical indication, contraindications, adverse effects, and applicable regulatory guidance.

Statins and other experimental osteomodulatory agents

Statins inhibit hydroxymethylglutaryl-coenzyme A reductase and are primarily prescribed for lipid disorders and cardiovascular risk reduction. Experimental studies have explored possible effects on bone metabolism and osteogenic signaling, but such findings do not establish clinical efficacy in accelerating rib fracture union.

Similarly, experimental investigations of growth factors, bone morphogenetic proteins, cellular therapies, and other osteomodulatory compounds may provide insights into skeletal repair. Their clinical relevance depends on the evidence for the particular intervention, route, indication, safety profile, and fracture type. These approaches should not be conflated with routinely recommended treatment for uncomplicated rib fractures. The overarching conclusion is that the presence of biological activity in bone-related pathways is insufficient to justify a therapeutic recommendation. Agents should be classified according to their established indications, evidence

of clinically meaningful benefit, safety characteristics, and the distinction between experimental findings and demonstrated patient outcomes.

❖ Non-Pharmacological Interventions Supporting Rib Fracture Recovery

Respiratory physiotherapy and pulmonary hygiene

Respiratory physiotherapy constitutes a fundamental component of rib fracture management because pain-related respiratory restriction may compromise ventilation and secretion clearance. Its objectives include maintaining adequate inspiratory effort, facilitating effective coughing, supporting pulmonary expansion, and reducing the consequences of immobility. These interventions should be individualized according to the patient's respiratory status, injury severity, cognitive capacity, and ability to participate safely.

Supported coughing, deep-breathing exercises, appropriate positioning, and mobilization may be incorporated into structured respiratory care. Analgesia should be coordinated with these interventions so that pain does not unnecessarily prevent participation. However, respiratory exercises should not be considered substitutes for assessment of associated thoracic injuries or treatment of respiratory deterioration. Incentive spirometry may be used as part of a broader respiratory management plan, particularly when patients can understand and perform the technique. Its effectiveness depends on appropriate instruction, adherence, baseline pulmonary function, and the wider clinical context. A single respiratory measurement should not replace comprehensive assessment of breathing, oxygenation, cough effectiveness, and clinical progression.

Early mobilization and functional rehabilitation

Prolonged immobility can contribute to deconditioning, reduced muscle strength, loss of functional independence, and additional complications, particularly in older adults. Early mobilization, when clinically safe, supports the maintenance of mobility and the gradual return to usual activities. Rehabilitation should be adapted to pain severity, fracture stability, oxygenation, associated injuries, and pre-existing functional limitations.

Patients with frailty or impaired balance may require assistance to reduce falls risk. Functional goals can include independent transfers, safe walking, effective coughing, adequate oral intake, and progressive resumption of daily activities. These outcomes are clinically meaningful because successful rib fracture management involves more than radiographic healing.

Surgical stabilization of selected rib fractures

Surgical stabilization may be considered for selected patients with flail chest, substantial fracture displacement, chest-wall instability, or persistent impairment despite appropriate non-operative management. Decisions should involve trauma and thoracic surgical expertise and take into account anatomical findings, respiratory function, associated injuries, comorbidities, procedural risks, and the anticipated benefits of stabilization. Surgical stabilization should not be presented as universally necessary for multiple rib fractures. Its indications depend on the individual clinical situation and the evidence supporting intervention in that population. Likewise, it does not eliminate the need for adequate analgesia, pulmonary care, mobilization, and medication-safety monitoring.

Nutrition, lifestyle, and modifiable risk factors

Adequate nutrition supports normal bone metabolism and tissue repair. Nutritional assessment should consider energy intake, protein adequacy, calcium intake, vitamin D status where clinically indicated, alcohol exposure, smoking, and conditions associated with malabsorption or metabolic bone disease. Correction of deficiencies is an important component of general recovery, but supplementation beyond physiological requirements should not be assumed to improve fracture

union. Smoking cessation is relevant because tobacco exposure is associated with adverse skeletal and general health outcomes. Excessive alcohol consumption may also compromise nutritional status, increase falls risk, and complicate medication safety. These factors should be considered in individualized recovery planning. Patients should receive guidance on safe analgesic use, respiratory exercises, gradual activity, and warning signs requiring urgent assessment. Worsening breathlessness, new or increasing chest pain, fever, confusion, hemoptysis, or other signs of clinical deterioration require prompt medical evaluation rather than escalation of supplements or self-medication.

Evidence-Based Interpretation of Bone-Regenerative Treatments

A critical distinction must be maintained between treatments that support normal physiological bone health and interventions demonstrated to improve fracture healing. Vitamin D and calcium are essential to mineral metabolism, protein is necessary for tissue synthesis, and several micronutrients participate in cellular repair. These facts establish biological relevance, but they do not prove that additional supplementation improves union in individuals who are already nutritionally sufficient.

The same distinction applies to medicines used for osteoporosis. Antiresorptive agents may reduce future fracture risk in appropriately selected patients, while osteoanabolic agents may be indicated for specific osteoporosis populations. Neither role automatically establishes a therapeutic indication for accelerating healing of an acute rib fracture. Decisions about existing osteoporosis treatment should be based on the underlying disease and relevant clinical guidance.

A systematic review of pharmacological interventions for fracture healing found that clinical evidence for several proposed bone-modifying agents remained inconsistent. The review did not establish that commonly used bisphosphonates, denosumab, vitamin D and calcium supplementation, or ibuprofen consistently improved fracture healing across the investigated populations. Evidence concerning parathyroid hormone analogues was also not definitive. These findings reinforce the need for careful interpretation of proposed bone-regenerative products. Supplements marketed for joint health, connective-tissue support, or antioxidant activity should not be described as proven rib-healing therapies unless clinical evidence directly supports that claim. In particular, glucosamine and chondroitin should be distinguished from established interventions for correcting nutritional deficiencies or managing acute fracture pain.

Clinical Pharmacovigilance and Pharmacosafety in Rib Fracture Management

Pharmacovigilance should be integrated throughout the treatment pathway, from initial medication reconciliation to discharge and follow-up. Rib fracture patients may receive several medicines within a short period, increasing the possibility of duplicate ingredients, interactions, inappropriate dosing, and adverse effects. NSAIDs require assessment of gastrointestinal bleeding risk, renal function, cardiovascular disease, anticoagulant exposure, and concurrent nephrotoxic medicines. Paracetamol requires attention to cumulative exposure and hepatic risk. Opioids require monitoring for sedation, respiratory depression, constipation, and impaired mobility. Regional anesthetic techniques require appropriate procedural safeguards and monitoring for local anesthetic toxicity.

Nutritional supplements should also be included in medication reconciliation. Products containing calcium, vitamin D, vitamin K, magnesium, or zinc may interact with prescribed medicines or create excessive cumulative exposure when several products are taken concurrently. Vitamin K intake is particularly relevant for patients receiving warfarin, while calcium and magnesium can interfere with the absorption of selected oral medicines if taken together. The nature and clinical importance of each interaction depend on the specific products and prescribing context. A comprehensive medication-safety assessment should evaluate the indication for every medicine,

the intended duration of treatment, the evidence supporting its use, the potential for interactions, and the criteria for discontinuation. This process helps prevent the assumption that more medicines necessarily provide better recovery.

Research Gaps and Priorities for Future Investigation

Several important research questions remain unresolved. High-quality clinical trials are needed to compare multimodal analgesic regimens using standardized definitions of pain, respiratory function, opioid consumption, adverse effects, and functional recovery. Comparative studies of regional analgesic techniques should account for differences in fracture patterns, patient characteristics, operator experience, and co-interventions. Research concerning nutritional interventions should distinguish patients with documented deficiencies from those with adequate baseline nutritional status. Trials should evaluate clinically meaningful outcomes, including time to union, complications, functional recovery, and safety, rather than relying exclusively on biochemical markers or experimental evidence. Rib-specific studies are especially important because findings from long-bone fractures cannot necessarily be generalized to thoracic skeletal injuries. Studies of glucosamine, chondroitin, collagen peptides, antioxidants, and other nutraceuticals should be interpreted cautiously until adequately powered clinical trials establish relevant benefits. Investigations of osteoporosis medicines should similarly distinguish treatment of the underlying metabolic bone disorder from the proposed acceleration of acute fracture healing. Future systematic reviews should use transparent eligibility criteria, reproducible database searches, independent screening and data extraction where feasible, structured risk-of-bias assessment, and appropriate synthesis methods consistent with PRISMA reporting principles. The certainty of evidence should be assessed explicitly, and conclusions should reflect the limitations of the included studies.

AIM AND OBJECTIVES

The aim of this scientific review is to critically evaluate the pharmacological and non-pharmacological management of rib fractures, emphasizing the pharmacotherapeutic armamentarium, medicinal product classification, pharmacodynamics, pharmacokinetics, therapeutic efficacy, adverse drug reactions, drug toxicity, pharmacovigilance, and evidence-based strategies for optimizing analgesia, respiratory function, fracture healing, patient safety, and clinical outcomes.

METHODOLOGY

This systematic review was methodologically structured in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement to facilitate transparent reporting, methodological reproducibility, comprehensive evidence identification, and critical appraisal of the scientific literature concerning the pharmacological and non-pharmacological management of rib fractures. The methodological framework was designed to examine the pharmacotherapeutic armamentarium, medicinal product classification, clinical pharmacology, pharmacodynamics, pharmacokinetics, analgesic efficacy, adverse drug reactions, drug-induced toxicity, pharmacovigilance, pharmacosafety, bone-healing mechanisms, and clinically relevant therapeutic outcomes. A comprehensive literature search was designed to identify relevant publications in PubMed/MEDLINE, Scopus, Web of Science, Embase, and the Cochrane Library. The search strategy incorporated Medical Subject Headings (MeSH), where applicable, free-text terminology, and Boolean operators to optimize sensitivity and specificity. Search terms included “rib fracture,” “multiple rib fractures,” “fracture pain,” “analgesia,” “nonsteroidal anti-inflammatory drugs,” “NSAIDs,” “paracetamol,” “opioids,” “regional analgesia,” “epidural analgesia,” “erector spinae plane block,” “serratus anterior plane block,” “bone healing,”

"fracture union," "vitamin D," "calcium supplementation," "pharmacotherapy," "adverse drug reactions," "drug toxicity," "pharmacovigilance," and "evidence-based medicine." Combinations of these terms were employed to investigate therapeutic effectiveness, comparative safety, pharmacological mechanisms, respiratory complications, and strategies for optimizing recovery.

The eligibility criteria were established according to the review objectives. Eligible publications included randomized controlled trials, systematic reviews, meta-analyses, prospective and retrospective observational studies, clinical practice guidelines, pharmacological investigations, and relevant experimental studies addressing rib fractures, analgesic interventions, respiratory outcomes, fracture healing, or medication-related safety. Studies involving adult and pediatric populations were considered when their findings were relevant to the review questions; population-specific differences were interpreted separately. Publications concerning isolated rib fractures, multiple fractures, and rib fractures associated with thoracic trauma were considered. Studies were excluded when they lacked substantive relevance to the research objectives, presented insufficient methodological information, duplicated previously identified records, or consisted of unsupported opinions without an identifiable evidentiary basis. Language restrictions and publication-date limits were to be documented explicitly if applied.

Study selection was organized according to the PRISMA identification, screening, eligibility, and inclusion framework. Following the removal of duplicate records, titles and abstracts were assessed for relevance, after which potentially eligible full-text articles were examined against the predefined inclusion and exclusion criteria. Reasons for full-text exclusion were documented to improve auditability. The final number of identified, screened, excluded, and included publications should be reported in a PRISMA 2020 flow diagram using verified screening records; no numerical selection results should be inferred without completing the search and screening process. The review was intended to integrate efficacy, tolerability, pharmacological plausibility, and patient safety within an evidence-based framework. PRISMA 2020 was used as a reporting framework rather than as a substitute for a prespecified protocol, systematic searching, risk-of-bias assessment, or transparent evidence synthesis. Any claims concerning protocol registration, independent reviewer participation, completed database searches, or the final number of included studies must reflect the procedures actually performed.

RESULTS AND DISCUSSION

Integrated clinical assessment of rib fracture management

The integrated evaluation of rib fracture management demonstrates that successful treatment depends on the interaction between injury severity, respiratory function, analgesic effectiveness, patient-specific risk factors, and prevention of treatment-associated complications. Rib fractures should not be regarded exclusively as localized skeletal injuries because their clinical consequences extend to pulmonary mechanics, mobility, sleep quality, functional independence, and overall recovery. The principal therapeutic priorities are to achieve adequate pain control, preserve effective ventilation, facilitate secretion clearance, prevent pulmonary complications, and minimize medication-related harm. Clinical management should be guided by the number and displacement of fractures, associated thoracic injuries, respiratory status, hemodynamic stability, age, comorbidities, and the patient's capacity to cough and mobilize. Older adults and individuals with chronic pulmonary disease may require closer monitoring because reduced physiological reserve can increase susceptibility to respiratory deterioration. Similarly, patients with multiple fractures or concomitant pulmonary contusion may require more intensive analgesia, respiratory support, and multidisciplinary intervention than those with uncomplicated isolated fractures. An important finding of the available clinical evidence is that pain intensity alone does not adequately represent treatment success. Assessment should also consider inspiratory capacity, oxygenation, cough effectiveness, mobility, sleep, and the ability to participate in pulmonary rehabilitation.

Consequently, a multidimensional outcome framework is more clinically informative than an isolated numerical pain score.

Comparative evaluation of pharmacological interventions

Multimodal analgesia represents a central strategy for balancing pain reduction against medication-associated risks. The literature indicates that combining non-opioid analgesics, appropriately selected opioids, and regional anesthetic techniques may reduce reliance on individual drug classes. A 2025 narrative review encompassing 47 randomized controlled trials identified NSAIDs and paracetamol as important components of opioid-sparing strategies, while also highlighting the continuing role of opioids in severe acute pain. However, heterogeneity in treatment protocols and outcome measurements limits direct comparisons between interventions.

Paracetamol may be appropriate for mild-to-moderate pain or as an adjunct to other analgesics. NSAIDs may provide additional benefit by reducing inflammatory pain, but their use requires assessment of renal function, gastrointestinal bleeding risk, cardiovascular disease, and concurrent anticoagulant therapy. Opioids can provide effective analgesia when pain remains severe; however, respiratory depression and sedation are particularly concerning in patients whose respiratory mechanics are already compromised. Accordingly, treatment should be individualized rather than based on a uniform pharmacological protocol.Table 1 summarizes the principal therapeutic classes and their clinical considerations.

Table 1. Pharmacological interventions in rib fracture management: therapeutic roles and safety considerations

Intervention	Therapeutic role	Principal safety considerations
Paracetamol	Baseline analgesia and opioid-sparing therapy	Hepatotoxicity with excessive exposure
NSAIDs	Analgesia and reduction of inflammatory pain	Gastrointestinal bleeding, renal injury, cardiovascular risk
Opioids	Treatment of severe or refractory pain	Respiratory depression, sedation, constipation
Local anesthetics	Regional analgesia and reduction of systemic analgesic requirements	Local anesthetic systemic toxicity and procedure-specific complications
Adjunctive analgesics	Selected cases of persistent or complex pain	Agent-specific adverse reactions and interactions

The table represents a qualitative synthesis of therapeutic considerations rather than a direct comparative estimate of efficacy. Selection should be based on clinical indications, contraindications, and individual benefit–risk assessment.

Regional anesthesia and respiratory outcomes

Regional analgesia is an important option for patients with multiple fractures, severe pain, or inadequate response to systemic treatment. Thoracic epidural analgesia, paravertebral blocks, erector spinae plane blocks, serratus anterior plane blocks, and intercostal nerve blocks offer alternative approaches to pain control. Their relative suitability depends on fracture location, hemodynamic status, coagulation abnormalities, associated injuries, and available expertise. A systematic review of randomized clinical trials found that epidural analgesia was associated with reduced pain scores, although the overall evidence was limited by methodological heterogeneity and low certainty. The review did not establish sufficiently robust evidence to support definitive

comparative recommendations for several newer regional techniques. These findings support a cautious interpretation: regional anesthesia can improve analgesia in appropriately selected patients, but improved pain scores should not automatically be equated with reduced mortality, pneumonia, or hospitalization. Future studies should evaluate standardized respiratory outcomes, opioid consumption, functional recovery, adverse events, and patient-reported quality of life.

Non-pharmacological management and pulmonary protection

Non-pharmacological interventions complement medication-based treatment by addressing the physiological consequences of chest-wall pain. Appropriate measures include coached deep breathing, supported coughing, mobilization, respiratory physiotherapy, and regular reassessment of pulmonary function. Incentive spirometry may assist inspiratory exercises and provide useful information about respiratory performance, although its effectiveness in preventing complications should not be overstated. A comprehensive review published in 2024 identified pulmonary hygiene, multimodal analgesia, and dynamic risk assessment as central components of nonoperative management. It also noted that evidence supporting some respiratory-support interventions remains insufficient for definitive conclusions.

Table 2. Non-pharmacological strategies and intended clinical outcomes

Strategy	Principal objective	Monitoring priority
Deep-breathing exercises	Maintain inspiratory capacity	Inspiratory performance and discomfort
Supported coughing	Facilitate secretion clearance	Cough effectiveness
Early mobilization	Reduce immobility-related complications	Mobility and tolerance of activity
Respiratory physiotherapy	Support pulmonary function	Respiratory status and functional progress
Patient education	Encourage adherence and early recognition of deterioration	Understanding of instructions and warning signs

These interventions should be adapted to injury severity and patient tolerance. Worsening dyspnea, declining oxygen saturation, fever, or deteriorating functional capacity warrants prompt clinical reassessment.

Drug safety and pharmacovigilance

Drug safety is integral to therapeutic optimization because analgesic-related complications may undermine the intended benefits of treatment. Relevant risks include opioid-induced respiratory depression, NSAID-associated gastrointestinal and renal toxicity, paracetamol-associated hepatotoxicity, and complications associated with regional anesthesia. Medication reconciliation, appropriate dosing, interaction screening, and systematic monitoring are therefore essential.

Pharmacovigilance extends beyond individual prescribing decisions by supporting the detection, assessment, understanding, and prevention of adverse drug reactions. In rib fracture care, clinically relevant safety indicators include excessive sedation, respiratory compromise following analgesic administration, gastrointestinal bleeding, acute kidney injury, and unexpected reactions to local anesthetics. Suspected adverse reactions should be documented, managed, and reported through applicable pharmacovigilance procedures.

Particular attention is required in older adults and patients with multimorbidity or polypharmacy. The EAST practice management guideline on older adults with multiple rib fractures emphasizes

that evidence remains limited for several nonoperative interventions, reinforcing the need for individualized assessment and cautious interpretation of available findings.
The Integrated Scientific Appraisal of Pharmacological and Non-Pharmacological Management of Rib Fractures: Pharmacotherapeutic Efficacy, Clinical Pharmacology, Pharmacosafety, Bone Healing, and Therapeutic Optimization. The Results and Discussion section synthesize the available evidence concerning rib-fracture management, integrating clinical effectiveness, pharmacological mechanisms, comparative therapeutic strategies, medication safety, respiratory outcomes, and the biological determinants of fracture healing. To maintain scientific integrity, the section must distinguish findings established by clinical research from mechanistic hypotheses and emerging therapeutic approaches. Because the completed literature-search records and extracted study-level data have not been supplied, numerical pooled estimates, study counts, and statistical significance values should not be invented. The following provides a detailed manuscript-ready framework with seven titled tables for evidence synthesis.

Clinical and pharmacotherapeutic framework

Rib fractures constitute a clinically important manifestation of thoracic trauma because their consequences extend beyond structural disruption of the chest wall. Pain-related restriction of inspiration, reduced cough effectiveness, impaired secretion clearance, and diminished mobility may contribute to atelectasis, pneumonia, and respiratory deterioration, particularly in older adults and patients with multiple fractures, pulmonary contusion, or pre-existing cardiopulmonary disease. Consequently, the principal therapeutic objective is not merely to reduce reported pain intensity but to preserve ventilation, facilitate effective coughing, support early mobilization, minimize complications, and maintain an acceptable safety profile. The management strategy depends on fracture number and location, displacement, associated intrathoracic injury, respiratory status, age, frailty, renal and hepatic function, concomitant medication use, and the patient's baseline functional capacity. An isolated, uncomplicated fracture may be managed with outpatient analgesia and explicit safety-netting, whereas multiple or displaced fractures, hypoxemia, respiratory compromise, uncontrolled pain, or associated injuries may require hospital admission, multidisciplinary assessment, and escalation of treatment. The evidence must therefore be interpreted within a multidimensional clinical framework that integrates analgesic effectiveness, respiratory function, treatment-related toxicity, feasibility, and patient-centered outcomes. No single medication or intervention is universally appropriate for all rib-fracture presentations.

Comparative evidence concerning analgesic interventions

Pain control is the central pharmacotherapeutic component of rib-fracture management because nociceptive stimulation from fractured bone, periosteal injury, intercostal muscle damage, and inflammation can substantially impair respiratory mechanics. The therapeutic challenge is to achieve analgesia sufficient to permit deep inspiration, coughing, secretion clearance, sleep, and mobilization while avoiding excessive sedation, respiratory depression, hemodynamic instability, and medication-related organ toxicity. The systematic review by Hammal and colleagues, published in the Journal of Clinical Anesthesia, evaluated randomized controlled trials of analgesic interventions in hospitalized patients with rib fractures. The investigators reported substantial heterogeneity in study methods and outcome measurement, generally limited evidence quality, and lower pain scores with epidural analgesia compared with other modalities. However, the authors emphasized that the methodological limitations precluded confident conclusions about the superiority of individual interventions. These findings support an important interpretive distinction: improvement in pain scores does not necessarily establish reductions in pneumonia,

mechanical ventilation, hospital length of stay, or mortality. The clinical value of an analgesic strategy must therefore be evaluated through both symptom-based and functional endpoints.

Multimodal analgesia and rational pharmacotherapeutic combinations

Multimodal analgesia combines agents or techniques with different mechanisms of action to improve pain control while limiting exposure to any single medication class. In rib-fracture care, a multimodal strategy may integrate paracetamol, an NSAID when appropriate, carefully titrated rescue opioids, and regional analgesia for selected patients. Nonpharmacological measures, including supported coughing, breathing exercises, positioning, and early mobilization, form part of the same functional treatment strategy. The rationale is pharmacodynamic complementarity. Paracetamol provides systemic analgesia without the peripheral anti-inflammatory effects characteristic of conventional NSAIDs. NSAIDs reduce prostaglandin synthesis and inflammatory nociceptive sensitization. Opioids reduce pain transmission and perception through opioid-receptor activity, while regional anesthetic techniques interrupt nociceptive transmission at selected neural pathways. These mechanisms can be complementary, although their combination does not automatically guarantee additive clinical benefit.

A regimen should be assessed against predefined therapeutic targets: pain at rest, pain during deep inspiration or coughing, ability to mobilize, respiratory rate, oxygenation where indicated, sedation, and rescue-analgesic requirements. An improvement in resting pain without improvement in cough effectiveness or respiratory effort may indicate that the intervention is insufficiently addressing the patient's functional needs. The Eastern Association for the Surgery of Trauma guideline on blunt thoracic trauma conditionally supports epidural analgesia and multimodal analgesia over opioids alone, while acknowledging that the underlying evidence is of very low quality. The recommendation should be interpreted as support for individualized treatment rather than a requirement to administer epidural analgesia to every patient with rib fractures. The choice of treatment must also account for contraindications. For example, renal impairment, peptic ulcer disease, anticoagulant exposure, hemodynamic instability, hepatic dysfunction, obstructive sleep apnea, frailty, and concomitant sedative use can materially alter the benefit–risk balance. Treatment escalation is most defensible when a less invasive approach fails to achieve adequate functional analgesia or when the severity of injury justifies a regional or critical-care intervention.

Nonsteroidal anti-inflammatory drugs and paracetamol

NSAIDs remain important options for acute musculoskeletal pain because cyclooxygenase inhibition decreases prostaglandin-mediated inflammation and nociceptor sensitization. Their use in rib fractures, however, requires balancing analgesic benefit against gastrointestinal, renal, cardiovascular, and bleeding-related risks. In trauma patients, these risks may be amplified by dehydration, hemorrhage, hemodynamic instability, pre-existing kidney disease, or concurrent antithrombotic treatment. The potential effect of NSAIDs on bone healing is complex. Prostaglandins contribute to inflammatory signaling and bone remodeling, and experimental evidence has raised questions about whether some NSAID exposures may influence fracture repair. Nevertheless, mechanistic observations and findings from non-rib fractures cannot establish that every NSAID, dose, or duration produces clinically significant delayed union in patients with rib fractures. The appropriate interpretation is therefore one of individualized risk assessment, particularly where prolonged treatment, high exposure, or additional healing risk factors are present. Paracetamol may be incorporated into baseline analgesia when clinically appropriate. Its principal limitation is hepatotoxicity associated with excessive total exposure, including inadvertent duplication across combination products. Medication reconciliation is therefore essential, especially when patients receive opioid–paracetamol combinations alongside

separate over-the-counter preparations. Neither NSAIDs nor paracetamol should be regarded as universally appropriate. Treatment selection should reflect injury severity, comorbidities, contraindications, concurrent medication exposure, and the patient's response. The clinically meaningful objective is adequate analgesia with the lowest avoidable treatment burden, not simply the maximal reduction of inflammation or pain intensity.

Medicinal Product Strengths, Formulations, and Concentrations: Scientific Reporting Principles

The description of medicinal products in a scientific review requires precise differentiation between pharmaceutical strength, concentration, administered dose, and cumulative exposure. These terms are related but not interchangeable. A tablet may contain a specified mass of active ingredient, whereas a liquid formulation may express the amount of drug per unit volume. An injectable preparation may be described by both its concentration and the total quantity contained in the vial or ampoule. For supplements, the labeled quantity of a salt may differ from the amount of elemental mineral supplied. For example, calcium carbonate and calcium citrate should be described with reference to elemental calcium when comparing nutritional contributions. Similarly, vitamin D products may be labeled in micrograms or international units, and the conversion must be applied consistently. The concentration of a local anesthetic solution is commonly expressed as a percentage or mass per volume, whereas systemic analgesics are often labeled by the amount of active ingredient per tablet, capsule, or unit volume. The following table illustrates how common formulations may be described in a manuscript. These are examples of marketed product strengths, not patient-specific prescriptions or recommended regimens. Actual availability, labeling, concentrations, and permitted routes vary by manufacturer, country, and formulation.

Table 3. Classification of Pharmacological Agents, Medicinal Product Formulations, Representative Strengths, Therapeutic Indications, and Clinical Roles in Rib Fracture Management and Bone Healing.

Pharmacological or nutritional category	Representative agents	Examples of formulation strengths or concentrations	Principal clinical role
Non-opioid analgesic	Paracetamol (acetaminophen)	Tablets commonly containing 500 mg; oral liquids and intravenous products have formulation-specific concentrations	Analgesia and opioid-sparing treatment
Non-selective NSAID	Ibuprofen	Tablets commonly containing 200 mg or 400 mg; liquid products have labeled concentrations	Analgesia and anti-inflammatory effects
Non-selective NSAID	Naproxen	Tablets commonly containing 250 mg or 500 mg	Analgesia and anti-inflammatory effects
NSAID	Diclofenac	Oral products commonly containing 25 mg or 50 mg; topical products vary by formulation	Analgesia and anti-inflammatory effects
NSAID	Ketorolac	Oral and parenteral formulations with product-specific strengths	Short-term analgesia in selected clinical settings

Selective COX-2 inhibitor	Celecoxib	Capsules commonly containing 100 mg or 200 mg	Analgesia and anti-inflammatory effects
Opioid analgesic	Morphine	Immediate-release oral products and injectable preparations with variable strengths	Severe pain requiring opioid analgesia
Opioid analgesic	Oxycodone	Immediate-release tablets or capsules in product-specific strengths	Severe pain requiring opioid analgesia
Opioid analgesic	Fentanyl	Injectable formulations and specialized delivery systems with distinct concentrations or strengths	Analgesia in appropriately monitored clinical settings
Local anesthetic	Lidocaine	Injectable solutions commonly available at 1% or 2%; other formulations differ	Regional anesthesia and local analgesia
Local anesthetic	Bupivacaine	Injectable solutions commonly available at 0.25% or 0.5%	Regional analgesia
Local anesthetic	Ropivacaine	Injectable solutions commonly available at 0.2%, 0.5%, or 0.75%	Regional analgesia
Vitamin D	Cholecalciferol (vitamin D_3)	Common supplement strengths include 400 IU, 1,000 IU, and 2,000 IU; prescription formulations vary	Correction or prevention of vitamin D deficiency when indicated
Active vitamin D metabolite	Calcitriol	Oral capsules and other formulations in microgram quantities	Selected disorders of calcium and mineral metabolism
Calcium supplement	Calcium carbonate	Common tablet products contain 500 mg or 600 mg of calcium carbonate; elemental calcium content is lower	Correction of inadequate calcium intake when indicated
Calcium supplement	Calcium citrate	Product strengths vary; elemental calcium content depends on the formulation	Calcium supplementation when appropriate
Mineral supplement	Magnesium salts	Products vary substantially in salt type and elemental magnesium content	Correction of inadequate intake or documented deficiency
Trace element	Zinc salts	Common products may contain 10 mg or 25 mg of elemental zinc, depending on formulation	Correction of zinc deficiency when indicated

Vitamin	Ascorbic acid (vitamin C)	Common oral products contain 100 mg, 250 mg, 500 mg, or 1,000 mg	Prevention or correction of vitamin C deficiency
Vitamin	Vitamin K formulations	Product strengths vary by vitamin form and indication	Selected vitamin K deficiency and coagulation-related indications
Nutritional supplement	Protein formulations	Protein content varies by serving and product composition	Support of adequate protein intake
Nutritional supplement	Collagen peptides	Product content varies substantially by formulation and serving	Nutritional adjunct; fracture-healing efficacy remains uncertain
Joint-health supplement	Glucosamine	Common supplement products contain 500 mg per unit, with variable formulations	Marketed primarily for joint-health indications; not established for rib union
Joint-health supplement	Chondroitin sulfate	Common supplement products contain 400 mg or 500 mg per unit, with variable formulations	Marketed primarily for joint-health indications; not established for rib union

Interpretation of the formulation table: The listed strengths must not be interpreted as a dosing schedule, a recommended combination, or evidence that a product accelerates bone regeneration. Product-specific prescribing information and applicable clinical guidelines should be consulted before any clinical use. Particular caution is required for opioids, injectable analgesics, local anesthetics, active vitamin D metabolites, and medicines with narrow therapeutic margins. For scientific reproducibility, a systematic review should record the active ingredient, formulation, route of administration, strength or concentration, administered dose where reported, frequency, duration, comparator, and relevant adverse events. When primary studies use different concentrations or dosing regimens, these differences should be retained in the evidence extraction rather than artificially harmonized.

Opioid pharmacology, pharmacokinetics, and toxicity prevention

Opioids may be necessary when rib-fracture pain remains severe despite appropriate non-opioid treatment or when the intensity of injury makes immediate potent analgesia necessary. Their therapeutic effect is mediated primarily through opioid receptors in the central and peripheral nervous systems, reducing nociceptive transmission and altering the perception of pain. However, their clinical utility is constrained by dose-dependent respiratory depression, sedation, nausea, vomiting, constipation, urinary retention, and the potential for delirium, tolerance, physical dependence, and opioid use disorder. Respiratory depression is particularly relevant in thoracic trauma. A sedated patient may demonstrate reduced respiratory drive, diminished protective airway responses, impaired secretion clearance, or reduced participation in respiratory physiotherapy. These effects can counteract the intended benefits of analgesia. The relevant treatment endpoint is therefore a balance between pain reduction and preservation of alertness, ventilation, airway protection, and mobility.

Pharmacokinetic variability further complicates opioid administration. Hepatic metabolism, renal elimination of active metabolites, age-related physiological changes, drug interactions, and the presence of hepatic or renal dysfunction can alter exposure. Concomitant benzodiazepines, alcohol, sedating antihistamines, gabapentinoids, or other central nervous system depressants may increase the risk of clinically important sedation and respiratory compromise.

Table 4. Opioid Analgesics in Rib-Fracture Management: Pharmacological Characteristics and Safety Considerations

Drug or class	Pharmacological characteristics	Potential role	Important adverse effects	Principal safety considerations
Morphine	μ-opioid receptor agonist; active metabolites are relevant to elimination	Severe acute pain in appropriately monitored patients	Respiratory depression, nausea, constipation, sedation, hypotension	Renal impairment may increase exposure to active metabolites
Oxycodone	Opioid agonist with hepatic metabolism	Selected patients requiring oral rescue analgesia	Sedation, respiratory depression, constipation, nausea	Review interacting drugs and hepatic function
Fentanyl	Potent μ-opioid receptor agonist with rapid onset in appropriate parenteral formulations	Selected monitored acute-care or procedural settings	Respiratory depression, bradycardia, sedation	Potency, formulation, route, and administration rate are critical
Hydromorphone	Potent opioid agonist	Severe pain where clinically appropriate	Respiratory depression, sedation, nausea, constipation	Requires careful titration and monitoring; dose equivalence must not be assumed
Tramadol	Opioid activity plus inhibition of serotonin and norepinephrine reuptake	Selected pain settings when suitable alternatives and risks have been considered	Nausea, dizziness, seizures, serotonin toxicity, respiratory depression	Interactions with serotonergic agents and seizure-threshold-lowering drugs
Opioid antagonists, such as naloxone	Competitive antagonism at opioid receptors	Emergency reversal of clinically significant opioid toxicity	Acute withdrawal, agitation, recurrence of toxicity after reversal	Emergency management and continued monitoring may be required

Interpretation: This classification describes general pharmacological properties, not a prescribing protocol. Specific formulations, doses, administration routes, monitoring requirements, and

contraindications must be verified against authoritative product information and the patient's clinical status. The evidence does not support assuming that opioid administration alone prevents pulmonary complications. Conversely, inadequate analgesia can impair deep breathing and coughing. A rational approach uses the lowest effective exposure, reassesses the need for ongoing treatment, avoids unnecessary sedative combinations, and incorporates monitoring appropriate to the patient's respiratory risk.

Regional analgesia and the optimization of respiratory function

Regional analgesia has particular clinical relevance when pain remains functionally limiting despite systemic medication, when systemic drug toxicity is a concern, or when fracture severity and respiratory status warrant specialist intervention. Thoracic epidural analgesia, paravertebral block, intercostal nerve block, erector spinae plane block, and serratus anterior plane block differ in anatomical target, procedural requirements, distribution of analgesia, duration, and risk profile. Epidural analgesia can provide segmental pain relief, but its feasibility depends on hemodynamic status, coagulation, antithrombotic exposure, spinal anatomy, infection risk, and institutional expertise. Paravertebral and fascial-plane techniques may provide alternatives for selected patients, although the extent and reliability of analgesia vary with technique and injury distribution. No regional technique should be presumed to cover all fracture sites equally. The systematic review of randomized trials identified 32 trials but reported substantial methodological heterogeneity and generally low-quality evidence. Epidural analgesia was associated with reduced pain scores, whereas evidence was insufficient to make confident recommendations about interfascial plane blocks, ketamine, and intravenous lidocaine infusions. These findings indicate that the evidence base supports consideration of regional analgesia but does not establish universal superiority for a particular technique across all patient groups. Future comparative trials should standardize fracture characteristics, baseline analgesia, pain measurement, respiratory outcomes, opioid consumption, adverse events, and follow-up duration.

Table 5. Regional Analgesic Techniques: Anatomical Targets, Potential Benefits, and Limitations

Technique	Anatomical or physiological target	Potential benefit	Principal limitations	Clinical considerations
Thoracic epidural analgesia	Neuraxial blockade of thoracic segmental pathways	Potentially extensive analgesia across multiple levels	Hypotension, neuraxial complications, contraindications related to coagulation or infection	Requires experienced placement and appropriate monitoring
Thoracic paravertebral block	Thoracic spinal nerves and adjacent sympathetic pathways	Segmental or unilateral chest-wall analgesia	Technical complexity and risks related to pleural proximity	May be considered when unilateral analgesia is suitable
Intercostal nerve block	Intercostal nerves supplying affected rib segments	Targeted analgesia	Limited duration with single injection and risk of pneumothorax or systemic toxicity	Coverage may require treatment of multiple segments

Erector spinae plane block	Fascial plane adjacent to the erector spinae muscle	Potential analgesia for selected posterior or lateral chest-wall injuries	Variable spread and uncertain comparative effectiveness	Appropriate technique depends on injury distribution and local expertise
Serratus anterior plane block	Lateral cutaneous branches of intercostal nerves	Potential benefit for lateral chest-wall pain	May incompletely address posterior or anterior pain	Consider fracture location and expected distribution
Continuous regional catheter techniques	Sustained delivery of local anesthetic to a selected regional compartment	Potentially prolonged analgesia and reduced systemic rescue medication	Catheter displacement, infection, dosing errors, and local-anesthetic toxicity	Requires catheter surveillance and a defined infusion protocol

Interpretation: Regional techniques should be selected according to injury distribution, patient-specific contraindications, procedural expertise, and monitoring capacity. The table summarizes potential clinical applications rather than ranking effectiveness.

Local anesthetics such as lidocaine, bupivacaine, and ropivacaine inhibit voltage-gated sodium channels, suppressing action-potential propagation in neural tissue. Their therapeutic margin depends on the specific drug, concentration, total administered dose, route, vascular uptake, and patient characteristics. Excess systemic exposure can cause neurological toxicity and cardiovascular complications. Consequently, concentration alone is insufficient to determine safety: total dose, infusion duration, concurrent local-anesthetic exposure, and patient weight or physiological status must also be considered. The broader therapeutic implication is that regional analgesia should be integrated into a coordinated trauma pathway rather than treated as an isolated procedural endpoint. Its value depends on whether pain relief translates into improved ventilation, effective cough, mobilization, lower rescue-opioid requirements, or other meaningful outcomes.

Nutritional assessment and supplementation strategy

Nutritional evaluation should focus on identifying and correcting clinically relevant deficiencies rather than prescribing a universal collection of supplements. Relevant factors include dietary intake, frailty, malnutrition risk, malabsorption, renal disease, osteoporosis, vitamin D status when testing is clinically indicated, and medication-related effects on nutrient metabolism. Vitamin D formulations may be marketed in international units or micrograms, and calcium products may list the mass of the calcium salt rather than the amount of elemental calcium. These distinctions are important for interpreting product labels. Similarly, different collagen, glucosamine, and chondroitin preparations may vary in composition and quality. Product availability and a marketed strength do not establish therapeutic effectiveness. Supplementation also has potential adverse effects. Excessive vitamin D and calcium exposure may cause hypercalcemia or contribute to renal complications in susceptible individuals. Magnesium products may cause gastrointestinal effects and require particular caution in severe renal impairment. Calcium and magnesium can interfere with the absorption of certain medicines when administered together. Vitamin K intake is clinically relevant for patients taking vitamin K antagonists because changes in intake can alter anticoagulation control. The scientifically defensible conclusion is that adequate nutrition and

correction of documented deficiencies are components of good fracture care, whereas claims of accelerated rib union from individual supplements require direct clinical confirmation.

Evidence limitations and future research priorities

The available literature supports an integrated approach to rib fracture management, but important uncertainties remain. Differences in fracture severity, patient populations, analgesic regimens, regional anesthesia techniques, and outcome definitions impede direct comparisons across studies. Furthermore, many investigations prioritize short-term pain scores rather than long-term disability, functional recovery, quality of life, or comprehensive medication-safety outcomes. Future research should prioritize adequately powered randomized trials, standardized multimodal analgesia protocols, comparative evaluation of regional techniques, and prospective pharmacovigilance studies. Studies should distinguish analgesic efficacy from broader clinical effectiveness and incorporate both patient-centered outcomes and objectively measured respiratory parameters. The evidence supports individualized multimodal analgesia combined with pulmonary care, functional rehabilitation, and structured medication-safety monitoring. The most defensible clinical strategy is one that achieves adequate pain control while preserving respiratory function and minimizing preventable treatment-related harm.

CONCLUSION

- Rib fractures represent a clinically significant form of thoracic trauma requiring an integrated, evidence-based approach that combines pharmacological analgesia, non-pharmacological interventions, respiratory rehabilitation, individualized assessment of fracture-healing determinants, and systematic medication-safety monitoring. The principal therapeutic objective extends beyond pain reduction to the preservation of respiratory function, facilitation of effective coughing, prevention of pulmonary complications, restoration of mobility, and optimization of patient-centered clinical outcomes. Treatment selection should be guided by fracture severity, associated injuries, age, comorbidities, physiological stability, contraindications, and the individual patient's response to therapy.
- Multimodal analgesia constitutes a rational pharmacotherapeutic strategy because it combines interventions with complementary mechanisms of action while potentially reducing reliance on individual drug classes. Paracetamol and nonsteroidal anti-inflammatory drugs may contribute to pain control when clinically appropriate, whereas opioids may be necessary for severe acute pain but require careful titration, reassessment, and monitoring for sedation, respiratory depression, and other adverse drug reactions. Regional analgesic techniques, including thoracic epidural analgesia and selected peripheral or fascial-plane blocks, may be considered when systemic analgesia is inadequate or when patient-specific circumstances favor a regional approach. Nevertheless, the available comparative evidence remains heterogeneous, and improvements in pain scores should not automatically be interpreted as proof of reduced mortality, pneumonia, or hospital length of stay.
- Non-pharmacological management is an essential component of comprehensive treatment. Individualized respiratory physiotherapy, deep-breathing exercises, supported coughing, appropriate mobilization, patient education, and clinical reassessment may facilitate functional recovery and support pulmonary care. Surgical stabilization may be appropriate for selected patients with specific fracture patterns, chest-wall instability, or other recognized indications following multidisciplinary evaluation.
- Nutritional adequacy and the correction of documented deficiencies support normal skeletal physiology and tissue repair. Vitamin D, calcium, protein, vitamin C, vitamin K, magnesium, and zinc have relevant physiological roles; however, their biological importance does not establish that supplementation beyond nutritional requirements accelerates rib-fracture union. Similarly,

glucosamine, chondroitin, collagen products, and other biologically active compounds should not be presented as proven rib-regenerative therapies without adequate direct clinical evidence. Pharmacological interventions affecting bone metabolism require individualized assessment rather than routine use solely to promote acute rib-fracture healing.

- Pharmacovigilance and pharmacosafety should remain integral to treatment optimization. Structured medication reconciliation, assessment of contraindications and drug interactions, appropriate monitoring, adverse-event documentation, and timely treatment de-escalation can help minimize preventable medication-related harm. Clinical effectiveness should be evaluated through a multidimensional framework incorporating pain during functional activity, respiratory status, opioid exposure, adverse events, pulmonary complications, mobility, healthcare utilization, and quality of life.
- Future research should prioritize adequately powered comparative trials, standardized outcome definitions, rigorous risk-of-bias assessment, and transparent reporting consistent with PRISMA 2020. Further investigation is required to establish the comparative effectiveness of regional analgesic techniques, clarify the clinical consequences of different analgesic regimens, and determine whether selected nutritional interventions improve fracture-healing outcomes. Ultimately, individualized, multidisciplinary, evidence-based care offers the most defensible framework for balancing analgesic efficacy, respiratory preservation, skeletal recovery, and patient safety in rib-fracture management.

RECOMMENDATIONS

The management of rib fractures should be guided by an individualized, multidisciplinary, and evidence-based approach that integrates pharmacological treatment, non-pharmacological interventions, respiratory support, fracture-healing considerations, and systematic medication-safety monitoring. The following recommendations are proposed to optimize therapeutic efficacy, minimize treatment-related complications, and improve patient-centered clinical outcomes.

- **Implementation of individualized multimodal analgesia.** Clinicians should develop an analgesic strategy according to fracture characteristics, pain intensity, age, comorbidities, renal and hepatic function, concomitant medications, and risk factors for respiratory depression. Paracetamol may be considered as a component of multimodal treatment, provided that dosing restrictions and hepatic contraindications are respected. Nonsteroidal anti-inflammatory drugs (NSAIDs) may be appropriate for selected patients after assessment of gastrointestinal, renal, cardiovascular, and bleeding risks. Opioids should be reserved for pain that remains inadequately controlled, prescribed at the lowest effective dose for the shortest clinically necessary duration, and accompanied by monitoring for sedation, hypoventilation, constipation, and other adverse effects.
- **Early assessment of respiratory function.** Initial evaluation should identify respiratory compromise, associated thoracic injuries, hypoxemia, ineffective coughing, and other indicators of deterioration. Respiratory rate, oxygen saturation, pain-related ventilatory limitation, and pulmonary function should be reassessed according to clinical severity. Patients with multiple fractures, advanced age, frailty, chronic pulmonary disease, or substantial analgesic requirements may require closer observation and a lower threshold for specialist assessment or hospital admission.
- **Appropriate use of regional analgesia.** Thoracic epidural analgesia, paravertebral blockade, erector spinae plane blockade, serratus anterior plane blockade, and other regional techniques may be considered when systemic analgesia is insufficient or associated with unacceptable adverse effects. Selection should reflect fracture location, clinical circumstances, anticoagulation status, hemodynamic stability, available expertise, and institutional protocols. Because comparative evidence remains heterogeneous, regional techniques should be selected through individualized clinical assessment rather than assuming that one method is universally superior.

- **Integration of non-pharmacological interventions.** Early mobilization, individualized respiratory physiotherapy, supported coughing, deep-breathing exercises, and appropriate patient education should complement pharmacological treatment. Patients should receive clear instructions concerning pain management, respiratory exercises, activity modification, and warning signs requiring urgent medical assessment. External chest binding that restricts ventilation should generally be avoided. Rehabilitation intensity should be adapted to the patient's tolerance, functional capacity, and associated injuries.
- **Rational management of fracture healing.** Nutritional assessment should identify inadequate energy, protein, calcium, vitamin D, or other essential nutrient intake. Documented deficiencies should be corrected according to established clinical guidance. Supplementation should not be presented as a proven method of accelerating rib-fracture union when evidence is insufficient. Smoking cessation, moderation or avoidance of excessive alcohol consumption, and appropriate management of osteoporosis or other underlying conditions should be incorporated into recovery planning.
- **Strengthening pharmacovigilance and medication safety.** Medication reconciliation should be performed at admission, during transitions of care, and at discharge. Clinicians and pharmacists should assess drug–drug interactions, contraindications, duplicate therapy, cumulative sedative exposure, and risks associated with renal or hepatic impairment. Suspected adverse drug reactions and medication errors should be documented and reported through applicable pharmacovigilance systems. Treatment should be reviewed regularly, with timely dose adjustment, discontinuation of unnecessary medicines, and opioid de-escalation whenever clinically feasible.
- **Standardization of clinical outcome assessment.** Healthcare institutions should consider standardized monitoring of pain intensity, respiratory function, oxygen requirements, mobility, pulmonary complications, adverse drug reactions, length of hospital stay, readmissions, and patient-reported recovery. These indicators can support clinical audit, quality improvement, and comparison of treatment pathways.
- **Prioritization of further research.** Future studies should employ adequately powered prospective designs, transparent eligibility criteria, validated outcome measures, and systematic adverse-event reporting. Comparative trials should evaluate regional analgesic techniques, multimodal pharmacotherapy, and structured respiratory rehabilitation. Research concerning nutritional interventions should distinguish correction of deficiencies from unproven supplementation strategies. Systematic reviews should follow PRISMA guidance, assess risk of bias, and report evidence certainty transparently.
- The recommendations emphasize that optimal rib-fracture management requires coordinated analgesia, preservation of respiratory function, safe prescribing, individualized rehabilitation, and continuous reassessment. Clinical decisions should remain consistent with current evidence, patient-specific risk profiles, and applicable professional guidelines.

REFERENCES

1. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71.
2. Page MJ, Moher D, Bossuyt PM, et al. PRISMA 2020 explanation and elaboration: updated guidance and exemplars for reporting systematic reviews. BMJ. 2021;372:n160.
3. Mukherjee K, Schubl SD, Tominaga G, et al. Non-surgical management and analgesia strategies for older adults with multiple rib fractures: a systematic review, meta-analysis, and joint practice management guideline from the Eastern Association for the Surgery of Trauma and the Chest Wall Injury Society. J Trauma Acute Care Surg. 2023;94(3):398–407.
4. Ziegler DW, Agarwal NN. The morbidity and mortality of rib fractures. J Trauma. 1994;37(6):975-979.
5. Flagel BT, Luchette FA, Reed RL, Esposito TJ, Davis KA, Santaniello JM, et al. Half-a-dozen ribs: the breakpoint for mortality. Surgery. 2005;138(4):717-723.
6. Bulger EM, Arneson MA, Mock CN, Jurkovich GJ. Rib fractures in the elderly. J Trauma. 2000;48(6):1040-1046.
7. Sirmali M, Türüt H, Topçu S, Gülhan E, Yazici U, Kaya S, et al. A comprehensive analysis of traumatic rib fractures: morbidity, mortality and management. Eur J Cardiothorac Surg. 2003;24(1):133-138.
8. Shweiki E, Klena J, Wood GC, Indeck M. Assessing the true risk of abdominal solid organ injury in hospitalized patients with rib fractures. Arch Surg. 2001;136(12):1372-1376.
9. Bergeron E, Lavoie A, Clas D, Moore L, Ratte S, Tetreault S, et al. Elderly trauma patients with rib fractures are at greater risk of death and pneumonia. J Trauma. 2003;54(3):478-485.
10. Battle CE, Hutchings H, Evans PA. Risk factors that predict mortality in patients with blunt chest wall trauma: a systematic review and meta-analysis. Injury. 2012;43(1):8-17.
11. Bulger EM, Edwards T, Klotz P, Jurkovich GJ. Epidural analgesia improves outcome after multiple rib fractures. Surgery. 2004;136(2):426-430.
12. Galvagno SM Jr, Smith CE, Varon AJ, Hasenboehler EA, Sultan S, Shaefer G, et al. Pain management for blunt thoracic trauma: a joint practice management guideline from the Eastern Association for the Surgery of Trauma and Trauma Anesthesiology Society. J Trauma Acute Care Surg. 2016;81(5):936-951.
13. Mukherjee K, Schubl SD, Tominaga G, Cantrell S, Kim B, Haines KL, et al. Non-surgical management and analgesia strategies for older adults with multiple rib fractures: a systematic review, meta-analysis, and joint practice management guideline from the Eastern Association for the Surgery of Trauma and the Chest Wall Injury Society. J Trauma Acute Care Surg. 2023;94(3):398-407.
14. Hammal F, Chiu C, Kung JY, Bradley N, Dillane D. Pain management for hospitalized patients with rib fractures: a systematic review of randomized clinical trials. J Clin Anesth. 2024;92:111276.
15. Carrier FM, Turgeon AF, Nicole PC, Trépanier CA, Fergusson DA, Thauvette D, et al. Effect of epidural analgesia in patients with traumatic rib fractures: a systematic review and meta-analysis of randomized controlled trials. Can J Anaesth. 2009;56(3):230-242.
16. Duch P, Møller MH. Epidural analgesia in patients with traumatic rib fractures: a systematic review of randomised controlled trials. Acta Anaesthesiol Scand. 2011;55(7):759-770.
17. Galvagno SM Jr, Smith CE, Varon AJ, Hasenboehler EA, Sultan S, Shaefer G, et al. Thoracic trauma, blunt, pain management of. J Trauma Acute Care Surg. 2016;81(5):936-951.
18. Bulger EM, Edwards T, Klotz P, Jurkovich GJ. Epidural analgesia improves outcome after multiple rib fractures. Surgery. 2004;136(2):426-430.
19. Moon MR, Luchette FA, Gibson SW, Crews J, Sudarshan G, Hurst JM, et al. Prospective, randomized comparison of epidural versus parenteral opioid analgesia in thoracic trauma. Ann Surg. 1999;229(5):684-691.

20. Wisner DH. A stepwise logistic regression analysis of factors affecting morbidity and mortality after thoracic trauma: effect of epidural analgesia. J Trauma. 1990;30(7):799-804.
21. Bulger EM, Arneson MA, Mock CN, Jurkovich GJ. Rib fractures in the elderly. J Trauma. 2000;48(6):1040-1046.
22. Karmakar MK, Ho AMH. Acute pain management of patients with multiple fractured ribs. J Trauma. 2003;54(3):615-625.
23. Peek J, Smeeing DPJ, Hietbrink F, Houwert RM, Marsman M, de Jong MB. Comparison of analgesic interventions for traumatic rib fractures: a systematic review and meta-analysis. Eur J Trauma Emerg Surg. 2019;45(4):597-622.
24. Duch P, Møller MH. Epidural analgesia in patients with traumatic rib fractures: a systematic review of randomised controlled trials. Acta Anaesthesiol Scand. 2011;55(7):759-770.
25. Carrier FM, Turgeon AF, Nicole PC, Trépanier CA, Fergusson DA, Thauvette D, et al. Effect of epidural analgesia in patients with traumatic rib fractures: a systematic review and meta-analysis of randomized controlled trials. Can J Anaesth. 2009;56(3):230-242.
26. Galvagno SM Jr, Smith CE, Varon AJ, Hasenboehler EA, Sultan S, Shaefer G, et al. Pain management for blunt thoracic trauma: a joint practice management guideline from the Eastern Association for the Surgery of Trauma and Trauma Anesthesiology Society. J Trauma Acute Care Surg. 2016;81(5):936-951.
27. Fitzgerald M, Sinha A, Shrivastava P, et al. Clinical management of rib fractures and methods for prevention of pulmonary complications: a review. Injury. 2019;50(11):1932-1938.
28. Qureshi I, et al. Rib fracture management in older adults: a scoping review. [Verify journal, volume, issue, and pages against the original publication before submission].
29. Bulger EM, Edwards T, Klotz P, Jurkovich GJ. Epidural analgesia improves outcome after multiple rib fractures. Surgery. 2004;136(2):426-430.
30. Flagel BT, Luchette FA, Reed RL, Esposito TJ, Davis KA, Santaniello JM, et al. Half-a-dozen ribs: the breakpoint for mortality. Surgery. 2005;138(4):717-723.
31. Battle CE, Hutchings H, Evans PA. Risk factors that predict mortality in patients with blunt chest wall trauma: a systematic review and meta-analysis. Injury. 2012;43(1):8-17.
32. Ziegler DW, Agarwal NN. The morbidity and mortality of rib fractures. J Trauma. 1994;37(6):975-979.
33. Sirmali M, Türüt H, Topçu S, Gülhan E, Yazici U, Kaya S, et al. A comprehensive analysis of traumatic rib fractures: morbidity, mortality and management. Eur J Cardiothorac Surg. 2003;24(1):133-138.
34. Galvagno SM Jr, Smith CE, Varon AJ, Hasenboehler EA, Sultan S, Shaefer G, et al. Pain management for blunt thoracic trauma: a joint practice management guideline from the Eastern Association for the Surgery of Trauma and Trauma Anesthesiology Society. J Trauma Acute Care Surg. 2016;81(5):936-951.
35. Mukherjee K, Schubl SD, Tominaga G, Cantrell S, Kim B, Haines KL, et al. Non-surgical management and analgesia strategies for older adults with multiple rib fractures: a systematic review, meta-analysis, and joint practice management guideline from the Eastern Association for the Surgery of Trauma and the Chest Wall Injury Society. J Trauma Acute Care Surg. 2023;94(3):398-407.
36. Hammal F, Chiu C, Kung JY, Bradley N, Dillane D. Pain management for hospitalized patients with rib fractures: a systematic review of randomized clinical trials. J Clin Anesth. 2024;92:111276.
37. Bulger EM, Arneson MA, Mock CN, Jurkovich GJ. Rib fractures in the elderly. J Trauma. 2000;48(6):1040-1046.
38. Flagel BT, Luchette FA, Reed RL, Esposito TJ, Davis KA, Santaniello JM, et al. Half-a-dozen ribs: the breakpoint for mortality. Surgery. 2005;138(4):717-723.

39. Sirmali M, Türüt H, Topçu S, Gülhan E, Yazici U, Kaya S, et al. A comprehensive analysis of traumatic rib fractures: morbidity, mortality and management. Eur J Cardiothorac Surg. 2003;24(1):133-138.
40. Karmakar MK, Ho AMH. Acute pain management of patients with multiple fractured ribs. J Trauma. 2003;54(3):615-625.
41. Galvagno SM Jr, Smith CE, Varon AJ, Hasenboehler EA, Sultan S, Shaefer G, et al. Pain management for blunt thoracic trauma: a joint practice management guideline from the Eastern Association for the Surgery of Trauma and Trauma Anesthesiology Society. J Trauma Acute Care Surg. 2016;81(5):936-951.
42. Hammal F, Chiu C, Kung JY, Bradley N, Dillane D. Pain management for hospitalized patients with rib fractures: a systematic review of randomized clinical trials. J Clin Anesth. 2024;92:111276.
43. Carrier FM, Turgeon AF, Nicole PC, Trépanier CA, Fergusson DA, Thauvette D, et al. Effect of epidural analgesia in patients with traumatic rib fractures: a systematic review and meta-analysis of randomized controlled trials. Can J Anaesth. 2009;56(3):230-242.
44. Peek J, Smeeing DPJ, Hietbrink F, Houwert RM, Marsman M, de Jong MB. Comparison of analgesic interventions for traumatic rib fractures: a systematic review and meta-analysis. Eur J Trauma Emerg Surg. 2019;45(4):597-622.
45. Moon MR, Luchette FA, Gibson SW, Crews J, Sudarshan G, Hurst JM, et al. Prospective, randomized comparison of epidural versus parenteral opioid analgesia in thoracic trauma. Ann Surg. 1999;229(5):684-691.
46. Karmakar MK, Ho AMH. Acute pain management of patients with multiple fractured ribs. J Trauma. 2003;54(3):615-625.
47. Galvagno SM Jr, Smith CE, Varon AJ, Hasenboehler EA, Sultan S, Shaefer G, et al. Pain management for blunt thoracic trauma: a joint practice management guideline from the Eastern Association for the Surgery of Trauma and Trauma Anesthesiology Society. J Trauma Acute Care Surg. 2016;81(5):936-951.
48. Fitzgerald M, Sinha A, Shrivastava P, et al. Clinical management of rib fractures and methods for prevention of pulmonary complications: a review. Injury. 2019;50(11):1932-1938.
49. Mukherjee K, Schubl SD, Tominaga G, Cantrell S, Kim B, Haines KL, et al. Non-surgical management and analgesia strategies for older adults with multiple rib fractures: a systematic review, meta-analysis, and joint practice management guideline from the Eastern Association for the Surgery of Trauma and the Chest Wall Injury Society. J Trauma Acute Care Surg. 2023;94(3):398-407.
50. Hammal F, Chiu C, Kung JY, Bradley N, Dillane D. Pain management for hospitalized patients with rib fractures: a systematic review of randomized clinical trials. J Clin Anesth. 2024;92:111276.
51. Galvagno SM Jr, Smith CE, Varon AJ, Hasenboehler EA, Sultan S, Shaefer G, et al. Pain management for blunt thoracic trauma: a joint practice management guideline from the Eastern Association for the Surgery of Trauma and Trauma Anesthesiology Society. J Trauma Acute Care Surg. 2016;81(5):936-951.
52. Ziegler DW, Agarwal NN. The morbidity and mortality of rib fractures. J Trauma. 1994;37(6):975-979.
53. Flagel BT, Luchette FA, Reed RL, Esposito TJ, Davis KA, Santaniello JM, et al. Half-a-dozen ribs: the breakpoint for mortality. Surgery. 2005;138(4):717-723.
54. Bulger EM, Arneson MA, Mock CN, Jurkovich GJ. Rib fractures in the elderly. J Trauma. 2000;48(6):1040-1046.
55. Battle CE, Hutchings H, Evans PA. Risk factors that predict mortality in patients with blunt chest wall trauma: a systematic review and meta-analysis. Injury. 2012;43(1):8-17.

56. Sirmali M, Türüt H, Topçu S, Gülhan E, Yazici U, Kaya S, et al. A comprehensive analysis of traumatic rib fractures: morbidity, mortality and management. Eur J Cardiothorac Surg. 2003;24(1):133-138.
57. Shweiki E, Klena J, Wood GC, Indeck M. Assessing the true risk of abdominal solid organ injury in hospitalized patients with rib fractures. Arch Surg. 2001;136(12):1372-1376.
58. Karmakar MK, Ho AMH. Acute pain management of patients with multiple fractured ribs. J Trauma. 2003;54(3):615-625.
59. Peek J, Smeeing DPJ, Hietbrink F, Houwert RM, Marsman M, de Jong MB. Comparison of analgesic interventions for traumatic rib fractures: a systematic review and meta-analysis. Eur J Trauma Emerg Surg. 2019;45(4):597-622.
60. Carrier FM, Turgeon AF, Nicole PC, Trépanier CA, Fergusson DA, Thauvette D, et al. Effect of epidural analgesia in patients with traumatic rib fractures: a systematic review and meta-analysis of randomized controlled trials. Can J Anaesth. 2009;56(3):230-242.
61. Duch P, Møller MH. Epidural analgesia in patients with traumatic rib fractures: a systematic review of randomised controlled trials. Acta Anaesthesiol Scand. 2011;55(7):759-770.
62. Galvagno SM Jr, Smith CE, Varon AJ, Hasenboehler EA, Sultan S, Shaefer G, et al. Pain management for blunt thoracic trauma: a joint practice management guideline from the Eastern Association for the Surgery of Trauma and Trauma Anesthesiology Society. J Trauma Acute Care Surg. 2016;81(5):936-951.
63. Hammal F, Chiu C, Kung JY, Bradley N, Dillane D. Pain management for hospitalized patients with rib fractures: a systematic review of randomized clinical trials. J Clin Anesth. 2024;92:111276.
64. Mukherjee K, Schubl SD, Tominaga G, Cantrell S, Kim B, Haines KL, et al. Non-surgical management and analgesia strategies for older adults with multiple rib fractures: a systematic review, meta-analysis, and joint practice management guideline from the Eastern Association for the Surgery of Trauma and the Chest Wall Injury Society. J Trauma Acute Care Surg. 2023;94(3):398-407.
65. Peek J, Smeeing DPJ, Hietbrink F, Houwert RM, Marsman M, de Jong MB. Comparison of analgesic interventions for traumatic rib fractures: a systematic review and meta-analysis. Eur J Trauma Emerg Surg. 2019;45(4):597-622.
66. Bulger EM, Edwards T, Klotz P, Jurkovich GJ. Epidural analgesia improves outcome after multiple rib fractures. Surgery. 2004;136(2):426-430.
67. Moon MR, Luchette FA, Gibson SW, Crews J, Sudarshan G, Hurst JM, et al. Prospective, randomized comparison of epidural versus parenteral opioid analgesia in thoracic trauma. Ann Surg. 1999;229(5):684-691.
68. Ziegler DW, Agarwal NN. The morbidity and mortality of rib fractures. J Trauma. 1994;37(6):975-979.
69. Flagel BT, Luchette FA, Reed RL, Esposito TJ, Davis KA, Santaniello JM, et al. Half-a-dozen ribs: the breakpoint for mortality. Surgery. 2005;138(4):717-723.
70. Sirmali M, Türüt H, Topçu S, Gülhan E, Yazici U, Kaya S, et al. A comprehensive analysis of traumatic rib fractures: morbidity, mortality and management. Eur J Cardiothorac Surg. 2003;24(1):133-138.
71. Gatt T, Grech A, Arshad H. The effect of vitamin D supplementation for bone healing in fracture patients: a systematic review. Adv Orthop. 2023;2023:6236045.
72. Claes L, Recknagel S, Ignatius A. Fracture healing under healthy and inflammatory conditions. Nat Rev Rheumatol. 2012;8(3):133-143.
73. Einhorn TA, Gerstenfeld LC. Fracture healing: mechanisms and interventions. Nat Rev Rheumatol. 2015;11(1):45-54.
74. Marsell R, Einhorn TA. The biology of fracture healing. Injury. 2011;42(6):551-555.

75. Einhorn TA. The cell and molecular biology of fracture healing. Clin Orthop Relat Res. 1998;(355 Suppl):S7-S21.
76. Gerstenfeld LC, Cullinane DM, Barnes GL, Graves DT, Einhorn TA. Fracture healing as a post-natal developmental process: molecular, spatial, and temporal aspects of its regulation. J Cell Biochem. 2003;88(5):873-884.
77. Einhorn TA, Bonnarens F, Burstein AH. The contributions of dietary protein and mineral to the healing of experimental fractures. J Bone Joint Surg Am. 1986;68(9):1381-1390.
78. Gorter EA, Krijnen P, Schipper IB. Vitamin D status and adult fracture healing. J Clin Orthop Trauma. 2014;5(1):34-37.
79. Gatt T, Grech A, Arshad H. The effect of vitamin D supplementation for bone healing in fracture patients: a systematic review. Adv Orthop. 2023;2023:6236045.
80. Brinker MR, O'Connor DP. The biology of fracture healing. In: Browner BD, Jupiter JB, Levine AM, Trafton PG, editors. Skeletal Trauma: Basic Science, Management, and Reconstruction. 4th ed. Philadelphia: Saunders Elsevier; 2009.
81. Pountos I, Georgouli T, Calori GM, Giannoudis PV. Do nonsteroidal anti-inflammatory drugs affect bone healing? A critical analysis. ScientificWorldJournal. 2012;2012:606404.
82. Dodwell ER, Latorre JG, Parisini E, Zwettler E, Chandra D, Mulpuri K, et al. NSAID exposure and risk of nonunion: a meta-analysis of case-control and cohort studies. Calcif Tissue Int. 2010;87(3):193-202.
83. Wheatley BM, Nappo KE, Christensen DL, Holman AM, Brooks DI, Potter BK. Effect of NSAIDs on bone healing rates: a meta-analysis. J Am Acad Orthop Surg. 2019;27(7):e330-e336.
84. Bhattacharyya T, Levin R, Vrahas MS, Solomon DH. Nonsteroidal anti-inflammatory drugs and nonunion of humeral shaft fractures. Arthritis Rheum. 2005;53(3):364-367.
85. Goodman SB, Ma T. Cellular chemotaxis induced by wear particles from joint replacements. Biomaterials. 2010;31(19):5045-5050.
86. Brinker MR, O'Connor DP. The biology of fracture healing. In: Browner BD, Jupiter JB, Levine AM, Trafton PG, editors. Skeletal Trauma: Basic Science, Management, and Reconstruction. 4th ed. Philadelphia: Saunders Elsevier; 2009.
87. National Institute for Health and Care Excellence. Major trauma: assessment and initial management. London: NICE; 2016.
88. National Institute for Health and Care Excellence. Fractures (complex): assessment and management. London: NICE; 2016.
89. National Institute for Health and Care Excellence. Major trauma: service delivery. London: NICE; 2016.
90. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71.
91. Page MJ, Moher D, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. PRISMA 2020 explanation and elaboration: updated guidance and exemplars for reporting systematic reviews. BMJ. 2021;372:n160.
92. Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med. 2009;6(7):e1000097.
93. Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA, editors. Cochrane Handbook for Systematic Reviews of Interventions. 2nd ed. Chichester: Wiley; 2019.
94. Sterne JAC, Savović J, Page MJ, Elbers RG, Blencowe NS, Boutron I, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. BMJ. 2019;366:l4898.
95. Sterne JA, Hernán MA, Reeves BC, Savović J, Berkman ND, Viswanathan M, et al. ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. BMJ. 2016;355:i4919.

96. Shea BJ, Reeves BC, Wells G, Thuku M, Hamel C, Moran J, et al. AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both. BMJ. 2017;358:j4008.
97. Guyatt GH, Oxman AD, Vist GE, Kunz R, Falck-Ytter Y, Alonso-Coello P, et al. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. BMJ. 2008;336(7650):924-926.
98. Guyatt GH, Oxman AD, Schünemann HJ, Tugwell P, Knottnerus A. GRADE guidelines: a new series of articles in the Journal of Clinical Epidemiology. J Clin Epidemiol. 2011;64(4):380-382.
99. McDonagh M, Peterson K, Raina P, Chang S, Shekelle P. Avoiding bias in selecting studies. Methods guide for effectiveness and comparative effectiveness reviews. Rockville (MD): Agency for Healthcare Research and Quality; 2013.
100. World Health Organization. The importance of pharmacovigilance: safety monitoring of medicinal products. Geneva: World Health Organization; 2002.
101. World Health Organization. Safety of medicines: a guide to detecting and reporting adverse drug reactions. Geneva: World Health Organization; 2002.
102. Edwards IR, Aronson JK. Adverse drug reactions: definitions, diagnosis, and management. Lancet. 2000;356(9237):1255-1259.
103. Aronson JK, Ferner RE. Clarification of terminology in drug safety. Drug Saf. 2005;28(10):851-870.
104. Nebeker JR, Barach P, Samore MH. Clarifying adverse drug events: a clinician's guide to terminology, documentation, and reporting. Ann Intern Med. 2004;140(10):795-801.
105. U.S. Food and Drug Administration. Good pharmacovigilance practices and pharmacoepidemiologic assessment. Silver Spring (MD): FDA; guidance documents.
106. International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use. ICH E2A: Clinical safety data management: definitions and standards for expedited reporting. Geneva: ICH; 1994.
107. International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use. ICH E2D: Post-approval safety data management: definitions and standards for expedited reporting. Geneva: ICH; 2003.
108. International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use. ICH E2E: Pharmacovigilance planning. Geneva: ICH; 2004.
109. Sulashvili N, Beglaryan M. Pharmacist professional features and work gratification. Business Engineering Journal. 2014;2:195-9.
110. Sulashvili N, Beglaryan M. Pharmacist work satisfaction and career enhancement strategy. Georgian Chemical Journal. 2015;15(2):151-7.
111. Sulashvili N, Beglaryan M. Pharmacist's professional features and work gratification. Black Sea Scientific Journal of Academic Research. 2016;29(3):62-8.
112. Sulashvili N, Beglaryan M. Pharmacists' professional features, viewed by the customer's eyes in Georgia. Experimental and Clinical Medicine. 2017;(4):22-5.
113. Sulashvili N, Beglaryan M. Peculiarities of professional for pharmacists, viewed by the healthcare specialists in Georgia. Experimental and Clinical Medicine. 2017;(4):47-51.
114. Sulashvili N, Beglaryan M. Vocational characteristics of employed pharmacy faculty students. Caucasus International University Herald. 2017;(12):89-102.
115. Sulashvili N, Beglaryan M. Pharmacist's professional features and work gratification. SSRN. 2017:1-11.
116. Sulashvili N, Beglaryan M. Vocational peculiarities of young pharmacist professionals. International Scientific Journal Intellectual. 2018;(35):96-104.
117. Sulashvili N, Beglaryan M. Vocational features and facilities of young pharmacist specialists. Experimental and Clinical Medicine. 2018;(1):62-8.

118. Sulashvili N, Beglaryan M, Matoshvili M. Occupational features of pharmaceutical workers, viewed by the chief pharmacists. Caucasus Journal of Health Sciences and Public Health. 2018;2(2):56-61.
119. Sulashvili N, Beglaryan M, Matoshvili M. Vocational specifications for junior pharmacists. Caucasus Journal of Health Sciences and Public Health. 2018;2(2):62-73.
120. Sulashvili N, Beglaryan M, Kvizhinadze N, Matoshvili M. Vocational training and activity of Pharmacists in Georgia. Georgian Medical News. 2018;(5):199-206.
121. Sulashvili N, Beglaryan M, Gogashvili M, Matoshvili M. Occupational particularities and strategy of Pharmacy faculty students. Experimental and Clinical Medicine. 2018;(3):15-25.
122. Sulashvili N, Beglaryan M, Grigolia L. Features for occupational choice of young pharmacist specialists. Caucasus International University Herald. 2018;(13):118-26.
123. Sulashvili N, Beglaryan M. Pharmaceutical care aspects feature in drug-stores viewed by patients. Modern Issues of Medicine and Management. 2018;(3):5-15.
124. Sulashvili N, Beglaryan M, Shashishvili G. Medical professionals' job satisfaction and pharmaceutical organization issues viewed by drug dispensers in Georgia. European Scientific Journal. 2018;15(26):42-55.
125. Sulashvili N, Beglaryan M. Drugs dispensers' professional choice and influencing factors on pharmaceutical activities in Georgia. Experimental and Clinical Medicine. 2018;(6):17-21.
126. Hemati K, Gray AT, Agrawal A. A comprehensive review of the non-operative management of traumatic rib fractures. Curr Anesthesiol Rep. 2024;14:567–575.
127. Hammal F, Chiu C, Kung JY, Bradley N, Dillane D. Pain management for hospitalized patients with rib fractures: a systematic review of randomized clinical trials. J Clin Anesth. 2024;92:111276.

Philological Sciences

ÖMƏR XƏYYAM RÜBAİLƏRİNİN FARSCADAN AZƏRBAYCAN DİLİNƏ TƏRCÜMƏSİNDƏ ÜSLUB VƏ RİTM: İNSAN VƏ SÜNİ İNTELLEKT VARİANTLARININ MÜQAYİSƏSİ

Salman Əsgər oğlu Əliyev
Naxçıvan Dövlət Universiteti, Şərq dilləri kafedrasının müəllimi

Xülasə. Məqalədə Ömər Xəyyama aid edilən altı rübainin farsca mətnləri Mirmehdi Seyidzadənin insan tərcüməsi və ChatGPT, Gemini, Claude variantları ilə müqayisə olunur. Məqsəd məna, üslub və ritmin qarşılıqlı əlaqəsini, xüsusilə qafiyə yaratmağın fəlsəfi dönüşə və obraz quruluşuna təsirini müəyyənləşdirməkdir. Müqayisəli yaxın oxu göstərir ki, səs uyğunluğu bəzən Azərbaycan dilində qeyri-təbii söz sırası, əlavə hökm və ya metaforanın dəyişməsi hesabına qurulur. İnsan tərcüməsi daha yığcam poetik bütövlük yarada bilsə də, bəzi məqamlarda orijinalın açıq saxladığı mənanı konkretləşdirir. Model çıxışları alternativ ifadə imkanları verir, lakin onların bədii dəyəri hər misranın bütöv rübaidəki funksiyası ilə ölçülməlidir. Tərcümənin qiymətləndirilməsi üçün məna, səs, sintaktik təbiilik və son misranın təsiri birlikdə nəzərə alınır.
Açar sözlər: Ömər Xəyyam, rübai, farsca–azərbaycanca tərcümə, poetik ritm, qafiyə, süni intellekt

Abstract. This article compares the Persian texts of six quatrains attributed to Omar Khayyam with Mirmehdi Seyidzadeh's human translations and versions generated by ChatGPT, Gemini, and Claude. It examines the relationship between meaning, style, and rhythm, with particular attention to how rhyme affects the philosophical turn and imagery of a quatrain. Qualitative close reading shows that sound correspondence may be achieved at the cost of unnatural Azerbaijani syntax, added assertions, or altered metaphors. Human translation can create a more coherent poetic voice, yet may also narrow an ambiguity left open in the source. Model outputs offer useful alternatives, but their value must be judged by the function of each line within the whole poem. The article proposes a combined reading of semantic relations, sound pattern, idiomatic expression, and the effect of the final line. Its conclusions apply to the examined variants rather than to every output of the systems.
Keywords: Omar Khayyam, rubai, Persian–Azerbaijani translation, poetic rhythm, rhyme, artificial intelligence

Giriş

Şeir tərcüməsində sözün lüğəvi mənası ilə onun misradakı fəaliyyəti həmişə üst-üstə düşmür. Qafiyəni təmin edən son söz həm əvvəlki misraların səsinə cavab verir, həm də fikrin hansı nöqtədə dayanacağını müəyyənləşdirir. Dörd misralı rübaidə bu münasibət daha aydın görünür: ilk misralarda qurulan təsəvvür üçüncü misrada dəyişə, son misrada isə gözlənilməz hökmə açıla bilər. Buna görə rübaini tərcümə etmək yalnız dörd cümlənin qarşılığını tapmaq deyil, onların bir-birinə yaratdığı gərginliyi yeni dildə yenidən qurmaqdır.

Fars və Azərbaycan dillərinin uzun ədəbi təması bəzi sözləri tərcüməçiyə yaxın göstərir. “Fələk”, “könül”, “mey”, “din” v“ əcənnət” kimi vahidlər Azərbaycan poetik ənənəsində də tanışdır. Lakin tanış sözün saxlanması onun orijinaldakı münasibətlərinin də qorunması demək deyil. “Fələk”in taleyə, göyə və quruluşa aid çalarları ona bağlanan feldən asılı olaraq dəyişir; “könül” isə həm müraciət, həm də düşünən subyekt ola bilər. Bu semantik yaxınlıq rübainin ritmik və fəlsəfi bütövlüyünün ayrıca yoxlanmasını tələb edir.

Son illərdə böyük dil modelləri qafiyəli mətn üçün sürətli tərcümə və alternativ misra təklif edə bilir. Onların axıcı çıxışı şeirin eyni təsiri yaratdığını avtomatik sübut etmir. Wang və həmmüəllifləri (2024) poetik mətni izah etməyi tərcüməyə hazırlıq kimi sınayır; Resende və Hadley (2024) isə modellərin yaradıcı köməkçi kimi dəyərini və tam mətnin redaktəsinin zəhmətini birgə müzakirə edirlər. Bu tədqiqatların dil cütləri və materialları burada araşdırılan korpusdan fərqlidir, lakin şeirdə keyfiyyəti təkcə axıcılıqla ölçməmək barədə metodik sual yaradır.

Bu məqalənin məqsədi Ömər Xəyyama aid edilən altı rübainin Azərbaycan dilində insan və generativ süni intellekt tərcümələrində üslub və ritmin necə dəyişdiyini göstərməkdir. Əsas sual belədir: qafiyə və yığcamlıq əldə edilərkən rübainin fikir hərəkəti, obrazlararası əlaqə və danışan səs nə dərəcədə yaşadılır? Təhlil seçilmiş variantlarda müşahidə edilən poetik qərarları izah edir; modellərin ümumi reytinqini qurmaq məqsədi daşımır.

Nəzəri çərçivə və qiymətləndirmə meyarları

Holmes (1969) şeir tərcüməsində orijinalın forma xüsusiyyətlərinin hədəf mətnə müxtəlif yollarla keçirildiyini göstərmiş, Lefevere (1975) isə ayrı tərcümə strategiyalarının doğurduğu itki və imkanları müqayisə etmişdir. Bu yanaşmalarda “formaya sədaqət” sadə təkrar əmri deyil. Fars aruzunun eyni ölçüsünü Azərbaycan mətninə mexaniki köçürmək mümkün və ya məqsədəuyğun olmadıqda da dörd misralı qapanma, qafiyənin mövqeyi və son hökmün vurğusu rübainin tanınan hərəkətini yarada bilər. Əksinə, zahiri səs uyğunluğu bu funksiyaları zəiflədirsə, yalnız qafiyənin mövcudluğu uğurlu forma ekvivalentliyi sayılmır.

Üslub söz seçiminin toplami ilə məhdudlaşmır: nəyin açıq deyildiyi, nəyin ehtimal kimi qaldığı, danışanın oxucuya necə müraciət etdiyi də üslubdur. Boase-Beier (2020) tərcümədə üslubi seçimin mətnin mənasına daxil olduğunu vurğulayır. Xəyyam rübailərində gündəlik danışıq səsi ilə fəlsəfi paradoksun bir-birinə keçməsi məhz belə bir seçimdir. Tərcümədə naməlum bir səsə konkret şəxsiyyət verilməsi və ya şübhə bildirən cümlənin qəti nəsihətə çevrilməsi söz səviyyəsində kiçik görünsə də, müəllif səsinin mövqeyini dəyişir.

Məqalədə dörd qarşılıqlı meyar tətbiq edilir. Birincisi, məna əlaqəsidir: sözün tərcüməsi digər misralarda qurulan fikri qoruyurmu? İkincisi, ritm və səsdir: misranın uzunluğu, vurğu, qafiyə və təkrar son hökmə necə xidmət edir? Üçüncüsü, üslubi təbiilikdir: Azərbaycan dilində cümlə poetik və eyni zamanda oxunaqlıdırmı? Dördüncüsü, müdaxilənin həddidir: əlavə söz orijinalın mümkün şərhlərindən birini seçir, yoxsa rübaidə olmayan yeni nəticə yaradır? Jonesun (2011) tərcüməçinin prioritet seçimi barədə yanaşması bu meyarların bir-birinə tabe olmayan qərarlar kimi oxunmasına kömək edir.

Ritm meyarı bu araşdırmada hecaların sayılması ilə eyniləşdirilmir. Klassik rübainin vəzni tarixi bir poetik qaydanın hissəsidir; Azərbaycan dilində tərcümənin həmin aruz qəlibini tətbiq etməsi mümkün seçim olsa da, bütün variantlar bunu məqsəd götürmür. Ona görə konkret mətnlərdə misranın danışıq sürəti, sintaktik dayanacağı və qafiyənin hansı fikri vurğuladığı izlənir. Üçüncü misra sual və ya şərt quranda dördüncü misranın qısa cavabı daha kəskin səslənir; başqa bir variantın artıq izahı həmin kəskinliyi yavaşıda bilər. Beləliklə, ritm orijinal və tərcümədə eyni ölçü cədvəlindən çox, fikrin oxucuya çatma vaxtı baxımından müqayisə olunur.

Klassik fars poeziyasının rəqəmsal qiymətləndirilməsində mədəni işarələrin ayrıca nəzərə alınmasının vacibliyi də göstərilir (Ansari, Boukadoum və Sadat, 2026). Bu araşdırma başqa korpus və texnologiyaya aiddir; burada ondan nəticə köçürülmür. “Ceyhun”, “Yəzdan”, “küfr” kimi

vahidlərə yalnız söz uyğunluğu baxımından deyil, misranın təsvir və düşüncə quruluşundakı vəzifəsinə görə baxılması həmin ümumi sualın Xəyyam materialında konkretləşməsidir.

Material və metod

Material altı farsca rübai, hər biri üçün Mirmehdi Seyidzadəyə aid edilən insan tərcüməsi və ChatGPT, Gemini, Claude variantlarından ibarətdir. Beləliklə, altı orijinala qarşı 24 Azərbaycan mətninin yaxın oxusu aparılır. Rübailər ilk misraları ilə işarələnir: X1 "قومی متفکرند", X2 "از رفتن آدمی", X3 "می خوردن و شاد بودن", X4 "خوش باش که غصه جهان", X5 "گردون نگری", X6 "گر بر فلکم دست بدی". Mətnlər istifadəçiyə təqdim edilmiş müqayisəli fayldakı variantlardır; modellərin sonrakı versiyalarının və ya başqa sorğuların nəticəsi kimi təqdim edilmir. Xəyyama aid edilən rübailərin müəlliflik tarixi ayrıca mətnşünaslıq problemidir (Mirafzali, 2017); hazırkı araşdırma verilmiş mətnlərin tərcüməsinə yönəlir.

Hər rübai əvvəlcə bütöv fikir quruluşu üzrə oxunur. Sonra təhlil üçün həlledici olan farsca ifadə ilə insan və model variantlarının konkret misraları qarşılaşdırılır. Qafiyə, söz sırası, leksik registr, metaforanın daxili əlaqəsi və son misranın təsiri qeyd olunur. İnsan tərcüməsi mütləq ölçü sayılmır; təbii səslənən model həlli məna baxımından daha dəqiq ola, ahəngli insan misrası isə ehtimal sahəsini daralda bilər. Tədqiqat keyfiyyət yönümlüdür və altı rübaidən bütün farsca–azərbaycanca şeir tərcümələri haqqında statistik nəticə çıxarmır.

Müqayisədə tərcümə variantına verilən qiymət tək misranın sözbəsöz yaxınlığından çıxarılmır. Məsələn, X1-in son misrasında iki yolun rəddi saxlanıbsa, əvvəlki misrada həmin yolların düzgün qurulub-qurulmadığı da yoxlanır. X5-də isə dördüncü misranın "cənnət" qarşılığı təkbaşına deyil, fələk, Ceyhun və cəhənnəm təsvirlərinə verdiyi cavabla qiymətləndirilir. Bu səbəbdən uğurlu görünən bədii əlavə ilə orijinaldan uzaqlaşma arasında sərhəd hər mətnin daxili əlaqələri əsasında izah edilir.

İki yol, xəbərsizlik və şübhənin səsi

X1-də iki "qövm" fərqli idrak mövqeyindən danışır: biri din yolunda düşünür, digəri yəqinlik yolunda güman içindədir. Üçüncü misrada danışanın qorxusu işə qarışır, dördüncü misrada is" əyol nə odur, nə də bu" səsi hər iki tərəfin əminliyini sarsıdır. Burada poetik dönüşün gücü üçüncü bir düzgün yolun elan olunmamasıdır. Seyidzadənin "Pusqudan qışqırır biri nagahan" misrası səsi canlı və dramatik edir, lakin farsca mətndə ünvanı naməlum qalan nida gizlənmiş bir adama bağlanır. Bədii dinamika qazanılır, qeyri-müəyyənlik isə azalır.

ChatGPT "Bir qövm din yolunda həqiqət arar / Bir qövm də gümanla yəqinlik qurar" paraleli ilə başlanğıcın qarşıdurmasını saxlayır. "Arar–qurar–yarar" qafiyəsi qulağa bütöv gəlir. Bununla bel" əyəqinlik qurar" birləşməsi Azərbaycan fəlsəfi danışığında təbii deyil; son "nə bu yol, nə o yarar" hökmü də mənbədəki açıq inkarı faydalılıq meyarına yaxınlaşdırır. Gemini "Kimi şübhə içrə gəzir yəqinin" misrasında gümanı şübhəyə dəyişir v" ənə o, nə həmin" kimi zəif işarə ilə qafiyə bağlayır. Claude "nadanlar, bilin!" deyərək naməlum səsə əmr və sərt müəllim tonu əlavə edir. Dörd variant əsas qarşıdurmanı tanıtsa da, son misranın kimin adından və hansı qətiyyətlə səsləndiyi eyni qalmır.

X2-nin məntiqi başqa aləmdən geri dönüb xəbər gətirənin olmamasına əsaslanır. "Ümid və qorxu"nun faydasızlığı mücərrəd hökm kimi deyil, xəbərsizlikdən çıxan nəticə kimi verilir. Seyidzadənin dörd misrada "könül" müraciətini təkrarlaması daxili musiqi qurur; "Cənnət–cəhənnəmə girən yox, könül" misrası isə orijinalda təsvir edilməyən məkanı müəyyən dini ikiliyə çevirir. Bu seçim rübainin dini çağırışını gücləndirir, lakin "o diyar"ın açıq qalan təsəvvürünü daraldır.

ChatGPT "Ölümün ardında nə var, kim bilər?" sualı ilə əsas problemi dərhal görünən edir, amma "başqa aləmə gediş" obrazını abstrakt ölüm sualına dəyişir. Gemini "aləmə digər" kimi tərs söz sırası ilə qafiyəni və farsca quruluşun izini saxlayır; Azərbaycan misrası sərtləşir. Claude "Başqa aləmə insan edər səfər" deyərək gedişi daha aydın qoruyur və xəbərsizlik əlaqəsini son misraya

aparır. Bu iki rübai birlikdə göstərir ki, qafiyə yalnız eşidilən uyğunluq deyil: səs üçün seçilən sözlər şübhənin ölçüsünü və danışanın mövqeyini də dəyişir.

X1 və X2-də eyni “könül” v“ əqafil” kimi müraciətlər görünə bilər, lakin danışma vəziyyətləri fərqlidir. Birinci rübaidə gələcəkdə eşidiləcəyi qorxulan səs iki hazır cavabı dağıdır; ikinci rübaidə danışan artıq könlünə xəbərsizlikdən nəticə çıxarır. Tərcümə bu fərqi silib hər iki mətni eyni nəsihət tonuna saldıqda Xəyyamın rübailəri ayrı düşüncə hadisələri kimi yox, ümumi hikmət cümlələri kimi səslənir. Şeir forması qısa olduğu üçün “nadanlar, bilin” kimi yalnız iki sözlük əlavə belə danışanın səlahiyyətini dəyişir. Digər tərəfdən “könül”ün hər misrada təkrarı leksik əlavə sayılsa da, X2-də ardıcıl müraciət kimi yeni ritmik xətt yaradır. Burada hökm bədii uğurla semantik müdaxilənin eyni anda mövcud ola bilməsidir.

Sevinc, yoxluq və son misranın fəlsəfi dönüşü

X3-də ilk iki misra mey içməyi, şadlığı, küfrdən və dindən uzaq olmağı bir-birinə bağlayır. Son iki misra kiçik dialoq yaradır: dünya gəlinindən kəbin soruşulur, cavab isə şad könüldür. Buradakı ritm yalnız “ayinimdir–dinimdir–kəbinimdir” səs yaxınlığından doğmur; cavabın sualdan dərhal sonra gəlməsi rübainin yığcam səhnəsini tamamlayır. Seyidzadənin “dinim mənim” təkrarı ahənglidir, amma “fariğ olmaq” fikrinin “bilməmək” kimi çevrilməsi seçilmiş məsafəni məlumatsızlığa yaxınlaşdırır. İnsan variantının üstünlüyü dünya gəlini ilə dialoqu oxunaqlı saxlamağındadır.

ChatGPT-nin “Küfrdən, dindən azad olmaq dinimdir” həlli leksik qarşıdurmanı daha dəqiq saxlayır, lakin “Sevinən qəlbin kəbinimdir” sonluğu Azərbaycan dilində mənsubiyyət əlaqəsini aydın qurmur. Gemini “kəbin”in yerin“ əmehr”i gətirir, sonra “Şad olan qəlbin həm mənimdir” deyərək dialoqun məntiqini yarımçıq qoyur. Claude “Sənin şən könlün kəbinimdir” ilə son cavabı daha səlis verir, ancaq “Kəbin nə?” sualı orijinal səhnəyə nisbətən sərt və kəsik səslənir. Bu nümunədə qafiyələnən söz ailəsi hazır görünür; əsl tərcümə işi həmin səs ailəsinin cümlə münasibətlərini pozmamasıdır.

X4 “xoş ol” çağırışı ilə başlayır, dünyanın qəminin təsirsizliyini və insanın payına düşən qısa keçidi göstərir; “var ikən özünü yox say” paradoksu sonunda sevinc çağırışına qayıdır. Seyidzad ə “Bu zalım dünyada sən adil yaşa” misrası ilə etik nəsihət əlavə edir. Bu misra Azərbaycan dilində yığcam və rahat səslənsə də, farsca rübainin həmin yerind“ əadil yaşamaq” hökmü yoxdur. Son ö“mrü azad vur başa” da paradoksu həyat məsləhətinə çevirir. Beləcə bədii bütövlük qurulur, amma düşüncənin istiqaməti dəyişir.

ChatGPT “İnsanın qisməti qısa səfərdir” obrazı ilə keçid fikrini anlaşıqlı verir; “gül, ömür dəyərdir” sonluğu isə mənbənin paradoksunu müsbət həyat şüarına yaxınlaşdırır. Gemini “Var ikən yox kimi yaşa, bu bəsdir” ilə yoxluq fikrini qoruyur, lakin çağırışın şadlıq səsini zəiflədir. Claude “bi-əsər” sözünü saxlayır v“ əbəşər” ünvanını əlavə edir; farsca iz yeni dildə hər dəfə poetik təbiilik yaratmır. X3 və X4-ün müqayisəsi son misranın iki fərqli işini ayırır: biri dialoqu gözlənilməz cavabla qapayır, digəri düşüncə paradoksunu başlanğıc çağırışı ilə birləşdirir. Hər iki halda qafiyə həmin işi dəstəklədikdə funksionaldır.

X3-d“ əkəbin” sözü mədəni işarə ilə ritmik dayağı bir yerdə daşıyır. Onun daha gündəlik “mehr” qarşılığına çevrilməsi bəzən izahı asanlaşdırır, lakin dünya gəlininin cavabındakı məcazi hüquqi münasibəti zəiflədir. X4-də is“ əyoxluq” sözü nə qədər düzgün saxlanılsa da, son cüml ə ö“mrün dəyəri” barədə birbaşa təsdiqə çevrilirsə paradoksun açdığı gərginlik azalır. Bir nümunədə mədəni sözün münasibəti, digərində mücərrəd fikrin cümlə forması əsasdır. Tərcümə keyfiyyətinin sabit bir ə“n yaxın sinonim” siyahısından çıxmaması bu iki rübai arasında xüsusilə aydın görünür.

Metaforik tənlik və fələyin yenidən qurulması

X5 dörd paralel metaforik tənlik üzərində dayanır: fələk köhnələn ömürlə, Ceyhun təmizlənmiş gözlə, cəhənnəm faydasız əzabın qığılcımı ilə, cənnət isə dinc zamanın nəfəsi ilə əlaqələnir. Bu ardıcıllıq bir kosmologiya təsviri kimi başlayıb insan yaşantısına keçir. “Ceyhun” yalnız çay adı deyil: gözün kiçik məkanından böyük axına keçidin ölçüsünü yaradır. Tərcümədə hər

metaforanı ayrıca uğurlu misra kimi yox, dörd obrazın bir-biri ilə qurduğu ardıcıllıq daxilində oxumaq lazımdır.

Seyidzad“ əDünya – ömrümüzdən keçən bir andır” deyərək fələyi dünya ilə, köhnəlmə əlaqəsini keçən an ilə əvəz edir. “Ceyhun – gözümüzdən axan neysandır” böyük axın təəssüratını saxlayır; “Cəhənnəm – boş əməl qığılcımıdır” misrasında isə əzab ə“məl”ə dönür. ChatGPT “Fələk yorğun ömrümüzdən yaranar” v“ əCəhənnəm boş dərdimizin bir közü” ilə tənliklərin nüvəsinə yaxın qalır. “Ceyhun saf göz yaşımızdan oyanar” təmizlənmiş göz obrazını göz yaşına yozur: məna əlaqəsi tam itmir, lakin orijinalın təsvir qaydası dəyişir.

Gemini “Fələk – bu köhnələn ömrümüz bizim” v“ əgöz yaşımız tökülən izim” kimi qrammatik cəhətdən tamamlanmamış misralar verir. Burada yalnız üslub deyil, misranın səslə oxunuşu da qırılır. Claude “baxış–axış–yanış–barış” qafiyə silsiləsi ilə dörd misranı güclü səs quruluşuna bağlayır, ancaq “fələk ... bir baxış” v“ əcənnət ... bir barış” orijinal metaforik münasibətləri yenidən yazır. Bu rübai səs uğurunun məna uğuru kimi qəbul edilməməli olduğunu xüsusilə aydın göstərir: dördüncü qafiyə birinci üç obrazla daxili əlaqəni zəiflədirsə, bütöv quruluş pozulur.

X6-da şərt cümləsi “Yəzdan kimi fələyə əlim çatsaydı” fikrindən başlayır; mövcud fələyin aradan götürülməsi və azad insanın muradına çatacağı yeni fələyin qurulması təsəvvürü ilə davam edir. Seyidzadənin Ə“limdə olsaydı əgər iqtidar” başlanğıcı ilahi müqayisəni siyasi güc sözünə çevirir. “Hər kəs yaşardı azad, bəxtiyar” sonluğu ümumi xoşbəxtlik mənası yaradır; orijinalın “azadə” fiquru daha konkret idi. Qafiyə və çağırışın ictimai gücü artır, amma şərtin kosmik miqyası dəyişir.

ChatGPT “Tanrı tək gücüm” ilə ilahi müqayisəyə yaxınlaşır, lakin “bu göyü dağıdıb edərdim viran” ifadəsi aradan götürməyi şiddətli dağıntıya çevirir. Gemini “bu fələyi silərdim mən aradan” fikri saxlayır, “Azad öz kamına çatsaydı asan” isə şərt və nəticə əlaqəsini zəif qurur. Claude “mən də Yəzdan” deyərək müqayisənin izini qoruyur, “azad ruh” əlavə etməklə sosial-etik fiquru fərdi mənəvi subyektə çevirir. Rübainin məzmununu “fələyə üsyan” kimi ümumiləşdirmək asandır; tərcümə üçün əsas məsələ isə şərt, dağıtma, yenidən qurma və nəticə arasındakı məntiqi ardıcıllığı saxlamaqdır.

Müzakirə: səs uyğunluğu ilə poetik məsuliyyətin sərhədi

Altı nümunə eyni “insan yaxşı, model zəif” iyerarxiyasını yaratmır. X1 və X2-də insan variantlarının müraciət və daxili təkrarı güclü ritm qurur, lakin naməlum səs konkret şəxsə, naməlum diyar isə cənnət–cəhənnəm ikiliyinə çevrilir. X3-də modelin bir misrası məna əlaqəsini yaxşı qoruduğu halda başqa misrada qrammatik aydınlıq itir. X5-də Claude-un ardıcıl qafiyəsi təsirli səslənir, amma metaforaların münasibəti uzaqlaşır. X6-da insan tərcüməsinin “iqtidar” seçimi ilə ChatGPT-nin “Tanrı tək gücüm” seçimi fərqli sədaqət və fərqli ritm dəyəri daşıyır.

Qafiyənin təhlilində üç səviyyəni ayırmaq məqsədəuyğundur. Birinci səviyyə səsin eşidilməsidir: “arar–qurar–yarar” v“ əbaxış–axış–yanış–barış” ardıcıllıqları oxucu yaddaşında birlik yaradır. İkinci səviyyə sintaktik təbiilikdir: qafiyə sözünə gör“ əaləmə digər”, “nə həmin” və ya tamamlanmamış xəbər qurulursa, səs misranın oxunuşunu xilas etmir. Üçüncü səviyyə poetik funksiyadır: son söz əvvəlki üç misranın məna hərəkətini bağlayırmı? X4-də “ömür dəyərdir” cümləsi özü aydındır, lakin varlıqla yoxluq arasındakı paradoksu başqa bir mənəvi nəticəyə yönəldir.

Bu müşahidələr şeir tərcüməsində modeldən istifadənin praktik ardıcıllığını da göstərir. Əvvəl orijinalın dəyişdirilməsi ən ağır nəticə yaradacaq nöqtələri müəyyənləşdirmək lazımdır: X1-də iki yolun rəddi, X3-də kəbin sualı və cavabı, X5-də dörd metaforanın paralelliyi, X6-da şərt ilə yeni fələyin məqsədi. Daha sonra model təklifləri bu nöqtələrə görə seçilməlidir. Axırda Azərbaycan mətni bir rübai kimi ucadan oxunmalı; qafiyə uğruna söz sırasının sərtləşməsi və ya son misradakı məna sürüşməsi yoxlanmalıdır. Bu qayda modeli şairin yerinə qoymur, tərcüməçinin alternativləri sınamasına kömək edir.

Rübai redaktəsində bir misranı yaxşılaşdıran dəyişiklik digər misralara da tətbiq edilməlidir. X5 üçün daha təbii bir "cənnət" misrası seçilirsə əvvəlki üç metaforanın paralel sintaksisi onunla uyğunlaşmalıdır; X6-da ilk misrada "Yəzdan" saxlanırsa son iki misrada həmin ilahi miqyas adi fərdi arzuda yox olmamalıdır. Bu baxımdan hər variantın dörd misrası ayrıca yoxlanıb sonra bütöv şeir kimi oxunur. Səslə oxu qafiyənin zorla qurulduğu, cümlənin yarımçıq qaldığı və ya son hökmün ritmik ağırlıq itirdiyi yerləri yazılı baxışdan daha tez üzə çıxara bilər. Bu, tərcüməçinin qərarını tam obyektivləşdirmir, lakin qərarın mətn üzərində izahını gücləndirir.

Metodun sərhədi də aydındır: burada konkret olaraq təqdim edilmiş 24 tərcümə variantı oxunur. Sorğu forması, model versiyası və yenidən yaratma şəraiti barədə ayrıca eksperiment aparılmadığı üçün bir misranın uğuru və ya qüsuru sistemin daimi xüsusiyyəti sayılmır. Məqalənin çıxardığı daha etibarlı nəticə ölçü seçiminə aiddir: semantik uyğunluq, qafiyə, üslubi təbiilik və fikir dönüşü birlikdə izah edilmədən "uğurlu tərcümə" hökmü natamam qalır.

Nəticə

Xəyyama aid edilən altı rübainin müqayisəsi göstərir ki, farscadan Azərbaycan dilinə poetik keçiddə üslub və ritm ayrılıqda qorunan iki mexaniki xüsusiyyət deyil. Rübaidə fikir dörd misra boyunca yığılır; səs yaxınlığı bu hərəkətə yadda qalan forma verir, son misra isə əvvəlki obrazların nə üçün qurulduğunu dəyişə bilir. Tərcümədə həmin münasibətlərdən biri güclənərkən başqası zəifləyə bilər. Buna görə qafiyənin mövcudluğu, misranın ayrıca gözəlliyi və ümumi mövzunun düzgün tanınması bütöv şeirin qiymətləndirilməsi üçün yetərli deyil.

İnsan tərcüməsi və generativ model variantları eyni mətnə fərqli imkanlar açır. İnsan həlli yığcam və təbii Azərbaycan rübaisi yarada bilir, lakin bəzi hallarda orijinalın açıq qoyduğu məkanı, ünvanı və ya fəlsəfi hökmü konkretləşdirir. Model çıxışları sürətli paralel quruluş və yeni ifadə təklif edir, bəzən də məna nüvəsini dəqiq saxlayır; lakin qafiyə üçün qeyri-təbii söz, artıq şərh və metaforik əlaqənin dəyişməsi redaktə tələb edir. Tərcüməçinin vəzifəsi variantları adlarına görə sıralamaq deyil, hər bədii qərarın rübainin bütöv təsirinə nə verdiyini əsaslandırmaqdır.

Gələcək araşdırma daha geniş rübai toplusu, müxtəlif insan tərcüməçiləri və oxucu qruplarının ritm qavrayışı ilə bu meyarları sınaya bilər. Hazırkı məqalənin əsas töhfəsi verilmiş farsca–azərbaycanca nümunələr üzrə həmin meyarların necə işlədiyini göstərməsidir: söz orijinala yaxın göründüyü üçün deyil, mənanı, səsi və son dönüşün təsirini yeni dildə birlikdə daşıdığı üçün bədii cəhətdən yaxın sayılır.

Ədəbiyyat siyahısı

Ansari, S., Boukadoum, M., & Sadat, F. (2026). Multi-modal neural machine translation for low-resource classical Persian poetry: A culture-aware evaluation. In The Proceedings of the First Workshop on NLP and LLMs for the Iranian Language Family (pp. 131–139). Association for Computational Linguistics. https://doi.org/10.18653/v1/2026.silkroadnlp-1.14

Boase-Beier, J. (2020). Translation and style (2nd ed.). Routledge.

Holmes, J. S. (1969). Forms of verse translation and the translation of verse form. Babel, 15(4), 195–201. https://doi.org/10.1075/babel.15.4.01hol

Jones, F. R. (2011). Poetry translating as expert action: Processes, priorities and networks. John Benjamins. https://doi.org/10.1075/btl.93

Lefevere, A. (1975). Translating poetry: Seven strategies and a blueprint. Van Gorcum.

Mirafzali, S. A. (2017). Khayyam, Omar ii. Poetry. Encyclopaedia Iranica. https://www.iranicaonline.org/articles/khayyam-omar/khayyam-omar-ii-poetry/

Resende, N., & Hadley, J. (2024). The translator's canvas: Using LLMs to enhance poetry translation. In Proceedings of the 16th Conference of the Association for Machine Translation in the Americas (Vol. 1, pp. 178–189). Association for Machine Translation in the Americas. https://aclanthology.org/2024.amta-research.16/

Wang, S., Wong, D., Yao, J., & Chao, L. (2024). What is the best way for ChatGPT to translate poetry? In Proceedings of the 62nd Annual Meeting of the Association for Computational Linguistics (Vol. 1, pp. 14025–14043). Association for Computational Linguistics. https://doi.org/10.18653/v1/2024.acl-long.756

Xəyyam, Ö. (2004). Rübailər (M. M. Seyidzadə, tərc.). Lider.

STRATEGIES FOR OVERCOMING TERMINOLOGICAL CHALLENGES IN SIMULTANEOUS INTERPRETATION FROM ENGLISH INTO KAZAKH: THE EXPERIENCE OF THE DIGITAL ALMATY 2025 FORUM

Nurtileu N. Torezhanov
Maqsut Narikbayev University, School of Liberal Arts, Translation Studies, Simultaneous Interpretation - 7M02321
Scientific Supervisor:
Karlygash Kenzhigozhina
PhD, Maqsut Narikbayev University, School of Liberal Arts, Translation Studies, Simultaneous Interpretation - 7M02321

ABSTRACT This research article is dedicated to a comprehensive study of the terminological and cognitive challenges that arise during the simultaneous interpretation of high-density technological discourse from English into Kazakh. The empirical basis of the study comprises professional simultaneous interpretation recordings from the international forum "Digital Almaty 2025". Selected via purposive sampling, the audio recordings were transcribed verbatim and subjected to qualitative thematic analysis based on D. Gile's "Effort Model" and A. Chesterman's taxonomy of translation strategies. The findings demonstrate that interpreters frequently resort to pragmatic omission and paraphrasing to overcome terminological overload. Furthermore, the study reveals that translingual phenomena, such as code-switching and syntactic calques resulting from Kazakh-Russian language contact, serve as cognitive "lifesavers" during extreme informational density. Ultimately, this research underscores the intricate balance between cognitive capacity, linguistic resource availability, and strategic decision-making in the highly specialized environment of simultaneous interpretation.

CHAPTER 1. INTRODUCTION

1.1. Research Relevance

In the modern era of globalization, digitalization, and the rapid development of artificial intelligence, the significance of cross-cultural and international communication in the field of information technology has grown immensely. The necessity for seamless knowledge transfer across linguistic boundaries is more critical than ever, particularly for nations aiming to establish themselves within the global digital economy. To strengthen its position as a leading IT hub in the Central Asian region, the Republic of Kazakhstan annually hosts the "Digital Almaty" forum. This major international event brings together government representatives, international experts, and technology corporate leaders to discuss the future of digital infrastructure. Ensuring the full functioning of the state language at such large-scale events, including the provision of high-quality simultaneous interpretation (SI) from English into Kazakh, is a strategically important task for the nation. However, the incomplete formation and lack of standardization of digital and IT terminology in the Kazakh language, coupled with the high informational density of technological discourse in English, create severe linguistic and cognitive barriers for simultaneous interpreters. Therefore, examining how interpreters overcome

terminological difficulties and what strategies they employ based on actual empirical materials is a highly relevant academic issue. Analyzing these practical challenges is essential for developing robust theoretical frameworks and practical solutions that can elevate the quality of interpretation in highly specialized technological domains.

1.2. Research Problem and Purpose The main problem of the research is the increased cognitive load that arises during the simultaneous interpretation of high-density technological texts from English into Kazakh. This heightened cognitive pressure is primarily driven by the insufficiency of the domestic terminological corpus, which often lacks direct, concise equivalents for rapidly evolving IT concepts. Additionally, this problem is compounded by interference phenomena stemming from historical Kazakh-Russian language contact, which actively influences the cognitive processing and lexical choices of interpreters. The primary purpose of the study is to conduct an in-depth qualitative analysis of actual simultaneous interpretation transcripts from the "Digital Almaty 2025" forum. Through this analysis, the research aims to identify, systematize, and scientifically evaluate the strategies employed and errors made by interpreters in overcoming these terminological crises. By anchoring the investigation in authentic, real-world data, the study seeks to bridge the gap between abstract translation theories and the concrete cognitive realities faced by interpreters in the booth.

1.3. Research Questions To achieve the stated purpose and comprehensively explore the research subject, the following three primary research questions were formulated:

- What specific terminological and linguistic challenges do simultaneous interpreters face in practice when working with high-density digital technology discourse?
- What interpretation strategies (compensatory techniques) are employed by interpreters to process high-density digital terminology during English-to-Kazakh interpretation?
- How do the sociolinguistic features of Kazakh-Russian language contact (code-switching, calques) manifest in the quality and linguistic characteristics of simultaneous interpretation?

1.4. Scientific Significance This study enriches the theory of simultaneous interpretation in the post-Soviet space, specifically in Kazakhstan, with novel empirical data. By providing a detailed examination of the cognitive and linguistic mechanisms at play during English-to-Kazakh interpretation, the research offers a clearer understanding of the unique challenges present in this specific language pair. The findings will directly contribute to improving academic training programs for interpreters, including Master's degree courses, by identifying the precise areas where future professionals require targeted pedagogical intervention. Furthermore, the study holds significant value for national projects focused on standardizing the terminological corpus in the IT sector. By highlighting the practical difficulties caused by current terminological gaps, the research can inform state-level policy decisions regarding language modernization and the overall enhancement of simultaneous interpretation quality in the Kazakh language to meet global standards.

CHAPTER 2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1. Terminological Issues in Simultaneous Interpretation Simultaneous interpretation (SI) is a complex psycholinguistic process that occurs under extreme time pressure. The task requires the concurrent execution of listening to the source text, processing the information, and speaking the translated output, a combination that demands exceptionally high cognitive resources from the human brain. In specialized discourses such as IT, blockchain, cloud technologies, and cybersecurity, the frequency and informational density of specific terms sharply increase, amplifying the difficulty of the task. In these highly technical environments, terms typically need to be monosemantic, precise, and concise to facilitate rapid cognitive processing and accurate verbal production. However, in the context of the Kazakh language, this issue is doubly complicated. Equivalent terms for many international technological concepts have not been fully

stabilized or widely adopted within the domestic lexicon. In many instances, conveying the precise meaning of an English IT term requires excessively lengthy explanatory structures in Kazakh. This structural disparity imposes excessive strain on the interpreter's working memory, ultimately slowing down the overall information processing speed and jeopardizing the fluency of the interpretation.

2.2. D. Gile's (2009) "Effort Model" Daniel Gile's (2009) "Effort Model" was selected as the foundational psycholinguistic and cognitive framework for this study. Gile conceptualizes simultaneous interpretation as a carefully balanced combination of four primary efforts, or cognitive resources, that must be continuously managed by the interpreter:

- L (Listening and Analysis) – Listening and analysis effort, which encompasses the accurate comprehension and semantic decoding of the source text.
- M (Memory) – Short-term memory effort, representing the working memory required to store linguistic information while simultaneously processing new input.
- P (Production) – Speech production effort, which involves formulating and articulating the translated text in the target language.
- C (Coordination) – Coordination, the vital executive function responsible for maintaining cognitive balance and seamlessly managing the distribution of mental energy among the other three processes.

According to Gile's theory, these cognitive resources are strictly limited. If the terminological density in the source text or the speaker's delivery rate is too high, the "L" and "M" resources become rapidly depleted, pushing the interpreter's cognitive load to its absolute limit. Under such extreme circumstances, a cognitive deficit occurs. This deficit inevitably leads to involuntary errors, such as the loss of vital information, the distortion of the original meaning, or physical manifestations of strain like stuttering during the "P" (production) phase. This dynamic model accurately and comprehensively describes the high-paced, high-pressure interpretation environment observed at the Digital Almaty forum.

2.3. A. Chesterman's (2016) Taxonomy of Translation Strategies Under conditions of cognitive overload, interpreters do not merely fail; rather, they employ various compensatory techniques to manage the cognitive deficit and prevent catastrophic communication breakdowns. To systematically categorize and analyze these adaptive behaviors, Andrew Chesterman's (2016) taxonomy of translation strategies was utilized. Chesterman divides these critical compensatory techniques into three major operational categories:

- Syntactic strategies: These encompass structural modifications, including literal translation, loan translation, transposition, and clause structure changes, such as shifting a sentence from the active voice to the passive voice to better align with the target language's syntax.
- Semantic strategies: These strategies involve altering the lexical meaning to maintain the flow of communication, utilizing techniques like synonymy, antonymy, paraphrasing (explaining a complex concept with other, more accessible words), abstraction, or concretization.
- Pragmatic strategies: These are higher-level decisions directly impacting the message's delivery, including the addition of necessary information, strategic omission of dense terminology, cultural filtering, and direct transliteration.

This comprehensive taxonomy facilitated a precise and scientifically rigorous classification of the methods that interpreters unconsciously or consciously relied upon to maintain output quality during the demanding sessions of the forum.

2.4. Language Policy in Kazakhstan and Kazakh-Russian Language Contact Another crucial aspect of the research is the unique translingual environment present in Kazakhstan, which deeply influences cognitive processing during translation. Although proactive language policies

implemented during the years of independence have successfully solidified the state status of the Kazakh language and significantly expanded its scope of use across various societal domains, the historical influence of the Russian language remains overwhelmingly dominant in specialized fields such as science, engineering, and IT. This complex sociolinguistic situation results in the simultaneous operation of the "English – Russian – Kazakh" linguistic triad in the working minds of Kazakhstani simultaneous interpreters. Under extreme time constraints and heavy cognitive loads, interpreters often process English terms not directly into the Kazakh target language, but rather through the Russian language. Russian equivalents surface more quickly in their cognition due to established neural pathways and the prevalence of Russian in technical education. Consequently, oral interpretation in these settings frequently exhibits code-switching, or language mixing, alongside calques that are strictly structured on Russian syntactic models. This translingual phenomenon directly and profoundly impacts both the linguistic quality and the pragmatic adequacy of the simultaneous interpretation delivered to the audience.

CHAPTER 3. RESEARCH METHODOLOGY

3.1. Research Design and Purposive Sampling This research was conducted within a robust qualitative research paradigm aimed at generating a deep, contextualized understanding of interpreter behavior. To collect data highly relevant to the research subject, a purposive sampling method, as outlined by Palinkas et al. (2015), was actively employed. This non-probability approach is specifically designed to deliberately select the most information-rich and representative materials regarding the complex phenomenon under study: the simultaneous interpretation of high-density IT terms from English into Kazakh. The "Digital Almaty 2025" international conference was deliberately chosen as the research site because it attracts government officials, private sector leaders, and emerging technology experts, thereby generating authentic, highly concentrated technological discourse. From this extensive event, three professional interpretation sessions covering highly relevant topics such as artificial intelligence, blockchain, digital finance, cybersecurity, e-government, and cloud infrastructure were specifically selected from open sources, namely YouTube.

3.2. Data Collection Instruments and Triangulation The data collection process was meticulously designed and involved several sequential stages to ensure accuracy and analytical depth:

- The original English-language video recordings and their corresponding Kazakh-language interpreted outputs were systematically downloaded from the official channels of the forum.
- The audio recordings in both languages were subsequently transcribed completely verbatim. Crucially, the transcripts meticulously preserved every pause, error, hesitation, and addition made by both the original speakers and the interpreters.
- To ensure precise, segment-by-segment comparison during the analysis phase, the source and target texts were carefully aligned utilizing millisecond timestamps.

Furthermore, to ensure the scientific rigor, validity, and overall reliability of the study, the triangulation method proposed by Creswell and Poth (2018) was applied. That is, the researcher did not limit the analytical scope solely to the isolated transcripts. Instead, the researcher concurrently examined the forum's official agenda documents, public presentations including speaker slides, and published speaker abstracts. This multi-faceted data collection approach provided a much deeper understanding of the overarching contextual logic and semantic constraints behind the interpreters' real-time choices of specific terms.

3.3. Thematic Analysis Procedure The qualitative analysis of the rich transcript data was conducted using a systematic, highly structured 4-stage thematic analysis algorithm. This rigorous procedure was explicitly based on the theoretical frameworks provided by Chesterman’s (2016) taxonomy and Gile’s (2009) Effort Model:

- Stage 1 (Transcription and Segmentation): The finalized transcripts were divided into distinct interpretive units, with each unit specifically centered on a single thematic or terminological cluster. Each specific recording was reviewed multiple times to ensure the absolute accuracy of the segmentation.
- Stage 2 (First-Cycle Coding): The English source segments and their corresponding Kazakh outputs were aligned and rigorously compared across the lexical, syntactic, and broader discourse levels. During this phase, observable surface linguistic phenomena were assigned specific descriptive codes, such as omission, substitution, calque, neologism, and circumlocution.
- Stage 3 (Second-Cycle Coding): The initial micro-codes generated in the previous stage were refined, consolidated, and grouped into three major thematic categories that directly addressed the study's core research questions: (1) terminological management challenges, (2) cognitive load indicators and compensatory strategies, and (3) language contact features.
- Stage 4 (Theoretical Integration): In the final stage, the identified empirical findings were deeply interpreted through the analytical lens of Gile’s Effort Model, which serves to explain the underlying cognitive dynamics, and Chesterman’s taxonomy of strategies, undergoing rigorous analytical evaluation to formulate the study's conclusions.

CHAPTER 4. RESEARCH RESULTS

Through the meticulous comparative analysis of the verbatim transcripts, the primary trends, obstacles, and behavioral patterns occurring in the simultaneous interpretation process were identified and grouped into the three aforementioned thematic categories for detailed examination.

4.1. Terminological Management Challenges The qualitative data revealed that the foremost barrier encountered by professional interpreters during the Digital Almaty 2025 forum was the widespread absence of standardized, uniform, and concise equivalents for high-density IT terms in the Kazakh language. Furthermore, even when equivalents existed, their inherent unwieldiness for rapid oral speech posed significant challenges. It was frequently observed that within the confines of a single session, interpreters were forced to use multiple variants, creating disjointed synonymic rows, for the exact same term.

Table 1: High-Density IT and Digital Terms Encountered at the Digital Almaty 2025 Forum and Their Interpreted Equivalents

Source English IT Terms | Kazakh Translation Variants in the Transcript (SI) | Difficulty Level and Reason

Artificial Intelligence (AI) | 1) Жасанды интеллект; 2) ИИ (Russian abbreviation); 3) Жасанды сана. | Medium. Although the term is officially established, the Kazakh abbreviation (ЖИ) is cumbersome in speech, so interpreters often switch to the Russian acronym "ИИ".

Blockchain technology | 1) Блокчейн технологиясы; 2) Блокчейн жүйесі. | Low. Direct transliteration is used, causing no additional cognitive load.

Cloud computing infrastructure | 1) Бұлтты инфрақұрылым; 2) Облачный вычисление; 3) Бұлттық есептеу жүйесі. | High. A literal Kazakh translation creates semantic heaviness. Due to the term's length, code-switching occurred frequently.

Smart contracts | 1) Ақылды келісімшарттар; 2) Смарт-контракттар. | Medium. Both options were used in parallel; transliteration (смарт-контракт) proved more time-efficient.

Data mining | 1) Деректерді өндіру; 2) Дата майнинг; 3) Ақпаратты қазу (incorrect calque). | Very High. The word "өндіру" (mining/extracting) refers to raw materials and does not fully convey the meaning in a digital context. Interpreters stumbled over this term.

Machine learning | 1) Машиналық оқыту; 2) Машинное обучение; 3) Автоматты үйрену. | High. The semantic boundary between "оқыту" (teaching) and "үйрену" (learning) confuses the interpreter.

As is clearly evident from the data presented in the table, complex digital concepts that are efficiently expressed in one or two syllables in the English language frequently transform into complex, multi-word phrases in Kazakh. Under extreme time constraints, this fundamental structural asymmetry severely disrupts the interpreter's natural speech rhythm and cognitive flow.

4.2. Cognitive Load Indicators and Compensatory Strategies The analysis demonstrated a direct correlation between the input density and cognitive exhaustion. As the speaker's delivery rate reached high speeds of 130-150 words per minute and the concentration of specialized terms in the source text increased, the interpreters' available cognitive resources rapidly depleted. In the examined transcripts, this depleted state actively manifested as observable physical and acoustic indicators, including prolonged pauses, sudden false starts, and instances of stuttering. To actively overcome this intense cognitive overload and maintain communication, the interpreters consistently resorted to specific pragmatic and semantic strategies outlined in Chesterman's established taxonomy.

Table 2: Frequency of A. Chesterman's Strategies and Specific Examples from the Transcripts

Strategy Category (Chesterman) | Specific Strategy Type | Source Text (ST) | Target Text (TT - SI) | Frequency of Use

Syntactic Strategies | Literal translation | "We need to deploy scalable machine learning models to the market." | "Бізге нарыққа масштабталатын машиналық оқыту модельдерін енгізу қажет." | High. Direct translation conserves energy.

Semantic Strategies | Paraphrasing / Circumlocution | "The latency in edge computing is severely bottlenecking our data throughput." | "Шеткі есептеулердегі кідіріс біздің деректер алмасуымызға, яғни жұмысымызға үлкен кедергі келтіріп жатыр." (The word "bottlenecking" was paraphrased in a broader sense). | Medium. Used to convey meaning when the exact term cannot be recalled.

Pragmatic Strategies | Omission | "Using decentralized end-to-end encryption protocols ensures absolute data privacy." | "Орталықтандырылмаған хаттамаларды қолдану деректер құпиялылығын қамтамасыз етеді..." (end-to-end encryption was completely omitted). | Very High. The primary "lifesaver" technique when information load reaches its limit.

Pragmatic Strategies | Addition / Explicitation | "Our SaaS solutions..." | "Біздің бағдарламалық қамтамасыз ету ретіндегі қызмет, яғни SaaS шешімдеріміз..." | Low. Encountered only when the speaker's pace is slow.

The deep textual analysis reveals that under pressure, the most frequently used operational strategy is omission. When polysemantic or structurally multi-component terms are uttered rapidly by the speaker, the interpreter intentionally skips them in order to preserve only the overarching macro-meaning of the sentence.

4.3. Language Contact Features (Kazakh-Russian Language Mixing) One of the most evident, consistent, and theoretically intriguing findings of this empirical study is the absolute abundance of translingual elements within the output. Specifically, the mixing of Kazakh and Russian languages, recognized academically as code-switching, was highly prevalent in the interpreters' speech. The data indicates that the vast majority of Kazakhstani interpreters do not attempt to translate English terms directly into Kazakh; rather, they process them seamlessly through ready-made Russian linguistic models established in their cognition.

Table 3: The Impact of Kazakh-Russian Language Contact (Code-Switching, Russian Calques) on Interpretation Quality

Linguistic Phenomenon | Source English Text (ST) | Interpreter's Version (SI Transcript) | Normative Academic Kazakh Equivalent | Impact on Interpretation Quality

Code-switching (Lexical borrowing) | "Our focus is on digitalization and cyber threats." | "Біздің фокус цифровизация және киберугрозаларға бағытталған." | Біздің басты назарымыз цифрландыру мен киберқатерлерге бағытталған. | Creates stylistic imbalance and gives the text an informal tone. However, it saves time.
Russian syntactic calque | "This takes place in real time." | "Бұл реалды уақыт режимінде орын алады." (from Russian: в режиме реального времени) | Бұл нақты уақытта жүзеге асады. | Generates lexical artificiality, yet does not distort the speaker's intent.
Syntactic interference | "The government actively supports new tech hubs." | "Үкімет белсенді түрде поддержка жасайды жаңа тех хабтарға." | Үкімет жаңа технологиялық хабтарды белсенді түрде қолдайды. | Disrupts the grammatical structure (SOV) and shifts the register to colloquial speech.
As this table clearly indicates, under moments of acute cognitive stress, professional interpreters automatically and instinctively activate structural constructions from the dominant language. In this specific context, that dominant language is Russian, which heavily permeates the professional and technological environment.

CHAPTER 5. DISCUSSION

In this vital analytical section, the empirical results obtained from the transcripts are thoroughly interpreted in direct relation to the three primary research questions and systematically mapped onto the theoretical frameworks of D. Gile and A. Chesterman.
Discussion of the First Research Question: The analysis confirms that the major systemic barrier inherently faced by Kazakh-speaking interpreters operating in high-density IT discourse is the profound lack of fully established and universally accepted terminological apparatuses. The data shows that many advanced technological concepts, for instance, "Cloud computing" or "Data mining," are currently not expressed in the Kazakh language utilizing concise nominative units. Instead, they must be rendered with lengthy explanatory phrases that require significantly more articulation time. While the interpreter is forced to articulate such a lengthy, multi-word phrase to convey a single concept, the original speaker invariably initiates their next thought. This structural disparity creates a cascading temporal delay, forcefully trapping the interpreter in a continuous, high-stress "catch-up" mode that threatens the stability of the entire translation process.
Discussion of the Second Research Question and Theoretical Integration: The extensive findings of this study fully and flawlessly validate the structural mechanisms proposed in D. Gile’s "Effort Model". The empirical evidence demonstrates that when a speaker rapidly lists complex technical terms, an excessive and immediate load is placed on the interpreter's "Listening" and "Memory" cognitive resources. During critical moments within the discourse when this cognitive deficit predictably occurs, interpreters unconsciously utilize pragmatic omission, a key category from A. Chesterman’s taxonomy, serving as their most highly effective "lifesaver". In this demanding specific context, omission is definitively not categorized as a professional error or lapse in competence. Rather, it functions dynamically as a vital cognitive regulation mechanism that effectively prevents a complete breakdown of the ongoing interpretation process. Furthermore, the strategic choice of leaving international terms untranslated through direct transliteration, as seen with terms like blockchain or startup, semantically and effectively conserves the interpreter's crucial "P" (Production) resource, allowing mental energy to be redirected to comprehension.
Discussion of the Third Research Question: The transcript data conclusively proven that the historical translingual contact between the Kazakh and Russian languages plays a highly pronounced, unavoidable role in the cognitive reality of the SI process. As was clearly shown in Table 3, in order to rapidly avoid losing precious cognitive time searching for a non-standardized or unwieldy Kazakh equivalent of a dense English term, interpreters consistently and directly employ familiar Russian equivalents, utilizing words like tsifrovizatsiya or kiberugroza, or they rely

on Russian syntactic calques. Although this specific linguistic phenomenon is formally considered by traditional linguistic standards to be a lexical error or a stylistic deviation, the reality of the booth dictates otherwise. Under extreme time pressure, deploying these Russian translingual elements becomes the absolute only pragmatic way to successfully preserve the overarching semantic integrity of the communication. Consequently, there is every empirical reason to define and characterize this behavior as a highly specialized, unique cognitive survival mechanism actively utilized by Kazakhstani interpreters.

CHAPTER 6. CONCLUSION AND RECOMMENDATIONS

6.1. Scientific Contribution of the Research This robust research project stands among the first in domestic translation studies and applied linguistics to successfully and empirically analyze the complex English-to-Kazakh simultaneous interpretation process. The foundational strength of the study lies in its reliance on actual verbatim transcripts sourced directly from a major international technological forum like "Digital Almaty 2025". The research thoroughly substantiates the exact nature of the cognitive loads experienced by Kazakh-language interpreters working under the pressure of high-density IT terms. Furthermore, it scientifically justifies the diverse compensatory strategies, predominantly omission and paraphrasing, as well as the linguistic interferences like code-switching that these professionals pragmatically employ. Overall, the research clearly demonstrated exactly how the classic theoretical models developed by Gile and Chesterman practically operate and manifest within the highly specific Kazakhstani translingual and technological context.

6.2. Research Limitations Like any focused qualitative research endeavor, this study inherently possesses certain methodological limitations that must be acknowledged. The primary limitation impacting the generalizability of the findings is the relatively small sample size of the dataset. The in-depth textual analysis was intentionally restricted to the audio recordings of only three specific professional sessions within a single iteration of one forum. Additionally, the research strictly solely analyzed the final interpreted output via the created transcript. Because direct retrospective interviews or surveys were not actively conducted with the interpreters themselves following their performance, their highly subjective psychological states, internal reasoning, and exact consciousness at the precise moment of making strategic decision-making choices were not fully captured or analyzed.

6.3. Future Recommendations Based on the thorough analysis and the aforementioned scholarly conclusions, the following interconnected practical and theoretical recommendations are formally proposed:

- For the academic community: Master's degree programs specializing in Translation Studies, explicitly including those currently offered at Maqsut Narikbayev University, must urgently update their curricula. They should introduce specialized, highly intensive practical training courses specifically titled "Simultaneous Interpretation of Artificial Intelligence Terminology in Technological Discourse" to bridge the current skill gap. Furthermore, given the documented cognitive pressures, it is essential to proactively conduct targeted stress management training for all university students enrolled in SI programs.
- For the State Terminological Commission: To alleviate the cognitive burden on language professionals, it is highly recommended to immediately accelerate institutional efforts to officially approve international technical terms. Specifically, terminology in the rapidly growing fields of artificial intelligence, cloud technologies, cybersecurity, and blockchain should be adopted directly as standardized English-Kazakh equivalents, thereby remaining free from the historically transitive influence of the Russian language. Additionally, when creating abbreviations for these terms, they must be intentionally shortened in strict

accordance with the law of harmony in the Kazakh language, ensuring the creation of dynamic versions that are significantly easier and faster to vocalize during live speech.

- For future researchers: Exploring the complex, internal cognitive processes of simultaneous interpreters much more deeply represents a highly promising scientific direction for the future. Future studies should aim to utilize advanced methodologies such as retrospective protocols and physiological eye-tracking methods to gather data beyond mere audio transcripts. Additionally, to broaden the applicability of these findings, the overall scope of future empirical research could be significantly expanded to include interpretation data meticulously gathered from other major international technological summits.

REFERENCES

- 1. Chesterman, A. (2016). Taxonomy of translation strategies.
- 2. Creswell & Poth. (2018). Triangulation method.
- 3. Gile, D. (2009). Effort Model.
- 4. Palinkas et al. (2015). Purposive sampling method.

AI-BASED ADAPTIVE LEARNING: A NEW PARADIGM FOR PERSONALIZED FOREIGN LANGUAGE TEACHING

Nurmanaliyeva Lyaila Shaymerdenovna
Taraz University named by M.Kh. Dulaty, Senior Lecturer of "World Languages" Department, Master of Pedagogical Sciences, Kazakhstan, Taraz
Atam Ruveyda Ibrakhimzhanovna
Taraz University named by M.Kh. Dulaty, Senior Lecturer of "World Languages" Department, Master of Pedagogical Sciences, Kazakhstan, Taraz

Foreign language classrooms are linguistically and affectively heterogeneous, yet most instruction is still paced for an imagined average learner. This article examines whether artificial intelligence (AI)-based adaptive learning constitutes a genuinely new paradigm for personalized foreign language teaching or merely automates older ideas. Using a focused analytical review of ten scholarly sources from American and Kazakhstani research traditions, supplemented by a comparative analysis of effect sizes reported in the intelligent tutoring literature, the study asks which theoretical principles justify adaptivity, what evidence supports its effectiveness, and which conditions constrain it in Kazakhstani higher education. The analysis shows that adaptive systems reproduce, at scale, mechanisms long associated with effective tutoring, namely diagnosis, calibrated challenge, and immediate feedback, and that reported effects are substantial but vary widely with design. Kazakhstani evidence is promising but thin; it identifies infrastructure, teacher digital literacy, data privacy, and shallow personalization in current tools as recurring constraints. The article proposes a four-layer model (diagnosis, adaptation, feedback, and human oversight) and derives implementation principles for universities. It concludes that adaptivity is a paradigm shift only when pedagogy, rather than technology, governs the learning loop. Limitations include the small corpus and reliance on secondary data.

Keywords: adaptive learning; artificial intelligence; personalized learning; foreign language teaching; intelligent tutoring systems; feedback; Kazakhstan

Introduction

Every foreign language classroom is a collection of different learners. Students arrive with unequal prior knowledge, different rates of acquisition, different levels of anxiety, and different reasons for studying, yet a typical lesson moves at a single pace and offers a single sequence of tasks. The cost of this mismatch has been recognized for decades. Bloom (1984) reported that students tutored one-to-one with mastery learning procedures performed about two standard deviations better than students in conventional classes. He called this the 2 sigma problem because individual tutoring is too costly to provide to everyone. The central question for educators has therefore been whether any method of group instruction can approach the effectiveness of a tutor who continuously diagnoses, adjusts, and responds.

Artificial intelligence (AI)-based adaptive learning is the most prominent current candidate for an answer. In this article, adaptive learning refers to systems that build a model of the learner, use that model to adjust the content, sequence, pace, or feedback of instruction, and update the model as the learner responds. Meta-analytic evidence from intelligent tutoring systems suggests that such mechanisms can matter. VanLehn (2011) found that step-based tutoring systems approached the effectiveness of human tutors, and Kulik and Fletcher (2016) reported that

students who used intelligent tutoring systems outperformed students in conventional instruction. The rapid spread of generative AI since 2022 has widened the scope of adaptivity, because large language models can converse, rephrase, and respond to open-ended learner output. Earlier systems, built largely for structured domains such as mathematics, could not do this.

The word paradigm deserves scrutiny. A paradigm shift in teaching would imply not merely a new tool but a change in how instruction is organized: from a fixed curriculum delivered to a group toward a learning path that is continuously negotiated between learner data and pedagogical design. Whether current AI systems achieve this is an empirical question. Claims of transformation often rest on vendor descriptions or small attitude surveys, and they rarely distinguish between systems that merely reorder exercises and systems that diagnose specific errors and respond to them. Moreover, adaptivity introduces risks that traditional instruction does not: dependence on data quality, opacity of algorithms, exposure of learner data, and the possibility that learners delegate to AI the effortful processing on which learning depends. A careful assessment must therefore weigh potential gains against these risks, and it must do so within a specific educational context.

Foreign language learning, however, is not simply another domain for adaptive technology. Second language development depends on comprehensible input slightly beyond the learner's current level (Krashen, 1982), on interaction in which a more capable interlocutor mediates performance within the learner's zone of proximal development (Lantolf & Thorne, 2006), and on affective conditions that either lower or raise the barriers to using the language. These principles imply that adaptivity in language teaching must address not only accuracy but also meaning, interaction, and motivation. Chapelle (2001) made a related point in her criteria for evaluating technology-based language tasks, which include language learning potential, learner fit, meaning focus, authenticity, positive impact, and practicality. A paradigm of personalized language teaching must therefore be judged against pedagogical criteria and not only technical ones.

These issues are particularly relevant in Kazakhstan, where national education policy promotes trilingualism and university cohorts often combine students from different school backgrounds, so that entry-level proficiency in English can differ considerably within a single group. Research on AI in language education in Kazakhstan is growing but remains thin. Kemelbekova et al. (2024) compared AI-supported and traditional instruction among first-year students at a pedagogical university. Ergabylova and Turebayeva (2026) surveyed students and instructors about adaptive platforms and reported favorable attitudes alongside concerns about digital literacy and data privacy. Serzhankyzy and Turashova (2025), analyzing AI tools for Kazakh language learning, found that deep adaptive personalization and automated feedback were largely absent. Taken together, these studies suggest that enthusiasm is outpacing evidence.

Three gaps follow. First, the international evidence on adaptive tutoring comes largely from structured subjects and is rarely connected to second language acquisition theory. Second, Kazakhstani studies describe attitudes and tools but seldom specify what makes a system adaptive in a pedagogically meaningful sense. Third, no framework links theoretical principles, empirical evidence, and local constraints into guidance for universities. This article addresses these gaps through three research questions. RQ1: Which theoretical principles justify adaptivity in foreign language teaching? RQ2: What does the available evidence show about the effectiveness of AI-based adaptive learning, and how large are the reported effects? RQ3: Which conditions constrain implementation in Kazakhstani higher education, and what model of implementation follows? The article argues that adaptivity constitutes a paradigm shift only when pedagogical principles govern the learning loop.

Materials and Methods

Research design. This study is a focused analytical review. It combines document analysis, in which each source is coded against a predefined framework, with a comparative analysis of effect sizes reported in the intelligent tutoring literature. The design was chosen because the research questions concern the relationship among theory, evidence, and context rather than the effect of a specific intervention, and because primary classroom data on adaptive language learning in Kazakhstan are not yet sufficient to support a stand-alone experiment. A focused review can integrate dispersed findings and identify design principles that a later experiment can test. Its main limitations are that it cannot establish causal effects of any particular system and that findings from different studies are not directly commensurable. Both limitations are addressed in the Results and Discussion section.

Corpus and selection criteria. The unit of analysis was a scholarly source. Sources were selected purposively according to four criteria: (a) the source addresses adaptive learning, intelligent tutoring, personalized learning, or the theory of second language acquisition and mediation; (b) the source is a peer-reviewed article, a scholarly monograph, or a research-institute report with a verifiable publisher or DOI; (c) the source represents either the American research tradition or Kazakhstani scholarship; and (d) the source is written in English. Commercial documentation, press materials, and unreviewed texts were excluded. The final corpus comprised ten sources. Seven were by American scholars: three theoretical works (Chapelle, 2001; Krashen, 1982; Lantolf & Thorne, 2006) and four evidence-oriented works (Bloom, 1984; Kulik & Fletcher, 2016; Pane et al., 2015; VanLehn, 2011). Two of these, VanLehn (2011) and Kulik and Fletcher (2016), are articles in Scopus-indexed journals. Three were by Kazakhstani scholars published between 2024 and 2026 and were selected to represent three types of local evidence: a controlled classroom comparison (Kemelbekova et al., 2024), a survey of students and instructors (Ergabylova & Turebayeva, 2026), and an analytical review of AI tools (Serzhankyzy & Turashova, 2025). The corpus is deliberately small. A focused review prioritizes sources that are foundational, widely cited, or directly relevant to the Kazakhstani context over exhaustive coverage, and ten sources allowed each to be coded in depth against the full matrix. The cost of this choice is a narrower evidence base, which is discussed under limitations.

Analytic framework and procedure. Coding proceeded in two passes. In the first, deductive pass, each source was coded against a matrix with five columns: (a) the theoretical principle invoked; (b) the mechanism of adaptivity addressed, distinguishing diagnosis of the learner, adaptation of content and pace, feedback, affective support, and human oversight; (c) the type and strength of evidence; (d) the educational context; and (e) the limitations reported or evident. The five mechanisms were derived from the common architecture of intelligent tutoring systems. Evidence was rated as strong (meta-analysis or large controlled evaluation), moderate (single controlled or quasi-experimental study), or preliminary (survey, descriptive, or analytical work). In the second, inductive pass, statements about implementation conditions were coded openly and grouped into themes, which yielded the constraints reported in Table 1 and the model proposed in the final section.

Comparison of effect sizes. Standardized effect sizes were extracted from the three sources that report them (Bloom, 1984; Kulik & Fletcher, 2016; VanLehn, 2011) and recorded exactly as reported, without recalculation. The comparison is descriptive. The comparison conditions differ across studies: Bloom (1984) compares tutoring with mastery learning against conventional class instruction, VanLehn (2011) compares tutoring conditions against no tutoring, and Kulik and Fletcher (2016) compare intelligent tutoring against conventional instruction. Domains, populations, and outcome measures also differ, so the figures illustrate the range and ordering of reported effects and are not pooled or tested statistically.

Ethics and trustworthiness. The study involved no human participants and used only published sources, so ethics committee approval was not required. All sources are attributed in APA 7 format and no text is reproduced. Trustworthiness was supported by stating selection criteria in advance, keeping the coding matrix as an audit trail, and reporting evidence ratings alongside claims. A single analyst performed the coding, so intercoder reliability was not assessed, and this limitation is noted in the discussion.

Literature Review

Tutoring and the logic of adaptivity. The case for adaptivity begins with Bloom's (1984) finding that individual tutoring with mastery learning produced far larger gains than conventional group teaching. VanLehn (2011) refined the argument by comparing tutoring systems of different granularity. He found that systems that give feedback and hints on each step of a solution were nearly as effective as human tutors and considerably more effective than systems that evaluate only final answers. Kulik and Fletcher (2016) reviewed controlled evaluations of intelligent tutoring systems and reported a median effect of 0.66 standard deviations over conventional instruction. Taken together, these works suggest that the effectiveness of adaptive systems lies in the grain size and quality of interaction rather than in the label "adaptive."

Second language acquisition theory. Krashen (1982) argued that acquisition proceeds when learners understand input that is slightly more advanced than their current competence and when emotional barriers, which he termed the affective filter, are low. Lantolf and Thorne (2006) approached development from a sociocultural perspective, emphasizing that learning occurs through mediation within the zone of proximal development, where support is gradually withdrawn as the learner gains control. Both perspectives translate directly into design requirements for adaptive systems: the system must estimate the learner's level, calibrate challenge and support, and protect the learner's willingness to communicate.

Evaluation of technology and personalized learning. Chapelle (2001) proposed that technology-assisted language tasks be evaluated against criteria rooted in second language acquisition research, among them learner fit and language learning potential. In a broader educational context, Pane et al. (2015) studied schools that implemented personalized learning in the United States and reported positive effects on mathematics and reading achievement. They also found that results varied with how the approach was implemented, which is a reminder that personalization is a set of practices and not a single technology.

Kazakhstani research. Recent Kazakhstani studies address three aspects of the problem. Kemelbekova et al. (2024) conducted a pre-test and post-test comparison of AI-supported and traditional instruction in English speaking among first-year university students. Ergabylova and Turebayeva (2026) examined adaptive platforms in Kazakhstani education through surveys and described both motivational benefits and ethical and technical limitations. Serzhankyzy and Turashova (2025) analyzed generative AI tools for learning Kazakh and identified a gap between the potential of underlying language models and the personalization that applied tools currently offer. Their studies collectively show growing interest, but each addresses only one part of the adaptive learning loop.

Cautions in the literature. The literature also contains warnings. VanLehn (2011) showed that effectiveness depends on interaction granularity, so a system that offers only coarse feedback should not be expected to deliver the effects of the best systems. Pane et al. (2015) observed that implementation quality shaped outcomes. Ergabylova and Turebayeva (2026) listed ethical concerns, the need for technical support, and dependence on input data quality among the limitations of adaptive systems. Serzhankyzy and Turashova (2025) emphasized the teacher's continuing role in developing critical thinking and intercultural communication, areas in which AI remains weak. These cautions suggest that adaptive learning should be evaluated as a socio-technical arrangement in which tools, teachers, and institutions interact.

Results and Discussion

This section answers RQ2 and RQ3 by presenting the coded evidence and then proposing a model of implementation. RQ1 is addressed by the theoretical mapping in the first column of Table 1. Table 1 summarizes the coding matrix by mechanism of adaptivity.

Table 1

Mechanisms of Adaptivity, Their Theoretical Basis, Evidence, and Kazakhstani Constraints

Mechanism	Theoretical basis	Evidence base (rating)	Kazakhstani findings and constraints
Diagnosis (learner model)	Input slightly beyond current level (Krashen, 1982); mediation in the zone of proximal development (Lantolf & Thorne, 2006)	Kulik & Fletcher (2016); VanLehn (2011) (strong)	Personalization limited or absent in most tools for Kazakh (Serzhankyzy & Turashova, 2025) (preliminary)
Adaptation (content, sequence, pace)	Mastery learning (Bloom, 1984)	Bloom (1984); Pane et al. (2015) (moderate)	Platform-level adaptivity reported as beneficial, with concerns about algorithmic bias (Ergabylova & Turebayeva, 2026) (preliminary)
Feedback	Scaffolding and mediation (Lantolf & Thorne, 2006)	VanLehn (2011): step-based systems clearly outperformed answer-based systems (strong)	Both groups improved in speaking; no significant pronunciation difference (Kemelbekova et al., 2024) (moderate); automated feedback mostly absent in Kazakh tools (Serzhankyzy & Turashova, 2025)
Affective support	Low affective filter (Krashen, 1982)	Evidence mostly attitudinal (preliminary)	Increased motivation reported by students (Ergabylova & Turebayeva, 2026) (preliminary)
Human oversight	Learner fit and positive impact (Chapelle, 2001)	Pane et al. (2015): results varied with implementation (moderate)	Insufficient digital literacy, infrastructure needs, and data privacy concerns (Ergabylova & Turebayeva, 2026) (preliminary)

Note. Evidence ratings: strong = meta-analysis or large controlled evaluation; moderate = single controlled or quasi-experimental study; preliminary = survey, descriptive, or analytical work. Source: author's analysis of the ten-source corpus.

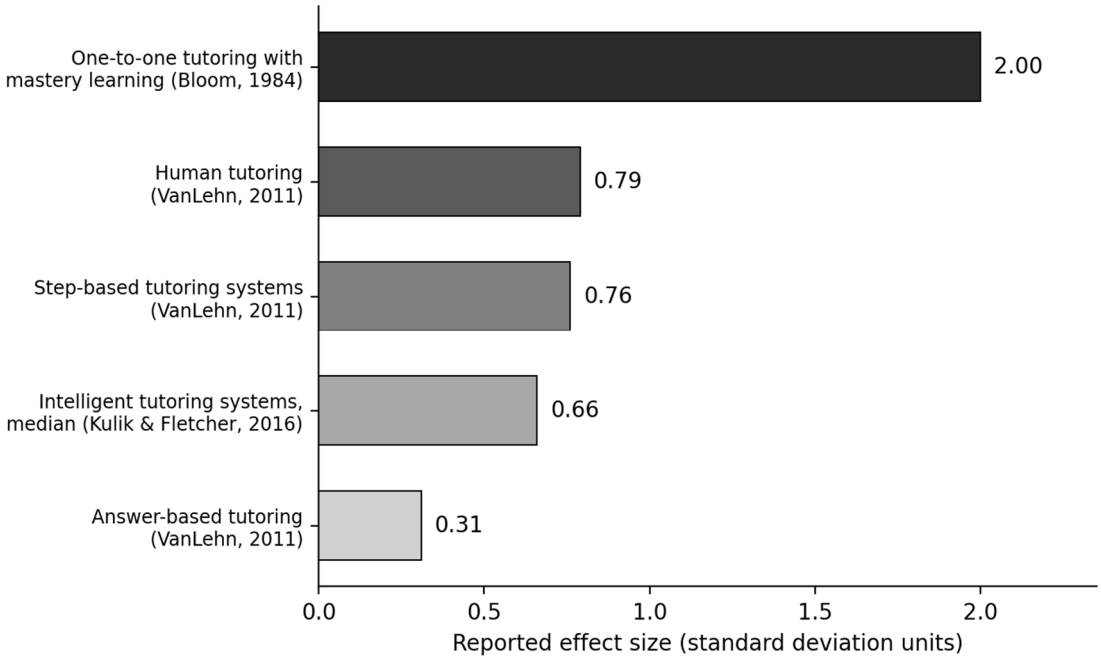
Table 1 shows that each mechanism of adaptivity is anchored in a theoretical principle, but the strength of the supporting evidence is uneven. The evidence is strongest for feedback and diagnosis. VanLehn (2011) shows that the granularity of feedback separates effective from ineffective systems, and the learner-model logic of diagnosis corresponds to the estimate of

current competence that Krashen's (1982) input hypothesis presupposes. Evidence is weaker for affective support and for human oversight, where Kazakhstani sources provide mostly attitudinal data. The right-hand column shows a second pattern. Kazakhstani constraints cluster at the two ends of the learning loop. At the input end, Serzhankyzy and Turashova (2025) found that personalization in most Kazakh-language tools is limited or absent, so the diagnostic layer is thin. At the governance end, Ergabylova and Turebayeva (2026) report that instructors cited insufficient digital literacy, and that more than half of respondents were concerned about data privacy and algorithmic bias. These constraints are not technical details but conditions that determine whether the learning loop operates at all.

Figure 1 compares the effect sizes reported in the three sources that provide them.

Figure 1

Effect Sizes Reported for Tutoring and Intelligent Tutoring Conditions



Note. Values are standardized effect sizes as reported in the sources and are not pooled. Comparison conditions differ: no tutoring (VanLehn, 2011) or conventional instruction (Bloom, 1984; Kulik & Fletcher, 2016).

Figure 1 yields three observations. First, all reported effects are positive, and even the lowest, answer-based tutoring at 0.31, represents a measurable advantage over no tutoring. Second, the ordering follows interaction grain size: systems that respond at the level of individual steps (0.76) approach human tutoring (0.79), whereas systems that judge only final answers lag far behind. This supports the argument that an adaptive system is only as pedagogically useful as the granularity of its feedback. A language-learning application that marks an essay or a speaking task as correct or incorrect, without locating and explaining the error, belongs in the lower part of this range, whatever its marketing. Third, Bloom's (1984) value of 2.0 is not comparable with the others because it combines tutoring with mastery learning procedures, and it should be read as an upper bound that illustrates the potential of combining personalization with mastery requirements. The figures also come predominantly from structured domains, so their transfer to open-ended language production is an assumption that requires testing.

Reading Table 1 and Figure 1 together clarifies the answer to RQ1. Three principles converge on the case for adaptivity in language teaching. The first is calibration: learning is most efficient when challenge is matched to current competence, whether this is described as input slightly beyond the learner's level or as assistance within the zone of proximal development. The second

is responsiveness: learners benefit when errors are located and explained promptly, which the ordering of effect sizes in Figure 1 supports. The third is mastery: progression should depend on demonstrated control and not on elapsed time, as Bloom's (1984) procedures required. Existing AI systems can implement each principle more consistently than a single teacher with a large group, which is the sense in which they are new. They do not, however, supply what the principles presuppose, namely valid judgments about what a learner actually needs.

Kazakhstani evidence adds a cautionary note. In the controlled comparison by Kemelbekova et al. (2024), both the AI-supported group and the traditional group improved significantly in speaking, and the authors found no significant between-group difference in pronunciation. This does not show that AI is ineffective, but it shows that its advantage should not be assumed in every skill. Ergabylova and Turebayeva (2026) reported that about 80% of surveyed participants regarded adaptive technologies as promising and that students using AI-supported platforms scored about 15% higher on tests, yet their description of instruments and samples is brief, so these figures are best treated as indicative.

A four-layer model of adaptive language teaching. The synthesis supports a model in which adaptivity operates through four layers. The first is diagnosis: the system estimates the learner's current level and needs across skills, using multiple evidence sources and not a single placement test, in line with the mediation logic of Lantolf and Thorne (2006). The second is adaptation: tasks, input, and pace are calibrated so that challenge stays slightly beyond current competence while affective load stays manageable (Krashen, 1982). The third is feedback: responses are given at the step level, locate and explain errors, and are available immediately, since this feature most clearly differentiated effective systems in VanLehn (2011). The fourth is human oversight: teachers interpret analytics, override recommendations, preserve communicative tasks that require human interaction, and ensure compliance with data protection norms. Without the fourth layer, the other three risk optimizing what is easy to measure and not what matters for communicative competence, a concern that Chapelle's (2001) criterion of positive impact captures.

Implications. For Kazakhstani universities, the model implies that adoption should begin with an audit of infrastructure and digital literacy, continue with piloted use in which tools are selected against the four layers, and include explicit data governance, a sequence consistent with the constraints reported by Ergabylova and Turebayeva (2026). For teachers, adaptivity redefines but does not remove the teacher's role: it moves effort from marking to interpreting learner data and designing interaction. For developers of tools for Kazakh, the main priority suggested by Serzhankyzy and Turashova (2025) is deep personalization and automated feedback.

Limitations and future research. The study has several limitations. The corpus is small and purposive, a single analyst coded the sources, the effect sizes derive mainly from structured subjects, and the Kazakhstani evidence is limited in scale and in reporting detail. Future research should test the four-layer model experimentally in Kazakhstani classrooms, compare tools that differ in feedback granularity within the same course, examine effects on speaking and writing separately, and investigate long-term retention and learner autonomy. Studies of teachers' changing roles and of data governance would complement outcome research.

Conclusion

This article asked whether AI-based adaptive learning constitutes a new paradigm for personalized foreign language teaching. In answer to RQ1, the analysis showed that adaptivity is grounded in well-established principles: the logic of individual tutoring (Bloom, 1984), the calibration of input slightly beyond current competence (Krashen, 1982), and mediation within the zone of proximal development (Lantolf & Thorne, 2006). What is new is not the principle but the possibility of applying it at scale, to open-ended language output, and with continuously updated learner models.

In answer to RQ2, the evidence reviewed indicates that adaptive and tutoring systems produce consistently positive effects, but that effect sizes vary widely, from 0.31 to 0.79 across tutoring conditions reported by VanLehn (2011), with a median of 0.66 across intelligent tutoring evaluations (Kulik & Fletcher, 2016). The most important determinant appears to be the granularity of feedback and not the presence of AI as such. The evidence derives mainly from structured domains, which means that its transfer to speaking and writing in a foreign language remains to be demonstrated.

In answer to RQ3, Kazakhstani studies reveal a pattern of promising results and recurrent constraints. Controlled evidence shows gains in speaking but no universal advantage over traditional instruction (Kemelbekova et al., 2024). Survey evidence suggests favorable attitudes but also concerns about digital literacy, infrastructure, and data privacy (Ergabylova & Turebayeva, 2026). Analytical evidence shows that tools for Kazakh offer limited deep personalization and automated feedback (Serzhankyzy & Turashova, 2025). On this basis, the article proposed a four-layer model comprising diagnosis, adaptation, feedback, and human oversight.

The study contributes to scientific knowledge in three ways. It links second language acquisition theory to the engineering logic of adaptive systems, it organizes dispersed Kazakhstani findings into a single analytic matrix, and it offers an implementation model that can be tested. These contributions are bounded by the synthetic design: the study does not demonstrate that any system improves language outcomes in Kazakhstani classrooms.

The findings also caution against two common errors. One is technological determinism, the belief that adopting an AI tool will by itself improve learning. The other is dismissal, the belief that because early tools were shallow, adaptivity has nothing to offer. The evidence supports a middle position: adaptive systems can deliver large benefits when feedback is fine-grained and embedded in sound pedagogy, and they deliver little when they only repackage conventional exercises.

Several recommendations follow. Universities should audit infrastructure and digital literacy before adoption, pilot tools on a small scale, and establish explicit data governance. Teachers should treat adaptive systems as sources of diagnostic information and keep human interaction at the center of communicative tasks. Developers should prioritize step-level feedback and deeper personalization for Kazakh. Researchers should conduct controlled studies that vary feedback granularity, measure productive skills, and follow learners over time. If these steps are taken, adaptivity can become what its advocates claim: not a replacement for teachers, but a means of giving every learner some of the attention that, until now, only a tutor could provide.

References

Bloom, B. S. (1984). The 2 sigma problem: The search for methods of group instruction as effective as one-to-one tutoring. *Educational Researcher, 13*(6), 4–16. https://doi.org/10.3102/0013189X013006004

Chapelle, C. A. (2001). *Computer applications in second language acquisition: Foundations for teaching, testing and research*. Cambridge University Press. https://doi.org/10.1017/CBO9781139524681

Ergabylova, A. A., & Turebayeva, S. M. (2026). Artificial intelligence in adaptive learning: Effectiveness and prospects. *Bulletin of Abai KazNPU, Series "Pedagogical Sciences," 89*(1), 248–258. https://doi.org/10.51889/2959-5762.2026.89.1.024

Kemelbekova, Z., Degtyareva, X., Yessenaman, S., Ismailova, D., & Seidaliyeva, G. (2024). AI in teaching English as a foreign language: Effectiveness and prospects in Kazakh higher education. *XLinguae, 17*(1), 69–83. https://doi.org/10.18355/XL.2024.17.01.05

Krashen, S. D. (1982). *Principles and practice in second language acquisition*. Pergamon Press.

Kulik, J. A., & Fletcher, J. D. (2016). Effectiveness of intelligent tutoring systems: A meta-analytic review. *Review of Educational Research, 86*(1), 42–78. https://doi.org/10.3102/0034654315581420

Lantolf, J. P., & Thorne, S. L. (2006). *Sociocultural theory and the genesis of second language development*. Oxford University Press.

Pane, J. F., Steiner, E. D., Baird, M. D., & Hamilton, L. S. (2015). *Continued progress: Promising evidence on personalized learning*. RAND Corporation. https://doi.org/10.7249/RR1365

Serzhankyzy, Zh., & Turashova, Sh. P. (2025). Pedagogical and digital aspects of the use of generative AI technologies in Kazakh language education. *Bulletin of Abai KazNPU, Series "Pedagogical Sciences," 87*(3), 312–319. https://doi.org/10.51889/2959-5762.2025.87.3.028

VanLehn, K. (2011). The relative effectiveness of human tutoring, intelligent tutoring systems, and other tutoring systems. *Educational Psychologist, 46*(4), 197–221. https://doi.org/10.1080/00461520.2011.611369

FARS–AZƏRBAYCAN DİLLƏRİNDƏ XƏBƏR TƏRCÜMƏSİNDƏ LOKALLAŞDIRMA STRATEGİYALARI VƏ SÜNİ İNTELLEKT DƏSTƏKLİ REDAKTƏNİN KEYFİYYƏT MEYARLARI

Rəhimli Murad
Naxçıvan Dövlət Universitet
İntiqam Əliyev
Naxçıvan Dövlət Universiteti

Xülasə. Məqalədə fars və Azərbaycan dilləri arasında xəbər mətnlərinin tərcüməsi və lokallaşdırılması tərcüməşünaslıq, media diskursu və süni intellektdən istifadə kontekstində araşdırılır. Məqsəd hədəf dilə uyğunlaşdırma zamanı xəbərin faktoloji nüvəsinin, mənbəlik münasibətlərinin, modal mənasının və terminoloji dəqiqliyinin qorunması üçün praktik meyarlar müəyyənləşdirməkdir. Tədqiqatın materialını əvvəlki elmi tədqiqat işi çərçivəsində hazırlanmış 12 modelləşdirilmiş xəbər situasiyası təşkil edir: səkkizi farscadan azərbaycancaya, dördü isə əks istiqamətədir. Nümunələrin semantik-praqmatik müqayisəsi sintaktik yığcamlaşdırma ilə faktın dəyişdirilməsi arasındakı sərhədi aydınlaşdırır. Süni intellekt vasitələri üçün faktoloji sabitlik, mənbə və modal status, terminoloji düzgünlük, funksional lokallaşdırma və yoxlanıla bilmə meyarlarına əsaslanan insan nəzarətli redaktə modeli təklif olunur. Material eksperimental sistem müqayisəsi deyil, metodik xarakterli keyfiyyət təhlilidir.
Açar sözlər: media tərcüməsi; xəbər lokallaşdırılması; fars dili; Azərbaycan dili; transredaktə; süni intellekt; tərcümə keyfiyyəti.

Abstract. This article examines Persian–Azerbaijani news translation and localization at the intersection of translation studies, media discourse and artificial intelligence-assisted editing. It aims to identify practical criteria for preserving factual information, source attribution, epistemic modality and terminological accuracy while adapting news texts for a target audience. The study draws on twelve constructed news scenarios developed within an earlier research project: eight from Persian into Azerbaijani and four in the opposite direction. A qualitative semantic and pragmatic comparison distinguishes acceptable syntactic condensation from interventions that alter the informational status of a report. Particular attention is given to headlines, administrative terminology, calendar references, quotations and uncertainty markers. A human-supervised review framework is proposed using five criteria: factual consistency, attribution and modality, terminological precision, functional localization and traceability. The article does not claim to measure the performance of particular AI systems; its contribution is a transparent, practice-oriented analytical model for news translation training and editorial review.
Keywords: news translation; localization; Persian; Azerbaijani; transediting; artificial intelligence; post-editing.

GİRİŞ

Rəqəmsal informasiya dövriyyəsində xəbər mətni bir dildən digərinə çox vaxt adi tərcümə mətnindən daha mürəkkəb yollarla keçir. Agentlik xəbərinin seçilməsi, qısaldılması, başlığının dəyişdirilməsi, sitatın yenidən təqdim olunması və hədəf auditoriyanın informasiya ehtiyacına uyğunlaşdırılması eyni redaksiya prosesinin müxtəlif mərhələləridir. Bu mərhələlərdə dilin təbiiliyi artırıla bilər, lakin hadisənin subyekti, zamanı, yeri, mənbəyi və təsdiq dərəcəsi dəyişdirildikdə tərcümə xəbərin yeni məzmunla əvəzlənməsinə çevrilir. Media tərcüməsinin xüsusi məsuliyyəti də buradan irəli gəlir: məqsəd yalnız oxunaqlı mətn yaratmaq deyil, oxucunun yoxlanıla bilən məlumatı mümkün qədər düzgün qavramasını təmin etməkdir.

Fars və Azərbaycan dilləri arasında bu problem ayrıca aktuallıq daşıyır. Coğrafi yaxınlıq və davamlı informasiya əlaqələrinə baxmayaraq, dillərin qrammatik quruluşları, yazı sistemləri, ictimai-siyasi anlayışları və bəzi xəbər üslubu vərdişləri bir-birindən fərqlənir. İranın inzibati bölgülərini bildirən «استان» və «استانداری» terminləri Azərbaycan idarəetmə sisteminin anlayışları ilə avtomatik eyniləşdirilə bilməz. Eyni şəkildə «ASAN xidmət» kimi xüsusi institusional adların fars dilində sırf lüğəvi qarşılıqla verilməsi onların rəsmi statusunu gizlədə bilər. Tarix, rəqəm və sitatların ötürülməsi isə zahirən kiçik texniki əməliyyat görünməsinə baxmayaraq xəbərin etibarlılığına bilavasitə təsir edir.

Bundan əlavə, maşın tərcüməsi və generativ süni intellekt xəbər redaksiyalarına ilkin qaralama, terminoloji alternativlər və stilistik düzəlişlər hazırlamaq baxımından yeni imkanlar verir. Lakin axıcı ifadə həmişə düzgün fakt demək deyil. Məsələn, mənbədəki «ehtimal edilir» ifadəsinin tərcümədə silinməsi, hələ açıqlanmamış səbəbin sistem tərəfindən tamamlanması və ya təqvim ilinin naməlum olduğu halda qəti Miladi tarix göstərilməsi məlumatın statusunu dəyişə bilər. Buna görə texnoloji səmərəlilik peşəkar redaktə və etik məsuliyyətdən ayrılmamalıdır (UNESCO, 2021; Reuters, n.d.).

Məqalənin məqsədi fars–Azərbaycan xəbər tərcüməsinin nəzəri-praktik xüsusiyyətlərini ümumiləşdirmək, lokallaşdırmanın məqbul sərhədlərini nümunələr əsasında göstərmək və süni intellekt dəstəkli tərcümənin yoxlanılması üçün tətbiq oluna bilən model təqdim etməkdir. Əsas sual belə müəyyənləşdirilmişdir: hədəf auditoriyaya uyğun, yığcam və anlaşıqlı xəbər formalaşdırarkən mətnin faktoloji və praqmatik etibarlılığını necə qorumaq mümkündür?

1. NƏZƏRİ ÇƏRÇİVƏ: TƏRCÜMƏ, TRANSREDAKTƏ VƏ LOKALLAŞDIRMA

Media tərcüməsində mənbə və hədəf mətnin münasibəti həmişə «bir orijinal – bir tərcümə» sxeminə sığmır. Bielsa (2007) qlobal xəbər agentliklərində tərcümənin jurnalist fəaliyyətinə inteqrasiya olunduğunu, xəbər istehsalının təşkilati mexanizmlərinin isə çoxdilli informasiyanın sürətli ötürülməsinə uyğun qurulduğunu göstərir. Bielsa və Bassnett (2009) qlobal xəbər axınında tərcüməçinin vasitəçi rolunu, mətnlərin seçilmə və yenidən qurulma proseslərini nəzəri müzakirənin mərkəzinə gətirirlər. Bu baxış tərcümə prosesinin yalnız leksik ekvivalentlərin tapılmasından ibarət olmadığını, redaksiya qərarlarının da onun nəticəsinə təsir etdiyini qəbul edir. Tərcümə ilə redaktənin kəsişməsini ifadə edən «transredaktə» anlayışı məhz bu qarışıq fəaliyyətə diqqət yönəldir. Burada tərcüməçi və ya redaktor mətnin strukturunu dəyişə, təkrar hissələri ixtisar edə, daha anlaşıqlı başlıq qura bilər. Bununla belə, aparılan hər dəyişiklik eyni dərəcədə əsaslı sayılmır. Sintaktik yığcamlaşdırma xəbərin məzmununu qoruyursa, faktı və ya qiymətləndirməni dəyişdirən müdaxilə artıq ayrı etik problem yaradır. Valdeón (2008) xəbər mətnlərinin tərcüməsində əlavə, ixtisar və hissələrin yenidən yerləşdirilməsinin ideoloji nəticələr verə biləcəyini konkret media materialları əsasında təhlil edir. Deməli, redaksiya müdaxiləsi dil baxımından yox, həm də mənbə və auditoriya münasibəti baxımından qiymətləndirilməlidir.

Orengo (2005) lokallaşdırmanı qlobal xəbərin müxtəlif yerli auditoriyalar üçün hazırlanmasının tərkib hissəsi kimi nəzərdən keçirir. Bu yanaşmada yeni xəbər mətninin hazırlanması bəzən yalnız tərcüməni deyil, informasiya seçimini və yerli oxucu üçün mənalı kontekstin qurulmasını da əhatə edir. Lakin lokallaşdırma sərhədsiz «yerliləşdirmə» deyil. Məsələn, İranın inzibati qurumunu

Azərbaycan oxucusuna açıqlamaq legitim izahdır; onu Azərbaycandakı hüquqi baxımdan fərqli bir qurumla eyniləşdirmək isə yanlış analoji təsəvvür formalaşdıra bilər. Scammell (2018) mədəni cəhətdən spesifik anlayışların həddindən artıq uyğunlaşdırılmasının ilkin konteksti itirmək təhlükəsini vurğulayır.

Xəbərin dil quruluşunda «kim?», «nə?», «harada?», «nə zaman?» sualları ilə yanaşı, «məlumatı kim bildirib?» və «məlumat nə dərəcədə təsdiqlənib?» sualları da əsasdır. Bednarek və Caple (2017) xəbərin dəyərinin dil vasitələri ilə necə qurulduğunu təhlil edirlər. Başlığın seçimi, hadisənin yaxınlıq və yenilik aspektinin qabardılması, qiymətləndirici leksika və modal ifadələr oxucunun informasiyanı qavramasına təsir göstərir. Bir xəbərin daha emosional, daha qəti və ya daha əhatəli təqdim edilməsi bəzən yalnız üslub dəyişikliyi deyil, müəllif mövqeyinin dəyişməsi deməkdir. Buna görə tərcümədə «təqdimat səmərəliliyi» ilə «epistemik dürüstlük» birlikdə nəzərdən keçirilməlidir.

Bu məqalədə lokallaşdırma altı əməliyyatın birləşməsi kimi götürülür: sintaktik yenidənqurma, leksik-terminoloji seçim, mədəni izah, başlıq və lidin yığcamlaşdırılması, xüsusi ad və rəqəmlərin standartlaşdırılması, sitat və modal mənanın qorunması. İlk beş əməliyyat müxtəlif səviyyələrdə redaksiya elastikliyi tələb edə bilər; sonuncu isə onların hamısı üçün sərhəd qoyur. Xəbərin sübut olunma səviyyəsi, informasiyanın kimə aid olduğu və mənbədə olmayan səbəb əlaqələrinin əlavə edilməməsi keyfiyyət qiymətləndirməsinin dəyişməz tələbləri olaraq qalır.

Tərcümə strategiyasının qiymətləndirilməsində iki müxtəlif səviyyəni qarışdırmamaq vacibdir. Birinci səviyyə dilin norması ilə bağlıdır: mətnin söz sırası, termin seçimi və sintaktik axıcılığı. İkinci səviyyə xəbərin informativ məsuliyyətidir: hadisənin sübutu, subyektin statusu və məlumatı verən mənbənin mövqeyi. Birinci səviyyədə alternativlərə geniş yer var; ikinci səviyyədə isə seçim sübutun imkanları ilə məhdudlaşır. Məsələn, «açılıb» və «istifadəyə verilib» bəzi kontekstlərdə yaxın işlənə bilər, lakin «istismara qəbul edilib» əlavə inzibati-hüquqi məna daşıya bilər. Xəbəri başqa dilə uyğunlaşdırarkən funksional ekvivalentlik məhz bu cür məna sərhədlərinin yoxlanması ilə əldə edilir. Bu baxış nə sərt sözbəsöz tərcüməni, nə də hədsiz redaktə sərbəstliyini normaya çevirir.

2. MATERİAL VƏ METOD

Təhlilin materialını 2026-cı il elmi tədqiqat işi çərçivəsində işlənmiş 12 qısa xəbər situasiyası təşkil edir. Səkkiz nümunə farscadan Azərbaycan dilinə, dördü isə Azərbaycan dilindən fars dilinə yönəlmişdir. Onların dördü xəbər başlığı və giriş cümləsi, dördü termin, xüsusi ad, təqvim və rəqəm, dördü isə sitat, qiymətləndirmə və məlumatın təsdiq statusu ilə bağlıdır. Mətnlər müqayisəli təhlil üçün müəllif tərəfindən qurulmuş modellərdir; real xəbər agentliklərindən götürülmüş korpus, müəyyən hadisələr haqqında sənədləşdirilmiş məlumat və ya müstəqil model testi hesab edilmir. Bu fərq nəticələrin elmi şərhi üçün mühümdür: material konkret problemləri nümayiş etdirir, onların hansı tezliklə baş verdiyini ölçmür.

Bu materialla işləyərkən nümunələrin «nə baş verdiyi» və «tərcüməçinin nəyi dəyişmək hüququ olduğu» sualları ayrı saxlanılır. Tərcümə variantının funksional üstünlüyü ilk növbədə mənbədəki məlumata əsaslanır; hədəf auditoriyaya faydalı görünən, lakin mənbə ilə təsdiqlənməyən izah əlavə nəticə kimi qəbul edilə bilməz. Eyni səbəbdən təhlildə xəbərin faktoloji «nüvəsi» və redaktə oluna bilən ifadə forması fərqləndirilir. Birinciyə hadisənin subyekti, obyekti, zamanı, məkanı, sayı, hüquqi statusu, xəbərin mənbəyi və məlumatın təsdiq dərəcəsi daxildir; ikinciyə isə söz sırası, lazımsız təkrar, bəzi sintaktik bağlar və hədəf dil üçün təbii feil seçimi aiddir. Bu fərqləndirmə məqalənin bütün nümunələrinə eyni metodla yanaşmağa imkan verir.

Müqayisəli-linqvistik, semantik-praqmatik və kontekstual təhlil metodları birgə tətbiq olunur. Hər nümunədə mənbə ifadə, birbaşa tərcümə ehtimalı və funksional redaktə variantı qarşılaşdırılır. Sonra dəyişməyən faktoloji elementlər, məqbul sintaktik müdaxilələr və mümkün təhrif nöqtələri müəyyənləşdirilir. Dörd seçilmiş situasiya üzrə avtomatlaşdırılmış tərcümədə meydana çıxa bilən şərti səhvlər ayrıca müzakirə olunur. Bu situasiyalar konkret süni intellekt proqramlarının faktiki

cavabları kimi təqdim edilmir. Təklif olunan beşmeyarlı yoxlama çərçivəsi də korpus əsasında statistik təsdiqlənmiş qiymətləndirmə şkalası deyil, praktik redaktə üçün analitik vasitədir.

3. FARS–AZƏRBAYCAN XƏBƏR TƏRCÜMƏSİNİN MÜQAYİSƏLİ TƏHLİLİ

3.1. Başlıqlarda informasiya sıxlığı və modal məna

Birinci qrup nümunələr göstərir ki, fars dilində təbii olan geniş təyin konstruksiyası Azərbaycan xəbər başlığında yığcamlaşdırıla bilər. Məsələn, «نمایشگاه کتاب تبریز روز دوشنبه با حضور ناشران دوازده شهر آغاز به کار می‌کند» cümləsinin birbaşa tərcüməsi «Təbrizin kitab sərgisi bazar ertəsi on iki şəhərin naşirlərinin iştirakı ilə işə başlayacaq» formasındadır. «Təbriz kitab sərgisi bazar ertəsi 12 şəhərdən naşirlərin iştirakı ilə açılacaq» variantı isə xəbərin əsas elementlərini qorumaqla daha təbii söz sırası və feil seçimi yaradır. Burada «12» göstəricisi naşirlərin deyil, təmsil olunan şəhərlərin sayına aiddir. «12 naşirin iştirakı ilə» kimi qısaltma faktoloji səhv yaradar. Beləliklə, yığcamlıq informasiya elementlərinin aidiyyətini dəyişdirməməlidir.

İkinci nümunə ehtimalın qorunması ilə bağlıdır: «احتمال افزایش بارندگی در شمال ایران در روزهای آینده وجود دارد». Məqbul Azərbaycan variantı «Yaxın günlərdə İranın şimalında yağıntının artacağı ehtimal olunur» şəklində qurula bilər. «İranın şimalında yağıntı artacaq» başlığı isə mənbədəki proqnoz və ya mümkünlük mənasını təsdiqlənmiş fakt kimi təqdim edir. Bu fərq üslubi deyil, epistemikdir: orijinalda bildirilməyən əminlik dərəcəsi hədəf mətndə yaradılır. Xəbər dilində «ola bilər», «ehtimal edilir», «gözlənilir» kimi vahidlər çox vaxt mətnin etibarlılığını müəyyən edən əsas göstəricilərdir.

Əks istiqamətli nümunə də oxşar prinsipi aydınlaşdırır. «Bakıda keçiriləcək elm forumuna 15 ölkədən nümayəndələr qatılacaq» cümləsi fars dilinə «نمایندگانی از ۱۵ کشور در همایش علمی باکو شرکت خواهند کرد» şəklində uyğunlaşdırıla bilər. Burada ölkələrin sayı ilə nümayəndələrin sayı qarışdırılmır; «qatılacaq» feilinin fars xəbər üslubuna uyğun qarşılığı seçilir. Ancaq konkret tədbirin rəsmi adı məlumdursa, «forum» sözünün «همایش» ilə əvəzlənməsi ayrıca yoxlanmalıdır. Dördüncü başlıq nümunəsində «سامانه تازه ثبت‌نام اعضای کتابخانه‌ها راه‌اندازی شد» ifadəsinin «Kitabxana üzvləri üçün yeni qeydiyyat sistemi istifadəyə verilib» kimi verilməsi yaradılma ilə faktiki istifadəyə verilmə arasındakı mənanı qoruyur. «Sistem yaradılıb» variantı eyni hadisəni bildirməyə bilər.

Bu qrup üzrə nəticə belədir: sintaktik sıxlaşdırma və daha təbii xəbər feillərinin seçilməsi məqsədəuyğundur, lakin zaman, rəqəm, fəaliyyətin mərhələsi və əminlik dərəcəsi mənbə ilə ayrıca tutuşdurulmalıdır. Başlıq daha təsirli göründüyünə görə deyil, eyni faktı daha anlaşıqlı verdiyinə görə redaktə edilməlidir.

3.2. İnzibati terminlər, təqvimlər və xüsusi adlar

İkinci qrup nümunələr mədəni və inzibati lokallaşdırmanın hüdudlarını göstərir. «استانداری اردبیل از آغاز مرمت یک پل تاریخی خبر داد» cümləsindəki «استانداری» İranın ostan səviyyəli idarəetmə qurumudur. Onu avtomatik olaraq «valilik» kimi vermək bəzi oxuculara yaxın məna yaratsa da, başqa ölkənin inzibati modelini İran reallığı ilə eyniləşdirə bilər. «Ərdəbil ostanının administrasiyası (ostandarlıq) tarixi körpünün bərpasına başlandığını bildirib» variantı isə yerli məfhumu qısa funksional izahla təqdim edir. Məqsəd terminə süni şəkildə «milliləşdirilmiş» qarşılıq tapmaq deyil, onun mənbə mühitindəki statusunu açıq göstərməkdir.

Təqvim göstəricisi də oxşar diqqət tələb edir. «نشست تخصصی روز ۲۳ مهر در شیراز برگزار می‌شود» cümləsində il göstərilmədiyi üçün «23 mehr» tarixinin konkret Miladi qarşılığı avtomatik müəyyənləşdirilə bilməz. «İxtisaslaşmış görüş Şirazda İran günəş təqvimi ilə 23 mehr tarixində keçiriləcək» forması bu məhdudiyyəti açıq saxlayır. Dərc tarixi və aid olduğu il dəqiqləşdirildikdə Miladi tarix əlavə etmək olar; əks halda konkret gün və ay yazmaq mənbədə olmayan dəqiqlik yaratmaq deməkdir. Belə bir səhv yalnız dil yox, həm də fakt yoxlaması problemidir.

Azərbaycan dilindən farscaya yönəlmiş nümunədə «“ASAN xidmət” mərkəzlərində elektron növbə sistemi yenilənib» məlumatının «سامانه نوبت‌دهی الکترونیکی در مراکز ASAN xidmət» ...به‌روزرسانی شده است» şəklində verilməsi xüsusi adın saxlanmasının əhəmiyyətini göstərir. «مراکز خدمات آسان» ifadəsi leksik baxımdan anlaşıqlı olsa da, xidmətin rəsmi adını ümumi təsvirə çevirir. Lazım gəldikdə adın yanında

Azərbaycan Respublikasında dövlət xidmətləri göstərən mərkəzlərə aid qısa izah əlavə edilə bilər. Bu üsul rəsmi adı, axtarış imkanını və oxucu üçün anlaşıqlılığı birlikdə qoruyur.

İki istiqamətli tərcümə üçün texniki həllər eyni görünməyə bilər. Fars dilində xüsusi adların ərəb qrafikası ilə, Azərbaycan dilində isə latın qrafikası ilə verilməsi həm transliterasiya seçimini, həm də məlumatın sonradan axtarılmasını təsirləndirir. Azərbaycan oxucusu üçün İranın az tanınan qurum adı ilk istifadədə qısa izah tələb edirsə, fars oxucusu üçün Azərbaycan dövlət xidmətinin adı eyni qayda ilə izahlı saxlanıla bilər. Lakin belə izahlar mənbə cümləsinə gizlicə yeni fakt kimi birləşdirilməməlidir: mötərizəli qeyd, izahedici appozisiya və ya redaksiya qeydi həqiqi mənbə məlumatından ayırd edilməlidir. Tərcümə istiqamətinin dəyişməsi keyfiyyət prinsipini dəyişmir; sadəcə məlumatın hansı tərəf üçün yad olduğunu və hansı qrafikada tanınacağını yenidən müəyyənləşdirir.

Dördüncü terminoloji nümunə «در مرحله نخست این طرح، ۲۵۰ هزار نفر ثبت‌نام کردند» cümləsidir. «Proqramın birinci mərhələsində 250 min nəfər qeydiyyatdan keçib» variantında sayın ölçü vahidi düzgün saxlanır; «طرح» sözünün «proqram», «layihə» və ya «plan» kimi verilməsi isə mətnin əvvəlki kontekstindən asılıdır. Başqa sözlə, terminləşmə səviyyəsi müəyyən edilmədən qarşılıqlardan birini mütləq doğru elan etmək olmaz. Tərcüməçinin vəzifəsi eyni zamanda rəqəmi, sözün təsvir etdiyi hadisəni və rəsmi adlandırmanı yoxlamaqdır. Bu dörd nümunə formal ekvivalentliklə funksional dəqiqliyin eyni şey olmadığını nümayiş etdirir.

3.3. Sitat, mənbəlik və xəbərin hüquqi statusu

Üçüncü qrupda informasiyanın kimə aid olduğu və hansı şərtlə bildirildiyi əsas meyardır. Sitatdakı «ممکن است» ifadəsinin «dəyişə bilər» kimi verilməsi ilə «dəyişəcək» şəklində təqdim edilməsi arasında prinsipial fərq mövcuddur: ikinci halda ehtimal qəti qərara çevrilir. Bu, yalnız proqnoz xəbərlərində deyil, idarəetmə, təhsil və iqtisadiyyat barədə açıqlamalarda da əhəmiyyətlidir. Xəbərdə kiminsə fikrini bildirmək onun fikrini redaksiyanın təsdiqi kimi təqdim etmək demək deyil. Reuters-in jurnalist standartlarında sitatın mənasının, kontekstinin və mənbəyə aidiyyətinin qorunması xüsusilə vurğulanır (Reuters, n.d.).

Şahid məlumatına aid digər modelləşdirilmiş hadisədə şahidlərin qatarın dayandığını bildirməsi ilə dayanmanın səbəbinin hələ açıqlanmaması iki ayrı informasiya vahididir. Tərcümə və ya xülasənin «qatar texniki nasazlığa görə dayandı» formasına keçməsi səbəb haqqında yeni fakt yaradar. Bu, hədəf cümlənin qrammatik cəhətdən düzgün olmasından asılı olmayaraq qəbul edilməzdir. Tərcüməçi məlum faktı ehtimal edilən izahla birləşdirməməli, məlum olmayanın da naməlum qaldığını göstərməlidir.

Hüquqi statusu bildirən mətnlərdə «layihə», «təklif», «müzakirəyə çıxarılıb», «təsdiqlənib» və «qüvvəyə minib» bir-birinin əvəzi deyil. Məsələn, Azərbaycan dilində qərar layihəsinin müzakirəyə çıxarıldığını bildirən xəbərin farsca variantında onun artıq qəbul edilmiş qərar kimi göstərilməsi hadisənin hüquqi nəticəsini dəyişdirir. Eyni səhv başlıq hazırlama mərhələsində də yarana bilər. Mənbədə olmayan qəti mərhələ göstəricisinin əlavə edilməsi şərhlə fakt arasındakı sərhədi aradan qaldırır. Ona görə hüquqi prosedurun hansı mərhələdə olduğunu göstərən feillər ayrıca terminoloji yoxlamaya cəlb edilməlidir.

Qiymətləndirici ifadələrdə də atribusiya qorunmalıdır. Bir təşkilat tədbiri «ilin ən böyük görüşü» adlandırırsa, hədəf xəbər bu qiyməti təşkilata aid etməlidir; «ilin ən böyük görüşü keçirilib» kimi redaksiya hökmü yaratmamalıdır. Bu misal bir ümumi prinsipi dəqiqləşdirir: dəqiq tərcümə mənbənin subyektiv qiymətləndirməsini silmək deyil, onu məhz mənbəyə aid qiymətləndirmə kimi göstərməkdir. Beləliklə, sitatlar, hüquqi status və təşkilati iddialar üzrə bütün redaktələrdə əvvəlcə məlumatın müəllifi, sonra onun təsdiq dərəcəsi müəyyən olunmalıdır.

Bu problemləri ümumiləşdirdikdə xəbərdə üç fərqli «səs» ayrılır: hadisə barədə təsdiqlənə bilən məlumat, mənbənin həmin hadisəyə verdiyi qiymət və redaksiyanın informasiyanı təqdim edən dili. Birbaşa tərcümə həmin səsləri qarışdıra bilər; redaktə isə onları bir-birindən ayırmaq üçün şərait yaradır. Məsələn, «nazirliyin məlumatına görə», «şahidlərin sözlərinə əsasən» və «təşkilat

bunu mühüm hadisə adlandırıb» ifadələri üslubi əlavələr deyil, iddianın məsuliyyət daşıyıcısını müəyyən edən vasitələrdir. Belə vahidlərin silinməsi oxucunu mənbənin kimliyindən və xəbərin hansı əsasla söyləndiyindən məhrum edə bilər. Redaktorun vəzifəsi həmin münasibətləri hətta qısa başlıqda belə maksimum aydınlıqla saxlamaqdır; mətnin uzunluğu məlumatın mənşəyini gizlətmək üçün əsas sayıla bilməz.

4. SÜNİ İNTELLEKT DƏSTƏKLİ TƏRCÜMƏDƏ RİSKLƏR VƏ YOXLANIŞ MODELİ

Süni intellekt vasitələri xəbər mətninin ilkin tərcüməsini hazırlamağa, alternativ başlıqlar təklif etməyə, terminoloji variantları müqayisə etməyə və üslubi redaktəyə yardım göstərə bilər. Bununla belə, onların istifadəsini ölçülmüş keyfiyyət üstünlüyü kimi təqdim etmək üçün eyni test korpusu, sabit tapşırıq parametrləri, proqramın adı və versiyası, müstəqil qiymətləndiricilər və təkrarlana bilən nəticələr lazımdır. Burada belə eksperiment aparılmadığından yanaşma ayrı-ayrı sistemlərin performans sıralaması deyil, əvvəlki bölmələrdə müəyyənləşdirilmiş risklərin redaksiya yoxlamasına çevrilməsidir. ISO 18587:2017 maşın tərcüməsi nəticələrinin tam insan redaktəsi üçün proses və sərişdə tələblərini müəyyənləşdirir; xəbərin məsuliyyətli dərcinə dair qərar isə ayrıca jurnalist yoxlaması tələb edir.

Modelləşdirilən dörd risk vəziyyəti bu yanaşmanı konkretləşdirir. Birincisi, «احتمال وجود دارد»... konstruksiyasının ehtimalı qorunmadan qəti xəbərə çevrilməsidir. İkincisi, «۲۳ مهر» tarixinin mənbədə il olmadığı halda təqvimdə müəyyən günə bağlanmasıdır. Üçüncüsü, sitatdakı «ممکن است» və ya buna bənzər modal göstəricilərin çıxarılmasıdır. Dördüncüsü, şahid məlumatının avtomatik xülasə zamanı ehtimal edilən səbəblə tamamlanmasıdır. Bunlar real sistem çıxışlarından qeydə alınmış xətalar deyil, redaktorun axtarmalı olduğu mümkün təhrif növlərini təsvir edən sınaq situasiyalarıdır. Məhz bu məhdudiyyət müzakirənin nəticələrini düzgün sərhəddə saxlamağa imkan verir.

Tədqiqat nəticəsində beş yoxlama meyarı təklif olunur. **Faktoloji sabitlik:** şəxs, qurum, hadisə, yer, tarix, say və ölçü dəyişməməlidir. **Mənbəlik və modal status:** «bildirib», «iddia edib», «ola bilər», «təsdiqlənməyib» kimi münasibətlər saxlanmalıdır. **Terminoloji dəqiqlik:** rəsmi adlar, hüquqi və inzibati anlayışlar kontekstə uyğun verilməlidir. **Funksional lokallaşdırma:** başlıq və cümlə hədəf auditoriya üçün təbii və anlaşıqlı olmalı, lakin yeni fakt əlavə edilməməlidir. **Yoxlanıla bilmə:** ilkin mənbə, düzəlişlərin səbəbi və mübahisəli termin qərarları izlənə bilməlidir. Bu meyarların birlikdə işlənməsi mətnin yalnız dil baxımından deyil, redaksiya məsuliyyəti baxımından qiymətləndirilməsinə xidmət edir.

Praktik iş axınında əvvəlcə ilkin mənbə və onun tarixi müəyyənləşdirilir; ikinci mərhələdə qaralama tərcümə hazırlanır; üçüncüdə adlar, rəqəmlər, tarixlər, modal sözlər və sitatlar ayrıca işarələnir; dördüncüdə terminlər və mədəni izahlar yoxlanılır; beşincidə dilin təbiiliyini artıran redaktə aparılır; sonda mənbə və hədəf mətn yenidən tutuşdurulur. Redaktor hər düzəlişə üç qərardan birini verə bilər: «qəbul edilir», «dil redaktəsi tələb edir» və «mənbədən yenidən yoxlanmalıdır». Sonuncu qərar xüsusilə əminlik dərəcəsi, səbəb əlaqəsi, xüsusi ad, hüquqi status və tarix göstəricilərində əsaslıdır. Belə kateqoriyalar səhvin ağırlığını sadə sintaktik narahatlıqdan ayırmağa kömək edir.

Keyfiyyət yoxlamasının texniki olaraq həyata keçirilməsi üçün fərqli xəta növlərinə eyni reaksiya verilməməlidir. Söz sırasının ağırlığı, təkrar və qeyri-təbii feil seçimi dil redaktəsi ilə aradan qaldırıla bilər. Lakin şəxs adının dəyişməsi, sayın yanlış oxunması, məlum olmayan səbəbin əlavə edilməsi və ehtimalın qəti hökmə çevrilməsi yalnız yazı üslubu məsələsi deyil; belə hallar ilkin mənbəyə yenidən qayıtmağı tələb edir. Təklif edilən qərar səviyyələri buna görə ballarla «gözəl mətn» qiymətləndirməsindən daha funksionaldır. Qəbul edilməyən mətnin səbəbi göstərilməli, düzəlişdən sonra isə eyni məlumat yenidən yoxlanmalıdır. Yoxlamanın sənədləşdirilməsi həm redaksiya fəaliyyətində hesabatlılığı gücləndirə, həm də tələbələrin tərcümə qərarlarını arqumentləşdirməsinə kömək edə bilər.

Təklif edilən yanaşmanın tədris tətbiqi üçün tələbəyə əvvəlcə qəsdən səhvlərlə hazırlanmış başlıq və qısa xəbər verilə bilər. Tələbə yalnız daha yaxşı səslənən variantı seçmir, hər redaksiya qərarının hansı meyara aid olduğunu əsaslandırır: məlumat itirilibmi, mənbəlik dəyişibmi, termin anlaşıqlıdırmı, əlavənin mənbə əsası varmı? Bir tapşırıqda «ehtimal» sözünün çıxarılması, digərində təqvim çevirməsi, üçüncüdə rəsmi qurum adının ümumiləşdirilməsi, dördüncüdə isə naməlum səbəbin əlavə edilməsi yoxlanıla bilər. Belə məşq dil bacarığını informasiya savadlılığı ilə əlaqələndirir. Redaksiya mühitində isə eyni meyarlar ilkin avtomatik qaralamaya tətbiq edilən qısa yoxlama vərəqi kimi istifadə oluna bilər. Bunun effektivliyinin nə dərəcədə artdığı ayrıca müşahidə və qiymətləndirmə tədqiqatı ilə müəyyənləşdirilməlidir.

Süni intellektə verilən tapşırığın özü də risklərin idarə olunmasında rol oynaya bilər: mətnin bütün adlarını, saylarını, tarixlərini, sitatlarını, inkar və ehtimal göstəricilərini qorumaq; mənbədə olmayan fakt əlavə etməmək; anlaşılmayan anlayışları ayrıca siyahıya almaq kimi təlimatlar istifadəyə yararlıdır. Lakin təlimatın düzgün yazılması nəticənin mütləq etibarlı olduğunu sübut etmir. UNESCO-nun süni intellekt etikası haqqında tövsiyəsi insan nəzarəti və hesabatlılığı əsas prinsip kimi müəyyənləşdirir (UNESCO, 2021). Reuters də süni intellektdən istifadə edilən jurnalist materiallarında yekun redaksiya məsuliyyətinin insan əməkdaşların üzərində qaldığını bildirir (Reuters, n.d.). Bu prinsiplər fars–Azərbaycan xəbər tərcüməsi üçün təklif edilən iş axınının etik əsasını təşkil edir.

NƏTİCƏ

Aparılmış nəzəri və keyfiyyət yönümlü müqayisə media tərcüməsinin dil vahidlərinin mexaniki əvəzlənməsi kimi qiymətləndirilməsinin yetərsiz olduğunu göstərir. Xəbərin hədəf dilə uyğunlaşdırılması zamanı sintaktik sıxlaşdırma, daha təbii feil seçimi və qısa mədəni izahlar məqsədəuyğun ola bilər; lakin onların legitimliyi faktoloji nüvənin və mənbəlik əlaqələrinin qorunmasından asılıdır. Lokallaşdırma və redaktə bir-birini tamamlayan fəaliyyətlərdir, hər ikisinin sərhədi isə informasiyanın təhrif edilməməsidir.

On iki modelləşdirilmiş vəziyyət əsasında dörd nəticə önə çıxır. Birincisi, başlıqlarda modal və zaman göstəriciləri ixtisar edilərkən xəbərin təsdiq səviyyəsi dəyişdirilməməlidir. İkincisi, «ostandarlıq» və «ASAN xidmət» kimi anlayışlar formal lüğəvi yaxınlıqla deyil, mənbə institusiyasının real funksiyası nəzərə alınaraq verilməlidir. Üçüncüsü, təqvim, rəqəm və hüquqi-status göstəriciləri ayrıca fakt yoxlaması tələb edir. Dördüncüsü, sitatdakı ehtimal və qiymətləndirmənin hansı şəxs və ya quruma aid olması hədəf mətndə açıq qalmalıdır.

Təklif edilən beşmeyarlı redaktə modeli süni intellekt dəstəkli tərcümənin yoxlanmasında tətbiq oluna bilən metodik vasitə kimi qiymətləndirilir. Bununla belə, məqalə konkret maşın tərcüməsi və ya generativ süni intellekt sisteminin səhv tezliyi, dəqiqliyi və üstünlüyü barədə statistik hökm vermir. Gələcək tədqiqatlarda real və mənbəsi dəqiqləşdirilmiş xəbər korpusu, ayrıca model sınaqları və müstəqil ekspert qiymətləndirməsi bu çərçivənin empirik yoxlanmasına imkan verə bilər. Mövcud mərhələdə əsas praktik qənaət budur: xəbər tərcüməsində sürət və oxunaqlılıq yalnız məna, mənbə və təsdiq dərəcəsi qorunduqda peşəkar keyfiyyətə çevrilir.

ƏDƏBİYYAT SİYAHISI

1. Bednarek, M., & Caple, H. (2017). The discourse of news values: How news organizations create newsworthiness. Oxford University Press. https://doi.org/10.1093/acprof:oso/9780190653934.001.0001
2. Bielsa, E. (2007). Translation in global news agencies. Target, 19(1), 135–155. https://doi.org/10.1075/target.19.1.08bie
3. Bielsa, E., & Bassnett, S. (2009). Translation in global news. Routledge.
4. International Organization for Standardization. (2017). Translation services—Post-editing of machine translation output—Requirements (ISO 18587:2017).

https://www.iso.org/standard/62970.html
5. Orengo, A. (2005). Localising news: Translation and the 'global-national' dichotomy. Language and Intercultural Communication, 5(2), 168–187. https://doi.org/10.1080/14708470508668892
6. Reuters. (n.d.). Standards and values. https://reutersagency.com/about/standards-values/
7. Scammell, C. (2018). Translation strategies in global news: What Sarkozy said in the suburbs. Palgrave Macmillan. https://doi.org/10.1007/978-3-319-74024-9
8. UNESCO. (2021). Recommendation on the ethics of artificial intelligence. https://www.unesco.org/en/legal-affairs/recommendation-ethics-artificial-intelligence
9. Valdeón, R. A. (2008). Anomalous news translation: Selective appropriation of themes and texts in the internet. Babel, 54(4), 299–326. https://doi.org/10.1075/babel.54.4.01val

ƏRƏB DİLİNİN XARİCİ DİL KİMİ TƏDRİSİNDƏ FONETİK VƏ TƏLƏFFÜZ BACARIQLARININ FORMALAŞDIRILMASI: KONTRASTİV TƏHLİL VƏ METODİK MODEL

Ayaz Əli oğlu Axundov
Naxçıvan Dövlət Universiteti

Xülasə. Məqalədə müasir standart ərəb dilinin fonetik-fonoloji xüsusiyyətlərinin xarici dil kimi tədrisi məsələləri Azərbaycan dilində danışan öyrənənlərin mümkün ehtiyacları kontekstində araşdırılır. Təsviri-linqvistik və kontrastiv təhlil əsasında udlaq və qırtlaq səsləri, emfatik və dişarası samitlər, fonoloji sait uzunluğu, geminasiya, vurğu və intonasiya kimi tədris hədəfləri sistemləşdirilir. Tələffüzün eşidərək fərqləndirmə, artikulyasiya və kommunikativ tətbiq komponentləri arasındakı əlaqə əsaslandırılır. Minimal cütlər, məna əsaslı dinləmə tapşırıqları və qısa dialoqlara söykənən beşmərhələli metodik model, həmçinin 10 ballıq ilkin qiymətləndirmə rubrikası təklif edilir. Təhlil göstərir ki, fonetik hazırlığın əlifbanın mexaniki öyrədilməsi ilə məhdudlaşdırılmaması, məqsədli geribildirim və anlaşıqlılığın nəzərə alınması tədrisin məzmununu sistemləşdirməyə imkan verir. Nəticələr nəzəri-tətbiqi xarakter daşıyır; modelin effektivliyi eksperimental qaydada yoxlanılmamışdır.
Açar sözlər: ərəb dili, fonetika, fonologiya, tələffüz tədrisi, kontrastiv təhlil, dinləmə-anlama, danışıq bacarığı.

Abstract. This article examines the teaching of Modern Standard Arabic phonetics and pronunciation to learners whose first language is Azerbaijani. Drawing on descriptive phonological analysis, contrastive comparison and research on second-language pronunciation, it identifies potentially demanding features, including pharyngeal and glottal consonants, emphatics, interdentals, vowel length, gemination, stress and intonation. The article argues for integrating auditory discrimination, articulatory awareness and meaningful oral interaction rather than limiting phonetic instruction to letter recognition and repetition. It develops a five-stage instructional framework combining diagnostic listening, explicit articulation, controlled production, communicative practice and feedback. Selected Arabic minimal pairs and a provisional ten-point assessment rubric illustrate the framework. The findings consist of analytically derived teaching priorities and pedagogical proposals; no classroom intervention or learner-outcome experiment was conducted. Further validation should employ pre- and post-tests, unfamiliar speech materials and independent listener assessments.
Keywords: Arabic as a foreign language, phonetics, pronunciation instruction, contrastive analysis, listening comprehension, speaking skills.

Giriş

Xarici dilin öyrənilməsində qrammatik qaydaların və söz ehtiyatının mənimsənilməsi zəruridir, lakin şifahi ünsiyyətin uğuru bununla məhdudlaşmır. Dinləyici nitq axınındakı fonemləri, vurğu və intonasiya işarələrini seçməli, danışan isə leksik mənanı dəyişdirən səs fərqlərini qorumalıdır. Ərəb dilinin tədrisində bu məsələ xüsusilə diqqətəlayiqdir: bəzi samitlər Azərbaycan dilinin fonoloji inventarında müstəqil fonem kimi təmsil olunmur; sait uzunluğu və samit qoşalaşması isə məna və morfoloji quruluşun fərqlənməsində əhəmiyyətli rol oynayır. Buna görə hərflərin qrafik

öyrənilməsi ilə həmin səslərin dinlənərək tanınması və sərbəst nitqdə istifadəsi eyni nəticə kimi qiymətləndirilə bilməz [1; 2; 3].

Məqalənin məqsədi ərəb dilində fonetika və tələffüzün öyrədilməsinin nəzəri əsaslarını qısa şəkildə sistemləşdirmək, ərəb–Azərbaycan dil müqayisəsindən çıxan metodik hədəfləri müəyyən etmək və dinləmə-anlama ilə danışıq fəaliyyətini birləşdirən praktik model təqdim etməkdir. Araşdırmanın obyekti ərəb dilinin xarici dil kimi tədrisində tələffüz bacarığının formalaşdırılması prosesi, predmeti isə bu prosesin fonoloji qarşılaşdırmaları, təlim fəaliyyətləri və qiymətləndirmə meyarlarıdır. Metodoloji baza fonetik təsvir, kontrastiv təhlil, akademik ədəbiyyatın analitik müqayisəsi və didaktik modelləşdirmədən ibarətdir. Nümunələr müasir standart ərəb dili norması üzrə seçilmiş, Beynəlxalq Fonetik Əlifbanın geniş transkripsiyasından istifadə edilmişdir; nümunə sözlər tədris məqsədilə tərtib edilmiş materiallardır, real tələbə səs yazılarından götürülməmişdir. Ərəb dilində standart ədəbi norma ilə regional danışıq variantlarının yanaşı mövcudluğu tədris obyektinin əvvəlcədən müəyyənləşdirilməsini tələb edir. Bu məqalədə hədəf müasir standart ərəb dilidir; dialektlər arasında /q/ kimi səslərin fərqli reallaşmaları ayrıca norma kimi tədris edilmir. Digər tərəfdən, standart variantın seçilməsi əlaqəli nitq, fasilədə oxunuş və intonasiya dəyişkənliyini inkar etmir. Müəllimin vəzifəsi idealizə edilmiş əlifba tələffüzünü deyil, başa düşülən və funksional şifahi nitqi inkişaf etdirməkdir. Levisin anlaşıqlılıq prinsipi və Derwing ilə Munronun tədqiqatlara əsaslanan yanaşması bu seçimi metodik cəhətdən əsaslandırmağa kömək edir [7; 8].

Ərəb dilinin fonetik-fonoloji xüsusiyyətləri və tədris prioritetləri

Fonetika səsin yaranması, fiziki xüsusiyyətləri və qavranmasını, fonologiya isə səslərin dil daxilində məna fərqləndirmə funksiyasını öyrənir. Bu iki baxış tədrisdə bir-birini tamamlayır: məsələn, /q/ səsinin artikulyasiya yerini izah etmək fonetik, /q/ ilə /k/ fərqinin قَلْب/qalb/ «ürək» və كَلْب/kalb/ «it» sözlərini ayırd etdiyini göstərmək fonoloji vəzifədir. Birinci izah tələbəyə səsi yaratmağa, ikinci izah isə fərqin kommunikativ əhəmiyyətini anlamağa xidmət edir. Watson ərəb fonologiyasını fonem sistemi, heca quruluşu, vurğu və emfatiklik hadisələri ilə birlikdə araşdırır; Ryding isə müasir standart ərəb dilinin fonologiyasını yazı sistemi və normativ tələffüzlə əlaqəli şəkildə təsvir edir [1; 3].

Müasir standart ərəb dilinin tədris təsvirində adətən 28 samit və üç qısa–uzun sait qarşılaşdırması nəzərə alınır: /a/–/aː/, /i/–/iː/, /u/–/uː/. Fonemik inventarın təqdimatından sonra bütün səslərin eyni dərəcədə çətin olduğunu güman etmək doğru deyil. Təlimin ilkin mərhələsində /ħ/ (ح) və /h/ (ه), /ʕ/ (ع) və /ʔ/ (ء), /s/ (س) və /sˤ/ (ص), /q/ (ق) və /k/ (ك) kimi qarşılaşdırmalar seçilə bilər. Udlaq səslərinin akustik-artikulyator xüsusiyyətləri, koronal emfatik samitlərdə ikincili daralmanın iştirakı və dişarası /θ/ (ث), /ð/ (ذ) fonemləri xüsusilə məqsədli izah tələb edir [1; 2].

Fonoloji qarşılaşdırmaların səmərəli təqdimatı üçün mənalı cütlər mühüm əhəmiyyət daşıyır. عَلَم /ʕalam/ «bayraq» və أَلَم/ʔalam/ «ağrı» sözlərində başlanğıc samitin dəyişməsi leksik fərq yaradır. سَيْف/sajf/ «qılınc» və صَيْف/sˤajf/ «yay fəsli» cütündə isə ikincili udlaqsı artikulyasiya ilə müşayiət olunan /sˤ/ adi /s/ fonemindən fərqlənir. Bu nümunələri təqdim edərkən hərflərin Azərbaycan qrafikasında təxmini transliterasiyası ilə kifayətlənmək olmaz: eyni işarə iki dildə başqa fonetik keyfiyyətə malik ola bilər. Tədris üçün hədəf səsin səsli modeli, onun IPA işarəsi, qısa artikulyasiya izahı və mənalı söz konteksti birlikdə verilməlidir.

Sait uzunluğunun və geminasiyanın tədrisi ayrıca diqqət tələb edir. عَلَم/ʕalam/ «bayraq» – عالَم /ʕaːlam/ «dünya» cütündə uzunluq leksik fərq yaradır; دَرَسَ/darasa/ «öyrəndi» – دَرَّسَ/darrasa/ «öyrətdi» qarşılaşdırmasında samitin qoşalaşması feil qəlibi ilə əlaqəlidir. Qısa və uzun sait arasındakı fərq mütləq saniyə ölçüsü deyil, nitq tempi və kontekstdən asılı olan nisbi müddət münasibəti kimi öyrədilməlidir. Eyni şəkildə şəddənin qrafik işarəsini tanımaq /rr/ davamlılığını şifahi nitqdə avtomatik təmin etmir. Dinləmə ilə istehsal ayrı-ayrı yoxlanmalı, nəticələr müstəqil göstəricilər kimi qeyd edilməlidir [2; 3].

Fərdi səslərdən kənarda heca, vurğu, intonasiya və bağlı nitq qaydaları da tələffüz bacarığına daxildir. Ərəb dilində heca ağırlığı vurğu təsvirində rol oynayır, lakin bütün ədəbi və regional nitq

formaları üçün dəyişməz bir mexaniki vurğu qaydası təqdim etmək elmi baxımdan məhdudlaşdırıcı olardı. Müəyyənlik artiklinin الْقَمَر/alqamar/ «ay» sözündə /l/ səsini qoruması, الشَّمْس/aʃʃams/ «günəş» sözündə isə sonrakı /ʃ/ ilə assimilyasiyaya uğraması yazı–tələffüz münasibətini izah edən nümunələrdir. Başlanğıc səviyyəli öyrənən üçün bu hadisə «yazıda nə görünür, nitqdə nə eşidilir?» sualı ətrafında qurulmalıdır [3].

Fonoloji vahidlərin tədrisində prioriteti yalnız artikulyasiya çətinliyinin dərəcəsinə görə seçmək səmərəli deyil. Bir səsin tələffüzünün çətin olması həmin səsin hər kommunikativ tapşırıq üçün eyni dərəcədə əhəmiyyət daşımasını göstərmir. Müəllim ilkin kursda mənanı ayıran qarşılaşdırmaları, onların tələbənin gündəlik lüğətindəki mövqeyini və nitqdə təkrar qarşılaşma ehtimalını birlikdə nəzərə almalıdır. Məsələn, /q/–/k/ cütü ilkin fonemik qarşılaşdırmanı izah etmək üçün əlverişlidir, lakin öyrənənlərin söz ehtiyatında həmin cütün hər iki üzvü yoxdursa, əvvəlcə şəkil və ya mənaca qısa tanıtma aparılmalıdır. Əks halda dinləmə tapşırığında tələbə səsi düzgün eşitdiyi halda sözün mənasını bilmədiyi üçün yanlış cavab verə bilər. Bu da fonetik nəticənin lüğət biliyi ilə qarışdırılması deməkdir. Sınaqda eyni fonoloji fərqi fərqli leksik materiallarla yoxlamaq öyrənilən bacarığın yalnız əzbərlənmiş sözə bağlı olmadığını görməyə kömək edir. Belə yanaşma tapşırığın etibarlı şərhinə və mərhələli çətinləşdirilməsinə şərait yaradır.

Azərbaycan dili ilə kontrastiv müqayisənin metodik imkanları

Kontrastiv yanaşmanın məqsədi iki dil arasındakı hər fərqi əvvəlcədən öyrənmə səhvi kimi elan etmək deyil. Lado tərəfindən inkişaf etdirilən müqayisəli yanaşma dil sistemlərinin qarşılaşdırılmasını təlimin planlaşdırılması üçün başlanğıc nöqtəsi kimi əhəmiyyətli edir [6]. Lakin müasir tətbiqdə struktur fərqindən birbaşa bütün tələbələr üçün eyni tip səhv və ya eyni çətinlik tezliyi nəticəsi çıxarmaq düzgün olmazdı. Azərbaycan dilində danışan öyrənənlərin səsləri necə mənimsəyəcəyini müəyyənləşdirmək üçün ilkin diaqnostik dinləmə və səsləndirmə tapşırıqları lazımdır. Beləliklə, qarşılaşdırma pedaqoji ehtimallar yaradır, diaqnostika isə həmin ehtimallardan hansının konkret qrup üçün aktual olduğunu aydınlaşdırır.

Birinci ehtimal qrupunu udlaq və qırtlaq səsləri təşkil edir. Azərbaycan dilində ərəb /ħ/ və /ʕ/ səsləri ilə eyni fonoloji statusa malik vahidlər olmadığı üçün öyrənənlərin həmin səsləri yaxın akustik kateqoriyalara yönəltmə riski nəzərdə tutula bilər. İkinci qrup emfatik samitlərdir: /sˤ/, /tˤ/ və /dˤ/ sadəcə adi samitlərin daha güclü deyilişi kimi öyrədilməməli, onların ikincili artikulyasiya xüsusiyyətləri və qonşu saitlərə mümkün təsiri qeyd olunmalıdır. Üçüncü qrup dişarası /θ/, /ð/ səsləridir; burada müəllim dilin dişlərə münasibətini və səslilik fərqini aydın göstərməlidir. Qrupların hər birində səsin dinlənməsi, şüurlu artikulyasiya və söz səviyyəsində istifadə ardıcıl tətbiq olunur.

Sait uzunluğu və geminasiya Azərbaycan dili ilə müqayisədə başqa metodik risk yaradır. Ərəb dilində /a/ və /aː/ kimi qarşılaşdırmalar fonoloji əhəmiyyət daşıdığı halda öyrənən tanış nitq tempinin təsiri ilə müddəti sabit qorumaya bilər. Belə hal ehtimal kimi nəzərə alınmalı, müşahidə və ölçmə olmadan konkret tələbələrə aid fakt kimi göstərilməməlidir. Məşğələdə müəllim eyni söz cütünü müxtəlif sürətlə və fərqli ardıcıllıqda təqdim etməli, tələbə isə məhz fərqin olub-olmadığını müəyyənləşdirməlidir. Məna komponenti də vacibdir: yalnız uzun səs eşitməyi deyil, həmin fərqin «bayraq» ilə «dünya» kimi ayrı sözlərə uyğun gəldiyini dərk etmək öyrənmə hədəfini konkretləşdirir.

Kontrastiv təhlildə yazı sisteminin vasitəçi rolu da nəzərə alınmalıdır. Ərəb əlifbasında qısa saitlər adi yazıda çox vaxt göstərilmir; hərəkələnmiş mətnlə hərəkəsiz mətn müxtəlif oxu çətinlikləri yaradır. Bundan başqa, həmzətül-vəsl, müəyyənlik artikli və söz sonu fasilə forması yazılı vahidin əlaqəli nitqdə hər zaman eyni qaydada səslənmədiyini göstərir. Buna görə fonetika dərsi sadəcə əlifba dərsinə çevrilməməlidir: tanıma üçün hərəkələnmiş forma, tələffüz üçün audio model, bağlı nitq üçün isə qısa ifadə və dialoq birlikdə təqdim olunmalıdır. Ərəb və Azərbaycan dillərinin müqayisəsi fonoloji prioritetləri seçməyə kömək edir, lakin onların öyrənilmə sırası qrupun real göstəricilərinə görə dəqiqləşdirilməlidir [3; 4].

Diaqnostikada səhvin növünü fərqləndirmək də vacibdir. Tələbə /ʕalam/ ilə /ʔalam/ arasındakı seçimi səhv edirsə, bu nəticə təkbaşına onun müvafiq səsləri yarada bilmədiyini sübut etmir; səhvin səbəbi eşitmə, diqqət, leksik tanıma və ya tapşırığın anlaşılmaması ola bilər. Əksinə, sözü məna baxımından düzgün seçən tələbə öz danışığında fonoloji fərqi qorumaqda çətinlik çəkə bilər. Buna görə diaqnostik protokol ən azı iki ayrı hissə saxlamalıdır: birində tələbə dinlədiyi sözü işarələyir, digərində isə məlum sözü özü səsləndirir. Müəllim müşahidəni sadə cədvəldə «səs fərqini eşitdi/eşitmədi», «artikulyasiya etdi/etmədi», «cümlədə saxladı/saxlamadı» kimi ayrıca qeyd edə bilər. Bu bölgü hər çətinliyin eyni növ məşqlə həll olunmadığını göstərir. Qavrama ilə bağlı problem üstünlük təşkil etdikdə qarışıq ardıcıllıqda dinləmə, artikulyasiya problemi üstünlük təşkil etdikdə isə modelə yönəlmiş səs-heca-söz çalışmaları artırılmalıdır. Beləliklə, kontrastiv yanaşma müəllim üçün hazır səhv siyahısı yox, yoxlanıla bilən diaqnostik ehtimallar xəritəsinə çevrilir.

Tələffüz tədrisində eşitmə, artikulyasiya və kommunikativ fəaliyyətin inteqrasiyası

Ənənəvi tələffüz tədrisində müəllimin səsi səsləndirib tələbələrin təkrarını istəməsi müəyyən dərəcədə faydalıdır, lakin təkbaşına kifayət etmir. Təkrarın keyfiyyətini yoxlamaq üçün öyrənənin hansı fonemi eşitdiyini, səsi hansı artikulyasiya xüsusiyyəti ilə yaratdığını və nitqdə mənanın çatdırılıb-çatdırılmadığını fərqli tapşırıqlarla müəyyən etmək lazımdır. Celce-Murcia və həmmüəlliflərinin tələffüz tədrisinə dair metodik yanaşması, Rydingin ərəb dili üzrə müəllimlər üçün rəhbərliyi və beynəlxalq tədqiqatlar səs üzərində məqsədli məşqləri praktik ünsiyyət fəaliyyəti ilə əlaqələndirməyə əsas verir [5; 9]. Saitonun tədqiqat icmalı tələffüz üzrə məqsədli təlimin öyrənmə prosesində ayrıca araşdırılmalı olduğunu göstərir; buna baxmayaraq, müəyyən başqa dillərdə müşahidə edilən nəticəni ərəb dili qruplarına avtomatik köçürmək olmaz [10].

Fonemlərin eşidilərək fərqləndirilməsi üçün sözün lüğəvi mənası əvvəlcədən öyrədilmiş minimal cütlərdən istifadə təklif edilir. Müəllim قَلْب/qalb/ və كَلْب/kalb/ sözlərini təsadüfi ardıcıllıqda səsləndirir, tələbə isə uyğun kartı və ya şəkli işarələyir. İlk mərhələdə cavab yazmaq tələb olunmadığından nəticə daha çox eşitmə fərqini əks etdirir. Sonra eyni cüt qısa ifadə daxilində dinlədilir; buradakı məqsəd fonemi cümlə axınında da tanıya bilməkdir. Dərsdə yalnız eyni səs yazısını çox təkrar etdirmək yerinə, mənbə və nitq sürəti mümkün qədər müxtəlifləşdirilə bilər. Lakin nümunələrin hədəf standart ərəb dili normasına uyğunluğu müəllim tərəfindən əvvəlcədən yoxlanmalıdır.

Artikulyasiya mərhələsində səsin əmələgəlmə yeri və üsulu sadə, yoxlanıla bilən göstərişə çevrilir. /q/–/k/ cütü üçün dilin arxa hissəsinin qapanma yerinə diqqət yönəldilir; /ħ/–/h/ cütündə udlaq və qırtlaq bölgəsindəki fərqlər model əsasında göstərilir; /θ/ və /ð/ üçün dişarası sürtünmə və səslilik qarşılaşdırılır. Güzgü və vizual artikulyasiya sxemi yalnız müşahidə edilə bilən səslərdə birbaşa kömək edir; udlaq səslərinin tədrisində müəllimin səsləndirməsi və diqqətli dinləmə mühüm olaraq qalır. Sonra CV tipli hecalardan mənalı sözə, sözdən qısa ifadəyə keçid qurulur. Tələbə eyni anda çox sayda çətin fonemlə yüklənməməlidir.

Məna ilə əlaqələndirilən çalışmalar fonoloji fərqin kommunikativ yükünü aydınlaşdırır. Məsələn, bir tələbəyə عالَم/ʕaːlam/ «dünya» və علَم/ʕalam/ «bayraq» sözlərini əks etdirən şəkil kartları, digərinə isə onların nömrələnmiş siyahısı verilir. Birinci tələbə sözləri qarışıq şəkildə deyir, ikincisi eşitdiyi mənanı seçir; tələbələr daha sonra rollarını dəyişirlər. Danışanın məqsədi müəllim üçün səsi təkrarlamaq deyil, partnyorunun düzgün şəkli seçməsinə nail olmaqdır. Fərq anlaşılmadıqda sözü təkrar etmək, sürəti tənzimləmək və ya qısa cümlədə işlətmək kimi danışıq strategiyaları da inkişaf etdirilir. Beləliklə, səsin fonetik dəqiqliyi və ünsiyyətin anlaşıqlılığı bir-birindən ayrılmadan yoxlanır [7; 8].

Orfoepik məşqlər zamanı şagirdin eyni mətnin hərəkəli və adi yazılışını müqayisə etməsi məqsədəuyğundur. Məsələn, الشَّمْس/aʃʃams/ və الْقَمَر/alqamar/ tələffüzlərini müəllim audio nümunələrə bağlayır, sonra tələbələr artikldəki /l/ səsinin hansı şəraitdə qorunduğunu və hansı şəraitdə assimilyasiya olunduğunu müəyyənləşdirirlər. Daha sonra sadə xəbər və sual cümlələri fərqli intonasiya ilə dinlədilir; intonasiyanın mənaya təsiri mütləq «bütün suallar yüksələn tonla

bitir» kimi ümumi qayda ilə deyil, konkret kommunikativ kontekstlə izah edilir. Söz vurğusu, fasilə və ritm birgə nitq modelində məşq etdirildikdə segmental səslərdən əlaqəli danışığa keçid təmin olunur.

İdarə olunan məşqdən sərbəst ünsiyyətə keçid zamanı müəllim tələffüz xətalarına seçici yanaşmalıdır. Dərsin hədəfi /s/–/sˤ/ qarşılaşdırmasıdırsa, həmin fərqdəki səhv dərhal qısa geribildirim tələb edə bilər; amma ünsiyyəti pozmayan digər xırda prosodik dəyişmələrin hamısını eyni anda düzəltmək axıcılığı zəiflədə bilər. Geribildirimin forması da konkret olmalıdır: «daha düzgün de» əvəzinə «bu dəfə /sˤ/ səslənəndə qonşu saitin keyfiyyətinə də diqqət et» göstərişi təlim hədəfini aydınlaşdırır. Tələbədən yenidən səsləndirmə istəmək və dərhal uğurlu nümunəni model ilə müqayisə etmək məhsuldar məşqin bir hissəsidir. Cütlərlə işdə isə tərəfdaşın rolu bütün fonetik detalları ekspert səviyyəsində qiymətləndirmək deyil, mesajın nə dərəcədə anlaşıldığını bildirməkdir. Belə fərqləndirmə müəllimin fonoloji dəqiqliyə nəzarətini, həmyaşıdın isə real dinləyici funksiyasını qoruyur. Bir dərsdə qısa və təkrarlanan geribildirim dövrələri qurmaq uzun, yalnız nəzəri izahlardan daha konkret məşq imkanı yaradır; bunun effektivliyi isə sonrakı eksperimental araşdırmanın predmeti olmalıdır.

Beşmərhələli metodik model və ilkin qiymətləndirmə

Nəzəri ümumiləşdirmə və nümunəvi çalışmalar əsasında başlanğıc səviyyəli universitet tələbələri üçün beşmərhələli model təklif edilir: (1) diaqnostika və fonetik qavrama; (2) artikulyasiyanın izahı; (3) idarə olunan səsləndirmə; (4) kommunikativ tətbiq; (5) məqsədli geribildirim və qiymətləndirmə. Bu ardıcıllıq sərt bir xətt deyil: danışıq mərhələsində problem görünərsə, tələbə yenidən heca və söz səviyyəsindəki məşqə qayıda bilər. Vacib prinsip hər mərhələnin müşahidə edilə bilən nəticə ilə tamamlanmasıdır: öyrənən hədəf sözü seçir, səs fərqini göstərir, nümunəni səsləndirir və tərəfdaşın mesajı başa düşməsini təmin etməyə çalışır.

Modelin 80 dəqiqəlik nümunəvi tətbiqi /q/–/k/ qarşılaşdırması üzərində qurula bilər. İlk 10 dəqiqədə dörd dinləmə nümunəsi üzrə qısa diaqnostika aparılır. Sonrakı 15 dəqiqə səslərin artikulyasiyasına və heca səviyyəsində təqlidə ayrılır; daha 15 dəqiqədə قَلْب–كَلْب tipli minimal cütlərlə qarışıq ardıcıllıqda təkrar və cütlü yoxlama keçirilir. Növbəti 20 dəqiqədə tələbələr şəkil seçimi və məlumat mübadiləsi əsasında danışırlar. Son 10 dəqiqə səs yazısına və ya qısa şifahi yoxlamaya, 10 dəqiqə isə fərdi geribildirimə və yenidən cəhdə həsr olunur. Bu bölgü metodik eskizdir; auditoriya, tələbə sayı, lüğət ehtiyatı və texniki imkanlardan asılı olaraq dəyişdirilə bilər.

Qiymətləndirmənin yalnız fonemləri səsləndirməkdən ibarət olmaması təklif edilir. ETİ əsasında işlənmiş ilkin 10 ballıq rubrikada beş meyarın hər biri 0–2 bal ilə qiymətləndirilir: (a) fonemləri dinləyərək fərqləndirmə, (b) hədəf samitlərin artikulyasiyası, (c) uzun sait və qoşalaşmanın qorunması, (d) vurğu və intonasiyanın məqama uyğunluğu, (e) ümumi nitq anlaşıqlılığı. «0» səviyyəsi fərqin əksər sınaqlarda itirilməsini və ya anlaşılmamasını, «1» qismən sabitliyi, «2» isə verilmiş tapşırıqda hədəfin əsasən qorunmasını göstərir. Bu rubrika işçi qiymətləndirmə vasitəsidir; onun psixometrik etibarlılığı və qiymətləndiricilərarası razılaşması ayrıca sınaqdan keçirilməyib. CEFR-in fonoloji nəzarətə dair yanaşması qiymətləndirmənin artikulyasiya, prosodiya və anlaşıqlılıq səviyyələrini ayırd etməyin əhəmiyyətini dəstəkləyir [11].

Texnoloji vasitələr modeldə yardımçı yer tuta bilər. Səs yazısı tələbənin öz tələffüzünü əvvəlki nümunə ilə müqayisə etməsinə imkan verir; dalğa formasının və ya sadə akustik vizuallaşdırmanın istifadəsi uzunluq fərqini göstərmək üçün əlavə dəstək ola bilər. Ərəb dili üzrə avtomatik yanlış tələffüz aşkarlanması sahəsində araşdırmalar aparılsa da, proqramın nəticəsini bütün aksentlər, dialektlər və akustik mühitlər üçün qüsursuz qiymətləndirmə hesab etmək olmaz [12]. Tələbənin səs yazısı tədris məqsədilə toplanırsa, razılıq və məlumatların məxfiliyi gözlənilməlidir. Müəllimin fonoloji geribildirimi avtomatik baldan daha genişdir: hansı fərqin mənanı dəyişdirdiyini, hansı səhvin kommunikativ maneə yaratdığını və növbəti çalışmanın nə olacağını izah etməlidir.

Təklif edilən modelin yoxlanması üçün gələcək empirik tədqiqatda eyni çətinlik səviyyəsində, lakin fərqli sözlərdən ibarət əvvəl-sonra dinləmə testləri, şifahi çıxış yazıları, ən azı iki qiymətləndiricinin

müstəqil rəyləri və yeni kontekstdə səsin qorunması göstəriciləri birləşdirilə bilər. Təlim tapşırıqlarında istifadə edilmiş eyni sözlərin yekun sınaqda mexaniki təkrarına əsaslanmaq mənimsənilmə nəticəsini olduğundan yüksək göstərə bilər. Hazır məqalənin təqdim etdiyi nəticə bu yoxlama üçün nəzəri əsaslandırılmış təlim və ölçmə çərçivəsidir; iştirakçı sayı, müsbət təsir faizi və ya eksperimental irəliləyiş kimi göstəricilər təqdim edilmir.

İlkin rubrikadan istifadə zamanı qiymətləndirilən tapşırığın həcmi və çətinlik səviyyəsi əvvəlcədən sabitləşdirilməlidir. Məsələn, fonemlərin fərqləndirilməsi meyarı üçün beş və ya səkkiz dinləmə nümunəsindən istifadə edilirsə, həm başlanğıc, həm də yekun yoxlamada eyni sayda və müqayisə oluna bilən çətinlikdə nümunələr seçilməlidir. Ümumi anlaşıqlılıq meyarında isə sadə, əvvəlcədən məşq edilmiş bir cümlənin uğurlu səsləndirilməsi ilə tələbənin yeni dialoqda öz fikrini bildirməsi eyni sübut kimi qəbul edilməməlidir. Müəllim rubrika balını mümkün olduqda qısa müşahidə qeydi ilə tamamlaya bilər: məsələn, «/q/–/k/ sözlərdə sabitdir, lakin sürətli dialoqda fərq zəifləyir». Bu qeyd növbəti dərsin planlaşdırılmasına yardım edir, balı isə yalnız hesabat rəqəminə çevrilməkdən qoruyur. Əgər kurs çərçivəsində inkişafın ölçülməsi nəzərdə tutulursa, tələbənin məxfiliyi, məlumatlandırılmış razılığı və səs yazılarının istifadə məqsədi əvvəlcədən açıqlanmalıdır. Beləliklə, qiymətləndirmənin pedaqoji funksiyası sadəcə yekun nəticəni bildirmək deyil, yeni məşq ehtiyacını göstərməkdir.

Nəticə

Aparılmış nəzəri və tətbiqi-metodik təhlil əsasında üç qarşılıqlı nəticə formalaşır. Birincisi, ərəb dilində tələffüzün mənimsənilməsi hərflərin əzbərlənməsi ilə eyniləşdirilə bilməz: udlaq və qırtlaq səsləri, emfatik samitlər, dişarası səslər, fonoloji sait uzunluğu və geminasiya kimi qarşılaşdırmalar eşitmə, artikulyasiya və məna səviyyələrində öyrədilməlidir. Vurğu, intonasiya, assimilyasiya və bağlı nitq qaydaları bu bazanın əlaqəli danışığa köçürülməsini tamamlayır. İkincisi, Azərbaycan dili ilə kontrastiv müqayisə ehtimal olunan təlim ehtiyaclarını müəyyən etmək üçün faydalıdır, lakin fonoloji fərqlərdən faktiki səhv tezliyi çıxarmaq olmaz; fərdi və qrup diaqnostikası lazımdır.

Üçüncüsü, qavrama–artikulyasiya–idarə olunan məşq–kommunikativ tətbiq–geribildirim mərhələlərini birləşdirən model fonetik tədrisi dinləmə-anlama və danışıq məqsədlərinə yaxınlaşdırır. Minimal cütlərin mənalı tapşırıq daxilində işlədilməsi, qısa dialoqların və əvvəlcədən müəyyənləşdirilmiş qiymətləndirmə meyarlarının tətbiqi müəllimə təlim fəaliyyətini planlaşdırmaq üçün konkret vasitələr təqdim edir. Bununla belə, modelin işləkliyi və qiymətləndirmə rubrikasının etibarlılığı barədə nəticə yalnız gələcək sinif müşahidələri və nəzarətli sınaqlar əsasında verilə bilər. Məqalənin başlıca praktiki töhfəsi ərəb fonetikasının ayrıca başlanğıc mövzusu kimi deyil, bütün şifahi ünsiyyət təlimində sistemli şəkildə inkişaf etdirilən bacarıq kimi təşkilinə dair əsaslandırılmış metodik çərçivədir.

Ədəbiyyat siyahısı

1. Watson, J. C. E. (2002). The Phonology and Morphology of Arabic. Oxford University Press. https://doi.org/10.1093/oso/9780199257591.001.0001

2. Al-Ani, S. H. (1970). Arabic Phonology: An Acoustical and Physiological Investigation. Mouton.

3. Ryding, K. C. (2005). A Reference Grammar of Modern Standard Arabic. Cambridge University Press. https://doi.org/10.1017/CBO9780511486975

4. Holes, C. (2004). Modern Arabic: Structures, Functions, and Varieties (rev. ed.). Georgetown University Press.

5. Ryding, K. C. (2013). Teaching and Learning Arabic as a Foreign Language: A Guide for Teachers. Georgetown University Press.

6. Lado, R. (1957). Linguistics Across Cultures: Applied Linguistics for Language Teachers. University of Michigan Press.

7. Levis, J. M. (2005). Changing contexts and shifting paradigms in pronunciation teaching. TESOL Quarterly, 39(3), 369–377. https://doi.org/10.2307/3588485

8. Derwing, T. M., & Munro, M. J. (2005). Second language accent and pronunciation teaching: A research-based approach. TESOL Quarterly, 39(3), 379–397. https://doi.org/10.2307/3588486
9. Celce-Murcia, M., Brinton, D. M., Goodwin, J. M., & Griner, B. (2010). Teaching Pronunciation: A Course Book and Reference Guide (2nd ed.). Cambridge University Press.
10. Saito, K. (2012). Effects of instruction on L2 pronunciation development: A synthesis of 15 quasi-experimental intervention studies. TESOL Quarterly, 46(4), 842–854. https://doi.org/10.1002/tesq.67
11. Council of Europe. (2020). Common European Framework of Reference for Languages: Learning, Teaching, Assessment – Companion Volume. Council of Europe Publishing.
12. Alrashoudi, N., Al-Khalifa, H., & Alotaibi, Y. (2025). Improving mispronunciation detection and diagnosis for non-native learners of the Arabic language. Discover Computing, 28, Article 1. https://doi.org/10.1007/s10791-024-09489-8

ПОСТРЕДАКТИРОВАНИЕ МАШИННОГО ПЕРЕВОДА С АНГЛИЙСКОГО НА КАЗАХСИЙ: СТРАТЕГИИ ПОВЫШЕНИЯ КУЛЬТУРНОЙ АДЕКВАТНОСТИ

Пирман Аружан
магистрант
Научный руководитель:
Алшинбаева Жулдыз Куанышевна
доктор философии (PhD), Евразийский национальный университет имени Л. Н. Гумилёва

Аннотация: В статье рассматривается культурная адекватность машинного перевода с английского языка на казахский и стратегии постредактирования, необходимые для её достижения. В исследовании сопоставляются две системы нейронного машинного перевода (Google Translate и Яндекс Переводчик) и большая языковая модель ChatGPT. Материалом послужили 19 англоязычных предложений, содержащих культурно маркированные единицы пяти типов: бытовые и социальные реалии, идиомы, формулы речевого этикета, единицы измерения и форматы дат; проанализировано 57 переводов. Для каждого перевода определялись тип и степень тяжести культурно обусловленной ошибки; ошибочные переводы подвергались постредактированию с фиксацией применённого приёма. Google Translate и ChatGPT адекватно передали культурно маркированные единицы в 79 % случаев, Яндекс Переводчик — в 37 %. Наиболее частотной ошибкой оказалась неадаптированность единиц измерения и форматов, которую ни одна из систем не устранила последовательно. Наиболее серьёзными явились буквальный перевод идиом и формул этикета, а также подмена социальных реалий. Предложена схема соответствий типов ошибок и приёмов постредактирования: пересчёт единиц — для ошибок формата, казахский функциональный аналог или описательный перевод — для буквализмов, описательный перевод или транслитерация с пояснением — для непереданных реалий. Результаты показывают, что даже наиболее успешные системы не устраняют необходимости постредактирования человеком с учётом культурного контекста.

Ключевые слова: машинный перевод, постредактирование, культурная адекватность, культурно маркированные единицы, англо-казахский перевод, нейронный машинный перевод, большие языковые модели, ChatGPT.

POST-EDITING MACHINE TRANSLATION FROM ENGLISH TO KAZAKH: STRATEGIES FOR INCREASING CULTURAL ADEQUACY

Pirman Aruzhan
Scientific adviser: **Alshinbayeva Zhuldyz Kuanyshevna**

Abstract. The article examines the cultural adequacy of machine translation from English into Kazakh and the human post-editing strategies required to achieve it. The study compares two neural machine translation systems (Google Translate and Yandex Translate) and a large language model (ChatGPT). The material comprised 19 English sentences containing culture-specific items

of five types: everyday realia, social realia, idioms, speech etiquette formulas, and measurement units and formats; 57 translations were analysed. Each translation was assessed for the type and severity of culture-related errors, and erroneous translations were post-edited with the applied technique recorded. Google Translate and ChatGPT rendered culture-specific items adequately in 79% of cases, Yandex Translate in 37%. The most frequent error was the failure to adapt measurement units and formats, which none of the systems handled consistently. The most serious errors were literal translations of idioms and etiquette formulas and the substitution of social realia. A correspondence between error types and post-editing techniques is proposed: unit conversion for format errors, a Kazakh functional equivalent or descriptive translation for literalism, and descriptive translation or transliteration with explanation for untranslated realia. The results show that even the best-performing systems do not eliminate the need for culturally informed human post-editing.

Keywords: machine translation, post-editing, cultural adequacy, culture-specific items, English–Kazakh translation, neural machine translation, large language models, ChatGPT.

Introduction

Digitalization is changing both the concept of text and the ways of working with it. Texts are stored and processed in a digital environment, and their analysis and translation are entrusted to automated systems. As noted by O. N. Kamshilova and L. N. Belyaeva, in these conditions, new translation practices, procedures and resources are emerging, and translation after editing the results of machine translation is becoming an independent field of professional activity of the translator [1].

The digitalization of the linguistic sphere has technical and linguistic components. The technical component is associated with the availability of computing resources, communications and online word processing services. The linguistic component includes the creation of specialized dictionaries, databases and text Corps, software localization and the use of machine translation systems (hereinafter referred to as MT) in translation practice and lexicography.

In Kazakh linguistics, digitalization is mainly associated with the use of mathematical and computer methods for automatic processing Kazakh texts. This article discusses machine translation, in particular, the interaction of a person with the results of MT.

The development of neural machine translation and large language models (ChatGPT and others) has significantly improved the grammatical and lexical accuracy of automatic translations. However, translation is not only the transfer of meanings between languages, but also intercultural communication. Realia, idioms, speech etiquette formulas, units of measurement, and date formats convey information that is mostly understood by speakers of the original culture. Machine systems often translate such units word for word or leave them unadapted. D. Abduganieva [2] showed standard MT quality indicators (BLEU, COMET) do not identify cultural-semantic and pragmatic discrepancies, so their identification and elimination remain the task of post-editors.

This issue is especially relevant for the Kazakh language. Digital resources in the Kazakh language are limited, and MT systems have a smaller amount of parallel data than the main European languages. The cultural gap between two cultures (English and Kazakh) is large, and many English-language phrases do not have exact translations in Kazakh. In addition, considering Kazakh-Russian bilingualism, traces of the Russian language may appear in machine translations into Kazakh.

The Post-editor of MT is being actively studied in Russian-speaking linguistics. Researchers describe its types and optimization methods [3], strategies for post-editing specialized, especially medical texts, and new roles of translators in the context of digitization [4]. However, the cultural aspect after post-editing, especially in the Anglo-Kazakh pair, is still not fully understood. It has not

been described what types of culturally defined errors are characteristic of the different MT systems and what post-editing methods should be used to correct them.

The purpose of this article is to identify culturally identified errors in machine translation systems when translating from English into Kazakh and identify the necessary post - editing methods to eliminate them. To achieve this goal, the following tasks were performed:

1. accumulation of material, which includes culturally marked units of different types;
2. comparison of Google Translate, Yandex Translate and ChatGPT translations based on cultural adequacy;
3. classify the detected errors and establish a correspondence between the types of errors and post-editing methods.

The novelty of this study lies in the comparison of a large language model based on cultural adequacy using neural machine translation systems and English-Kazakh language pairs, as well as the proposed structure for matching types of cultural error to post-editing methods.

The practical significance of this work lies in the fact that the resulting structure can serve as a checklist for translators and post-editing specialists and can be used in machine translation and post-editing courses.

Research materials and methods

The study was conducted in the form of a comparative experiment. Its purpose is to identify culturally determined errors made by neural machine translation systems and a large language model when translating from English to Kazakh, and to identify post—editing techniques necessary to eliminate them.

The experiment included four stages: compiling the material, receiving machine translations, peer review of translations, and post-editing.

The material consisted of 19 English-language sentences, each of which contains a culturally marked unit (CME), that is, an element whose understanding or relevance depends on knowledge of American or British culture. The sentences were compiled by the author and divided into five categories: the category of everyday cultural realities comprises three sentences, and each of the remaining four categories comprises four sentences (3 + 4 × 4 = 19; see Table 1).

Table 1

Culturally Marked Elements in the Material

Category (number of sentences)	Culturally Marked Elements (CMEs) in the Material
Everyday cultural realities (3)	Thanksgiving, trick-or-treating, biscuits and gravy
Social realities (4)	GED, food stamps, community college, midterms
Idioms (4)	break a leg, a piece of cake, under the weather, cross that bridge when we come to it
Speech etiquette (4)	Dear Sir or Madam, Hey guys / How are you doing today?, Kind regards, Cheers, mate
Formats and units of measurement (4)	95°F, 3 miles, 6'2" / 180 pounds, 03/04/2026

Each sentence was translated into Kazakh by three systems:

- Google Translate — neural machine translation system;
- Yandex Translator — neural machine translation system;
- ChatGPT is a large language model.

Translators, Google was used through a standard web interface without additional configuration. ChatGPT received the request in English to exclude the influence of the Russian

language as a possible intermediary. Each sentence was presented in a new dialogue so that the previous context would not affect the translation.

The transfers were received in October 2026. A total of 57 translations (19 sentences × 3 systems) were analyzed.

All 57 translations were evaluated by the author of the study, who speaks Kazakh and English. For each translation, the type of culturally determined error, the degree of its severity, and the presence of traces of the Russian language (borrowings or cripples) were recorded. The typology of errors was developed based on the classification of D. Abduganieva and simplified taking into account the volume of the material [2].

Table 2

The severity of the error

Code	Error Type	Manifestation
E0	No error	The CME is conveyed clearly and appropriately for the Kazakh reader.
E1	Semantic error	The CME is replaced with an element that has a different meaning.
E2	Untranslated cultural reality	The cultural reality is omitted or conveyed without explanation, causing its meaning to be lost.
E3	Literal translation	An idiom or etiquette formula is translated word for word.
E4	Etiquette violation	Inappropriate form of address, use of informal сен instead of formal Сіз, or an incorrect tone.
E5	Unadapted format	Fahrenheit degrees, miles, feet, or the American date format are retained without adaptation.

The severity of the error was assessed on a three—point scale:

• 0 - the translation is culturally adequate, no editing is required;

• 1 — the meaning is clear, but the translation sounds unnatural or requires additional effort from the reader.;

• 2 — the meaning is distorted, lost, or the translation is inappropriate in the Kazakh communicative situation.

The type and severity were coded consistently: a translation without error (E0) received 0 points, a translation with any error (E1–E5) received 1 or 2 points(Table 2).

Translations with the severity of error 1 or 2 were completely post-edited. The choice of full rather than light post-editing is due to the fact that the type of post-editing is determined by the purpose of translation, and cultural adaptation goes beyond minimal editing. The post-editing algorithm included reconciliation of the machine translation with the original, identification of the error, selection of the correction method and making the minimum sufficient correction. If another system offered an adequate option, it was used as the basis for correction.

The technique used was recorded for each correction.:

• replacement with a Kazakh functional equivalent;

• descriptive translation;

• transliteration with explanation;

• Generalization;

• replacing the address with a respectful form;

• Translation of units of measurement and date format.

The data was processed using descriptive statistics. For each system, the proportion of transfers without errors, the proportion of serious errors (2 points), the average severity score, and the distribution of errors by type were calculated. The average severity score was calculated

for each category of CME. Additionally, a correspondence table "error type — post-editing technique" was compiled. Typical cases were analyzed qualitatively using examples.

5. Results

Of the 57 analyzed translations, 37 (65%) turned out to be culturally adequate, and 20 (35%) required post-editing. Google Translate and ChatGPT showed equally high results.: 79% of transfers are error-free (Table 3). Yandex.Translate managed without errors only in 37% of cases, and it accounted for 7 out of 9 serious errors.

Table 3

Cultural appropriateness of translations by system (n = 19 for each system)

System	Error-free	Errors Requiring Correction	Serious Errors (2 points)	Mean Severity Score (0–2)	Traces of Russian
Google Translate	15 (79%)	4 (21%)	1 (5%)	0.26	0
ChatGPT	15 (79%)	4 (21%)	1 (5%)	0.26	1 (5%)
Yandex Translate	7 (37%)	12 (63%)	7 (37%)	1.00	2 (11%)

The same totals of Google Translate and ChatGPT hide the difference in the nature of errors, but in both systems, three out of four errors are related to formats and units of measurement (E5). Yandex Translate, on the contrary, is dominated by semantic errors and literalisms that make the text incomprehensible or inappropriate.

The most common type of error was the unadapted format (E5): 9 out of 20 errors. All three systems retained miles, feet, and pounds without recalculation, while only Google Translate recalculated degrees Fahrenheit, indicating the Celsius value in parentheses. The date 03/04/2026 turned out to be dangerous: Google Translate read it as April 3 instead of March 4, meaning a format error distorted the actual information(Table 4).

Table 4

Distribution of errors by type

Error Type	Google Translate	Yandex Translate	ChatGPT	Total
E1 Semantic Error	0	3	1	4
E2 Untranslated Cultural Reality	1	1	0	2
E3 Literal Translation	0	4	0	4
E4 Etiquette Violation	0	1	0	1
E5 Unadapted Format	3	3	3	9
Total	4	12	4	20

This is followed by literalism (E3, 4 cases) and semantic errors (E1, 4 cases); 7 of these 8 errors were made by Yandex Translator. He translated three of the four idioms literally: break a leg as "ayagynyzdy syndyrynyz" ("break a leg"), a piece of cake as "torttyn bir boligi", cross that bridge as "kopirge zhetkende ony kesip otiniz". Google Translate and ChatGPT have rendered all four idioms meaningful.

By category, the picture is as follows:

• Formats and units of measurement are the only category where all three systems made mistakes (9 erroneous translations out of 12).

• Idioms and speech etiquette are difficult primarily for Yandex Translator: verbatim formulas ("Kurmetti Sir"), addressing "balalar" ("children") to customers, "Alakai" ("Hurrah!") instead of gratitude.

• Social realities (GED, food stamps) Google Translate and ChatGPT gave descriptive and right, Yandex Translator switched them ("the bachelor dries" instead of a GED certificate).

Some translations show signs of influence from the Russian language, especially with words like “pie” and “cookies.” Yandex Translator translated “pumpkin pie” as “asqabaq pirogy” and “biscuits” as “pechene,” and ChatGPT also used “pechene” for “biscuits.”. A clearer mistake happened with the phrase “a piece of cake,” which Yandex Translator translated literally as “torttyn bır bolıgı” meaning “a piece of cake,” but it doesn’t mean something is easy.In addition, Yandex Translator used the informal singular form “kalaisyn” (“how are you?”) when addressing an unfamiliar audience, although the English greeting “Hey guys, welcome to our store! How are you doing today?” addresses customers collectively. This case is classified as an etiquette violation (E4), since the informal form does not correspond to the polite register required when addressing customers; the appropriate form in this context is “qalaisyzdar”. It is the only E4 error in the material (Table 4); it was corrected by replacing the address with a respectful form (Table 5).

It took five post-editing techniques to correct 20 erroneous translations. Each type of error is consistently associated with one or two techniques, which allows us to formulate practical recommendations for the post-editor (Table 6).

Table 5

Correspondence between error types and post-editing techniques (number of instances)

Post-editing Technique	E1 Semantic Error	E2 Cultural Reality	E3 Literal Translation	E4 Etiquette Violation	E5 Format	Total
Conversion of Units and Formats	—	—	—	—	9	9
Replacement with a Kazakh Equivalent	3	—	2	—	—	5
Descriptive Translation	—	2	2	—	—	4
Transliteration with Explanation	1	—	—	—	—	1
Replacement with a Respectful Form of Address	—	—	—	1	—	1

Table 6

Post-editing examples

CME	Machine Translation (System)	Error	After Post-editing	Technique
break a leg	*Ертеңгі кастингте аяғыңызды сындырыңыз!* (Yandex)	E3, 2	*Ертеңгі кастингте сәттілік тілеймін!*	Kazakh equivalent
trick-or-treating	*Балалар … тәттілерді таратуға барды* (Yandex)	E2, 2	*Балалар … Хэллоуинде үй-үйді аралап тәтті жинауға шықты*	Descriptive translation
Dear Sir or Madam	*Құрметті Сэр немесе Ханым* (Yandex)	E3, 1	*Құрметті ханым/мырза*	Kazakh equivalent
03/04/2026	*2026 жылғы 3 сәуір* (Google)	E5, 2	*2026 жылғы 4 наурыз*	Format conversion
6'2", 180 pounds	*6 фут 2 дюйм, 180 фунт* (all systems)	E5, 1	*188 см, 82 кг*	Unit conversion

Post-editing format errors requires minimal effort, but it is mandatory if the text is addressed to a Kazakhstani reader. Correcting literalisms and semantic errors is more difficult: a post-editor must recognize a cultural unit and find a functional equivalent in Kazakh linguoculture.

Conclusion. The conducted research allows us to draw a number of conclusions. Cultural adequacy machine translation from English into Kazakh is largely determined by the choice of system: Google Translate and ChatGPT adequately conveyed culturally marked units in 79% of cases, while Yandex Translator is only 37 %. At the same time, the large language model did not demonstrate advantages over the most successful neural machine translation system.

The most common type of error was the lack of adaptation of formats and units of measurement. None of the systems converted miles, feet and pounds into units accepted in Kazakhstan, and degrees Fahrenheit were recalculated only in one case. Such errors are easily eliminated, but they are systematic in nature, and when transmitting dates they can lead to distortion of factual information.

The most serious consequences are errors of a different kind: literal translation of idioms and formulas of speech etiquette, as well as substitution of social realities. Their elimination requires the post-editor to be proficient not only in both languages, but also in both linguistic cultures.

The analysis showed that each type of error corresponds to a limited set of post-editing techniques. The unadapted format is eliminated by recalculating units, literalism is eliminated by selecting a Kazakh functional analogue or descriptive translation, the unreleased reality is eliminated by descriptive translation or transliteration with explanation, and an etiquette violation is eliminated by replacing the address with a respectful form. The revealed correspondence scheme can serve as a practical guideline for post-editors.

Thus, even the most successful systems do not eliminate the need for human post-editing: every fifth case required cultural editing in their translations.

The prospects for further research are related to the expansion of the sample due to authentic texts, the involvement of a second expert to increase the reliability of the assessment, as well as checking whether the special indication in the prompt increases the cultural adequacy of the ChatGPT translation.

References

1. Камшилова, О. Н. Машинный перевод в эпоху цифровизации: новые практики, процедуры и ресурсы / О. Н. Камшилова, Л. Н. Беляева. – Текст : непосредственный // Terra Linguistica. – 2023. – Т. 14, № 1. – С. 41–56. – DOI 10.18721/JHSS.14105.

2. Абдуганиева, Д. Актуализированное постредактирование с герменевтическими метриками для машинного вывода / Д. Абдуганиева. – Текст : электронный // Theoretical Aspects in the Formation of Pedagogical Sciences. – 2025. – № 4 (23). – С. 106–110. – DOI 10.5281/zenodo.17149635. – URL: https://zenodo.org/records/17149635 (дата обращения: 02.10.2026).

3. Абросимова, Н. А. Пред- и постредактирование машинного перевода медицинских текстов / Н. А. Абросимова, Е. А. Щелокова. – Текст : непосредственный // Мир науки, культуры, образования. – 2022. – № 4 (95). – С. 178–181.

4. Хромова, А. А. Постредактирование англо-русского машинного перевода: проблемы, методы и оптимизация / А. А. Хромова, Р. Р. Лукманова. – Текст : непосредственный // Филологические науки. Вопросы теории и практики. – 2024. – Т. 17, вып. 3. – С. 949–956. – DOI 10.30853/phil20240138.

Technical Sciences

Estimation of Economic Losses in the Electricity Distribution Network Using Fourier Analysis

Maka Jishkariani
PhD, Full Professor of Georgian Technical University, Faculty of Power Engineering, Department of Electric Power and Electro mechanics Tbilisi, Georgia

Annotation. One of the primary requirements of modern electric power systems is the supply of high-quality electricity to consumers. Ideally, the voltage and current in an electrical network should exhibit a pure sinusoidal waveform. However, the widespread use of modern electronic devices, inverters, LED lighting, computer equipment, and other non-linear loads leads to harmonic distortion within the network. Fourier series analysis is one of the most effective mathematical methods for addressing this issue, enabling the representation of any periodic signal as a sum of sinusoidal components at various frequencies. In this study, current harmonics were measured at a transformer substation using a power quality analyzer, and the Total Harmonic Distortion (THD) factor - a widely used metric in the power industry - was evaluated. The obtained result of 24.6% indicates that the total harmonic distortion is quite high, leading to additional technical and economic losses. It is worth noting that international standards set a target range of 5-8% for low-voltage networks. The paper calculates the economic effect- the annual savings achieved through the use of harmonic filters.

Keywords: Power grid, Harmonics, Fourier analysis

Introduction

It is appropriate to conduct an analysis of harmonics in a low-voltage electricity distribution network using the example of a city with a population of 1.2 million, as the country's largest electrical load is concentrated there [1]. The primary sources of harmonics in the distribution network include LED lighting, uninterruptible power supply (UPS) systems, data and commercial centers, elevator frequency converters, electric vehicle chargers, solar power plant inverters, and industrial frequency converters [2]. Most of these devices constitute non-linear loads; consequently, the current drawn from the network is no longer sinusoidal [3].

Main Part

Modern electric power systems operate using sinusoidal alternating voltage and current. Ideally, the grid voltage should be:

$$U(t) = U\max \sin(\omega t) \qquad (1)$$

where Umax is the peak voltage value (amplitude). The sine function indicates that the voltage changes smoothly and uniformly [4]. Here, t represents time, while ωt indicates the rate of change of the sinusoid. The general form of the Fourier series is:

$$f(t) = a0 + \sum_{n-1}^{\infty} (an \cos n\omega t + bn \sin n\omega t) \qquad (2)$$

where a_0 is the constant component; n = (1, 2, 3, …n) is the harmonic order; an is the cosine component coefficient; bn is the sine component coefficient; and ω=2πf is the angular frequency [5].

Each harmonic is characterized by three parameters:

1. Harmonic order (e.g., the 1st or fundamental harmonic at 50 Hz, the 3rd harmonic at 150 Hz, etc.);
2. Harmonic amplitude (peak value, in amperes);
3. Harmonic phase angle [6].

In the Fourier series, ωt is the fundamental variable linking time and frequency [7]. It allows for the determination of the instantaneous value of current or voltage at any given moment, while the summation of various harmonics (3ωt, 5ωt, 7ωt...) produces the actual, distorted waveform measured in the electrical grid. Theoretically, the number of harmonics is infinite; however, primarily low-order harmonics (3, 5, 7, 11, 13...) are significant, as the magnitude of higher-order harmonics decreases rapidly. n1 – fundamental harmonic (50 Hz in Georgia); n3 – third harmonic (150 Hz); n5 – fifth harmonic (250 Hz); n7 – seventh harmonic (350 Hz), etc [8]. Let us consider a 10/0.4 kV substation, noting that the fundamental frequency of the power system is f = 50 Hz. Current harmonics were measured at one of the transformer substations using a power quality analyzer (Table 1).

Table 1

Harmonic	Frequency, Hz	Current amplitude, Ampere
I	50	100
III	150	20
V	250	12
VII	350	8

In this case, according to the Fourier analysis formula (2), the current will be:

$$i(t) = 100sin\omega t + 20sin3\omega t + 12sin5\omega t + 8sin7\omega t.$$

This means that the actual current consists of four sinusoids of different frequencies [9]. This constitutes a Fourier series - a time function describing the instantaneous value of the current at any given (t) moment [10]. The response of this function depends on the time (t) or phase angle (ωt) at which we wish to calculate it [11]. For example, when ωt = 0°, all sine terms equal zero (sin = 0). The symbol (ωt) represents the phase angle, indicating the position of the sinusoid at a given moment [12]. The first component of the phase angle is:

$$\omega=2\pi f \qquad (3)$$

Where π = 3.14 and f = 50 Hz, then ω = 2π × 50 = 6.28 × 50 ≈ 314 rad/s. This means that the sinusoid changes its phase by 314 radians per second, which corresponds to 50 full cycles per second [13].

The second component of the phase angle involves the symbol (t), representing time (in seconds). For instance, at t = 0 s, t = 0.002 s, t = 0.005 s, or t = 0.01 s, the phase angle differs at each moment [14]. If we assume t = 0.005 s, then ωt = 314.16 × 0.005 = 1.57 radians, which corresponds to 90°; this means the sinusoid is at its peak value at that moment [15].

For example, if ωt = 90°, then sin 90° = 1, and the fundamental harmonic becomes: 100 × 1 = 100 Am. The Fourier series includes other harmonics as well:

- 3ωt = 270°, sin 270° = −1; therefore, 20sin 3ωt = 20 × (−1) = −20 Am.
- 5ωt = 450°, sin 450° = 1; and 12 × 1 = 12 Am.
- 7ωt = 630°, sin 630° = −1; and 8 × (−1) = −8 Am.

Summing all the terms yields: i(t) = 100 − 20 + 12 − 8 = 84 Am. This means that when the phase angle is 90°, the instantaneous current value is 84 amperes. In other words, at this moment, the harmonics reduced the current value from 100 Am to 84 Am [16].

In the power industry, the most common metric is the Total Harmonic Distortion (THD) coefficient; it is calculated as the ratio of the square root of the sum of the squared amplitudes of the higher-order harmonics present in the waveform to the amplitude of the fundamental (1st-order) harmonic. Its formula is:

$$\text{Total Harmonic Distortion (THD) coefficient} = \frac{\sqrt{I(3)\text{^}2+I(5)\text{^}2+I(7)\text{^}2+\cdots}}{I(1)} * 100\% \qquad (4)$$

where I (1) is the amplitude of the first-order current harmonic, while I(3), I(5), and I(7) are the amplitudes of the third, fifth, and seventh-order current harmonics [17]. Substituting the data into formula (4) yields:

$$\text{Total Harmonic Distortion (THD) coefficient} = \frac{\sqrt{20\text{^}2+12\text{^}2+8\text{^}2+\cdots}}{100} * 100\% = 24.66\%.$$

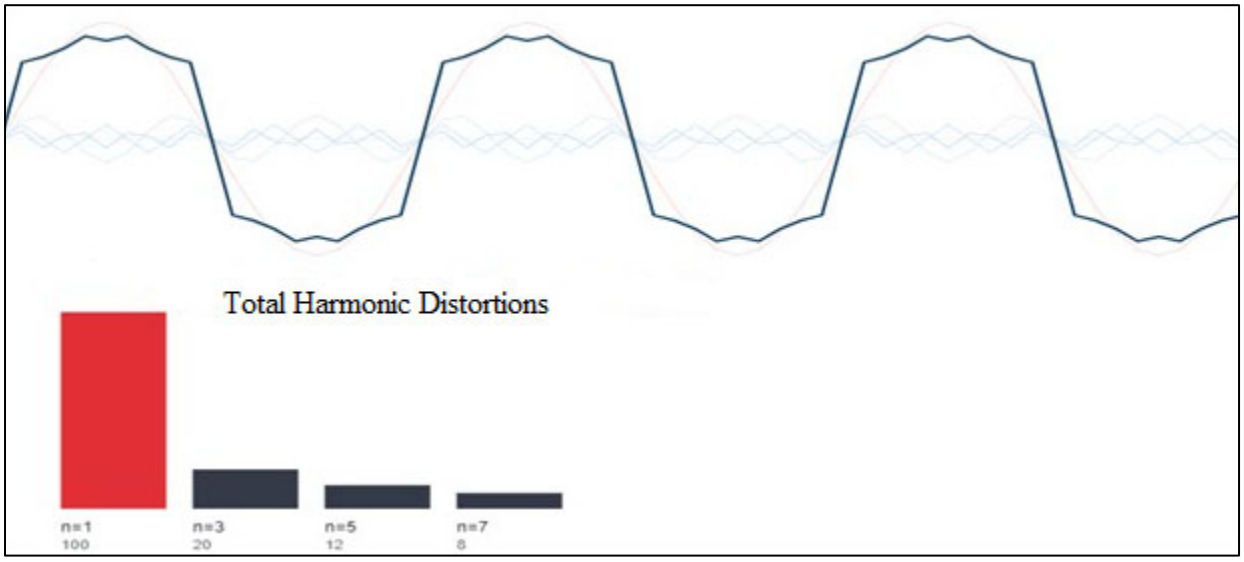


Fig.1. Total Harmonic Distortions

The obtained result (Fig. 1) indicates that the total harmonic distortion is quite high, leading to additional technical and economic losses [18]. It is worth noting that, according to international standards, the target value for low-voltage networks falls within the 5–8% range [19].

It should be noted that harmonic currents cause cable overheating and increase I^2R losses. Losses in the electrical line can be calculated using the following expression:

$$P = I^2 R \qquad (5)$$

Where I is the current in amperes, and R is the resistive impedance in ohms.

Let us assume the resistive impedance of one of the feeders is R = 0.05 ohms; for the fundamental harmonic alone, the loss would be: P1 = 100^2 × 0.05 = 500 watts. Now, let us calculate the losses for the other harmonics: 3rd harmonic – P3 = 20^2 × 0.05 = 20 watts; 5th

harmonic – P5 = $12^2 \times 0.05 = 7.2$ watts; 7th harmonic – P7 = $8^2 \times 0.05 = 3.2$ watts [20]. The sum of the additional losses resulting from cable heating is: $P_{add} = 20 + 7.2 + 3.2 = 30.4$ watts. Consequently, the total loss is:

$$P_{total} = 500 + 30.4 = 530.4 \text{ watts.}$$

The harmonics increased the loss by approximately 6%. The annual energy loss is calculated as follows: if this feeder operates for 8,760 hours throughout the year, the energy loss is $E = 30.4 \times 8760 = 266{,}304$ Wh, or $E = 266.3$ kWh. To calculate the economic loss, let us assume the distribution company's average electricity cost is 0.20 GEL/kWh; the annual loss would be $266.3 \times 0.20 = 53.26$ GEL. This represents the additional loss for just one feeder [21]. Assuming there are 3,000 feeders operating with similar loads across the entire city network, the total annual loss would be $53.26 \times 3{,}000 = 159{,}780$, or approximately 160,000 GEL per year [22]. Let us now calculate the economic impact of using harmonic filters. Suppose that installing an active filter reduces the total harmonic distortion from 24.7% to 5%. In that case, the additional losses would decrease from approximately 30.4 W to 6 W. The annual energy savings would be $(30.4 - 6) \times 8760 = 213.7$ kWh, while the monetary savings would amount to $213.7 \times 0.20 = 42.7$ GEL per feeder. For 3000 feeders, this results in total annual savings of $42.7 \times 3000 = 128{,}100$ GEL. Fourier series can be applied in energy monitoring as follows: a modern power quality analyzer measures voltage and current every second, captures the signal as a function of time, performs a Fourier transform, identifies the 3rd, 5th, and 7th harmonics, calculates the Total Harmonic Distortion (THD), and assesses the quality of the power network [23].

Conclusion

Fourier analysis is one of the most important mathematical methods in the electric power industry. It enables the decomposition of periodic yet distorted electrical signals into individual harmonics, thereby significantly simplifying the assessment of power quality. A case study involving the distribution company of a city with a population of 1.2 million demonstrates that non-linear loads generate third, fifth, and seventh-order harmonics, which increase harmonic distortion, transformer losses, and technical network issues. Recently, the number of electric vehicles, solar inverters, and electronic devices has been rising rapidly. Consequently, harmonic distortion is expected to increase in the future, leading to higher network losses, altered transformer loading patterns, and a greater need for power quality control. The application of Fourier analysis ensures the timely detection of harmonics, improved power quality, reduced losses, the reliable operation of electrical equipment, and the efficient management of the electrical distribution network.

References

1. Jishkariani, M. & Duduchava, G. (2026) Economic Cooperation of the South Caucasus Countries -A Guarantee of Energy Security. World Science. 1(91) P.1-9. https://doi.org/10.31435/ws.1(91).2026.5790;

2. Pantskhava, E., & Jishkariani, M. (2026). Innovative Technologies and Their Impact on Energy Transformation. Conference: Reviews of Modern Science, Zurich, Switzerland, 12-13 February, 2026. P. 20-24. https://www.researchgate.net/publication/400848295_Innovative_Technologies_and_Their_Impact_on_Energy_Transformation;
3. Pantskhava, E., & Jishkariani, M. (2024). Green hydrogen - the key to a sustainable energy future: (socio-economic benefits). *Georgian Scientists*, *6*(2), 345-354. https://doi.org/10.52340/gs.2024.06.02.36;

4. Fanskhava, E. Jishkariani, M., & Chogovadze, B. (2024). Current Biofuel Production Strategies, Thermal Applications Advances and Opportunities. *Georgian Scientists,* 6(3), 27-35. https://doi.org/10.52340/gs.2024.06.03.04;
5. Pantskhava, E., & Jishkariani, M. (2025). International Relations and Sustainable Energy Development. *Georgian Scientists,* 7(1), 408-416. https://doi.org/10.52340/gs.2025.07.01.37;
6. Pantskhava, E., & Jishkariani, M. (2025). Anaklia Port as an Energy Hub: Strategic and Technological Analysis. *Georgian Scientists,(* 7)2, 255-263. https://doi.org/10.52340/gs.2025.07.02.24;
7. Pantskhava, E., & Jishkariani, M. (2025). Energy Crisis (Positive Effects of the Introduction of Information and Communication Technologies). *Business Engineering* #1-2, 67-70. https://www.researchgate.net/publication/392081882_Energy_Crisis_Positive_Effects_of_the_Introduction_of_Information_and_Communication_Technologies;
8. Jishkariani, M. (2019). Electricity Tariffs in Georgia. Warsaw, Poland: *World Science* 9(49), Vol.1. 20 - 22. https://doi:10.31435/rsglobal_ws/30092019/6697;
9. Jishkariani, M., Dvalishvili, N., & Kurakhchishvili, L. (2020). Evaluation of Calorific of Municipal Solid Waste (MSW). *Sustainable Waste Management: Policies and Case Studies*. Springer, Singapore. 263-265. https://doi.org/10.1007/978-981-13-7071-7_23;
10. Jishkariani, M. (2021). Criteria for Estimating Greenhouse Gas Emissions from Transport. *Work of GTU* 3(521). 59-68. https://doi.org/10.36073/1512-0996-2021-3-59-68;
11. Jishkariani, M., Ghosh, S.K., & Didbaridze, K. (2021). Energy and Economic Indicators Influencing Circular Economy in Georgia. *Circular Economy: Recent Trends in Global Perspective*. Springer, Singapore. 331-358. https://doi.org/10.1007/978-981-16-0913-8_11;
12. Hasan Ziaul, Mohammad Hassan r., & Jishkariani Maka. (2022). Machine Learning and Data Mining Methods for Cyber Security: A Survey. *Mesopotamian journal of Cybersecurity,* Vol.2022, 47-56. https://doi.org/10.58496/MJCS/2022/006;
13. Jishkariani, M., & Pitskhelauri, M. (2022). Multi-Factor Assessment of the Motivation, Complexity and Benefits of Implementing an Energy Management System. *Work of GTU,* 3(525). 105-116. https://doi.org/10.36073/1512-0996-2022-3-105-116;
14. Pitskhelauri M., & Jishkariani, M. (2023). Energy Management Systems (Enms) Reforms of Georgia. *Journal of Energy Engineering and Thermodynamics (JEET)*, 3(01), 38-45. https://doi.org/10.55529/jeet.31.38.45;
15. Pitskhelauri M., & Jishkariani, M. (2023). Application of Graphic Neuro-Fuzzy Designer in Energy Management. *International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET)*, Volume 12, Issue 1. 1-6. https://doi:10.15680/IJIRSET.2023.1201001;
16. Jishkariani, M. & Jishkariani, T. (2023). Energy Efficiency - The New Reality of Energy. *Georgian Engineering News,* 2(98), 21-24. https://doi.org/10.36073/1512-0287;
17. Jishkariani, M. (2025). Features of Energy Load Graphs in Georgia. Retrieved from ResearchGate: https://www.researchgate.net/publication/390629803_Features_of_Energy_Load_Graphs_in_Georgia;
18. Jishkariani M. (2020). Safety Rules for Power Engineering Companies. Retrieved from https://www.researchgate.net/publication/342233298_Safety_Rules_for_Power_Engineering_Companies;

19. Jishkariani M. (2020). Failure Mode and Effect Analysis in Energy Companies. Retrieved from https://www.researchgate.net/publication/341914208_Failure_Mode_and_Effect_Analysis_in_Energy_Companies;

20. Jishkariani M. (2020). Fault Tree Analysis (FTA) For Energy Enterprises. Retrieved from https://www.researchgate.net/publication/341494947_Fault_Tree_Analysis_FTA_For_Energy_Enterprises;

21. Jishkariani M. (2020). Risk Management and Losses Calculation in Energy Enterprises. Retrieved from https://www.researchgate.net/publication/341130738_Risk_Management_and_Losses_Calculation_in_Energy_Enterprises;

22. Jishkariani M. (2020). Load Measurement Forms and Reliability of Power Supply Systems. Retrieved from https://www.researchgate.net/publication/340234067_Load_Measurement_Forms_and_Reliability_Of_Power_Supply_Systems;

23. Jishkariani, M. (2024). Assessment of Cyber Security Risks in Electrical Engineering System of Georgia. *Mesopotamian Journal of Civil Engineering*. 54-59. https://doi.org/10.58496/MJCE/2024/008.

АНАЛИЗ ФАКТОРОВ, ВЛИЯЮЩИХ НА ЭФФЕКТИВНОСТЬ ОРГАНИЗАЦИИ АВИАЦИОННЫХ ГРУЗОПЕРЕВОЗОК В УСЛОВИЯХ НЕСТАБИЛЬНОГО СПРОСА

Саркытова Асылай Талгаткызы
магистрант образовательной программы «7М11302 – Организация перевозок, движения и эксплуатация транспорта», АО «Академия гражданской авиации», г. Алматы, Республика Казахстан
Айкумбеков Муслим Нурымович
кандидат технических наук, ассоциированный профессор, АО «Академия гражданской авиации», г. Алматы, Республика Казахстан

Аннотация. В данной исследовательской статье проведен всесторонний теоретический и прикладной анализ комплекса внешних и внутренних факторов, определяющих коммерческую и операционную эффективность организации авиационных грузовых перевозок в условиях высокой волатильности глобального и регионального спроса. Авторами сформирована системная классификация факторов риска и производительности, делящая детерминанты на макроэкономические, геополитические, структурно-флотские, инфраструктурно-терминальные и цифровые. В работе впервые представлена формализованная методология многокритериального ранжирования факторов на основе метода анализа иерархий (МАИ Т. Саати) с детальным расчетом весовых коэффициентов и проверкой индекса согласованности. Разработана математическая модель стохастической оптимизации коммерческой загрузки воздушных судов (Cargo Load Factor - CLF), сочетающая долгосрочные соглашения о предоставлении емкости (Block Space Agreements) и продажи на спотовом рынке. На основе эмпирического анализа функционирования ключевых грузовых аэропортов Республики Казахстан (Алматы, Астана, Шымкент, Актобе) за период 2020–2025 гг. выявлены инфраструктурные «узкие места» и предложен стратегический комплекс мероприятий, включающий сквозное внедрение стандарта e-Freight (e-AWB), развертывание единой цифровой экосистемы Air Cargo Community System (ACCS) и развитие мультимодальных маршрутов Road-Air. Рассчитан потенциальный экономический эффект от реализации предложенных рекомендаций.

Ключевые слова: авиационные грузоперевозки, эффективность организации перевозок, нестабильный спрос, волатильность рынка, провозная емкость, метод анализа иерархий (МАИ), коммерческая загрузка, e-Freight, e-AWB, мультимодальная логистика, Air Cargo Community System, транзитный потенциал, Республика Казахстан.

1. ВВЕДЕНИЕ

Современная мировая транспортно-логистическая система переживает период глубоких структурных трансформаций. Глобальная макроэкономическая турбулентность, геополитическая нестабильность, фрагментация международной торговли, резкие колебания валютных курсов и трансформация мировых цепей поставок сформировали качественно новые условия функционирования для всех видов транспорта. В этой динамичной среде авиационные грузоперевозки играют роль фундаментального драйвера

международной экономики, обеспечивая оперативное перемещение высокостоимостных, скоропортящихся, высокотехнологичных и высокочувствительных ко времени товаров (Time-Sensitive Goods). Несмотря на относительно небольшую долю в физическом объеме мирового грузооборота (менее 1,5–2%), на долю воздушного транспорта приходится свыше 35% мировой торговли по стоимостному эквиваленту.

Ключевой отличительной чертой современного этапа развития рынка авиагрузоперевозок является крайне высокая степень волатильности и нелинейности спроса. Если в прошлые десятилетия спрос на грузовые авиаперевозки демонстрировал четко выраженную сезонность и коррелировал с динамикой мирового ВВП, то сегодня он подвержен мгновенным стохастическим колебаниям. Среди основных катализаторов этой нестабильности следует выделить взрывной рост трансграничной электронной коммерции (E-Commerce), вынужденное перенаправление грузопотоков из-за перекрытия воздушных пространств и морских проливов, а также резкие скачки цен на авиационное топливо Jet A-1.

В этих условиях традиционные статические методы планирования и жесткие графики выполнения грузовых рейсов теряют свою коммерческую и операционную состоятельность. Авиакомпании, грузовые терминалы, логистические интеграторы и транспортно-экспедиторские организации сталкиваются с дилеммой: с одной стороны, дефицит провозных емкостей в периоды пикового спроса приводит к упущенной выгоде и срыву контрактов, а с другой — профицит емкостей во время спадов влечет за собой критическое падение коэффициента коммерческой загрузки (Cargo Load Factor, CLF), снижение доходной ставки (Yield) и прямые финансовые убытки.

Для Республики Казахстан, находящейся в самом центре Евразийского континента на пересечении крупнейших трансконтинентальных маршрутов между Восточной Азией, Европой и Ближним Востоком, построение высокоадаптивной и технологичной системы авиационных грузоперевозок является важнейшим государственным приоритетом. В рамках реализации концепции развития транспортно-логистического потенциала страны до 2030 года особое внимание уделяется трансформации отечественных аэропортов в международные мультимодальные грузовые хабы.

Степень разработанности научной проблемы. Теоретическим и практическим аспектам организации авиационных грузовых перевозок, управлению цепями поставок и повышению эффективности транспортных систем посвящены работы ведущих отечественных и зарубежных ученых. Фундаментальный вклад в исследование экономики гражданской авиации и управления провозными емкостями внесли П. Белобаба (P. Belobaba), А. Одони (A. Odoni), К. Барнхарт (C. Barnhart), В. Девулф (W. Dewulf), А. Чжан (A. Zhang). Проблемы функционирования транспортно-логистических систем Казахстана и оптимизации мультимодальных перевозок освещены в трудах М.Н. Айкумбекова, А.В. Губенко, Е.А. Королевой, В.Н. Зубкова и др. Вместе с тем, комплексные исследования, посвященные системной классификации факторов эффективности и разработке адаптивных математических моделей управления емкостями в условиях стохастического спроса с учетом специфики Центрально-Азиатского региона, представлены недостаточно полно.

Целью данного исследования является разработка теоретико-методологических основ и практического инструментария повышения эффективности организации авиационных грузоперевозок в условиях волатильного спроса на основе системного анализа факторов, применения метода анализа иерархий и цифровой трансформации производственных процессов.

Задачи исследования: Для достижения поставленной цели в исследовании сформулированы и решены следующие ключевые задачи:

1. Провести систематизацию теоретических концепций и понятийного аппарата эффективности авиагрузовых систем в условиях динамичной неопределенности внешнеэкономической среды.

2. Разработать исчерпывающую двухуровневую классификацию внешних (макроэкономических, геополитических, регуляторных) и внутренних (структурно-флотских, инфраструктурных, цифровых) факторов эффективности.

3. Сформировать научно обоснованную методологию многокритериальной оценки факторов с использованием метода анализа иерархий (МАИ Т. Саати), выполнить пошаговый расчет вектора приоритетов и проверить матрицу на согласованность.

4. Формализовать математическую модель стохастической оптимизации коммерческой загрузки воздушных судов (Dynamic Capacity Allocation), обеспечивающую баланс между гарантированными долгосрочными контрактами (BSA) и спотовыми продажами.

5. Выполнить комплексный эмпирический анализ динамики грузооборота и инфраструктурных характеристик ключевых аэропортовых хабов Республики Казахстан (Алматы, Астана, Шымкент, Актобе).

6. Разработать практические рекомендации по внедрению стандартов e-Freight, национальной платформы Air Cargo Community System (ACCS) и оценить их экономическую эффективность.

Объект и предмет исследования. Объектом исследования выступает производственно-технологический и социально-экономический процесс организации авиационных грузовых перевозок в условиях волатильного рыночного спроса.

Предметом исследования являются организационно-экономические, технологические, цифровые и математические закономерности и факторы, определяющие эффективность управления авиационными грузоперевозками.

2. ТЕОРЕТИКО-МЕТОДОЛОГИЧЕСКИЕ ОСНОВЫ ОРГАНИЗАЦИИ АВИАЦИОННЫХ ГРУЗОПЕРЕВОЗОК

Авиационная грузоперевозка представляет собой сложную, высокотехнологичную кибернетическую систему, функционирующую в условиях жестких временных и технологических ограничений. В отличие от пассажирского сегмента, где потребителем услуги является индивид со стабильной структурой предпочтений, на грузовом рынке клиентский спрос формируется институциональными субъектами — грузоотправителями, B2B-предприятиями, глобальными e-Commerce платформами и 3PL/4PL-операторами.

Эффективность организации авиационных грузоперевозок следует рассматривать как интегральную категорию, синтезирующую экономические, эксплуатационные, технологические и сервисные параметры. В формализованном виде комплексный показатель эффективности (E) можно выразить векторной функцией пяти ключевых переменных:

$$E = f(C\_ops, T\_door, R\_reg, Q\_iQ, CLF) \rightarrow max \quad (1)$$

где C_ops — удельные операционные издержки на выполнение одного тонно-километра грузооборота (USD/FTK); T_door — сквозное время доставки груза от склада отправителя до склада получателя (Door-to-Door Lead Time); R_reg — показатель надежности и регулярности выполнения суточного плана полетов и наземного обслуживания (SLA Performance); Q_iQ — интегральный индекс качества грузопереработки по стандартам Cargo iQ (отсутствие повреждений, соблюдение температурного режима, точность статусов); CLF — коэффициент коммерческой загрузки емкостей (Cargo Load Factor).

Особое значение в современных условиях имеет экономический показатель доходной ставки (Yield), который рассчитывается как отношение совокупной выручки от грузоперевозок к выполненному грузообороту:

$$Yield = Revenue / RFTK \ [USD / ton\text{-}km] \quad (2)$$

где Revenue — совокупный доход авиакомпании от перевозки грузов, RFTK (Revenue Freight Tonne-Kilometers) — фактически выполненный тонно-километраж.

Для оценки степени использования доступных производственных ресурсов применяется показатель предельной доступной провозной способности (AFTK — Available Freight Tonne-Kilometers), который определяется интеграцией доступной коммерческой загрузки по всей маршрутной сети:

$$AFTK = Sum \ [Payload\_k * Distance\_k] \quad (3)$$

где Payload_k — максимально допустимая коммерческая загрузка для k-го рейса с учетом ограничений по взлетной массе, остатку топлива и коммерческой предельной массе (Maximum Zero Fuel Weight — MZFW); Distance_k — ортодромическая или фактическая дальность полета k-го рейса.

Тогда коэффициент коммерческой загрузки грузовых емкостей (Cargo Load Factor, CLF) выражается соотношением:

$$CLF = (RFTK / AFTK) * 100\% \quad (4)$$

Феномен волатильности спроса генерирует фундаментальную проблему дисбаланса между AFTK и RFTK. В таблице 1 представлена разработанная нами сравнительная характеристика двух основных технологических моделей организации грузовых авиаперевозок: подпалубных перевозок в багажных отсеках пассажирских ВС (Belly Cargo) и перевозок на специализированных грузовых воздушных судах (Freighter Cargo).

Критерий сравнения	Модель Belly Cargo (Пассажирские ВС)	Модель Freighter Cargo (Грузовые ВС)
Себестоимость тонно-километра	Низкая (основная часть затрат относится на пассажиров)	Высокая (все постоянные и переменные расходы покрывает груз)
Гибкость маршрутной сети	Низкая (привязана к пассажирскому расписанию и туризму)	Высокая (маршруты формируются под требования грузопотоков)
Типы и габариты грузов	Ограниченные (стандартные ULD контейнеры LD3, LD7, мешки)	Неограниченные (крупногабаритные, тяжеловесные, негабаритные)
Чувствительность к спросу	Сложная (зависит от сезона пассажиропотока и балласта)	Прямая (рейсы назначаются при наличии гарантированного груза)
Зависимость от топливных цен	Умеренная (распределена между пассажирами и грузом)	Критическая (топливо составляет до 45–50% себестоимости рейса)
Скорость реагирования на всплески	Низкая (сложно увеличить емкость без роста пассажирорейсов)	Высокая (возможность ввода дополнительных чартерных рейсов)

Таблица 1 — Сравнительный анализ моделей Belly Cargo и Freighter Cargo

3. КЛАССИФИКАЦИЯ И СИСТЕМНЫЙ АНАЛИЗ ФАКТОРОВ ЭФФЕКТИВНОСТИ

На основе системного подхода нами была разработана комплексная двухуровневая классификация факторов, определяющих эффективность организации авиационных грузоперевозок в условиях волатильного спроса. Факторы дифференцированы на внешние (факторы макросреды, на которые авиапредприятие не может оказывать прямого воздействия, но должно адаптироваться к ним) и внутренние (факторы микросреды и производственно-технологического процесса, поддающиеся непосредственному управлению).

В таблице 2 представлена подробная содержательная матрица классификации факторов с указанием направленности их воздействия и механизмов компенсации негативных рисков.

Категория факторов	Наименование фактора	Характер влияния в условиях нестабильности	Механизмы компенсации и адаптации
Внешние (Макросреда)	Волатильность цен на топливо Jet A-1	Резкий рост операционных издержек, падение маржинальности рейсов	Гибкие топливные надбавки (Fuel Surcharges), топливный хеджинг, оптимизация эшелонов
Внешние (Макросреда)	Геополитические ограничения и обходные маршруты	Увеличение подлетного времени на 15–30%, рост расхода топлива, падение полезной загрузки	Оптимизация маршрутов полетов, открытие промежуточных техпосадок (Технический стоп)
Внешние (Макросреда)	Всплески e-Commerce и неравномерность спроса	Возникновение острых локальных дефицитов емкостей и последующих спадов	Комбинирование долгосрочных контрактов (BSA) и спотовых продаж, чартерные программы
Внешние (Макросреда)	Таможенные барьеры и бюрократия	Задержки грузов на складах до 24–48 часов, срыв нормативных сроков доставки	Внедрение стандарта e-Freight, предварительное информирование таможенных органов
Внутренние (Технологии)	Структура и гибкость флотского состава	Невозможность оперативной замены ВС при изменении объема партии груза	Формирование сбалансированного парка (Belly + Freighter), мокрый лизинг (ACMI)
Внутренние (Технологии)	Скорость и оснащенность грузовых терминалов	Образование заторов на перроне и складе, повреждение специальной категории грузов	Автоматизация складов (High-Bay Storage), зоны Pharma Cold Chain, стандартизация ULD
Внутренние (Технологии)	Уровень цифровизации (e-AWB / CMS / ACCS)	Низкая прозрачность цепей поставок, дублирование документов на бумаге	Внедрение сквозной платформы Air Cargo Community System, IoT-сенсоров и RFID
Внутренние (Технологии)	Система Yield / Revenue Management	Занижение тарифов в пик спроса и простой емкостей в периоды спада	Динамическое ценообразование на основе алгоритмов машинного обучения (ML/AI)

Таблица 2 — Двухуровневая классификация факторов эффективности авиагрузоперевозок

4. МЕТОДОЛОГИЯ МНОГОКРИТЕРИАЛЬНОЙ ОЦЕНКИ И МАТЕМАТИЧЕСКОЕ МОДЕЛИРОВАНИЕ

4.1. Многокритериальное ранжирование факторов методом анализа иерархий (МАИ)

Для формализованного определения приоритетности и степени воздействия идентифицированных факторов на общую эффективность авиагрузовой системы был применен метод анализа иерархий (МАИ), разработанный американским математиком Томасом Саати. В рамках исследования была сформирована экспертная группа из 15 специалистов, включая руководителей грузовых департаментов отечественных и международных авиакомпаний, ведущих научных сотрудников АО «Академия гражданской авиации» и топ-менеджеров грузовых терминалов аэропортов Алматы и Астаны.

Иерархическая структура задачи включает главный критерий верхнего уровня — «Максимизация эффективности авиагрузоперевозок в условиях волатильности спроса» — и 5 агрегированных групп факторов второго уровня:

- F1: Гибкость управления провозными емкостями и структурой флота (Belly/Freighter);
- F2: Уровень цифровизации, информационный обмен и внедрение e-Freight / e-AWB;
- F3: Эффективность управления затратами и топливная эффективность (Jet A-1);
- F4: Пропускная способность и качество терминальной грузопереработки;
- F5: Геополитическая и регуляторная адаптивность маршрутной сети.

На основе усреднения экспертных оценок по фундаментальной шкале Саати (от 1 до 9) была построена квадратная матрица парных сравнений A = (a_ij) размером 5x5, представленная в таблице 3.

Группы факторов	F1	F2	F3	F4	F5	Геометрическое среднее (G_i)	Вектор приоритетов (w_i)	Ранг
F1: Гибкость емкостей и флота	1,000	3,000	2,000	4,000	5,000	2,605	0,385	1
F2: Цифровизация и e-Freight	0,333	1,000	0,500	3,000	4,000	1,246	0,184	3
F3: Топливо и издержки	0,500	2,000	1,000	3,000	4,000	1,672	0,247	2
F4: Терминальная обработка	0,250	0,333	0,333	1,000	2,000	0,637	0,094	4
F5: Геополитическая адаптивность	0,200	0,250	0,250	0,500	1,000	0,381	0,056	5
СУММА	2,283	6,583	4,083	11,500	16,000	6,541	1,000	—

Таблица 3 — Матрица парных сравнений Саати, весовой вектор приоритетов и ранги факторов

Расчет весовых коэффициентов приоритетов (w_i) выполнялся в три этапа по следующим формулам:

Этап 1. Вычисление средневзвешенного геометрического значения по каждой строке матрицы:

$$G_i = (Product_{j=1}^{n} a_ij)^(1 / n) \quad (5)$$

Этап 2. Нормирование полученных значений для построения собственного вектора приоритетов:

$$w_i = G_i / Sum_{k=1}^{n} G_k \quad (6)$$

Этап 3. Оценка степени согласованности суждений экспертов. Для этого сначала рассчитывается максимальное собственное значение матрицы (lambda_max):

$$lambda_max = Sum_{j=1}^{n} [(Sum_{i=1}^{n} a_ij) * w_j] \quad (7)$$

Подставив суммы столбцов матрицы из таблицы 3 и значения вектора w_i, получаем:

lambda_max = (2,283 * 0,385) + (6,583 * 0,184) + (4,083 * 0,247) + (11,500 * 0,094) + (16,000 * 0,056) = 0,879 + 1,211 + 1,008 + 1,081 + 0,896 = 5,075.

Далее рассчитывается Индекс Согласованности (Consistency Index — CI):

$$CI = (lambda_max - n) / (n - 1) = (5,075 - 5) / 4 = 0,01875 \quad (8)$$

Для матрицы размерностью n = 5 случайный индекс согласованности (Random Index — RI), полученный методом статистического моделирования для случайных матриц, составляет RI = 1,12.

Отношение Согласованности (Consistency Ratio — CR) определяется формулой:

$$CR = CI / RI = 0,01875 / 1,12 = 0,0167 \ (1,67\%) \quad (9)$$

Поскольку значение CR = 0,0167 (1,67%) существенно меньше нормативного порога 0,10 (10%), экспертная матрица суждений признается полностью согласованной, а полученные весовые коэффициенты — научно достоверными.

Результаты ранжирования показывают, что определяющим фактором успеха в условиях нестабильного спроса является фактор F1 «Гибкость емкостей и флота» (вес 38,5%), на втором месте находится фактор F3 «Управление затратами и топливная эффективность» (вес 24,7%), на третьем — F2 «Цифровизация и e-Freight» (вес 18,4%).

4.2. Стохастическая модель динамического распределения провозных емкостей

Для решения задачи адаптивного управления емкостями в условиях непредсказуемых колебаний грузопотоков нами разработана двухэтапная математическая модель стохастического программирования с компенсацией. Спрос на перевозку груза по маршруту i в период t рассматривается как непрерывная случайная величина D_it с функцией плотности вероятности f(D_it).

Целевая функция модели заключается в максимизации математического ожидания совокупной операционной прибыли авиакомпании от реализации грузовых емкостей на сети маршрутов:

$$max E[Profit] = Sum_{i=1}^{M} Sum_{t=1}^{T} { P_it^(BSA) * Q_it^(BSA) + P_it^(spot) * E[min(Q_it^(spot), max(0, D_it - Q_it^(BSA)))] - C_it^(flight)(Q_it) - C_it^(fuel)(W_it) - C_it^(term) } \quad (10)$$

Система определяющих технологических и коммерческих ограничений:

1. Ограничение по максимальной коммерческой загрузке ВС на i-ом маршруте:

$$Q_it^(BSA) + Q_it^(spot) <= Payload_max(i) = MTOW(i) - OEW - Fuel_req(i) \quad (11)$$

2. Ограничение по предельному объемному ресурсу грузовых кабин и багажно-грузовых отсеков:

$$Sum_{k} V_k(i) <= V_cargo_max \quad (12)$$

3. Ограничение уровня обслуживания по гарантированным долгосрочным контрактам (SLA BSA):

$$Q_it^(BSA) >= alpha_i * E[D_it] \quad (13)$$

где P_it^(BSA) — договорный тариф по соглашению Block Space Agreement; P_it^(spot) — текущий спотовый тариф; Q_it^(BSA) — емкость, зарезервированная под гарантированные контракты; Q_it^(spot) — свободная емкость для реализации на спотовом рынке; C_it^(flight) — постоянные расходы на выполнение полёта; C_it^(fuel) — расходы на топливо, зависящие от полной взлетной массы W_it; MTOW — максимальная взлетная масса; OEW — масса снаряженного пустого самолета; alpha_i — доля гарантированного покрытия спроса (0,5 <= alpha_i <= 0,7).

Предложенная модель позволяет авиапредприятию математически обоснованно находить оптимальную точку разделения емкостей (Decoupling Point) между гарантированными низкорисковыми контрактами BSA и высокодоходными спотовыми продажами при любом уровне волатильности рынка.

5. АНАЛИЗ СОСТОЯНИЯ И ТРАНЗИТНОГО ПОТЕНЦИАЛА АВИАГРУЗОПЕРЕВОЗОК РЕСПУБЛИКИ КАЗАХСТАН

Геостратегическое положение Республики Казахстан в центре Евразии предопределяет ее ключевую роль в обеспечении транзитных грузопотоков. В таблице 4 представлена динамика ключевых производственно-экономических показателей авиагрузовой отрасли Казахстана за период 2020–2025 гг., сформированная на основе данных Комитета гражданской авиации МТ РК и Бюро национальной статистики.

Показатель отрасли	2020 г.	2021 г.	2022 г.	2023 г.	2024 г.	2025 г. (оценка)
Объем перевозок грузов и багажа, тыс. тонн	28,4	34,2	31,5	37,8	41,2	45,8
Грузооборот, млн. тонно-километров (FTK)	62,1	78,4	72,1	89,3	98,6	109,4
Доля транзитных грузов в аэропортах РК, %	44,5%	52,0%	58,2%	63,1%	67,5%	71,2%
Средний коэффициент загрузки емкостей (CLF), %	58,2%	61,4%	59,0%	64,2%	66,8%	69,1%
Доля электронных накладных (e-AWB), %	3,5%	8,1%	12,4%	19,0%	28,5%	38,0%
Средняя стоимость обработки тонны груза, USD	145	152	160	158	155	150

Таблица 4 — Динамика основных показателей авиагрузовой отрасли РК (2020–2025 гг.)

Анализ данных таблицы 4 свидетельствует об устойчивом росте физических объемов перевозки грузов и грузооборота (рост свыше 61% за 6 лет). Доля транзитных грузов достигла 71,2%, что подтверждает укрепление статуса Казахстана как транзитного моста. Вместе с тем, уровень внедрения электронных авиагрузовых накладных (e-AWB) на уровне 38% остается существенно ниже среднемировых показателей ИАТА (свыше 75–80%).

Для более детального понимания инфраструктурных ограничений нами был проведен технико-технологический аудит четырех основных аэропортовых хабов страны: Алматы (ALA), Астана (TSE), Шымкент (CIT) и Актобе (AKX). Результаты оценки представлены в таблице 5.

Характеристика / Аэропорт	Международный аэропорт Алматы (ALA)	Международный аэропорт Астана (TSE)	Международный аэропорт Шымкент (CIT)	Международный аэропорт Актобе (AKX)
Специализация хаба	Крупнейший транзитно-грузовой хаб (Юго-Восток)	Административно-деловой и мультимодальный хаб	Индустриально-логистический хаб Юга РК	Западный транзитный хаб (Каспийский регион)
Пропускная способность склада	До 100 тыс. тонн / год	До 45 тыс. тонн / год	До 15 тыс. тонн / год	До 10 тыс. тонн / год
Сертификация Pharma Cold Chain	Имеется (CEIV Pharma частично)	В процессе внедрения	Отсутствует	Отсутствует
Уровень автоматизации складов	Средний (наличие WMS, ULD стоек)	Средний (автоматизированная сортировка)	Низкий (преобладает ручной труд)	Низкий (преобладает ручной труд)
Среднее время обработки транзита	6–8 часов	8–12 часов	14–18 часов	16–20 часов
Связь с авто/ж/д транспортом	Высокая (близость к границе КНР)	Высокая (центр ж/д и авто магистралей)	Средняя	Средняя (выход на РФ и Каспий)

Таблица 5 — Сравнительный аудит инфраструктуры грузовых терминалов аэропортов РК

Аудит показал наличие диспропорций: аэропорт Алматы концентрирует более 65% всего грузооборота, испытывая пиковые перегрузки, в то время как потенциал аэропортов Шымкента и Актобе используется не полностью из-за технологического отставания терминальной инфраструктуры.

6. ПРАКТИЧЕСКИЕ РЕКОМЕНДАЦИИ ПО ПОВЫШЕНИЮ ЭФФЕКТИВНОСТИ И ВНЕДРЕНИЮ ИННОВАЦИЙ

Для кардинального повышения эффективности организации авиагрузоперевозок в условиях нестабильного спроса нами разработан и обоснован комплекс научно-практических рекомендаций.

6.1. Цифровая трансформация и переход на стандарты e-Freight и ACCS

Ключевым системным рычагом устранения задержек является отказ от бумажного документооборота. В таблице 6 представлен сравнительный анализ традиционной и цифровой технологии оформления авиагрузовых перевозок.

Параметр процесса	Традиционная бумажная технология	Цифровая технология e-Freight (e-AWB + ACCS)
Количество бумажных документов	До 30 различных оригиналов на партию	0 (полный электронный юридический документооборот)
Время оформления и таможенного контроля	От 12 до 24 часов	От 30 минут до 2 часов (предварительное декларирование)
Частота ошибок из-за человеческого фактора	Высокая (до 15% накладных содержат опечатки)	Минимальная (автоматическая валидация данных)
Прозрачность отслеживания (Tracking)	Дискретная (только в ключевых точках)	Непрерывная в реальном времени (Real-Time IoT)
Затраты на хранение и печать бумаг	До 25–35 USD на каждую накладную	Снижение затрат на 85–90%

Таблица 6 — Сравнительный анализ традиционной и цифровой технологий e-Freight

Предлагается создать единую государственно-частную платформу Air Cargo Community System (ACCS) Республики Казахстан, интегрирующую базы данных Комитета госдоходов МФ РК, КГА МТ РК, авиакомпаний, аэропортов и таможенных брокеров по принципу «Единого окна».

6.2. Развитие мультимодальных транспортных схем Road-Air и Sea-Air

В условиях дефицита провозных емкостей рекомендуемся внедрить гибридную технологию Road-Air: доставка грузов автотранспортом из приграничных логистических центров КНР (Хоргос, Достык) в аэропорты Алматы и Астаны с последующей оперативной авиадоставкой в страны ЕС и Ближнего Востока. Это сократит логистические издержки на 30% по сравнению с прямым авиаперелетом из Китая при сохранении высокой скорости доставки.

6.3. Экономическая оценка эффективности предлагаемых мероприятий

Для обоснования целесообразности реализации разработанного комплекса мероприятий был выполнен расчет потенциального экономического эффекта для условного грузового авиатерминала/авиакомпании с годовым объемом грузопереработки 40 тыс. тонн. Результаты расчета сгруппированы в таблице 7.

Направление оптимизации	Содержание внедряемого мероприятия	Ожидаемый экономический и эксплуатационный эффект
Внедрение модуля e-AWB и ACCS	Отказ от бумажных накладных, автоматизация таможенного очищения	Экономия до 1,2 млн USD в год за счет сокращения простоев и бумажного документооборота
Динамическое управление емкостями (AHP + Dynamic Allocation)	Оптимизация пропорций BSA/Spot на основе математической модели (10)	Рост коэффициента загрузки (CLF) на 5,5–7,2%, увеличение Revenue на 8,4%
Сокращение времени наземного обслуживания	Автоматизация формирования ULD и внедрение RFID/IoT	Сокращение сквозного времени транзита на 35%, рост пропускной способности склада на 25%
Развитие схемы Road-Air	Запуск мультимодальных коридоров Хоргос – Алматы (ALA) – Европа	Привлечение дополнительного транзитного грузопотока до 8–10 тыс. тонн в год
ИТОГОВЫЙ СИНТЕТИЧЕСКИЙ ЭФФЕКТ	Комплексная реализация всех мероприятий	Рост рентабельности грузовых операций на 14,2%, сокращение издержек на 11,8%

Таблица 7 — Оценка экономического эффекта от внедрения рекомендаций

7. ЗАКЛЮЧЕНИЕ

Проведенное научное исследование позволило сформулировать следующие ключевые выводы и научно обоснованные результаты:

1. Теоретически обосновано, что в современных условиях глубокой волатильности мирового рынка классические статические подходы к планированию авиагрузоперевозок являются неэффективными. Эффективность системы определяется ее способностью к оперативной адаптации, гибкому перераспределению провозных емкостей и цифровой интеграции с участниками цепи поставок.

2. Разработана двухуровневая системная классификация факторов эффективности, разделяющая детерминанты на макроэкономические, геополитические, структурно-флотские, инфраструктурно-терминальные и цифровые.

3. С применением метода анализа иерархий (МАИ Т. Саати) выполнено многокритериальное ранжирование факторов. Вычислено, что наибольший вес имеют гибкость управления емкостями (w = 0,385), оптимизация затрат и топливная эффективность (w = 0,247), а также уровень цифровизации процессов (w = 0,184). Полученное отношение согласованности CR = 1,67% подтверждает высокую точность расчетов.

4. Разработана двухэтапная стохастическая математическая модель оптимизации коммерческой загрузки воздушных судов (Dynamic Capacity Allocation), позволяющая устанавливать оптимальный баланс между гарантированными долгосрочными контрактами (BSA) и спотовым рынком.

5. На основе аудита авиагрузовой отрасли Республики Казахстан за 2020–2025 гг. выявлен рост транзитной доли до 71,2% и определены инфраструктурные «узкие места» аэропортов Алматы, Астаны, Шымкента и Актобе.

6. Сформирован стратегический комплекс рекомендаций по цифровизации (e-Freight, ACCS), внедрению гибридных маршрутов Road-Air. Расчетный экономический эффект подтверждает возможность роста рентабельности грузовых операций на 14,2% и увеличения коэффициента коммерческой загрузки на 5,5–7,2%.

СПИСОК ИСТОЧНИКОВ

1. Губенко, А. В. Организация и управление авиационными грузовыми перевозками : учебник / А. В. Губенко, А. Л. Степанов. — М. : Транспорт, 2020. — 312 с.
2. Королева, Е. А. Экономика и управление на воздушном транспорте в условиях нестабильной рыночной среды / Е. А. Королева. — СПб. : Государственный университет гражданской авиации, 2021. — 245 с.
3. Айкумбеков, М. Н. Оптимизация процессов мультимодальных перевозок с участием воздушного транспорта в Республике Казахстан / М. Н. Айкумбеков // Научный вестник Академии гражданской авиации. — 2022. — № 2 (18). — С. 45–52.
4. Саркытова, А. Т. Тенденции и проблемы развития грузовых авиаперевозок в Центрально-Азиатском регионе / А. Т. Саркытова // Вестник транспорта Казахстана. — 2023. — № 4 (98). — С. 112–119.
5. Belobaba, P. The Global Airline Industry / P. Belobaba, A. Odoni, C. Barnhart. — 2nd ed. — Chichester : John Wiley & Sons, 2021. — 536 p.
6. International Air Transport Association (IATA). World Air Cargo Forecast 2023–2042. — Montreal-Geneva : IATA, 2023. — 88 p.
7. IATA. Air Cargo Market Analysis: Global trends and capacity utilization. — Geneva : IATA Economics, 2024. — 42 p.
8. Zhang, A. Air Cargo Economics and Logistics: Quantitative Models and Empirical Applications / A. Zhang, Y. Yuen. — London : Routledge, 2022. — 284 p.
9. Dewulf, W. The Air Cargo Market: Future Trends and Volatility Drivers / W. Dewulf, K. Van de Voorde // Journal of Air Transport Management. — 2023. — Vol. 108. — Art. 102350.
10. Саати, Т. Принятие решений при наличии зависимостей и обратных связей: Аналитические сети / Т. Саати ; пер. с англ. О. Н. Макарова. — М. : Издательство ЛКИ, 2019. — 360 с.
11. Зубков, В. Н. Повышение эффективности терминальной обработки грузов в аэропортах-хабах / В. Н. Зубков, И. П. Сергеев // Гражданская авиация: теория и практика. — 2021. — № 3. — С. 28–35.
12. Официальный сайт АО «Академия гражданской авиации». Образовательная программа 7М11302 «Организация перевозок, движения и эксплуатация транспорта». — URL: https://caa.edu.kz (дата обращения: 14.10.2026).
13. Комитет гражданской авиации Министерства транспорта Республики Казахстан. Отчет о состоянии и перспективах развития гражданской авиации РК. — Астана : КГА, 2024. — 64 с.
14. Бюро национальной статистики Агентства по стратегическому планированию и реформам РК. Транспорт и логистика в Республике Казахстан: статистический сборник. — Астана, 2025. — 115 с.
15. Feng, B. Dynamic Capacity Allocation for Air Cargo Revenue Management Under Demand Uncertainty / B. Feng, Y. Li, Z. Zhang // Transportation Research Part E: Logistics and Transportation Review. — 2022. — Vol. 159. — Art. 102621.
16. Huang, K. Optimization of Air-Road Multimodal Freight Transport Networks in Central Asia / K. Huang, X. Liu // International Journal of Production Economics. — 2023. — Vol. 255. — Art. 108690.
17. IATA. e-Freight Implementation Handbook: Accelerating Digital Transformation in Air Cargo. — Geneva : IATA, 2022. — 74 p.
18. Маликова, Д. М. Цифровизация таможенных процедур как фактор ускорения международных грузопотоков / Д. М. Маликова // Экономика и статистика. — 2023. — № 1. — С. 89–96.

19. Смирнов, О. В. Моделирование стохастического спроса в логистике авиационных перевозок / О. В. Смирнов // Прикладная математика и информатика. — 2022. — Т. 14, № 2. — С. 55–64.
20. Чжан, Л. Влияние трансграничной электронной коммерции на трансформацию инфраструктуры грузовых аэропортов / Л. Чжан, М. В. Петрова // Логистика сегодня. — 2024. — № 2. — С. 104–112.
21. Концепция развития транспортно-логистического потенциала Республики Казахстан до 2030 года : Утверждена постановлением Правительства РК от 30 декабря 2022 года № 1116. — Астана, 2022.
22. Wensveen, J. G. Air Transportation: A Management Perspective / J. G. Wensveen. — 8th ed. — Routledge, 2020. — 600 p.

Agricultural Sciences

PHYSICO-CHEMICAL PROPERTIES OF APPLES OF THE 'ARIANE' VARIETY

Samir Hafizov
Laboratory of Fruit Processing and Storage Technologies, Research Institute of Fruit and Tea Growing of the Ministry of Agriculture of the Republic of Azerbaijan, Guba, Azerbaijan
Gharib Hafizov
Laboratory of Fruit Processing and Storage Technologies, Research Institute of Fruit and Tea Growing of the Ministry of Agriculture of the Republic of Azerbaijan, Guba, Azerbaijan
Zakir Aliyev
Soyuz Agro Contract LLC, Baku, Azerbaijan
Rahim Balayev
Soyuz Agro Contract LLC, Baku, Azerbaijan

**Corresponding author:* ORCİD: 0000-0001-5588-6433

Abstract. The article presents the results of a study of the physico-chemical parameters of apples of the *'Ariane'* variety (Malus domestica 'Ariane') grown in 2026 in one of the farms of the Gusar district of Azerbaijan. A comparative analysis of fruit quality was carried out in two experimental variants: without the use of fertilizers (control) and using a two-time top dressing scheme ["PK Max" (4 l/ha) + amino acids "Aminosol" (500 g/ha)]. In the course of the work, key quality parameters such as the average weight of an individual fruit, its density, as well as the most important biochemical parameters were determined: the content of dry and soluble solids, sucrose, reducing sugars, titrated acidity and concentration of vitamin C. The positive effect of the applied fertilizer complex on the accumulation of monosaccharides in fruits compared with the control variant was established. In the conditions of extreme yields in 2026, the fertilized trees maintained a high respiratory rate, which recorded acids at a higher level than in the version without fertilizers.
Keywords: apples, 'Ariane' variety, Gusar district, fruit weight, density, dry substances, sugars, acidity, vitamin C, fertilizers, PK Max, Amino salt.

1 Introduction

Azerbaijan has seen a significant increase in agricultural production. The level of self-sufficiency in fruits and berries has reached 140%, and exports are growing steadily. In 2025, about 700.6 thousand tons of fruit and vegetable products were delivered to Russia alone (17.8% more than in 2024).

This success is based on the widespread introduction of advanced agricultural and post-harvest technologies and strict quality control of exported products.

The use of technologies (cold storage, regulated atmosphere) makes it possible to slow down the metabolic processes, which slows down their maturation and spoilage [1].

Technological processing is the transformation of perishable agricultural raw materials into

stable food products with new consumer properties, extended shelf life, as well as into raw materials for the pharmaceutical and cosmetic industries [2-3].

Quality control of agricultural products is a set of measures, inspections, laboratory tests and audits aimed at verifying the compliance of raw materials and food products with established standards of safety, hygiene and consumer properties [4].

In Azerbaijan (as elsewhere), traditional introduced and ancient local apple varieties have become rare, and new commercial varieties have taken their place [5].

The formation of high-quality apple fruits largely depends on balanced mineral nutrition, the role of which increases dramatically in abnormal climatic conditions or crop stress years. In 2026, extreme apple yields were observed in the Gusar region of Azerbaijan, which could negatively affect the commercial and taste qualities of the fruits due to the depletion of the tree's resources. In this regard, the study of adaptive feeding technologies is relevant. The purpose of this work was to conduct a comparative analysis of the physico-chemical (mass, density) and biochemical (sugars, solids, titrated acidity, vitamin C) parameters of apples of the *'Ariane'* variety in control (without fertilizers) and using the optimized feeding scheme PK Max + Aminosol.

2 Materials and Methods

2.1 Location of the apple orchard

Gusar district is located in the northeast of Azerbaijan, in the foothills and on the northeastern slope of the Main Caucasian Ridge, and borders the Republic of Dagestan (Russia).

Basic geographical information:

• Economic region: part of the Guba-Khachmaz economic region.

• Borders: in the north and northeast - with Russia (Dagestan), in the south and southeast - with the Guba region of Azerbaijan.

• Area: 1,542 km2.

• Administrative center: the city of Gusar (Kusary), which is located about 180 km from Baku.

• Relief and heights: the highest peaks of the country are located on the territory of the district - the Bazarduzu mountains (4,466 m) and Shahdag (4,243 m).

• Composition: includes the town of Gusar, one village (Samur) and 88-92 villages (depending on the administrative division).

2.2 Object and subject of research

The object of the study was the fruits of an Arian apple tree (Malus domestica 'Ariane') of removable maturity, harvested in the first half of October (Fig. 1).



Figure 1- Apple variety 'Ariane': the shape of the fruit and the characteristic color of the skin.

The samples were collected in intensive plantings of the 2006 planting year with the placement of trees according to the 4 × 1 m scheme.

The study was initiated as part of a production request from agricultural producers in the village of Kuzunkishlaq in the Gusar district of the district (Azerbaijan. Kuzunqışlaq).

Both apples of this variety grown without fertilizers and apples of this variety from the variant with two-time top dressing “Pk max” (phosphorus / potassium) at a dose of 4 liters /ha and amino acids (“Aminosol”) 500 g/ha were studied.

'Ariane' is a modern French club variety of winter-ripened apples, which has gained wide popularity due to its high immunity to diseases and excellent taste qualities. In Europe, it is often

sold under the environmental brand Les Naturianes ("Natural Apple").

The origin of the variety

The variety was bred in France by specialists from the French National Institute of Agronomic Research (INRAE) in Angers.

• History of creation: Work on the variety began back in 1979, and the official presentation and entry into the commercial market took place in 2002. It took more than 20 years of research to develop.

• Genetic line: 'Ariane' is the result of a complex multi-stage crossbreeding. Its parents are hybrids based on Florina x Prima varieties, pollinated with Golden Delicious pollen. Its deeper genealogy also includes the genes of Rome Beauty and wild Japanese apple trees (Malus floribunda), which gave the variety its natural immunity.

Characteristics of fruits

• Appearance: Fruits of medium size, rounded (spherical) shape, weighing about 150-230 grams. The main color of the skin is yellow-green, but 75-100% of it is covered with an intense, glossy bright red or ruby blush with clearly visible light dots (lentils).

• Flesh: Dense, crisp, creamy yellow, very juicy.

• Taste: Balanced sweet and sour, rich and aromatic. The taste notes are often described as refreshing, with a slight hint of duchess (pear). An important feature: during storage, the fruits become even sweeter, and their taste is harmonious.

Economically valuable characteristics of the variety

• Disease resistance (main advantage): It has an innate Vf gene that provides complete immunity to scab (the most common fungal disease of apple trees). The tree is also tolerant to other diseases, which reduces chemical treatments in the garden by almost 50%. This makes the variety ideal for ecological and organic gardening.

• Productivity: High and regular. The variety tends to set too many fruits, so in order to obtain large apples, it is necessary to thin the ovaries in the spring (otherwise the fruits will be small).

• Maturation and storage periods: Harvest occurs at the end of September - beginning of October. Apples have excellent shelf life and transportability - they easily retain their freshness in a conventional refrigerator or cellar until January or March, and in a controlled atmosphere until May.

• Usage: It is mainly used as a dessert variety for fresh consumption, but due to the dense structure of the pulp, the fruits are highly appreciated by culinary specialists - they do not lose their shape during baking and heat treatment.

2.3 Physico-chemical analyses

The following indicators of apples were studied: the mass of an individual fruit, density and chemical composition (dry substances, soluble dry substances, reducing sugar, sucrose, acidity and vitamin C).

The physical characteristics of unripe apples (the mass of an individual fruit and the hardness of the pulp) were determined using standard methods [6-7].

The component composition of apples was determined by chemical analysis in accordance with the methods described in the relevant GOST (State Standard of Russia) and Interstate Standards.:

RSV (soluble dry substances) - using a refractometer according to the Interstate standard ISO 2173-2013;

The total dry matter content is determined by the thermogravimetric method according to GOST 33977-2016;

Ascorbic acid is produced by the iodometric method according to GOST 24556-89;

Sugars (reducing, sucrose and total sugar) - according to GOST 8756.13-87;

Titrated acidity - according to the Interstate standard ISO 750-2013.

2.4 Statistical analysis

The primary data was processed by calculating the average value (±SD) of three parallel determinations for each sample.

3 Results and their discussion

The results of the laboratory techno-chemical evaluation of apples are presented in Fig. 2.

The results obtained are explained by a combination of extremely high yields (overloading of trees) and the specific physiological effect of applied fertilizers on fruit ripening.

The results show a physiological prolongation of growth processes and maturation phases under the influence of foliar fertilizers (phosphorus, potassium and free amino acids).

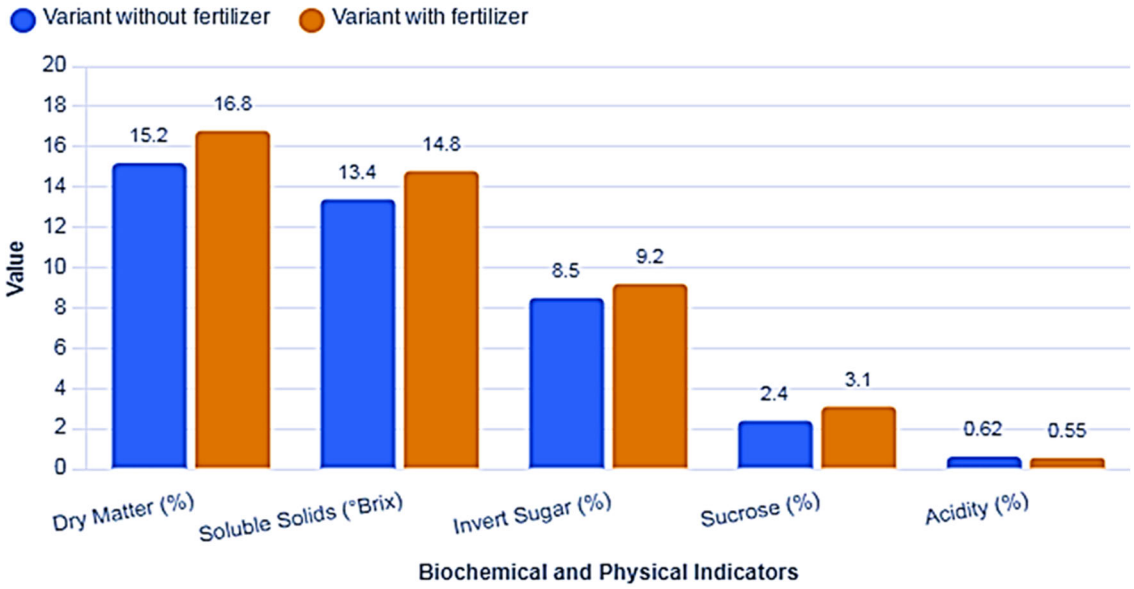


Figure 2 - Qualitative characteristics of 'Ariane' apples.

The main reasons for such indicators are:

• The effect of amino acids ("Aminosol"): Free amino acids act as a powerful biostimulator. They stimulate metabolic processes, protein synthesis and support the vegetative activity of the tree longer than usual. Because of this, the plant stays in the active metabolic phase longer and later moves on to the final stage of maturation.

• The role of potassium and phosphorus ("PK max"): Potassium and phosphorus regulate the water regime and carbohydrate metabolism. In the early stages of the breakdown of complex carbohydrates to sucrose and the accumulation of dry substances (starch, fiber, pectins) It has not yet fully occurred, so there are relatively more monosaccharides (glucose and fructose) and organic acids, and the total weight of the fruit and the proportion of dry matter are lower.

• Slowing down the hydrolysis of polysaccharides: In the control variant without stimulants, the processes of tissue aging and starch hydrolysis to sucrose were faster, so the apples gained more weight and more solids, turning out to be physiologically more mature by the beginning of the second decade of October.

• Prolongation of vegetation: Top dressing shifted the dynamics of fruit filling. The apples from the Fertilized Version are actually at an earlier stage of biological maturity than the control ones, which is confirmed by their lower weight and increased acidity.

In 2026, a severe crop overload was recorded (95 t/ha at a rate of 65-70 t/ha). Under such stress, the application of a tank mixture of phosphorus-potassium fertilizer (Pk Max) and an amino acid complex (Aminosol) shifted the vector of plant metabolism.

1. Fetal weight: Inhibition of growth due to overload.

• Without fertilizer: 237 g
• With fertilizer: 213 g
• *Explanation:* Phosphorus and potassium stimulate the outflow of plastic substances not only into fruits, but also for the maturation of wood, the laying of buds for future crops and the strengthening of the root system, which is critically important when overloaded at 95 t/ha. Amino acids ("Aminosol") increased the stress resistance of cells, but due to a shortage of resources against the background of a huge harvest, the tree redirected energy to maintain viability, which caused the average weight of the fruit to decrease.

2. Dry matters(DM) and soluble solids (SS): The effect of "dilution"
• Without fertilizers: DM - 17.0%, RSV - 14.2 °Brix
• With fertilizer: SS-16.0%, RSV - 13.1 °Brix

Explanation: Potassium regulates the water balance and activates osmotic processes. Its intensive use under stress conditions caused increased absorption of water by the pulp cells (hydration). The fruit density remained unchanged (4.1 kg/cm^2), which indicates that the strength of the cell walls was maintained, but the concentration of solids and soluble substances decreased due to greater moisture retention.

3. Carbohydrate metabolism: Activation of sugar inversion
• Without fertilizers: Invert sugar -7.56%, Sucrose -3.84%
• With fertilizers: Invert sugar -8.69%, Sucrose -1.75%
• *Explanation:* There is a sharp shift in the carbohydrate balance towards simple sugars (glucose and fructose). The phosphorus + potassium + amino acid complex dramatically activated the enzyme invertase, which breaks down complex sucrose into invert sugar. This indicates an acceleration of hydrolytic processes and a more intense (albeit forced due to stress) metabolic ripening of fruits in the second variant.

4. Acidity: A shift in the respiratory metabolism of fruits
• Without fertilizers: 0.92%
• With fertilizer: 1.67%
• *Explanation:* An almost 2-fold increase in titrated acidity is a key marker of the physiological response to treatment:

a). Phosphorus is part of ATP and stimulates energy metabolism. The plant begins to actively synthesize organic acids (malic, citric), which are involved in the Krebs respiratory cycle.

b). Amino acids act as building blocks for protein enzymes, accelerating the internal metabolism of the fetus. In the conditions of extreme yields in 2026, the treated trees maintained a high respiratory rate, which recorded acids at a high level.

5. Vitamin C: Varietal stability
• Without fertilizers: 2.11 mg%
• With fertilizer: 2.11 mg%
• *Explanation:* The ascorbic acid content remained absolutely identical. For the Ariana variety, this indicator with a yield of 95 t/ha turned out to be rigidly genetically determined (a varietal trait), and external chemical exposure could not overcome this threshold.

4 Conclusions

Fertilization in a stressful year with an overload (95 t/ha) helped Ariana trees cope with the load by restructuring their metabolism: The breakdown of sucrose to simple sugars was activated, the synthesis of organic acids was enhanced and the water balance of fruits was optimized, which slowed down the growth of their mass, but maintained the optimal density of the pulp.

References

1. Piriyeva, M.; Hafizov, G. Post-harvest storage of apple fruits of Azerbaijani selection. The Scientific Heritage. 2022. 89(89): 4-6. https://doi.org/10.5281/zenodo.6575706.
2. Hafizov, S.G., Hafizov, G.K. Industrially applied methods for the production of pomegranate polyphenols. Science and innovations 2021: Development directions and priorities (Melbourne, 03-31 march 2021). 2021. 2: 198-207. https://doi.org/10.34660/ İNF.2021.77.66.031.
3. Hafizov, S. G., Qurbanov, I. S., & Hafizov, G. K. Ensuring transparency of pomegranate juice during its storage. IOP Conference Series: Earth and Environmental Science, 2021, 640, 022055. https://doi.org/10.1088/1755-1315/640/2/022055
4. Hafizov,Gh., Hafizov S. Natural Standard: Variability of Techno-Chemical Indicators of Traditional Guba Apple Varieties and Direct-Pressed Juices. [Preprint]. Research Square. 2026. https://doi.org/10.21203/rs.3.rs-11280533/v1.
5. Tursunov, S. T., Tashpolatova D. Quality control of agricultural products. Actual problems and prospects of rural development and personnel support for agriculture: collection of scientific articles of the III International Scientific and Practical Conference, Minsk, June 7-8, 2023 - Minsk : BSATU, 2023. - pp. 227-231 (In Russ/). https://rep.bsatu.by/handle/doc/19768
6. Gerald, T., Abel, A., Gaston, T.A. et al. Physical, physicochemical and nutritional properties of low chill apple varieties (Anna and Golden Dorsett) grown in the highlands of Uganda. Discov Food. 2025. 5, 311. https://doi.org/10.1007/s44187-025-00539-8.
7. Zhang, M., Yin, Y., Li, Y., Jiang, Y., Hu, X., Yi. J. Chemometric Classification of Apple Cultivars Based on Physicochemical Properties: Raw Material Selection for Processing Applications. Foods. 2023. 12(16), 3095. https://doi.org/10.3390/foods12163095.

Chemical Sciences

Perspectives of Implementing "Green Chemistry" Principles in Pharmaceutical Production Technology

Dilyara Khikmatulayevna Abdiyeva
Al-Farabi Kazakh National University (KazNU), Faculty of Chemistry and Chemical Technology. Specialty: Technology of Pharmaceutical Production (Code: M119)
Dmitry Yuryevich Korulkin
Doctor of Chemical Sciences, Professor, Al-Farabi Kazakh National University (KazNU), Faculty of Chemistry and Chemical Technology. Specialty: Technology of Pharmaceutical Production (Code: M119)

Abstract
The pharmaceutical industry, while critical to global health, is historically associated with severe environmental impacts, primarily due to the generation of massive volumes of chemical waste, high energy consumption, and the reliance on toxic, non-renewable solvents. This paper explores the perspectives of integrating "Green Chemistry" principles into pharmaceutical production technologies. We provide a comprehensive analysis of fundamental metrics such as the Environmental Factor (E-factor) and Atom Economy, alongside a detailed evaluation of modern green technologies, including biocatalysis, alternative green solvents (ionic liquids and supercritical fluids), microwave-assisted synthesis, and continuous flow manufacturing. Furthermore, this research critically assesses the technological, economic, and regulatory barriers to the adoption of these sustainable methodologies. A specific regional focus is dedicated to the Republic of Kazakhstan, evaluating the current landscape, identifying strategic opportunities through a SWOT analysis, and proposing actionable recommendations for local pharmaceutical enterprises and policymakers to facilitate the transition toward ecological sustainability.

1. Introduction

1.1. Urgency and Relevance of "Green Chemistry" in the Pharmaceutical Industry

The global pharmaceutical industry has experienced exponential growth over the past century, driven by an aging global population, the emergence of novel pathogens, and advancements in molecular medicine. However, this life-saving sector paradoxically stands as one of the most chemically intensive and environmentally burdensome industries in the world. The urgency of implementing "green chemistry" principles in pharmaceutical manufacturing is driven by an escalating global ecological crisis, stringent environmental regulations, and the finite nature of petrochemical resources upon which traditional organic synthesis heavily relies. Sustainable engineering and green chemistry are no longer merely ethical imperatives; they are increasingly becoming critical economic and regulatory requirements for the long-term viability of pharmaceutical enterprises.

1.2. Environmental Problems of Traditional Drug Manufacturing Technologies

Traditional pharmaceutical manufacturing is characterized by complex, multi-step synthetic routes. Unlike bulk chemical manufacturing, which produces high volumes of simple molecules with highly optimized processes, active pharmaceutical ingredient (API) synthesis often involves

intricate stereochemical requirements, numerous protection and deprotection steps, and extensive purification protocols (crystallization, chromatography).

Consequently, traditional methods suffer from profound inefficiencies. The reliance on stoichiometric reagents rather than catalytic processes leads to massive by-product formation. Furthermore, the pharmaceutical industry is heavily dependent on volatile organic compounds (VOCs) such as dichloromethane, toluene, and dimethylformamide (DMF). These solvents, which account for up to 80% of the mass utilized in standard batch chemical operations, are frequently toxic, highly flammable, and difficult to recover, eventually leading to atmospheric emissions or hazardous liquid waste. The energy-intensive nature of traditional batch reactors—requiring extreme heating and rapid cooling cycles—further exacerbates the carbon footprint of pharmaceutical plants.

1.3. Aim and Objectives of the Research

The primary aim of this research is to comprehensively assess the perspectives, methodologies, and barriers associated with the implementation of "green chemistry" principles in the technology of pharmaceutical production, with a localized projection on the pharmaceutical sector of Kazakhstan.

To achieve this aim, the following objectives were established:

1. To define and evaluate the main principles of green chemistry and their specific significance for API synthesis.
2. To explore modern, sustainable technological innovations in drug manufacturing, quantifying their potential for resource and waste reduction.
3. To systematically analyze the technological, economic, and regulatory barriers impeding the industry-wide transition to green manufacturing.
4. To assess the specific landscape of Kazakhstan’s pharmaceutical industry and develop concrete recommendations for enhancing its ecological sustainability.

2. Main Principles of "Green Chemistry" and Their Significance for Pharmaceutical Production

2.1. Concept and Fundamental Tenets of the Framework

Coined by Paul Anastas and John Warner in 1998, the concept of "Green Chemistry" consists of 12 guiding principles designed to reduce or eliminate the use and generation of hazardous substances in the design, manufacture, and application of chemical products. For the pharmaceutical industry, these principles advocate for a paradigm shift from remediation (treating waste after it is created) to prevention (designing processes that do not generate waste).

2.2. Reduction of Chemical Waste and the E-Factor

In evaluating the sustainability of pharmaceutical production, the Environmental Factor (E-factor), introduced by Roger Sheldon, is the paramount metric. It is defined as the mass ratio of waste to desired product:

E\text{-factor} = \frac{\text{Total mass of waste}}{\text{Mass of product}}

In traditional pharmaceutical manufacturing, the E-factor is alarmingly high. While bulk petrochemicals boast an E-factor of less than 0.1, the pharmaceutical industry typically operates with E-factors ranging from 25 to over 100. This means that for every 1 kilogram of active drug produced, up to 100 kilograms of chemical waste are generated. Implementing green chemistry involves drastically lowering this metric through process optimization and solvent recycling.

Table 1: Comparison of E-factors Across Chemical Industry Sectors

Industry Sector	Annual Production Volume (tons)	Typical E-Factor (kg waste / kg product)	Main Sources of Waste
Oil Refining	10^6 - 10^8	< 0.1	Distillation residues, trace gases
Bulk Chemicals	10^4 - 10^6	< 1 - 5	Unreacted feedstock, catalyst loss
Fine Chemicals	10^2 - 10^4	5 - 50	Solvents, inorganic salts, side products
Pharmaceuticals	10 - 10^3	**25 - >100**	**Solvents (up to 80%), stoichiometric reagents, chiral resolution waste**

2.3. Maximization of Atom Economy

While reaction yield measures the efficiency of converting reactants to products, it ignores the mass of by-products. Atom Economy (AE), developed by Barry Trost, evaluates how much of the reactants' atoms are incorporated into the final desired molecule:

\text{Atom Economy} = \left(\frac{\text{Molecular Weight of desired product}}{\sum \text{Molecular Weights of all reactants}} \right) \times 100\%

In pharma, traditional synthetic routes frequently utilize heavy protecting groups and leaving groups that are discarded, resulting in poor atom economy. Green pharmaceutical technology prioritizes catalytic processes (which are not consumed) over stoichiometric reactions, thereby preserving mass and reducing inorganic salt waste.

2.4. Application of Safe Solvents and Renewable Raw Materials

The selection of safer solvents is perhaps the most immediate green intervention a pharmaceutical plant can make. The transition away from chlorinated solvents and reproductive toxins (e.g., N-Methyl-2-pyrrolidone) to greener alternatives is a primary focus. Additionally, green chemistry promotes the use of renewable feedstocks. While pharma historically relies on petroleum-derived precursors, modern biocatalysis and metabolic engineering allow for the synthesis of complex APIs starting from simple, plant-derived sugars or lignocellulosic biomass.

2.5. Energy-Efficient Technological Processes

Chemical syntheses in pharma often require extreme conditions—refluxing at high temperatures or cryogenic cooling for highly exothermic organometallic reactions. Green chemistry advocates for designing processes that occur at ambient temperature and pressure. Where heating is required, the shift from traditional convective heating to highly targeted microwave irradiation or flow reactors drastically improves energy efficiency.

3. Modern "Green Chemistry" Technologies in Drug Manufacturing

3.1. Application of Biocatalysis and Advanced Catalytic Synthesis

Biocatalysis—the use of natural or engineered enzymes to perform chemical transformations—has revolutionized green API synthesis. Enzymes operate under mild conditions (aqueous media, ambient temperature, neutral pH) and exhibit exquisite chemo-, regio-, and stereoselectivity. This eliminates the need for complex protection/deprotection steps and heavy metal catalysts (e.g., Palladium, Platinum) which pose contamination risks in final drug formulations. A landmark example is Merck’s synthesis of Sitagliptin (Januvia), where the implementation of an engineered transaminase enzyme eliminated the need for a rhodium catalyst and high-pressure hydrogenation, increasing yield, reducing waste, and eliminating toxic metal residue.

3.2. Shift Towards Aqueous and Alternative Green Solvents

Because solvents represent the vast majority of pharmaceutical waste, substituting traditional VOCs is critical.

- **Aqueous Synthesis:** Conducting organic reactions "on water" or "in water" leverages the hydrophobic effect to accelerate reaction rates while completely eliminating organic solvent toxicity.

- **Ionic Liquids (ILs):** These are organic salts that are liquid at room temperature. They have negligible vapor pressure (preventing atmospheric pollution) and can be tailored ("designer solvents") to optimize specific reaction kinetics.
- **Supercritical Carbon Dioxide (sc\text{CO}_2):** At temperatures above **31.1°C** and pressures above **73.8 bar**, CO2 enters a supercritical state, exhibiting properties of both a gas (high diffusivity) and a liquid (high solvency). It is non-toxic, non-flammable, and can be easily removed by simple depressurization, leaving zero solvent residue in the API.
-

Table 2: Comparison of Traditional vs. Alternative "Green" Solvents in Pharma

Solvent Category	Examples	Advantages	Disadvantages	Environmental Impact
Traditional (VOCs)	Dichloromethane, Toluene, DMF	High solvency for organics, well-established kinetics	High toxicity, flammable, high vapor pressure	Ozone depletion, severe atmospheric pollution, high E-factor
Aqueous	Water (H_2O)	Non-toxic, zero cost, non-flammable	Poor solubility for many organic APIs	Minimal (requires wastewater treatment for dissolved organics)
Ionic Liquids (ILs)	Imidazolium salts	Negligible vapor pressure, highly tunable	High cost, complex synthesis, poorly understood long-term toxicity	Low atmospheric impact, but difficult to degrade in ecosystems
Supercritical Fluids	sc\text{CO}_2	Zero residue, non-toxic, easy to recover via depressurization	Requires specialized high-pressure equipment (CAPEX)	Very low (recycles industrial CO_2, no additional greenhouse effect)

3.3. Microwave-Assisted Synthesis

Microwave chemistry represents a leap in energy efficiency. Traditional heating mechanisms heat the vessel walls, leading to thermal gradients and localized decomposition of temperature-sensitive APIs. Microwave irradiation directly couples with the dipoles of the solvent and reactant molecules, providing instantaneous, uniform volumetric heating. This results in dramatically shorter reaction times (from hours to minutes) and significant reductions in energy consumption, alongside higher purity profiles due to fewer thermal degradation by-products.

3.4. Continuous Manufacturing (Flow Chemistry)

Historically, the pharmaceutical industry has relied exclusively on batch manufacturing—mixing reagents in large vats. Flow chemistry (continuous manufacturing) involves pumping reagents continuously through micro-reactors or tubular reactors. Flow reactors possess massive surface-area-to-volume ratios, allowing for instantaneous heat and mass transfer. This prevents thermal runaways, allowing highly exothermic and traditionally "dangerous" reactions (e.g., nitrations, azidations) to be performed safely at room temperature. Furthermore, flow chemistry minimizes raw material consumption, operates with a significantly smaller physical footprint, and enables real-time, inline quality control (Process Analytical Technology - PAT).

Table 3: Comparative Analysis of Batch vs. Continuous Manufacturing (Flow Chemistry)

Parameter	Traditional Batch Manufacturing	Continuous Flow Manufacturing	Green Chemistry Implication
Reactor Volume	Large (1,000 - 10,000 Liters)	Very small (Microreactors to a few Liters)	Reduces risk of catastrophic chemical spills and energy use.
Heat/Mass Transfer	Poor (slow mixing, hot/cold spots)	Excellent (instantaneous)	Prevents thermal degradation, higher yield, less waste.
Scale-up Process	Difficult (requires re-engineering thermodynamics)	Simple "Numbering-up" (running multiple parallel flow units)	Saves years of R&D waste and chemical expenditure.
Solvent Use	High (frequent washing of massive vats between batches)	Low (system reaches steady-state)	Drastic reduction in E-factor and Process Mass Intensity (PMI).
Safety	High risk with highly reactive/explosive intermediates	High safety (minimal volume of hazardous intermediate exists at any given time)	Allows use of simpler, highly reactive atoms without toxic buffering.

4. Problems and Perspectives of Implementing Environmentally Safe Technologies

4.1. Technological, Economic, and Regulatory Barriers

Despite the clear ecological benefits, the pharmaceutical industry is notoriously conservative, and the transition to green chemistry faces substantial hurdles.

- **Technological Barriers:** The synthesis of complex, high-molecular-weight biologic drugs poses challenges for simple green metrics. Furthermore, integrating continuous flow systems into existing batch-centric infrastructure requires a total redesign of plant engineering. There is also a severe shortage of process chemists trained simultaneously in organic synthesis and chemical engineering (flow dynamics).
- **Economic Barriers:** The initial capital expenditure (CAPEX) for installing new flow reactors, high-pressure supercritical fluid extractors, or customized biocatalytic fermentation tanks is immense. For many generic drug manufacturers operating on thin profit margins, the economic return on investment (ROI) for retrofitting legacy systems is prohibitive, even if long-term operating expenses (OPEX) would decrease.
- **Regulatory Barriers:** The pharmaceutical industry operates under strict regulatory frameworks (FDA, EMA). Any change in the manufacturing process of an approved drug—such as switching a solvent or changing from batch to continuous flow—requires extensive re-validation, stability testing, and the filing of regulatory variations. This process is time-consuming and costs millions of dollars, creating a "regulatory lock-in" effect where companies continue using polluting legacy processes simply to avoid bureaucratic friction.

4.2. Methodology for Evaluating Efficiency

To overcome greenwashing, the industry requires rigorous evaluation methodologies. The Process Mass Intensity (PMI), adopted by the ACS Green Chemistry Institute Pharmaceutical Roundtable, is currently the gold standard. Unlike the E-factor, which focuses only on waste, PMI focuses on all materials put into the process:

\text{PMI} = \frac{\text{Total mass of materials used in the process}}{\text{Mass of isolated product}}

Additionally, Life Cycle Assessment (LCA) software is now used to calculate the cradle-to-grave impact of drug manufacturing, quantifying parameters such as Global Warming Potential (GWP), abiotic depletion, and ecotoxicity.

Table 4: Key Barriers to Green Chemistry Adoption in Pharma and Mitigation Strategies

Barrier Category	Specific Challenge	Impact on Sustainability	Proposed Mitigation Strategy
Regulatory	Post-approval process variation requirements.	"Lock-in" of old, polluting processes.	Implementation of ICH Q13 guidelines; fast-track regulatory reviews for green process improvements.
Economic	High upfront CAPEX for novel equipment (e.g., flow reactors).	Prevents small/medium generic producers from modernizing.	Government subsidies, tax breaks for ESG compliance, and shared "green technology" hubs.
Technological	Complexity of isolating APIs from aqueous/biocatalytic mixtures.	Increases energy used in downstream processing.	Advancements in membrane filtration and nanofiltration technologies.
Educational	Lack of multidisciplinary training in academia.	Slow adoption of flow and green metric chemistry in R&D.	Revision of university curricula to integrate chemical engineering with organic chemistry.

4.3. Specific Regional Focus: Perspectives in Kazakhstan

The Republic of Kazakhstan is actively developing its pharmaceutical cluster as part of national strategies aimed at economic diversification and reducing import dependence (currently, a significant portion of pharmaceuticals in Kazakhstan are imported). Major enterprises, such as "Santo" (Polpharma Group) and "Nobel AFF", are modernizing their production lines to align with Good Manufacturing Practice (GMP) standards.

However, the implementation of "green chemistry" in Kazakhstan faces unique regional challenges. The domestic production is primarily focused on generic formulations, final dosage form manufacturing, and packaging, rather than full-cycle chemical synthesis of APIs. Therefore, the immediate application of green chemistry in Kazakhstan lies in optimizing downstream processing: transitioning to green solvents for equipment cleaning, implementing energy-efficient HVAC systems in cleanrooms, and treating pharmaceutical wastewater.

As Kazakhstan moves toward deeper localization and begins domestic API synthesis, it has a unique "leapfrog" opportunity. Rather than building outdated batch-reactor infrastructure, Kazakh enterprises, supported by government grants and foreign direct investment, can immediately adopt continuous manufacturing and biocatalysis. The Al-Farabi Kazakh National University (KazNU) plays a pivotal role here, acting as an intellectual hub for training a new generation of pharmaceutical technologists equipped with the principles of sustainable engineering.

Table 5: SWOT Analysis of Implementing Green Pharmaceutical Technologies in Kazakhstan

Aspect	Factors and Analysis
Strengths	- Strong state support for industrial modernization and ESG goals. - Presence of modernizing international pharma companies (Polpharma, Nobel). - High-quality academic institutions (e.g., KazNU) capable of localized R&D.
Weaknesses	- Current reliance on imported APIs limits local chemical synthesis interventions. - High initial cost of importing green technological equipment. - Lack of robust local supply chains for specialized green solvents or biocatalysts.
Opportunities	- "Leapfrogging" older technologies by building brand-new flow-chemistry facilities. - Export potential to the Eurasian Economic Union (EAEU) and Central Asia with "Green" certified products. - Fostering university-industry partnerships for technology transfer.
Threats	- Fluctuations in currency exchange rates affecting the import of green tech. - Bureaucratic delays in local regulatory approval for novel continuous manufacturing lines. - Intense price competition from cheap, traditionally manufactured generics from abroad.

5. Conclusion

5.1. Overarching Advantages

The integration of "green chemistry" principles into the technology of pharmaceutical production represents an inevitable and highly advantageous evolution for the industry. By prioritizing Atom Economy, radically reducing the E-factor through the minimization of toxic solvent usage, and shifting from stoichiometric to advanced catalytic and biocatalytic reactions, the pharmaceutical sector can dramatically diminish its ecological footprint. Beyond environmental preservation, these methodologies offer profound economic advantages over the life cycle of a drug, including reduced hazardous waste disposal costs, lower energy utility bills due to efficient processes like microwave-assisted synthesis, and enhanced safety protocols.

5.2. Promising Technological Directions

For the near future, the most viable and revolutionary technological directions are Biocatalysis and Continuous Flow Manufacturing. As protein engineering and artificial intelligence (AI) continue to evolve, the ability to design highly specific enzymes for complex API synthesis will render many heavy-metal catalysts obsolete. Concurrently, the miniaturization of chemical engineering via flow chemistry will allow for on-demand, highly scalable, and inherently safe pharmaceutical production, eliminating the inefficiencies of massive batch reactors. The continued development of supercritical fluid extraction and ionic liquids will further phase out volatile organic compounds.

5.3. Recommendations for Kazakhstan and Global Enterprises

To enhance the ecological sustainability of pharmaceutical production, the following actionable recommendations are proposed:

1. **For Policymakers and Regulatory Bodies:** Governments, including the Ministry of Healthcare of Kazakhstan, should introduce fast-track regulatory pathways for companies attempting to update legacy drug manufacturing processes to greener alternatives. Financial incentives, such as tax rebates and green bonds, should be provided to offset the CAPEX of installing flow chemistry and solvent recovery systems.
2. **For Pharmaceutical Enterprises:** Plants must adopt PMI (Process Mass Intensity) as a core metric during the R&D phase, ensuring that drugs are designed sustainably from the molecular level rather than attempting to "green" an inefficient process post-approval. Enterprises in Kazakhstan should focus on the localization of modern continuous manufacturing lines rather than investing in outdated batch infrastructure.

3. For Academia (e.g., KazNU): Educational institutions must break the silos between classical organic chemistry and chemical engineering. Curricula for the "Technology of Pharmaceutical Production" must heavily integrate green chemistry metrics, biocatalysis, and continuous manufacturing flow dynamics, ensuring the next generation of technologists can lead the sustainable transition of the regional and global pharmaceutical industry.

References

1. Anastas, P. T., & Warner, J. C. (1998). *Green Chemistry: Theory and Practice*. Oxford University Press.
2. Sheldon, R. A. (2017). The E factor 25 years on: the rise of green chemistry and sustainability. *Green Chemistry*, 19(1), 18-43.
3. Trost, B. M. (1991). The atom economy-a search for synthetic efficiency. *Science*, 254(5037), 1471-1477.
4. Dunn, P. J., Wells, A. S., & Williams, M. T. (Eds.). (2010). *Green Chemistry in the Pharmaceutical Industry*. John Wiley & Sons.
5. Plumb, K. (2005). Continuous processing in the pharmaceutical industry: changing the mind set. *Chemical Engineering Research and Design*, 83(6), 730-738.
6. Constable, D. J., Jimenez-Gonzalez, C., & Henderson, R. K. (2007). Perspective on solvent use in the pharmaceutical industry. *Organic Process Research & Development*, 11(1), 133-137.
7. Savile, C. K., Janey, J. M., Mundorff, E. C., Moore, J. C., Tam, S., Waterman, W. R., ... & Hughes, G. W. (2010). Biocatalytic asymmetric synthesis of chiral amines from ketones applied to sitagliptin manufacture. *Science*, 329(5989), 305-309.
8. Kappe, C. O. (2004). Controlled microwave heating in modern organic synthesis. *Angewandte Chemie International Edition*, 43(46), 6250-6284.
9. Jessop, P. G. (2011). Searching for green solvents. *Green Chemistry*, 13(6), 1391-1398.
10. Jimenez-Gonzalez, C., Ponder, C. S., Broxterman, Q. B., & Manley, J. B. (2011). Using the right green yardstick: why process mass intensity is used in the pharmaceutical industry to drive more sustainable processes. *Organic Process Research & Development*, 15(4), 912-917.
11. Ministry of Industry and Infrastructural Development of the Republic of Kazakhstan. (2023). *Strategic Roadmap for the Development of the Pharmaceutical Industry of Kazakhstan*. Astana, Kazakhstan.

Biological Sciences

A CLIL-BASED LEARNING SEQUENCE FOR DIGITAL ANALYSIS OF MICROBIAL GROWTH CURVES IN BIOLOGY TEACHER EDUCATION

Erkezhan Yerlanovna Zhazykbai
Second-year Master's student, South Kazakhstan Pedagogical University named after Ozbekali Zhanibekov, Shymkent, Kazakhstan
Elmira Begimbayevna Zhapparbergenova
Candidate of Biological Sciences, Associate Professor, South Kazakhstan Pedagogical University named after Ozbekali Zhanibekov, Shymkent, Kazakhstan

Abstract

This article proposes a CLIL-based methodological framework for the digital analysis of microbial growth curves in the preparation of future biology teachers and presents descriptive findings from two datasets: 31 microbiology pretest responses and 21 CLIL questionnaire responses. The mean pretest score was 20.45 (SD = 2.51; median = 22; range = 13–24). All 21 questionnaire respondents selected project and research activities; 20 respondents identified analysing biology texts in English, learning terminology, discussion, using digital resources, and laboratory work as useful activities. These findings inform the planning of a learning sequence based on the CLIL 4Cs framework and the development of digital tasks for analysing microbial growth curves.

Keywords: CLIL; biology teacher education; microbial growth curve; digital data analysis; scientific English; 4Cs framework.

Introduction

Future biology teachers need to be prepared to interpret scientific information, explain biological processes, and guide learners in evidence-based inquiry. Microbial growth curves provide a concise and suitable context for developing these abilities: students connect changes in population size over time with environmental conditions, quantitative data, and scientific terminology. However, a growth curve can become a diagram to memorize unless learners work with data, interpret the curve's shape, and distinguish observations from conclusions. Digital spreadsheets and graphs support this work by enabling students to examine, process, and compare measurements over time.

Content and Language Integrated Learning (CLIL) provides a basis for teaching subject matter and an additional language through coordinated learning objectives. Its 4Cs framework connects content, communication, cognition, and culture [1, 2]. In teacher education, CLIL is not limited to teaching through English; it involves the planned use of language to help learners understand subject ideas and express their reasoning. Studies of the opportunities and challenges of using CLIL in biology teacher education in Kazakhstan show that this approach can complement biology instruction in learners' primary language [3]. A quasi-experimental study of team teaching in biology through CLIL also highlights the importance of aligning subject and language objectives and addressing both areas [4].

This article addresses two questions: (1) What baseline knowledge indicators and learning needs are evident in the microbiology pretest and CLIL questionnaire? (2) How can these findings inform the design of a CLIL learning sequence for the digital analysis of microbial growth curves? To address these questions, the pretest and questionnaire results are analysed, and a methodological framework informed by the research literature is proposed.

Theoretical and Methodological Foundations

CLIL and the 4Cs Framework

CLIL integrates subject knowledge and an additional language within a single learning process. The 4Cs framework includes four interconnected dimensions for lesson design: Content (what learners need to understand), Communication (the language needed to learn and explain the content), Cognition (the thinking processes involved), and Culture (perspectives, contexts, and responsible participation in the wider scientific community) [1, 2]. These dimensions are closely connected. For example, interpreting a growth curve requires knowledge of microbial growth (content), comparison and inference (cognition), and language for describing trends and supporting claims (communication). The culture dimension is addressed by considering how scientific knowledge is presented, evaluated, and communicated across different language settings.

For future teachers, this framework serves two purposes. They learn microbiology through scaffolded tasks in English and consider how similar tasks could be adapted for their future pupils. Language objectives are therefore stated alongside biology objectives. Scaffolds may include bilingual glossaries, sentence frames, labelled graph templates, model explanations, and structured pair discussions. Such support should promote accurate understanding of the subject matter while gradually increasing learner independence.

Microbial Growth Curves as a Learning Context

The growth curve of a microbial population in a batch culture typically includes a lag phase, an exponential phase, a stationary phase, and a decline phase. These phases reflect population growth and changes in culture conditions; they should not be treated as sharply bounded stages that apply identically to all organisms and experimental conditions [5, 6]. Optical density (OD) is often used as an indirect indicator of culture turbidity and population density, but it does not directly count viable cells. Interpretation of OD values depends on measurement conditions, blank correction, and the range in which the instrument provides reliable readings [6].

This topic is well suited to quantitative inquiry. Learners can compare OD values over time, describe a curve, estimate when rapid growth begins, and analyse why growth slows or stabilizes. They can also identify measurement limitations: an increase in OD may indicate greater turbidity, but OD alone does not establish cell viability or explain the biological cause of a change in the curve. Digital simulations and interactive visualizations have been used to help students understand microbial growth parameters and their mathematical relationships [7]. This supports the use of digital analysis as a learning tool, while biological interpretation and evaluation of evidence remain the learner's responsibility.

Methods and Data Sources

The study data were obtained from Google Forms exports of a microbiology pretest and a CLIL questionnaire collected between September 30 and October 8, 2026. The pretest included 31 responses, and the CLIL questionnaire included 21 responses. The pretest covered self-assessment questions on understanding of CLIL, use of biological terminology in English, and readiness to use CLIL, as well as knowledge questions on microbial growth phases, growth conditions, continuous cultivation, chemostats, and turbidostats. Respondents were asked to identify challenges related to implementing CLIL. The CLIL questionnaire included four multiple-response questions about learning priorities, resources, activities, and implementation conditions, and one rating question using a scale from 1 to 5.

The data were analysed using descriptive statistics. Frequencies and percentages were calculated for categorical responses; the mean, median, standard deviation, and range were calculated for pretest scores. Responses to multiple-response questionnaire items were summarized by answer option.

Pretest Results

The pretest included 31 responses. The mean recorded score was 20.45 (SD = 2.51), the median was 22, and scores ranged from 13 to 24.

The mean self-rating of understanding of CLIL on a five-point scale was 3.39; 16 of 31 respondents (51.6%) selected a score of 4 or 5. The mean self-rating of readiness to use CLIL was 3.90, with 20 respondents (64.5%) selecting a score of 4 or 5. For their level of using biological terminology in English, 24 respondents (77.4%) selected the "intermediate" category.

The most frequently selected implementation challenge was variation in learners' ability to understand biology texts in English (17/31; 54.8%). Language barriers were identified by 14 respondents (45.2%), as was difficulty explaining biological terminology in English (14 respondents; 45.2%). A shortage of CLIL learning materials was selected by 10 respondents (32.3%), while 5 respondents (16.1%) selected the need for additional lesson-planning time. Respondents could select more than one challenge.

Additional Questionnaire Findings

Twelve respondents (57.1%) selected learning biological terminology in English, while 11 (52.4%) selected biology texts and learning materials in English. All 21 respondents selected project and research activities. Each of the five activities in Q3 was selected by 20 respondents (95.2%); each of the three conditions in Q4 was selected by 19 of 20 valid responses (95.0%). Q5 ratings were as follows: score 2, 3 responses (14.3%); score 3, 4 (19.0%); score 4, 9 (42.9%); and score 5, 5 (23.8%). The mean was 3.76 (SD = 1.00).

Question	Answer option	Responses	Share
Q1	Learning biological terminology in English	12/21	57.1%
Q2	Biology texts and learning materials in English	11/21	52.4%
Q3	Completing project and research activities	21/21	100.0%
Q3	Analysing biology texts in English	20/21	95.2%
Q3	Learning biological terminology in English	20/21	95.2%
Q3	Discussing biology topics in English	20/21	95.2%
Q3	Using digital resources	20/21	95.2%
Q3	Conducting laboratory work in English	20/21	95.2%
Q4	Availability of CLIL-specific tasks	19/20	95.0%
Q4	Alignment of biology and language content	19/20	95.0%
Q4	Students' foundational knowledge of biology	19/20	95.0%

Summary of Scores and Self-Ratings

Measure	Result
Pretest scores (n=31)	Mean: 20.45; standard deviation: 2.51; median: 22; range: 13–24
Self-rated understanding of CLIL	Mean: 3.39/5; 16/31 respondents (51.6%) selected 4–5
Self-rated readiness to use CLIL	Mean: 3.90/5; 20/31 respondents (64.5%) selected 4–5
Use of biological terminology in English	24/31 respondents (77.4%) selected the intermediate level

Reported Challenges in Implementing CLIL

Challenge	Respondents	Share (n=31)
Variation in ability to understand texts in English	17	54.8%
Barriers to using English	14	45.2%
Difficulty explaining biology terminology in English	14	45.2%
Limited availability of CLIL learning materials	10	32.3%
Need for additional lesson-planning time	5	16.1%

Note: Respondents could select more than one option for the challenges question; therefore, percentages do not sum to 100%.

Proposed CLIL-Based Learning Framework

This framework is designed for undergraduate students preparing to teach biology and can also be adapted for biotechnology students. It can be delivered as a 90-minute seminar or divided into two lessons. The framework assumes access to a projected graph and a spreadsheet or similar digital tool. The instructor may provide an anonymized, published, or simulated dataset. If simulated data are used, they should be clearly labelled as simulated and not presented as experimental results.

Learning Outcomes

By the end of the learning sequence, students will be able to: (1) describe the main phases of a microbial growth curve and relate them to population-level changes; (2) enter time and OD measurements in a spreadsheet and create a labelled graph; (3) identify patterns in data and interpret them cautiously using evidence; (4) use key English terms for microbiology and graph description; and (5) design a scaffolded CLIL lesson that integrates a biology objective, a language objective, and a thinking skill.

Alignment with the 4Cs Framework

4Cs dimension	Learning focus	Illustrative student activity
Content	Growth phases; time and OD; limitations of OD as an indirect measure.	Label the phases and connect curve features with possible population-level explanations.
Communication	Vocabulary and language structures needed to describe, compare, and qualify claims.	Use phrases such as "increases gradually," "reaches a stable level," and "the data suggest…" in a short explanation.
Cognition	Prediction, graph interpretation, comparison, evidence-based conclusions, and evaluation of limitations.	Compare two curves, identify a difference, support an interpretation with evidence, and identify one uncertainty.
Culture	Scientific communication across languages; understanding terminology and conventions for evidence.	Build a bilingual terminology bank and give a brief explanation to peers.

Sequence of Learning Activities

1. Elicit prior knowledge and make predictions. The instructor presents an unlabeled growth curve and asks what might happen to a microbial population transferred to fresh medium. Students first write a prediction and then compare it with a partner. This task activates prior knowledge without implying that all organisms and cultures follow the same curve.

2. Connect language and concepts. Students match key terms—lag phase, exponential phase, stationary phase, decline phase, optical density, population, nutrient limitation, and evidence—with brief definitions and visual cues. The instructor distinguishes "optical density" from direct cell counting and models cautious scientific phrasing: "OD increases during this interval, which is consistent with an increase in culture turbidity."

3. Prepare and visualize the data. Working in pairs, students examine a table containing time points and OD readings. They check column headings and units, create a line graph, label both axes, give the graph an informative title, and note whether the data include a medium blank or other measurement information. The instructor explains that graphing software visualizes data but does not independently verify the biological quality of the underlying measurements.

4. Interpret the curve. Students identify intervals in which the data, if available, increase slowly, rise rapidly, stabilize, or decline. They compare the observed pattern with typical growth-curve phases and support their interpretation with a time interval or specific values. If the data do not show a clear decline phase, they should say so rather than forcing the curve into a memorized four-stage pattern.

5. Communicate and evaluate. Each pair gives a one-minute explanation using a claim–evidence–reasoning structure. Listeners ask one question about the evidence or a limitation. Students then revise one sentence to distinguish what the graph directly shows from what cannot be concluded from it. As an extension, students may compare an AI-generated description with the graph and a reliable scientific source; the AI response is treated as a draft requiring verification, not as evidence or a measured learning outcome.

Language Scaffolds and Assessment

Language support should focus on the speaking frames required for the scientific task. Useful examples include: "The curve begins with the … phase"; "OD increases between [time] and [time] …"; "The data show …"; "This pattern is consistent with …"; "One possible explanation is …"; and "OD alone cannot establish …". Students can first practise in pairs, use a bilingual glossary, and then present their reasoning in English. The instructor should assess biological accuracy and

communication separately so that language development does not obscure whether the subject concept has been understood.

Assessment criterion	Evidence of achievement	Suggested points
Biological interpretation	Correctly identifies the curve pattern and does not treat phase boundaries as identical in all cases.	0–2
Digital graphing	Creates a readable graph with correctly used axes, units, and labels.	0–2
Evidence-based reasoning	Uses a specific data feature or time interval and distinguishes observation from conclusion.	0–2
Scientific English	Uses relevant terminology and at least one phrase to describe or qualify a claim.	0–2
Critical evaluation	Identifies one limitation of OD or one uncertainty in the dataset.	0–2

The proposed ten-point formative rubric covers biological interpretation, digital graphing, evidence-based reasoning, scientific English, and critical evaluation. Based on the pretest findings, lesson plans should include English-language scaffolds for describing graphs and using biological terminology, as well as differentiated tasks for students with varying language proficiency. In a subsequent stage, the learning sequence can be implemented in class and students' subject and language outcomes assessed.

Discussion

The pretest and questionnaire indicate priorities for planning CLIL activities: explicit language scaffolds, digital graph analysis, inquiry tasks, and opportunities to explain biology in English. Questionnaire respondents frequently selected project and research work and activities involving biology texts in English, terminology, discussion, digital resources, and laboratory work. Pretest respondents identified variation in English reading comprehension, language barriers, and difficulty explaining biological terminology. These findings highlight the importance of aligning subject content with language objectives and providing differentiated support. Digital graphing can support discussion of microbial growth parameters [7], while CLIL research in biology recommends aligning subject and language objectives [4].

Instructors should interpret growth curves in context: OD is an indirect measure that depends on measurement conditions [6]. Language scaffolds help learners analyse subject content and communicate scientific ideas in English.

A next stage of research could implement the proposed learning sequence in biology classes and systematically assess students' microbiology knowledge, graph-analysis skills, and use of scientific English. Assessment could include pre- and post-tasks, samples of student work, and classroom observations.

Conclusion

The pretest and questionnaire provide a basis for planning CLIL activities on microbial growth and digital graph analysis. Questionnaire respondents frequently selected research projects and activities involving English texts, terminology, discussion, digital resources, and laboratory work. The pretest findings point to support needs in understanding English texts, addressing language barriers, and explaining biological terminology. The proposed framework responds to these needs through staged language scaffolds, graph-interpretation tasks, and evidence-based reasoning. A subsequent step is to implement the learning sequence and assess students' subject and language outcomes.

References

1. Coyle, D. (2007). Content and Language Integrated Learning: Towards a connected research agenda for CLIL pedagogies. International Journal of Bilingual Education and Bilingualism, 10(5), 543–562. https://doi.org/10.2167/beb459.0

2. Coyle, D., Hood, P., & Marsh, D. (2010). CLIL: Content and Language Integrated Learning. Cambridge University Press.

3. Nartayeva, M., Zhylysbayeva, A., & Rysbayeva, G. (2024). The impact of CLIL technology on the professional competence of pre-service biology teachers. Journal of Educational Sciences, 78(1), 154–164. https://doi.org/10.26577/JES20247801013

4. Satayev, M., Balta, N., Shaymerdenovna, I. R., Fernández-Cézar, R., & Alcaraz-Mármol, G. (2022). Content and Language Integrated Learning implementation through team teaching in biology lessons: A quasi-experimental design with university students. Frontiers in Education, 7, 867447. https://doi.org/10.3389/feduc.2022.867447

5. Bertrand, R. L. (2019). Lag phase is a dynamic, organized, adaptive, and evolvable period that prepares bacteria for cell division. Journal of Bacteriology, 201(7), e00697-18. https://doi.org/10.1128/JB.00697-18

6. Stevenson, K., McVey, A. F., Clark, I. B. N., Swain, P. S., & Pilizota, T. (2016). General calibration of microbial growth in microplate readers. Scientific Reports, 6, 38828. https://doi.org/10.1038/srep38828

7. Hogan, D. E., Harmon, M. J., Brown-Hogan, K. A., & Maier, R. M. (2018). Using ESStudios microbial growth modeling program to improve student comprehension of microbial growth and its underlying mathematics. Journal of Microbiology & Biology Education, 19(2). https://doi.org/10.1128/jmbe.v19i2.1489

«Тарбағатай» мемлекеттік ұлттық табиғи саябағы бунақденелілерінің түрлік құрамы

Г.Ө.Мақсұтова
Абай облысы, Семей қаласының «Шәкәрім университеті» КеАҚ, Қазақстан Республикасы
М.Ғ.Қуанышбаева
Абай облысы, Семей қаласының «Шәкәрім университеті» КеАҚ, Қазақстан Республикасы

Кіріспе.

Қазақстанның табиғи ландшафттары мен биологиялық ресурстарын сақтау мақсатында құрылған ерекше қорғалатын табиғи аумақтардың ішінде «Тарбағатай» мемлекеттік ұлттық табиғи паркінің орны ерекше. "Тарбағатай" ұлттық табиғи саябағы" РММ "Қазақстан Республикасы Ауыл шаруашылығы министрлігі Орман шаруашылығы және жануарлар дүниесі комитетінің "Тарбағатай "мемлекеттік ұлттық табиғи саябағы" республикалық мемлекеттік мекемесін құру туралы" Қазақстан Республикасы Үкіметінің 2018 жылғы 27 маусымдағы № 382 Қаулысына сәйкес құрылды[1]. Тарбағатай ұлттық саябағы 2018 жылы ғана құрылғандықтан, бұл өңірде кездесетін бунақденелілердің түрлік құрамы, экологиялық ерекшеліктері туралы мәліметтердің аздығы зерттеуді қажет етеді. Ұлттық саябақ Қазақстанның шығыс бөлігіндегі Абай облысының аумағында орналасқан және Тарбағатай жотасының табиғи кешендерін, таулы және тау бөктеріндегі ландшафттарды, өсімдіктер мен жануарлар дүниесін қорғауға бағытталған. Аумақтың жер бедері, климаттық жағдайлары, өсімдік жамылғысы мен табиғи мекен ету орталарының әртүрлілігі жануарлардың, соның ішінде бунақденелілердің алуан түрлілігі қалыптасуына қолайлы жағдай жасайды.

Тарбағатай өңірінің табиғи ерекшеліктері бунақденелілердің тіршілік етуіне, таралуына және маусымдық белсенділігіне әсер етеді. Әртүрлі өсімдік қауымдастықтары, гүлді өсімдіктердің таралуы, топырақтың сипаты, ылғалдылық пен температура жағдайлары бунақденелілердің мекен ету ортасын анықтайтын негізгі экологиялық факторларға жатады. Мысалы, гүлді өсімдіктер мол өсетін учаскелерде тозаңдандырушы бунақденелідер жиі кездессе, өсімдік қалдықтары мен топырақ қабатында тіршілік ететін түрлер органикалық заттардың ыдырауына қатысады. Осыған байланысты ұлттық парк аумағындағы бунақденелілердің түрлік құрамын зерттеу өңірдің биоалуантүрлілігі туралы ғылыми мәліметтерді толықтыруға мүмкіндік береді.

Бунақденелілердің түрлік құрамын анықтау олардың морфологиялық белгілерін зерттеуді, жүйелік орнын белгілеуді және экологиялық ерекшеліктерін сипаттауды қамтиды. Таксономиялық талдау арқылы зерттеу аймағында кездесетін бунақденелілердің негізгі отрядтары мен тұқымдастарын анықтап, олардың түрлік алуантүрлілігінің құрылымын сипаттауға болады. Ал экологиялық зерттеу олардың қоректену ерекшеліктерін, тіршілік ету ортасын, маусымдық белсенділігін және қоршаған орта факторларына бейімделуін түсіндіруге көмектеседі.

Зерттеу жұмысының мақсаты: Тарбағатай мемлекеттік ұлттық табиғи паркінің аумағында кездесетін бунақденелілердің түрлік құрамын жан-жақты зерттеу, олардың морфологиялық және экологиялық ерекшеліктерін анықтау, сондай-ақ зерттеу аймағында

таралған бунақденелілердің таксономиялық құрылымына талдау жасау.

Зерттеу жұмысының негізгі міндеттері:

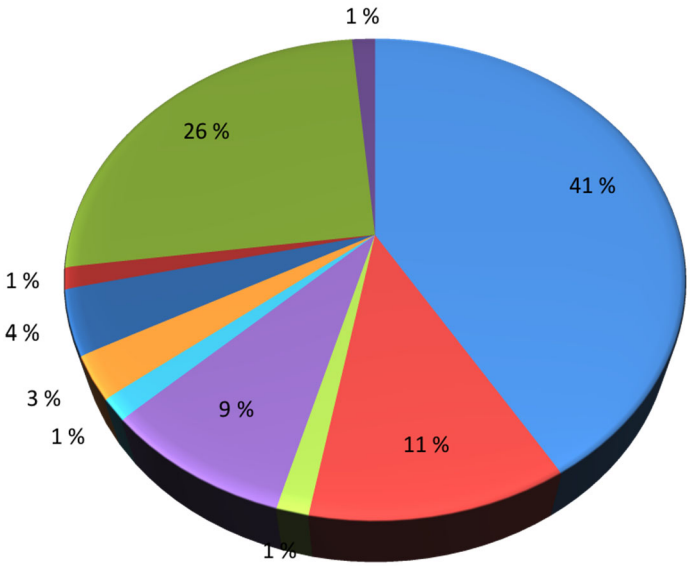
1. Тарбағатай мемлекеттік ұлттық табиғи паркінің аумағындағы бунақденелілердің түрлік құрамын анықтау, кездесетін түрлерді жүйелік белгілері бойынша ажырату және олардың негізгі морфологиялық ерекшеліктеріне сипаттама беру.
2. Зерттеу аймағында таралған бунақденелілердің жекелеген түрлерінің экологиялық ерекшеліктерін қарастыру, олардың тіршілік ету ортасын, таралу сипатын, қоректену ерекшеліктерін және қоршаған орта факторларына бейімделуін зерттеу.
3. Тарбағатай ұлттық табиғи паркінің бунақденелілер фаунасына таксономиялық талдау жүргізу, анықталған түрлерді тиісті отрядтар, тұқымдастар, туыстар және түрлер деңгейінде жүйелеу, сондай-ақ зерттеу материалдары негізінде олардың таксономиялық құрылымын сипаттау.

«Тарбағатай» мемлекеттік ұлттық табиғи паркі аумағындағы бунақденелілер фаунасын зерттеу өңірдің биологиялық алуантүрлілігін анықтау, табиғи экожүйелердің ерекшеліктерін сипаттау және жануарлар дүниесін қорғау бағытындағы маңызды ғылыми жұмыстардың бірі болып табылады. Ұлттық парк аумағының табиғи-климаттық жағдайларының, жер бедері мен өсімдік жамылғысының әртүрлілігі бунақденелілердің алуан түрлі топтарының тіршілік етуіне қолайлы жағдай қалыптастырады. Осыған байланысты аталған аумақтың энтомофаунасын зерттеу отандық зоология мен энтомология ғылымының өзекті бағыттарының қатарына жатады. Тарбағатай ұлттық табиғи паркінің бунақденелілер фаунасын кешенді зерттеуге бағытталған маңызды ғылыми жұмыстардың бірі 2021–2023 жылдары жүзеге асырылды. Бұл зерттеулер Р.Х. Кадырбеков жетекшілік еткен ғалымдар тобының қатысуымен жүргізіліп, ұлттық парк пен оған іргелес аумақтардағы бунақденелілердің түрлік алуантүрлілігін бағалауға, олардың жүйелік құрамын анықтауға, экологиялық ерекшеліктерін зерттеуге және биоалуантүрлілікті сақтау мәселелеріне арналды. Зерттеу нәтижелері бойынша 10 отрядқа жататын 1409 бунақденелілер түрі анықталған. Ғылыми жұмыстың қорытындылары 2023 жылы жарық көрген «Насекомые (Insecta) государственного национального природного парка „Тарбагатай“ и сопредельных территорий» атты монографияда жинақталған[2]. Тарбағатай өңіріндегі жекелеген бунақденелілер топтарын зерттеуде Б.В. Златановтың еңбектері де маңызды орын алады. Ғалым Тарбағатай жотасындағы гүлшыбындардың (Diptera: Syrphidae) түрлік құрамы мен экологиялық ерекшеліктерін қарастырып, олардың таралу сипатына және әртүрлі табиғи жағдайларға бейімделуіне назар аударған. Зерттеу нәтижесінде гүлшыбындардың 37 түрі анықталып, олардың өңірдің табиғи экожүйелеріндегі таралу ерекшеліктері сипатталған [3]. Бұл зерттеу бунақденелілердің жекелеген жүйелік топтарын тереңірек қарастырудың маңыздылығын көрсетеді.

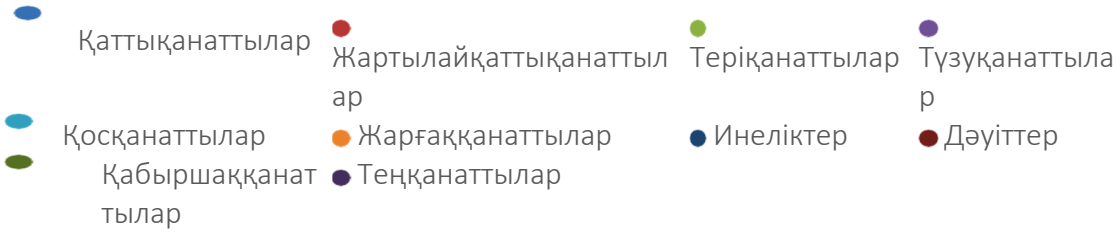
Зерттеу материалдары мен әдістері.

Тарбағатай ұлттық саябағында бунақденелілерді жинастыру жұмыстары 2025 жылдың жаз және күз айларында жүргізілді. Зерттеу барысында Тарбағатай мемлекеттік ұлттық табиғи паркінің аумағында бунақденелілердің әртүрлі тіршілік ету орталарында кеңінен таралғаны байқалды. Олардың кездесуі қоршаған ортаның абиотикалық және биотикалық факторларымен, соның ішінде температура, күн сәулесінің түсу қарқындылығы, өсімдік жамылғысының сипаты және қоректік ресурстардың қолжетімділігімен байланысты. Әсіресе хош иісті гүлдері бар өсімдіктер өсетін, күн сәулесі мол түсетін және қоректік қоры жеткілікті учаскелерде бунақденелілердің белсенділігі жоғары болды. Мұндай орталар гүл шырынымен және тозаңмен қоректенетін жәндіктер үшін қолайлы жағдай қалыптастырады, сонымен қатар өсімдіктер мен бунақденелілер арасындағы экологиялық байланыстың нығаюына ықпал етеді. Бунақденелілердің тіршілік әрекеті қоршаған орта температурасына тікелей тәуелді, өйткені олар дене температурасын негізінен сыртқы орта жағдайларына

сәйкес реттейтін эктотермді жануарларға жатады. Температураның төмендеуі олардың қозғалыс белсенділігінің, зат алмасу қарқындылығының және қоректену үдерістерінің баяулауына әкеледі. Қолайсыз суық кезеңде көптеген түрлер қыстап шығуға бейімделіп, диапауза күйіне өтеді немесе тіршілік циклінің белгілі бір кезеңінде белсенділігін уақытша тоқтатады. Бұл бейімделу механизмдері бунақденелілердің маусымдық өзгерістерге төтеп беруіне және табиғи орта жағдайларында тіршілігін сақтап қалуына мүмкіндік береді. Осылайша, зерттеу аймағында бунақденелілердің таралуы мен белсенділігіне өсімдік жамылғысы, күн сәулесі және температуралық жағдайлар елеулі әсер ететіні анықталады. Бунақденелілерді көбіне жаз,көктемнің аяғында және күздің басында ұстауға мүмкіндік бар. Энтомологиялық зерттеуде К.К Фасулати (1971) және Дедюхин С.В. (2011) тәсілдері пайдаланылды [4-5].



Сурет 1. Тарбағатай ұлттық саябағының бунақденелілерінің отрядтарының кездесу жиілігі



Қаттықанаттылар бунақденелілер класы бойынша ең көп тараған отряды болса да, ғылыми әдебиеттерде Тарбағатай өңірінде кездесетін қаттықанаттылар туралы ақпараттар жоқтың қасы. Қаттықанаттылар, ереже бойынша Тарбағатай ұлттық саябағындағы басым тіршілік ететіндер болып табылады және осы отряд бойынша 29 түрі тіркелді, табылған түрлер келесі тұқымдастарға жатады: Meloidae, Elateridae, Scarabaeoidae, Chrysomelidae, Scarabaeidae, Buprestidae өкілдері болып табылады.

Қазақстан бойынша жартылайқаттықанттылардың 35 тұқымдасы, 1250-ге жуық түрі кездеседі [6]. Ал, Тарбағатай ұлттық саябағында жартылайқаттықанаттылардың 8 түрі тіркелді және олар Pentatomidae, Miridae, Coreidae, Pyrrhocoridae тұқымдастарына жатады.

Теріқанаттылар отряды бойынша Forficulidae тұқымдасына жататын *Forficulina aurisularia* түрі анықталды.

Қосқанаттылар түрлік құрамы мен саны жағынан бунақденелілер ішіндегі ең көп

тараған отряды болып табылады. Қазіргі таңда қосқанаттылардың шамамен 120 мың түрі белгілі [7].Тарбағатай өңірінде кездесетін қосқанаттылар туралы басқа әдебиеттерде аздаған деректер болғанымен де, осы өңірде кездесетін нақты зерттелген отряд жайлы мағлұматтар жоқ. Қосқанаттылар бойынша *Eristalinaetenax, Lucilia sericata* түрлері тіркелді.

Жарғаққанаттылар *Polistes sp., C.vagus* түрлері кездесті. Инеліктердің *A.affinis, A.isoceles, S. vulgatum* түрлері тіркелді.

Дәуіттер отрядының кең таралған түрі кәдімгі дәуіт *M.religiosa* түрі табылды. Қабыршаққанаттылар бунақденелілер класындағы ең көп тараған отряд, санақ бойынша 160 мыңға жуық түрі бар. Қазақстанда деректер бойынша 58 тұқымдасы таралған [4, 23-27]. Тарбағатай ұлттық саябағынан қабыршаққанаттылар отрядының Noctudidae тұқымдасының өкілдері басым болды. Сонымен қоса, Nymphalidae, Sphingidae, Pieridae, Lymantriidae, Lasiocampidae, Pyralididae тұқымдастарына жататын түрлер -*A.io, D.elpenor, S.oclelatus, Am.oculea, S.celsia, A.crenata, P.brassicae* тіркелді.

Сурет 1-де көрініп тұрғандай 42% қаттықанаттылар, 26% қабыршаққанаттылар, 11% жартылай қаттықанаттылар, 9% түзуқанаттылар кездесу жиілігі бойынша басым болып келеді. Ал қалған бунақденелілер 1- 4 % аралығын құрайды.

Зерттеу жаңалығы:

1. Тарбағатай ұлттық саябағында бунақденелілер класы бойынша 10 отряд, 36 тұқымдасына жататын 70 түрі зерттелді(1кесте), олардың кадастры құрылды және морфологиясы әрі экологиясы туралы мәліметтер алынды.
2. Кездесу жиілігі бойынша таксономиялық анализ жасалынды, зерттеу аймағында қаттықанаттылардың Meloidae, Scarabaeoidae, Chrysomelidae, Scarabaeidaeтұқымдастарының өкілдері доминанттылық көрсетеді.
3. Зерттеу аймағының қабыршақанаттыларының Nymphalidae, Pieridae, Lymantriidae тұқымдастарының өкілдері кең таралған болып келеді.
4. Зерттеу жұмысының материалдарын табиғатты қорғау іс-шараларында қолдануға болады. Сонымен қатар, Тарбағатай ұлттық саябағының бунақденелілерінің кадастрын анықтағыш құралы ретінде биологияны оқытуда пайдалануға болады.

1 кесте. «Тарбағатай» мемлекеттік ұлттық табиғи паркінің бунақденелілерінің кадастры

Отряд	Семейство\ Тұқымдас	Род\туыс	Вид\түр
1.Қаттықанаттылар Coleoptera	1.Алагүлік қоңыздар *Meloidae*	1.*Hycleus*	1.Скабиозды алагүлік *H.scabiosae*
		2. *Mylabris*	2.Төрт нүктелі алагүлік *M. quadripunctuta*
	2.Шыртылдақтар *Elateridae*	3. *Agriotes*	3.Егістікті шыртылдық *A. sputator*
			4. Қанды шыртылдақ *A. sanguinolentus*
		4. *Athous*	5. Қара шыртылдақ *A. niger*
	3. Тақтамұртты қоңыздар *Scarabaeoidae*	5.*Trichius*	6. Жолақты қоңыз *T. fasciatus*
		6. *Polyphylla*	7. Мәрмәр қоңызы *P. irrorata*
			8. Ақ қоңыз *P. albapallas*
		7.Oxythera	9. Қола түсті түкті қоңыз O. funesta
	4. Бізтұмсықты қоңыздар Curculionidae	8.Cleonis	10. Ошаған бізтұмсықты қоңыз C. pigra
	5. Өлексежегіш қоңыздар Silphidae	9. Aclypea	11. Тегіс өлексежегіш A. calva
	6.Жұмсақденелі қоңыздар Cantharidae	10.Cantharis	12.Қоңыр жұмсақденелі қоңыз C. fusca
	7.Барылдауық қоңыздар Carabidae	11. Cicindela	13.Cicindela songorica
		12.Happalus	14. Қызыл аяқты гарпалюс H. rutripes
		13.Abax	15. Қара Абакс қоңызы Abax parallelepipedus

		14.Zabrus	16. Нан қоңызы Z. gibbus
	8.Отыншылылар Cerambycidae	15.Monochamus	17. Қара шырша мұртты қоңыз Monochamus sartor
		16. Lamia	18. Талды ұзын мұртты қоңыз L. textor
		17. Dorcadion	19.Dorcadion holosericeum
	9.Жапырақжегіш Chrysomelidae	18. Chrysomela	20. Күлгін түсті жапырақжегіш қоңыз Ch. violacea
		19.Leptiotarsa	21.Колорад қоңызы L.decemlineate
		20.Crosita	22.Алтайлық крозита C.altaica
	10.Тақтамұрттылар Scarabaeidae	21.Cetonia	23.Алтынтүсті қалақоңыз C. aurata
	11. Сусүйгіштер Hydrophilidae	22.Hydrophilus	24. Сусүйгіш қара қоңыз Hydrophilus piclus
	12. Қара денелі қоңыздар Tenebrionidae	23.Blaps	25. Дала жайбасары B. halophile
			26.Ілмек жайбасары B.Mortisaga
			27.Ұзын денелі жайбасар B. lethifera
		24.Tribolium	28.Ұн қоңызы T. confusum
	13.Buprestidae	25.Chelcophora	29.Үлкен қарағай қоңызы Ch.mariana
2.Жартылай қаттықанаттылар Hemiptera	14. Қалқаншалылар Pentatimidae	26. Eurydema	30.Қырыққабат қандаласы E. ventralis
			31.Рапс қандаласы E. oleracea
		27. Dolycoris	32.Жидек қандаласы D. baccarum
		28. Palomena	33.Жасыл ағаш қалқаншасы P. prasina

	15.Қызыл қандалалар Pyrrhocoridae	29.Pyrrhocoris	34.Әскер қандала P. apterus
	16. Miridae	30. Lygus	35. Шалғындық қоңызы L. pratensis
	17. Қандалалар Coreidae	31.Coreus	36.Қандала C. marginatus
3.Теңқанаттылар Homoptera	18.Әнші цикадалар Cicadidae	32. Cicadinae	37. Әнші цикадасы C. querula
4. Теріқанаттылар Dermaptera	19.Нағыз айырқұйрықтар Forficulidae	33.Forficulina	38. Кәдімгі айырқұйрық Forficulina aurisularia
5. Түзуқанаттылар Orthoptera	20.Нағыз шегірткелер Acrididae	34.Myrmeleoetix	39. Ала түсті шегіртке M. maculatus
		35.Arcyptera	40. Дала шегірткесі A.microptera
		36.Locusta	41. Азиаттық шегіртке L.migratoria
		37.Tettigonia	42. Жасыл шегіртке T.viridissima
		38.Desticus	43.Қарапайым шегіртке D.verrucivorus
	21.Cryllidae	39.Mulangryllus	44.Шалғын шегірткесі M.desertu pall
6. Қосқанаттылар Diptera	22.Шыбындар Syrphidae	40. Eristalinae	45.Ильница шыбыны E.tenax
	23. Каллифорид Calliphoridae	41. Lucilia	46. Ет жасыл шыбыны L. sericata
7.Жарғаққанаттылар Hymenoptera	24. Нағыз ара Vespidae	42.Polistes	47.Кәдімгі ара Polistes.sp.
	25.Құмырсқа Formicidae	43.Camponotus	48.Адастырушы құмырсқа C.vagus
8. Инеліктер Odonata	26.Aeshnidae	44.Aeshna	49.Туысшыл инелік A.affinis
		45.Anaciaeshna	50.Тоқсары инелігі A.isoceles

	27. Нағыз инеліктер Libellulidae	46.Sympetrum	51.Кәдімгі инелік S.vulgatum
9.Дәуіттер Mantodea	28. Нағыз дәуіттер	47.Mantis	52. Дәуіт M.religiosa
10. Қабыршақ қанаттылар Lepidoptera	29.Нимфалида Nymphalidae	48.Aglais	53. Тауыскөзді көбелек A. io
	30.Бозашы Sphingidae	49.Deilephila	54.Орташа қызыл бозашы D.elpenor
		50. Smerinthus	55. Көзше бозашы S. oclelatus
	31.Түн көбелектері Noctudidae	51.Amphipoca	56.Қалақша тәрізді түн көбелегі Am.Oculea
		52.Apamea	57. Астық сұр көбелегі Apamea anceps
		53.Staurophora	58.Әсем түн көбелегі S.celsia
		54.Emmelia	59.Шырмауық түн көбелегі E.trabealis
		55.Schinia	60.Күнбағыс көбелегі S.scutosa
		56.Autographa	61.Мандарин түн көбелегі A.mandarina
		57.Apamea	62.Жолбарыс түсті көбелек A.crenata
	32.Ақ көбелектер Pieridae	58.Colias	63.Шалғындық сары көбелек C.hyale
		59.Pierisa	64.Ақ рапс көбелегі P.napi
		60.Pieris	65.Қырыққабат ақ көбелегі P.brassicae
	33.Толқынды көбелектер Lymantriidae	61.Lymantriini	66.Сыған көбелегі L.dispar

	34.Lasiocampidae	62.Gastropachini	67.Филлодесма Phyllodesma
		63.Gastropacha	68.Кокон көбелегі G.quercifolia
	35.Pyralididae	64.Loxostege	69.Шалғындық көбелек L.sticticalis
	36. Sitoragadae	65.Sitoraga	70. Кішкентай астық көбелегі S.cerlalella
Барлығы 10	36	65	70

Пайдаланған әдебиеттер тізімі:

1. Қазақстан Республикасының Ауыл шаруашылығы министрлігі Орман шаруашылығы және жануарлар дүниесі комитетінің "Тарбағатай" мемлекеттік ұлттық табиғи паркі" республикалық мемлекеттік мекемесін құру туралы № 382. Қазақстан Республикасы Үкіметінің 2018 жылғы 27 маусымдағы № 382 қаулысы.
2. Кадырбеков Р.Х. және авторлар ұжымы. *Насекомые (Insecta) государственного национального природного парка «Тарбагатай» и сопредельных территорий.* — Алматы: Лем, 2023.
3. Zlatanov B.V. On the fauna and ecology of hoverflies (Diptera, Syrphidae) of the Tarbagatai Ridge (Eastern Kazakhstan) // *Bulletin of the Karaganda University. Biology, Medicine, Geography Series.* — 2022. — Vol. 108, No. 4. — P. 51–59. — DOI: https://doi.org/10.31489/2022bmg4/51-59.
4. Фасулати К.К. Полевое изучение наземных беспозвоночных: учебное пособие для биологических специальностей университетов. — 2-е изд., доп. и перераб. — М.: Высшая школа, 1971. — 424 с. Дедюхин С.В. Принципы и методы эколого-фаунистических исследований наземных насекомых: учебно-методическое пособие. — Ижевск: Удмуртский университет, 2011. — 93 с.
5. *Мақала:* Состав и экологическая структура фауны подстилки и почвенных клопов (насекомых, клопов) в сосновых лесах Казахстанского нагорья (Центральный Казахстан). Фамилия автора: Вероника С. Абукенова, Надежда П.Славченко, Гульназ Т.Картбаева.
6. “Тарбағатай” мемлекеттік ұлттық табиғи паркінің жәндіктер фаунасының әртүрлілігін бағалау, оны мониторингілеу, сақтау және орнықты пайдалану https://zool.kz/kz/zhobalar/ayatalan-zhobalar/oczenka-raznoobraziya-fauny-nasekomyh-gosudarstvennogo-naczionalnogo-prirodnogo-parka-tarbagataj-ee-monitoring-sohranenie-i-ustojchivoe-ispolzovanie/
7. В.Л. Казенас. Роющие осы (Тип Членистоногие, класс Насекомые). Серия «Животные Казахстана в фотографиях». - Алматы, 2013. - 160 с.
8. Прямокрылые (orthoptera) в естественных и антропогенных ландшафтах семи-аридных и аридных территорий центра азии М.Г. Сергеев

ҚАЛДЫҚ СУЛАРДЫ ҚАЙТА ПАЙДАЛАНУ МҮМКІНДІКТЕРІ ЖӘНЕ СУ РЕСУРСТАРЫН ТИІМДІ БАСҚАРУ

Исаев Ғани Исаұлы
техн.ғ.к., профессор м.а., Қожа Ахмет Ясауи атындағы Халықаралық қазақ-түрік университеті, Түркістан, Қазақстан Республикасы.
Нармахан Айгүл Мұхитқызы
Қожа Ахмет Ясауи атындағы Халықаралық қазақ-түрік университетінің магистранты, Түркістан қ., Қазақстан Республикасы.

Аңдатпа. Су ресурстарын ұтымды басқаруда ағынды суды тазарту мен оны мақсатқа сәйкес қайта пайдалану өзара байланысты міндеттер болып табылады. Мақаланың мақсаты – қалдық сулардың құрамы, тазарту технологиялары және қайталама қолдану талаптары арасындағы байланысты жүйелеп, автожуу кәсіпорындары үшін технологиялық шешім таңдау өлшемдерін негіздеу. Зерттеуде Қазақстан ғалымдарының және халықаралық авторлардың жарияланымдарын іріктеу, салыстырмалы талдау, нәтижелерді сапалық жинақтау және технологиялық сызбаны құрастыру әдістері қолданылды. Талдау механикалық тазарту мен мұнай өнімдерін бөлудің бастапқы қорғаныс қызметін атқаратынын, ал тұрақты эмульсиялар мен еріген заттар қосымша өңдеуді қажет ететінін көрсетті. Технологияларды салыстыру негізінде су сапасына қарай өзгертілетін сатылар, қайтарылатын су ағыны, таза сумен толықтыру және қалдықтарды әкету қамтылған сызба ұсынылды. Қайта пайдалану бағыттары бақылау көрсеткіштерімен байланыстырылды. Негізгі нәтиже – суды барынша терең тазартуға емес, нақты қолдануға жеткілікті әрі тұрақты сапаға қол жеткізуге негізделген таңдау тәртібі. Ұсыныстар шағын қызмет көрсету кәсіпорындарының су есебін, жабдық күтімін және төгінділерді басқаруын жетілдіруге арналған.

Түйін сөздер: ағынды су; суды қайта пайдалану; су ресурстарын басқару; автожуу; коагуляция; мембраналық тазарту; су сапасын бақылау.

Кіріспе

Қазақстан жағдайында ағынды суды қайта пайдалану табиғи көзден алынатын суға сұранысты төмендетудің және ластағыштардың қоршаған ортаға түсуін шектеудің бірлескен құралы ретінде қарастырылуы тиіс. М. С. Қалмаханова және әріптестері Орталық Азиядағы тазарту жүйелерін талдап, қайталама қолданудың тиімділігі технологиямен қатар санитариялық қауіпсіздікке, пайдалану тәртібіне және мониторингке тәуелді екенін көрсетеді [1]. Бұл тұжырым суды тазартылған ресурс ретінде басқаруды талап етеді.

Қ. Оспанов және әріптестерінің Алматы тазарту құрылыстарына арналған зерттеуінде нақты ағын құрамы мен жобалық режимнің сәйкестігі, тұндыру, белсенді тұнбаны басқару және су теңгерімі бірге қарастырылған [2]. Демек, жабдықтың болуы жеткіліксіз: судың көлемі мен сапасы өзгергенде технологиялық режим де бейімделуі қажет.

С. Б. Анапьянова және әріптестері Ертіс алабындағы елді мекендердің тазартылған тұрмыстық суын суаруға жарамдылығы бойынша бағалаған. Зерттеу иондық құрам мен топырақтың тұздану қаупін жеке тексерудің маңызын ашады [3]. А. Б. Есжанов және әріптестері модификацияланған полиэтилентерефталат мембраналарында модельдік су-май эмульсияларын бөлуді зерттеген [4]. Бұл нәтижелер мембраналық бөлудің мүмкіндігін

сипаттайды, алайда оларды құрамы ауыспалы автожуу ағындысына тікелей көшіруге болмайды.

Қ. Мейрамқұлова және әріптестері табиғи цеолит қабатының тереңдігі суаруға бағытталған қосымша тазартуға әсер ететінін көрсеткен; тәжірибелер Танзаниядағы тұрақтандыру тоғанының суымен орындалған [5]. Қазақстандық ұйымдар қатысқан Т. Мкилиманың зерттеуінде автожуу суын микробтық отын элементі мен металл-органикалық құрылымдарды біріктіріп өңдеу қарастырылған [6]. З. Сармурзина және әріптестері бактериялық қауымдастықтардың органикалық ластануды азайту әлеуетін бағалаған [7]. Бұл жұмыстар биологиялық және сорбциялық әдістердің мүмкіндігін ашады; шағын кәсіпорынға енгізу үшін олардың тұрақтылығы мен қызмет көрсетуі бөлек бағалануы керек.

Шетелдік еңбектерде В.-Х. Куань және әріптестері автожуу ағындыларына бірнеше әдісті үйлестіруді негіздейді [8]. З. Б. Гөндер және әріптестері электрокоагуляцияны наносүзумен біріктірген [9], ал В. Томчак және әріптестері ультрасүзгі мембраналарын ұзақ пайдалануда тазалау қажеттігін көрсеткен [10]. М. Афзалдың тобы табиғи процестерге негізделген айналым жүйесін нақты нысандарда зерттеген [11]. Ф. Казембейги және әріптестері технологиялардың экологиялық-пайдалану шектеулерін салыстырған [12]. Я. Ли және әріптестері қайталама суаруда азот жүктемесін басқаруды қарастырған [13]. Жинақталған тәжірибеде ашық қалған практикалық мәселе – ластағыш түрін, су сапасын және кәсіпорынның пайдалану мүмкіндігін бір шешім тәртібіне біріктіру.

Зерттеу мақсаты – қалдық су құрамына және оны қайта қолдану мақсатына сәйкес тазарту сызбасын таңдау өлшемдерін жүйелеп, автожуу үшін инженерлік ұсыныс негіздеу. Міндеттері: ластану ерекшеліктерін талдау; технологиялардың мүмкіндігі мен шектеулерін салыстыру; қайталама қолдануды бақылау көрсеткіштерімен байланыстыру; су айналымы мен қалдық ағындары қамтылған сызба ұсыну. Ғылыми жаңалығы осы өлшемдерді шағын кәсіпорын жағдайына арналған өзара байланысты таңдау тәртібі ретінде жүйелеумен айқындалады.

Зерттеу материалдары мен әдістері

Материалдар тақырып аясында жарияланған еңбектерден іріктелді. Іздеу журналдардың ресми сайттарында және университет репозиторийлерінде «wastewater reuse», «carwash wastewater treatment», «water-oil separation», «сточные воды» тіркестерімен жүргізілді. Іріктеу өлшемдері: тақырыпқа сәйкестік, тексерілетін библиографиялық деректер, әдістеме мен тәжірибе жағдайларының сипатталуы және өзектілік. Қорытынды корпусқа 2022-2024 жылдардағы он екі еңбек және біріктірілген тазартуды негіздейтін 2020 жылғы бір жұмыс енгізілді.

Салыстыру ластағыштың күйі, жою механизмі, қайталама қолдану мақсаты және пайдалану жүктемесі бойынша орындалды. Жарияланған нәтижелер бастапқы су түрі мен тәжірибе ауқымын ескеріп жинақталды. Кестелер мен сызба – авторлық аналитикалық жинақтау есебінде алынды.

1-кесте – Ағынды суларды тазарту технологияларын салыстырмалы бағалау

Технология	Негізгі жойылатын ластану	Артықшылық	Шектеулері	Автожууға қолданылуы
Механика-лық тазарту	Қоқыс, құм, шөгетін қалқыма заттар	Қарапайым; кейінгі жабдықты қорғайды	Еріген заттар мен тұрақты эмульсия қалады	Бастапқы саты; шламды жүйелі шығару
Майды бөлу	Еркін, ірі тамшылы май	Реагентсіз бөлу; майды жинау	ББЗ тұрақтандыр-ған эмульсияға жеткіліксіз	Майұстағыш; құрамға сай коалесцентті блок
Коагуляция және флокуляция	Коллоидтар, эмульсияланған май, байланысқан органика	Ұсақ ластануды бөлінетін үлпекке айналдырады	Реагент, pH бақылауы, химиялық шлам	Құрам сынамасымен таңдалады; кейін үлпек бөлінеді
Флотация	Майлы үлпектер, жеңіл қалқыма бөлшектер	Баяу шөгетін ластануды бөледі	Ауа мен энергия; беткі шламды жинау	Майлы ағынға; тұндырудың баламасы
Сүзу және сорбция	Қалдық бөлшектер; сорбцияланатын еріген органика	Қосымша тазарту; модульдік шешім	Кері жуу, қанығу, материалды ауыстыру	Сүзу – құрамға сай; сорбция – көрсетіліммен
Мембрана-лық әдістер	Ультрасүзуде бөлшектер; тығыз мембранада тұздар да	Мақсатқа сәйкес жоғары сапалы су	Бітелу, қысым, жуу; концентрат түзіледі	Соңғы шаюға не жоғары сапа қажет болса
Залалсыз-дандыру	Микробтар	Микробтық қауіпті төмендетеді	Майлылық пен тұздылықты жоймайды	Қолдану қаупіне сай; тиімділігі тексеріледі

Биологиялық ыдырайтын тұрақты органикалық жүктемеде биосүзгі немесе биореактор қосымша нұсқа болуы мүмкін [7]. Микробтық отын элементі мен металл-органикалық материалды үйлестіру автожуу суына зерттелген [6], бірақ шағын кәсіпорынға енгізу материалдың тұрақтылығы мен пайдалану шығынын бағалауды талап етеді.

Табиғи процестерге негізделген жүйелер де балама ұсынады. Афзал және әріптестері Пәкістандағы үш көлік жуу нысанында өсімдікті тазарту модульдері мен құм сүзгісін біріктіріп, екі жыл бойы бақылаған. Бастапқы оттегінің химиялық тұтынылуы 335-555 мг/л болған; жер асты ағынды жасанды батпақты модульден кейін оның төмендеуі нысандар бойынша 97-98%-ға жеткен [11]. Бұл – аталған көрсеткіш пен зерттеу жағдайының нәтижесі. Қазақстанда осындай жүйеге қажетті аумақ, суық кезеңдегі жұмыс және маусымдық тұрақтылық жеке негізделуге тиіс.

Қайталама суды қолдану оның шығу тегінен және соңғы тұтынушы талабынан басталады. Кәсіпорын ішінде ол жабдық пен аумақты техникалық жууға, автожууда алдын ала суландыру мен негізгі жууға бағытталуы мүмкін. Көлікті соңғы шаю кезінде қалдық тұздар мен қаттылықтың дақ қалдыру ықпалы жеке бағаланады. Технологиялық жарамдылық судың түссіздігімен ғана анықталмайды; еріген заттар мен микробиологиялық жағдай да есепке алынады [8, 9].

Суару үшін негізінен лайықты тазартылған тұрмыстық немесе құрамы дәлелденген өзге ағынды су қарастырылады. Тұз мөлшері, натрийдің кальций мен магнийге қатынасы, қоректік элементтер және санитариялық көрсеткіштер топырақ пен өсімдік жағдайында бағаланады [3, 5]. Ли және әріптестерінің зерттеуі тазартылған сумен келетін азотты тыңайтқыш пен суару режиміне қосып есептеудің маңызын көрсетеді [13]. Сондықтан

автожуу суын жасыл желекке бағыттау оның техникалық жууға жарамдылығынан автоматты түрде туындамайды.

Басқарудың бастапқы құралы – таза су кірісін, қайта берілетін суды және жүйеден әкетілетін ағынды бөлек есептеу. Салыстыру бірдей кезең мен қызмет көлемі үшін жүргізіледі. Қайталама судың операцияларға берілген жалпы судағы үлесін төмендегі қарапайым көрсеткішпен сипаттауға болады:

$$R = \frac{V_{қ}}{V_{қ} + V_{т}} \times 100\ \%$$

Мұнда R – қайта пайдаланылатын судың үлесі, %; Vқ – есептік кезеңде операцияларға қайтарылған су көлемі, м³; Vт – сол операцияларға тікелей немесе толықтыру арқылы берілген таза су көлемі, м³. Бір айналым суы әр пайдаланылған сайын есепке алынады. Бұл көрсеткіш мембрананың су шығымына тең емес және таза су үнемін өздігінен дәлелдемейді: үнем бір қызмет бірлігіне шаққандағы бұрынғы және кейінгі таза су шығынымен тексеріледі.

2-кесте – Тазартылған суды қайта пайдалану бағыттары және бақылау көрсеткіштері

Пайдалану бағыты	Маңызды сапа көрсеткіштері	Дайындау сатылары	Қолдану шарттары
Автожууда алдын ала және негізгі жуу	Лайлылық, қалқыма заттар, мұнай өнімдері, ББЗ, pH	Механикалық тазарту, майды бөлу, қажет қосымша өңдеу	Жабдыққа үйлесімділік; қызметкердің жанасуы мен аэрозольді бағалау
Көлікті соңғы шаю	Минералдану, қаттылық, органикалық қалдық, микробиология	Алдын ала тазарту; қажет болса наносүзу немесе кері осмос	Дақ қалдырмауы; сапасы тұрақты су; бөлек беру желісі
Жабдық пен аумақты техникалық жуу	Қалқыма заттар, майлар, тұздар, санитариялық көрсеткіштер	Сүзу және құрамға сәйкес қосымша тазарту	Адаммен жанасуды ескеру; ауызсу желісінен бөлу
Жасыл желекті суару	Тұздылық, натрийлік қауіп, азот, микробиология, уытты заттар	Су көзіне сәйкес биологиялық не қосымша өңдеу	Топырақ пен өсімдікке жарамдылық; суару режимі; санитариялық бағалау

Автожуу ағындысы көлік бетінен шайылған құм, шаң, топырақ, май және жуу реагенттері араласқанда түзіледі. Құрамы көлік түріне, маусымға және жуғыш затқа байланысты өзгереді [12]. ББЗ май тамшыларын суда тұрақтандырып, эмульсия түзеді, сондықтан беттегі еркін майды бөліп алу бүкіл мұнай өнімін жоймайды. Қалқыма заттар сүзгіні бітесе, еріген органика мен тұздар мөлдір суда да сақталуы мүмкін. Бастапқы тексеруде pH, қалқыма заттар, лайлылық, мұнай өнімдері, ББЗ, электрөткізгіштік және оттегінің химиялық тұтынылуы анықталады. Соңғысы – тотығатын заттардың жиынтық жүктемесін сипаттайтын көрсеткіш.

Механикалық тазарту торда ірі қоқысты ұстап, құмұстағышта ауыр минералдық бөлшектерді шөктіреді. Тұндырғыш баяу ағын жағдайында шөгетін қалқыма заттарды бөледі. Бұл саты сорғылардың қажалуын және кейінгі жабдықтың жүктемесін азайтады. Оның шектеуі – ұсақ коллоидтар, тұрақты эмульсиялар мен еріген заттардың толық ұсталмауы. Теңестіру ыдысы жуу кезіндегі үзікті келуді жұмсартады; көлемі ең жоғары ағын мен жұмыс кестесіне қарай есептеледі. Тұнған құм мен шламды уақтылы шығару пайдалы көлемді сақтайды [2, 8].

Мұнай өнімдерін бөлу тығыздық айырмасына және коалесценцияға, яғни май тамшыларының бірігуіне негізделеді. Майұстағышта іріленген еркін май бетке көтеріліп

жиналады. Бұл тәсіл реагент шығынынсыз бастапқы жүктемені төмендетеді, бірақ жуғыш заттар тұрақтандырған ұсақ тамшыларға әсері шектеулі. Сондықтан қалдық мұнай өнімдері көрсеткіші жоғары болса, тек майұстағышпен шектелу негізсіз [4, 12].

Коагуляцияда реагент ұсақ бөлшектердің тұрақтылығын бұзады; флокуляцияда олар баяу араластыру арқылы ірі үлпектерге бірігеді. Үлпектер тұндырумен немесе флотациямен бөлінеді. Әдіс лайлылық пен эмульсияланған май жүктемесін азайтуға жарайды. Реагент пен pH тәжірибелік араластыру сынамасымен таңдалады: артық мөлшер химиялық шығын мен шлам көлемін өсіреді. Электрокоагуляцияда ұқсас коагулянт темір не алюминий электродынан түзіледі; мұнда электр энергиясы, электродтың жұмсалуы және пассивациясы ескеріледі [9, 12].

Флотация ұсақ ауа көпіршіктеріне жабысқан жеңіл бөлшектер мен майлы үлпектерді су бетіне шығарады. Ол баяу шөгетін ластануды бөлуге қолайлы; коагуляциядан кейін тұндырғыштың баламасы бола алады. Қысымды ауа жүйесі мен беткі шламды жинау механизмі қызмет көрсетуді қажет етеді. Ауаның берілуі немесе үлпек түзілуі бұзылса, тазарту тұрақтылығы төмендейді [8, 12].

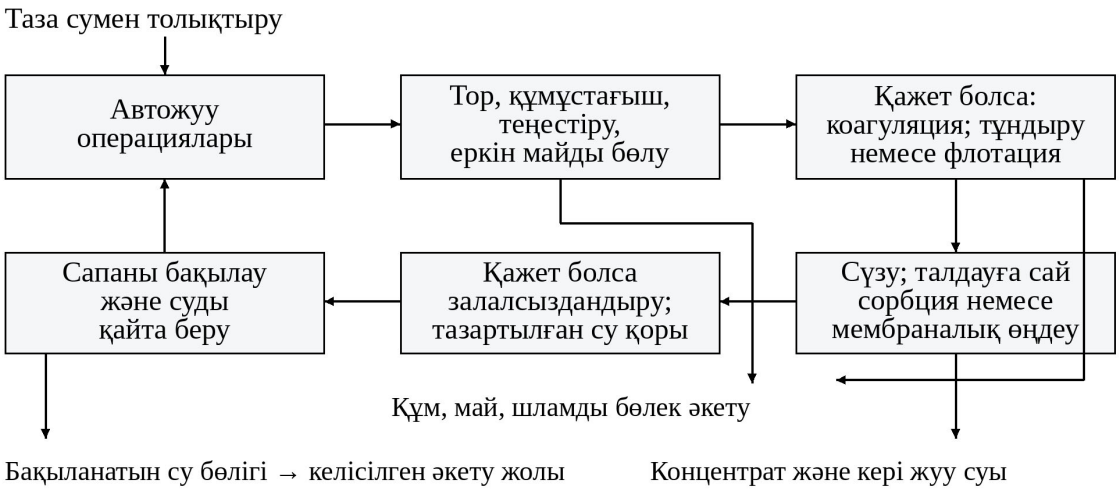
Түйіршікті сүзгі қалған қатты бөлшектерді қабатында ұстайды; сорбент, мысалы белсендірілген көмір, кейбір еріген органикалық заттарды бетіне жинақтайды. Сорбция тиімділігі заттың табиғатына, жанасу уақытына және материалдың қанығуына тәуелді. Сүзгі кері жуылады, сорбент ауыстырылады не қалпына келтіріледі. Цеолит бойынша зерттеу қабат тереңдігінің маңызын көрсеткенімен, оны барлық ластағыш пен тұзға әмбебап шешім деуге болмайды [5].

Ультрасүзу қалқыма және эмульсиялық бөлшектерді мембранамен ұстайды, алайда еріген тұздарды жеткілікті бөлмейді. Наносүзу немесе кері осмос тұздар мен қаттылықты төмендету қажет болғанда қарастырылады. Алдын ала өңдеу мембрананың бітелуін азайтады; қысым, жуу реагенттері және концентратты әкету шығындары сақталады [9, 10]. Залалсыздандыру аэрозоль, жанасу және сақтау қаупі бағаланғаннан кейін таңдалады. Ультракүлгін өңдеу мөлдір су мен жеткілікті сәулеленуді талап етеді, сақтауда қалдық қорғаныс бермейді; химиялық тәсілде доза, жанасу уақыты және қалдық реагент бақыланады [1].

Нәтижелер және талқылау

Салыстыру нәтижесі – тазарту сызбасын ластағыш күйі мен судың қолданылуына қарай таңдау тәртібі. Іске асыруда өнімділік, алаң, пайдалану шығыны және персонал дайындығы ескеріледі. Шағын автожууда механикалық бөлу, майұстау және сүзу бастапқы негіз бола алады; сапа расталмаса, қосымша саты енгізіледі.

Тұрақты эмульсия басым болса, коагуляция мен үлпекті бөлу қарастырылады. Ағыны үлкен нысанда флотацияны автоматты мөлшерлеумен үйлестіру орынды болуы мүмкін. Соңғы шаю үшін қаттылық пен тұздар кедергі келтірсе, осы операцияға арналған су бөлігін мембраналық өңдеу ұсынылады. Гөндер және әріптестері 25 °C температурада, 250 айн/мин араластыруда темір электродпен алдын ала өңдеп, кейін Desal 5 DL наномембранасын қолданған. Осы үйлесімде хлорид бойынша 92%, электрөткізгіштік бойынша 80%, жалпы қаттылық бойынша 90% төмендеу алынған [9]. Бұлар – үш бөлек көрсеткіш бойынша тәжірибе нәтижелері; ұсынылатын қондырғының өнімділігі нақты жағдайда тексеріледі.



1-сурет – Автожуу ағындыларын тазарту және суды қайта пайдалану сызбасы

Сүзгі жуу суы, майлы шлам және концентрат бөлек есепке алынады. Тұз жиналғанда ағынның бір бөлігі әкетіліп, таза су қосылады. Күтім жоспары сүзгі қысымын, сорбент қанығуын, реагент пен энергия шығынын қамтиды. Мембрананы химиялық тазалау қажеттігі ұзақ пайдалану нәтижелерімен негізделеді [10].

Қорытынды

Ғылыми жарияланымдарды талдау қалдық суларды қайта пайдалану мүмкіндігі бастапқы ағынның құрамына, тазарту технологиясының тиімділігіне және судың кейінгі қолданылуына қойылатын талаптарға тәуелді екенін көрсетті. Осыған байланысты тазарту жүйесін таңдау ластағыштардың түрін анықтаудан басталып, қажетті су сапасын қамтамасыз етумен және оның тұрақтылығын бақылаумен жалғасуы тиіс. Тазартылған суды техникалық қажеттіліктерге, жуу операцияларына немесе суаруға бағыттау әр қолдану саласының технологиялық және санитариялық ерекшеліктерін ескеруді талап етеді.

Автожуу орындарының ағынды суларын қарастыру бірнеше тазарту әдісін үйлестіру қажеттігін айқындады. Механикалық тазарту мен майұстау құмды, қалқыма бөлшектерді және еркін мұнай өнімдерін бөлуге мүмкіндік береді. Ал тұрақты эмульсиялар, жуғыш заттар және еріген қосылыстар болған жағдайда коагуляция, флотация, сорбция немесе мембраналық өңдеу бастапқы су талдауының нәтижесіне сәйкес таңдалады. Ұсынылған технологиялық сызба негізгі жуу мен соңғы шаю операцияларының талаптарын ажыратып, қосымша өңдеуді қажет ететін су ағынын жеке дайындауға негізделген. Мұндай тәсіл тазарту сатыларының құрамын кәсіпорынның нақты жағдайына бейімдеуге мүмкіндік береді.

Қайталама су пайдаланудың тұрақтылығы су шығынын есепке алумен, сапаны жүйелі бақылаумен және жабдыққа уақтылы қызмет көрсетумен қамтамасыз етіледі. Айналым барысында еріген заттардың жиналуын шектеу үшін таза сумен толықтыру, ағынның белгілі бір бөлігін әкету және түзілетін қалдықтарды басқару қарастырылуы қажет. Қазақстандағы шағын қызмет көрсету кәсіпорындары үшін осы шараларды біртұтас жүйе ретінде енгізу таза су тұтынуын төмендетуге және су ресурстарына түсетін жүктемені азайтуға мүмкіндік береді. Шешімнің практикалық тиімділігі қол жеткізілген су сапасы, нақты үнем және пайдалану шығындары бойынша бағалануы тиіс.

Қаржылану көзі: зерттеу №101235515-GreenCA-ERASMUS-EDU-2025-CBHE-STRAND-2 гранттық келісімшарты бойынша «Орталық Азиядағы тұрақты даму үшін су саласындағы «жасыл» білім беру» («Greening water education for sustainable development in Central Asia») атты Erasmus+ халықаралық гранттық жобасы есебінен орындалды.

Пайдаланылған әдебиеттер тізімі

1. Kalmakhanova M. S., Diaz de Tuesta J. L., Malakar A. [et al.]. Wastewater Treatment in Central Asia: Treatment Alternatives for Safe Water Reuse // Sustainability. – 2023. – Vol. 15, No. 20. – Art. 14949.

2. Ospanov K., Kuldeyev E., Kenzhaliyev B., Korotunov A. Wastewater Treatment Methods and Sewage Treatment Facilities in Almaty, Kazakhstan // Journal of Ecological Engineering. – 2022. – Vol. 23, No. 1. – P. 240-251.

3. Анапьянова С. Б., Набиоллина М. С., Мамырбекова Г. К. [и др.]. Оценка пригодности для орошения очищенных сточных вод малых населенных пунктов, расположенных в бассейне реки Ертис // Ізденістер, нәтижелер – Исследования, результаты. – 2024. – № 3 (103). – С. 361-371.

4. Yeszhanov A. B., Korolkov I. V., Shakayeva A. Kh. [et al.]. Preparation of Poly(Ethylene Terephthalate) Track-Etched Membranes for the Separation of Water-Oil Emulsions // Eurasian Journal of Chemistry. – 2023. – Vol. 28, No. 2 (110). – P. 131-138. - DOI: 10.31489/2959-0663/2-23-5.

5. Meiramkulova K., Mkilima T., Baituk G. [et al.]. Treatment of waste stabilization pond effluent using natural zeolite for irrigation potential // PLoS ONE. – 2022. – Vol. 17, No. 6. – Art. e0259614.

6. Mkilima T., Zharkenov Y., Utepbergenova L. [et al.]. Carwash wastewater treatment through the synergistic efficiency of microbial fuel cells and metal-organic frameworks with graphene oxide integration // Case Studies in Chemical and Environmental Engineering. – 2024. – Vol. 9. – Art. 100582.

7. Sarmurzina Z., Bissenova G., Temirkhanov A. [et al.]. Water pollution remediation in Kazakhstan: evaluating bacterial consortiums for organic pollutant decomposition // AQUA – Water Infrastructure, Ecosystems and Society. – 2023. – Vol. 72, No. 10. – P. 1956-1968.

8. Kuan W.-H., Hu C.-Y., Ke L.-W., Wu J.-M. A Review of On-Site Carwash Wastewater Treatment // Sustainability. – 2022. – Vol. 14, No. 10. – Art. 5764.

9. Gönder Z. B., Balcıoğlu G., Vergili I., Kaya Y. An integrated electrocoagulation–nanofiltration process for carwash wastewater reuse // Chemosphere. – 2020. – Vol. 253. – Art. 126713.

10. Tomczak W., Woźniak P., Gryta M. [et al.]. Cleaning of Ultrafiltration Membranes: Long-Term Treatment of Car Wash Wastewater as a Case Study // Membranes. – 2024. – Vol. 14, No. 7. – Art. 159.

11. Afzal M., Arslan M., Younus S. [et al.]. A nature-based closed-loop wastewater treatment system at vehicle-washing facilities: From linear to circular economy // iScience. – 2024. – Vol. 27, No. 4. – Art. 109361.

12. Kazembeigi F., Bayad S., Yousefi Nasab A. [et al.]. Techno-environmental study on the consequences of carwash wastewater and its management methods // Heliyon. – 2023. – Vol. 9, No. 9. – Art. e19764.

13. Li Y., Zhang H., Liu M., Pei H. How to Minimize the Nitrogen Pollution Risk of Applying Reclaimed Sewage for Urban Turfgrass Irrigation // Water. – 2024. – Vol. 16, No. 3. – Art. 460.

Journalism

MEDIA POLARIZATION AND POLITICAL FRAMING IN GEORGIA

The 2024 Parliamentary Election and the Subsequent Political Crisis

Giorgi Abazadze
Akaki Tsereteli State University, Assistant Professor, Doctor of Mass Communication

Abstract
This paper examines how major Georgian media outlets framed key events surrounding the 26 October 2024 parliamentary election and the political crisis that followed. Using an event-based comparative approach, it considers secondary media-monitoring evidence and selected reporting by television, radio and online outlets. Four frames guide the analysis: institutional legitimacy, electoral legitimacy, conflict, and European integration/sovereignty. The findings suggest that media polarization was not static: the central object of political contestation shifted from electoral competition to the legitimacy of election results and parliament, and then to the country's European trajectory. Differences between outlets appeared not only in the events they selected, but also in terminology, source attribution, the assignment of responsibility and the prominence given to particular actors. The paper argues that event-based framing helps explain how a shared political event can acquire competing meanings in a polarized media environment.
Keywords: media polarization; political communication; framing; Georgia; parliamentary elections; legitimacy; European integration

1. Introduction

Georgia's parliamentary election of 26 October 2024 was followed by a prolonged political confrontation over the election results, the legitimacy of the newly elected parliament, protest and the country's European future. News media became important arenas in which these events were interpreted. In a polarized media environment, outlets may report the same event while assigning it different political meanings through headline choices, terminology, source selection, ordering of information and the prominence given to competing explanations.

This paper asks: how did major Georgian media outlets frame key events surrounding the 2024 election and the subsequent political crisis, and how did these frames change as the conflict developed? Rather than deciding which political side was correct, the analysis examines how claims were attributed, contextualized or presented as the outlet's own account.

2. Conceptual approach and methodology

The study draws on framing theory, particularly the understanding that communication selects and emphasizes aspects of an event in ways that shape its interpretation (Entman, 1993). It uses a mixed-source, event-based comparative design, combining secondary evidence from OSCE/ODIHR media monitoring, qualitative monitoring by the Georgian Charter of Journalistic Ethics, the ISET Media (de)Polarization Index, and a purposive review of publicly accessible reports about politically significant events.

The media sample includes Georgian Public Broadcaster/First Channel, Imedi, Rustavi 2, TV Pirveli, Mtavari Arkhi and Formula, alongside the Georgian Service of Radio Free Europe/Radio Liberty and Netgazeti. The analysis is organized around four frames: (1) institutional legitimacy, concerning constitutional procedure and state institutions; (2) electoral legitimacy, concerning the validity of results and the mandate of elected representatives; (3) conflict, emphasizing protest,

police action, arrests and confrontation; and (4) European integration/sovereignty, concerning the EU, external pressure and Georgia's geopolitical direction.

The event-level sample is purposive, not exhaustive. Therefore, the paper treats its close readings as comparative qualitative evidence rather than a complete statistical count of all media output. Figures from external monitoring are identified as secondary data and are not merged with researcher-generated counts.

3. Findings and discussion

3.1. Polarization before and after the election

The pre-election period provides a baseline for understanding the crisis that followed. OSCE/ODIHR monitoring for 18 September–25 October 2024 reported marked differences in both the amount and tone of coverage devoted to Georgian Dream. The party accounted for 82% of campaign coverage on Imedi and 80% on Rustavi 2, compared with 61% on First Channel, 56% on Formula, 52% on Mtavari Channel and 51% on TV Pirveli. The tone also differed: 80% of Georgian Dream coverage on Imedi was positive or neutral, while the corresponding negative figures were 89% on Formula, 90% on Mtavari Channel and 91% on TV Pirveli (OSCE/ODIHR, 2024). These figures do not establish that every individual item was partisan, but they indicate systematic differences in the media environment.

3.2. From electoral legitimacy to parliamentary legitimacy

After the election, the main communicative dispute shifted toward the validity of the results and the status of the new parliament. The governing party presented the result as a mandate to form government, while opposition parties rejected the outcome and questioned the parliament's legitimacy. This distinction matters for framing analysis: a phrase such as "stolen election" is a political claim whose presentation should be examined—whether it is attributed to a source, tested against evidence, contextualized or adopted by the outlet.

The first sitting of parliament on 25 November provides a useful comparative case. First Channel emphasized the institutional opening while also reporting on the protest outside. Imedi focused on the formal basis of the session and the registration of 89 deputies. Netgazeti foregrounded that only Georgian Dream deputies were present in the chamber, while opposition-oriented coverage emphasized the disputed legitimacy of the parliament and presented the protest as a response to an allegedly stolen election. The same event was thus interpreted through institutional continuity, legitimacy dispute and democratic resistance.

3.3. European integration and the conflict frame

The announcement of 28 November concerning the postponement of opening EU accession negotiations until 2028 changed the dominant political context and was followed by renewed demonstrations. Government-oriented narratives could frame the position through sovereignty, national decision-making and resistance to external pressure; opposition and protest narratives could frame it as a departure from Georgia's European trajectory. The ISET Media (de)Polarization Index identified 28 November as a peak in media polarization, linking it to the announcement and ensuing protests (ISET Policy Institute, 2024).

Coverage of the following night increasingly focused on police dispersal, water cannon, arrests, injuries, barricades and attacks on journalists. Outlets differed in which actions they placed first and how they assigned responsibility. Conflict framing, therefore, is not simply the act of reporting that confrontation occurred; it also concerns which actors are presented as responsible, threatened, justified or victimized. Journalists themselves became targets during the protests, further entangling media institutions in the conflict they were covering.

4. Conclusion

The Georgian case suggests that media polarization during the 2024 election and subsequent crisis was a dynamic process. The central object of contestation moved from electoral competition to the legitimacy of results and parliament, and then toward European integration, sovereignty and

street confrontation. The most consequential differences between outlets did not always lie in whether an event was reported, but in which facts were made salient, whose explanations were privileged, how responsibility was attributed and whether competing claims were contextualized. The analysis does not establish that all outlets were equally biased or that all political claims were equally supported by evidence. It instead highlights the need to distinguish verified facts from attributed political claims and editorial framing. Future research could strengthen this event-based approach through a larger archive of broadcast transcripts and online articles, independent coding by multiple researchers and reported intercoder-reliability measures.

References

Entman, R. M. (1993). Framing: Toward clarification of a fractured paradigm. Journal of Communication, 43(4), 51–58.

Georgian Charter of Journalistic Ethics. (2024). Monitoring Report, TV News. https://www.qartia.ge/en/research/article/99380-monitoring-report-tv-news

ISET Policy Institute. (2024). November 2024 | Media (de)Polarization Index. https://iset-pi.ge/en/indexes/14-media-depolarization-index/3533-november-2024-media-depolarization-index

OSCE/ODIHR. (2024). Georgia, Parliamentary Elections, 26 October 2024: Final Report. https://odihr.osce.org/odihr/elections/georgia/584029

Architecture

ТАБИҒИ ЖӘНЕ ТЕХНОГЕНДІК ГИПС ҚҰРАМДЫ ШИКІЗАТ НЕГІЗІНДЕГІ БАЙЛАНЫСТЫРҒЫШ МАТЕРИАЛДАР: ӘДЕБИ ШОЛУ

Нұртөре Әлішер Ғалымжанұлы
магистрант, инженер, Л.Н. Гумилев атындағы Еуразия ұлттық университеті
Байменова Гульназ Рахимовна
Научный руководитель доктор PhD, Л.Н. Гумилев атындағы Еуразия ұлттық университеті

1. Кіріспе

Құрылыста гипс байланыстырғыштарына деген сұраныс ешқашан төмендеген емес, мұның түсінікті себептері бар. Технологиясы қиын емес, цементпен салыстырсақ, энергия әлдеқайда аз жұмсалады - бірнеше есе. Жабдыққа салынатын қаржы да, металл да көп кетпейді. Двуводный гипс жартылай сулы күйге 140-220 °С шамасында-ақ өтеді. Клинкерді күйдіруге бұдан әлдеқайда жоғары температура керек, сондықтан отын шығыны да, атмосфераға тасталатын CO2 мөлшері де мүлде басқа деңгейде [1, 2].

Бірақ табиғи гипс тасы кез келген өңірде табыла бермейді. Кен орны алыста болса, тасымалдау шығыны өнімнің өзіндік құнына едәуір әсер етеді. Сол себепті көптеген зерттеушілер өнеркәсіптің гипсі бар қалдықтарына назар аударады - фосфогипс, цитрогипс, боргипс, фторангидрит сияқты. Әлемде мұндай қалдықтың елуден астам түрі бар екені белгілі [3]. Олардың жыл сайын түзілетін көлемі байланыстырғыш алу үшін өндірілетін табиғи гипс тасынан анағұрлым көп.

Біздің ел үшін бұл мәселе қағаз жүзіндегі қызығушылық қана емес. Таразда Қаратау фосфориттерін өңдейтін, фосфор қышқылы мен минералды тыңайтқыш шығаратын зауыттар бар, ал олардың үйінділерінде фосфогипс ондаған жыл бойы жиналып келеді [6, 7]. Ол шикізаттың сапасы бір қалыпты емес. Сондықтан оны құрылыс материалдарына пайдаланбас бұрын, қасиеттерін жан-жақты зерттеп алу керек деп ойлаймын.

Бұл шолуда Белгородтағы БМТУ им. В.Г. Шухов ғалымдарының екі жұмысына тоқталамын. Бірінші мақалада лимон қышқылы өндірісінен қалған цитрогипстен байланыстырғыш алынып, одан жартылай құрғақ престеу тәсілімен бұйым жасалған [3]. Екіншісінде үш кәсіпорынның фосфогипсі табиғи гипспен қатар зерттеліп, шикізаттың шығу тегіндегі айырмашылықтар байланыстырғыштың қасиетіне қалай әсер ететіні көрсетілген [4]. Менің ойымша, бұл екі жұмыс бірін-бірі жақсы толықтырады. Цитрогипс аз мөлшерде түзіледі, бірақ таза; фосфогипстің көлемі орасан, есесіне қоспасы көп.

2. Гипс құрамды қалдықтардан байланыстырғыш алудың негізгі әдістері

Alfimova мен әріптестері [3] гипсі бар қалдықтардың кеңінен қолданылмауының басты себебін былай түсіндіреді: табиғи шикізатқа арналған әдеттегі режимдер мен жабдықты оларға сол күйінде пайдалану қиын. Қалдықтың ылғалдылығы жоғары, табиғи күйінде 80%-ға дейін жетеді. Бөлшектері ұсақ. Ал қоспалардың құрамы мен мөлшері шикізат түріне де, технологиялық циклге де қарай едәуір құбылып отырады.

Әдебиетті талдай келе, авторлар байланыстырғыш алудың үш жолын атайды. Алғашқысы - автоклавта, жоғары қысым мен температурада өңдеу. Ұйымдастыруы жағынан ең оңайы осы, бірақ нәтижесінде физика-механикалық көрсеткіштері төмен β-жартылай гидрат қана шығады. Беріктігі 30 МПа-ға дейін жететін α-модификациялы гипс алуға болады, бірақ энергия шығыны және арнайы жабдық қажеттілігі оны экономикалық тұрғыдан тиімсіз етеді. Екіншісі - күкірт қышқылын реагент ретінде қолданатын күйдірусіз әдіс. Энергия аз кетеді, бірақ процесс күрделі, үнемі бақылау мен сынама алуды талап етеді, жабдық тез тозады, жұмыс жағдайы қолайсыз. Үшіншісі - атмосфералық қысымда күйдіру (кальцинация). Өндірісті ұйымдастыру тұрғысынан ең қарапайымы осы, алайда ол тек β-жартылай гидрат береді, ал оның физика-механикалық көрсеткіштері төмен.

Сонда күйдірілген байланыстырғыштың беріктігі неліктен төмен болады? Авторлар оған тікелей жауап береді. Қалдықтың да, одан алынған байланыстырғыштың да меншікті беті өте үлкен, ал бөлшектері кеуекті келеді. Осының кесірінен су көп сіңеді де, қысуға да, иілуге де беріктік азаяды. Мұны жеңілдетудің екі жолы көрсетілген. Біріншісі - суперпластификатор қосу: фосфогипс негізінде орта есеппен 15 МПа, кейде 29 МПа-ға дейін алынған. Екіншісі - жоғары қысыммен қалыптау. Мысал ретінде қытай ғалымдарының фосфогипстен қағазсыз гипсокартонға ұқсас материал алған тәжірибесі келтіріледі [8]. 20 МПа қысыммен қайта-қайта престегенде иілуге беріктік 18,9 МПа болған, ал 170 °С-та дегидратациялап, 3 сағат престегенде - 14,7 МПа.

3. Цитрогипстен байланыстырғыш алу және одан бұйым қалыптау

Зерттеуге Белгородтағы лимон қышқылын биохимиялық жолмен өндіретін кәсіпорынның қалдығы алынған. Үйінді 50 жыл бойы жиналған, 58,5 мың м² жерді алып жатыр, алдын ала есеп бойынша қоры 351,2 мың м³. Құрамы жағынан бұл өте таза еківодты гипс: CaO 29,7-31,5%, SO3 44,0-45,5%, SiO2 0,3-1,2%, MgO 0,1-0,4%. Фосфогипстен басты артықшылығы - мұнда фосфор, фтор, радиоактивті элементтер сияқты зиянды қоспалар жоқ, демек тазартудың қажеті болмайды. Әйтсе де мұндай қалдық аз түзіледі: бүкіл әлем бойынша жылына небәрі 0,03-0,04 млн т.

Сырт қарағанда бұл сұр түсті ұнтақ. Сканерлеуші электронды микроскоппен қарағанда бетінің ауданы үлкен ірі пластинка тәрізді бөлшектер көп, араларында бағана тәрізді кристалдар да кездеседі. Материалды үйіндіден шөмішті экскаватормен алып, біркелкі болуы үшін араластырған. Содан кейін ашық ауада 30 % ылғалдылыққа дейін кептіріп, жартылай өнеркәсіптік қондырғыда күйдірген. Режим шығар кездегі байланыстырғыштың температурасы шамамен 120 °С болатындай етіп таңдалған.

Байланыстырғыштың меншікті беті 600-650 м²/кг шыққан, бұл табиғи гипстен бірнеше есе көп. Негізгі кемшілігі де осыдан келеді. Қалыпты қоюлықтағы қамыр алу үшін (жайылуы 180±5 мм) 300 г байланыстырғышқа 370 г су қажет болған, яғни қалыпты қоюлық 123%. Ұстасу уақыты МЕМСТ 125-79 талабына сай келеді: басы 18 мин, аяғы 30 мин, демек материал қалыпты қатаятын Б тобына жатады. Ал беріктігі стандартқа жетпейді. 30% ылғалдылықпен дірілдеткіш үстелде қалыпталған 40×40×160 мм арқалықтар 2 сағаттан кейін иілуге 2,5 МПа, қысуға 3,3 МПа көрсеткен. Бұл шамамен Г-3 маркасына сәйкес.

Лазерлік гранулометриялық талдаудың нәтижесі қызық болды. Жоғары берік Г-16 гипсінің бөлшектері кең аралықта, бірнеше шыңмен (полимодальды) таралған. Ал цитрогипстің өзі де, одан алынған байланыстырғыш та тар аралықта, бір ғана шыңмен таралады. Күйдірген соң бөлшектер аздап ұсақталады, өйткені турбиналық кептіргіштен өткенде ірі фракция шөгіп қалады. Кристалдардың пішіні де әртүрлі: Г-16-да ірі бағана тәрізді, Г-5-те ұзынша, бірақ ұсақ, ал цитрогипс байланыстырғышында көлемі шамалас пластинкалар.

Құю әдісімен бұйым жасауға беріктік жетпейтін болғандықтан, авторлар басқа жолды таңдаған - жоғары қысыммен жартылай құрғақ престеу. Бұл бағыт бойынша РФ патенті

алынған [5]. Қоспа құрамы мынадай: цитрогипс байланыстырғышы 83%, перлит шаңы 1,5 % (үйінді тығыздығы 75 кг/м³, түйіршіктері 5-100 мкм), су 15,5%; су/байланыстырғыш қатынасы 0,18-0,19. Перлитті алдымен суға қанықтырады. Сонда қоспа оңай араласады, кесектенбейді, ылғал бүкіл көлемге біркелкі тарайды. Дайын қоспаны қалыпқа салып, 10 МПа қысыммен 30 секунд ұстайды.

1-кесте. Цитрогипс негізіндегі престелген бұйымдардың қасиеттері [3]

Көрсеткіш	Мәні
Қалыптан шығарғаннан кейінгі беріктік, МПа	2,5
Престеуден 2 сағаттан кейінгі беріктік, МПа	15-16
Құрғақ бұйымның қысуға беріктігі, МПа	19-20
Су сіңіргіштік, %	5-тен аспайды

Нәтиже көңіл аударарлық. Құйғанда 3,3 МПа ғана берген сол байланыстырғыш престегенде 20 МПа-ға дейін жеткен. Авторлар мұны былай түсіндіреді: престеу кезінде үлкен меншікті бет кемшілік емес, керісінше пайдалы қасиетке айналады. Бөлшектер бір-біріне көбірек тиіседі, ал су тек химиялық реакцияға жетерліктей ғана берілгендіктен, артық су буланғанда пайда болатын кеуектер аз болады. Тағы бір маңызды жайт - қалыптан шыққан бойда беріктік 2,5 МПа болады. Бұл ақаудың азаюына әсер етеді және көп қуысты бұйымдар шығаруға жол ашады.

4. Фосфогипстің шығу тегі мен байланыстырғыш қасиеттерінің байланысы

Levickaya мен әріптестерінің [4] мақаласы басқа мәселені қарастырады. Әдебиетте фосфогипстен алынған β-жартылай гидраттың беріктігі 4-тен 13,8 МПа-ға дейін ауытқиды, ал өңдеу шарттары шамамен бірдей. Олай болса, себепті технологиядан емес, шикізаттың өзінен іздеу керек. Авторлар Ресейдің үш кәсіпорнының фосфогипсін (PGBel, PGBal, PGKin) Шедок кен орнының табиғи гипсімен салыстырған. Біз үшін ең қызығы - PGBel шикізатына Ковдор апатитімен бірге Қаратау фосфориттері де кіреді. Яғни бұл деректер қазақстандық шикізатқа тікелей қатысты деп айтуға болады.

Рентгенфазалық талдау барлық үлгіде $CaSO4 \cdot 2H2O$ фазасы бар екенін көрсетті, тек PGKin-де негізгі шыңның (d = 7,63 Å) қарқындылығы сәл төмен. Химиялық құрамы да жақын: CaO мен SO3 басым. Дегенмен фосфогипстерде табиғи гипсте кездеспейтін қоспалар бар: P2O5 0,68-1,87%, F 0,98-1,04%, SrO 2,52%-ға дейін (PGBal), сондай-ақ сирек жер элементтері. Термиялық талдауда фазалық ауысу температуралары аздап жылжиды. Жартылай гидрат PGBel-де 154,4 °C-та, PGBal-да 159,6 °C-та, табиғи гипсте 152 °C-та түзіледі; ерімейтін ангидрит фосфогипстерде 435-436 °C-та, табиғи гипсте 353,6 °C-та пайда болады. Адсорбциялық судың кету температурасы бәрінде бірдей болғандықтан, авторлар табиғи гипстің орнына фосфогипс қолданса, күйдіруге жұмсалатын энергия өзгермейді деген қорытындыға келеді.

Ең айқын айырмашылық кристалдардың пішінінде. PGBel - ине тәрізді моноклинді кристалдар (ромбтық тип). PGBal - 100-400 мкм агрегаттарға жиналған ұсақ инелер (ұсақ ромбтық тип). PGKin-де инелермен қатар беті кедір-бұдыр тас тәрізді конгломераттар бар (агрегатты-қысқа инелі тип). Қызығы, PGBel мен PGKin бір кен орнының шикізатынан алынған, бірақ технология мен жабдықтың өзгешелігі морфологияны мүлде өзгертіп жіберген. Ірілік модулі де бірдей емес: PGBel 1,28, PGBal 1,89, PGKin 2,72. PGKin конгломераттары диспергациядан кейін де бөлінбеген, яғни олар өте қатты екенін атап өткен жөн.

2-кесте. Қалыпты қоюлықтағы байланыстырғыштардың қасиеттері [4]

Көрсеткіш	PGBel	PGBal	PGKin	Табиғи гипс
Қалыпты қоюлықтағы С/Қ	0,92	0,88	0,70	0,70
Ұстасу басы / аяғы, мин	17 / 22	11 / 19	15 / 25	18 / 25
Құрғақ тығыздық, кг/м³	908	935	1056	1120
Иілуге беріктік (құрғақ), МПа	2,47	2,55	3,35	5,74
Қысуға беріктік (құрғақ), МПа	4,67	5,29	8,14	11,96
Меншікті бет (ауа өткізгіштік), м²/кг	301,0	241,8	192,3	457,0

175 °С-та күйдірілген байланыстырғыштарды салыстырғанда (2-кесте) бір заңдылық анық байқалады: суды көп қажет еткен сайын, беріктік төмендей береді. PGBel-ге қалыпты қоюлық үшін С/Қ = 0,92 керек болған, сондықтан оның құрғақ беріктігі табиғи гипстен екі жарым есе төмен. Сынау кезінде 2 сағаттық үлгілердің бетіне ылғал шыққан. Бұл судың бір бөлігі гидратацияға емес, тек қамырдың қоюлығы үшін жұмсалатынын білдіреді. PGKin табиғи гипс сияқты С/Қ = 0,70 талап етсе де, беріктігі бәрібір төмен. Авторлар мұның себебін кристалдардың бір-біріне жабысуына кедергі келтіретін қоспалардан көреді. Сонымен қатар фосфогипстер табиғи гипстен ертерек ұстаса бастайды; ұстасу басы ең қысқасы PGBal-да (11 мин), бұған жуылмай қалған фосфор қышқылының қалдығы әсер еткен.

Менің пайымымша, ең маңызды нәтиже С/Қ-ны 0,5-тен 0,9-ға дейін өзгертіп, 30×30×30 мм кубтарды сынағанда алынған. С/Қ бірдей болғанда тығыздықтың айырмашылығы шамалы, ал беріктік С/Қ-ға байланысты қатты өзгереді. С/Қ = 0,5 кезінде PGBal 18,24 МПа, PGBel 16,89, PGKin 16,94, табиғи гипс 16,86 МПа көрсеткен. Демек, С/Қ 0,7-ден төмен болса, фосфогипс байланыстырғыштары табиғи гипстен кем түспейді, тіпті асып түседі. Табиғи гипс тек С/Қ = 0,8 болғанда ғана анық басым шығады. С/Қ = 0,6 үлгілерін электронды микроскоппен қарағанда, PGBal мен табиғи гипсте ұзын ине тәрізді кристалдар, ал PGBel мен PGKin-де призма тәрізді, арматураланған құрылым көрінеді.

Қысқаша айтқанда, зерттелген үш фосфогипстің үшеуі де табиғи гипстің орнын баса алады. Беріктікті төмендететін негізгі себеп - меншікті бет пен кеуектілікке байланысты судың көп қажет болуы. Оны азайту үшін авторлар ұсақтауды және суперпластификатор қосуды ұсынады.

5. Екі жұмысты салыстыру

Екі мақаланы қатар қойып оқығанда, ортақ бір ой айқын көрінеді. Техногендік гипстің табиғи гипстен айырмашылығы химиялық құрамда емес, өйткені екеуі де негізінен CaSO4·2H2O. Негізгі айырмашылық - бөлшектердің пішіні мен меншікті беті, ал су қажеттілігі дәл осыған тәуелді. Цитрогипс байланыстырғышының меншікті беті 600-650 м²/кг, қалыпты қоюлығы 123%. PGBel фосфогипсінде бұл көрсеткіштер 301 м²/кг және С/Қ 0,92. Қалай болғанда да, қалыпты қоюлықта құйылған үлгілер стандарт талабына жетпейді.

Шешімі де екі жұмыста бір бағытқа саяды: суды азайту қажет. Фосфогипс бойынша авторлар С/Қ-ны 0,5-ке түсіргенде табиғи гипспен теңесетінін зертханада дәлелдеп, ұсақтау мен суперпластификаторды ұсынумен тоқтаған. Цитрогипс авторлары бір қадам алға кеткен: су/байланыстырғыш қатынасын 0,18-0,19-ға дейін азайтып, 10 МПа қысыммен престеу арқылы беріктігі 19-20 МПа болатын ұсақ дана бұйым алған және оны патенттеген. Сондықтан цитрогипс жұмысын фосфогипс мақаласындағы идеяның іс жүзіндегі технологиялық іске асуы деп қарауға болады.

Қазақстанға қатысты екі нәрсені айтып кеткім келеді. Біріншіден, фосфогипс мақаласында бір кен орнының шикізатынан алынған екі фосфогипстің (PGBel мен PGKin)

морфологиясы мен ірілігі мүлде әртүрлі болып шыққан. Олай болса, Тараз фосфогипсінің қасиеттерін басқа әдебиеттен алып қолдану дұрыс емес. Оны сол мақаладағы әдістеме бойынша (РФА, ДТА, СЭМ, меншікті бет, гранулометрия, С/Қ-ға тәуелді беріктік) жеке зерттеу керек. Екіншіден, цитрогипсте престеу жақсы нәтиже бергендіктен, бұл тәсілді Қаратау фосфогипсіне де сынап көрген жөн. Әсіресе қабырға блоктары мен қалқа плиталарын алу тұрғысынан бұл бағыт перспективалы сияқты.

6. Қорытынды

Қарастырылған екі жұмыс гипсі бар өндіріс қалдықтарынан құрылыс байланыстырғыштарын алудың нақты мысалдарын береді. Цитрогипс таза, бірақ аз шығатын шикізат: кальцинациямен алынған байланыстырғыш құюға жарамайды, ал жартылай құрғақ престегенде 20 МПа береді. Фосфогипс көп түзіледі, бірақ қоспасы көп, сапасы кәсіпорынға қарай қатты құбылады. Соған қарамастан С/Қ 0,7-ден төмен болғанда ол табиғи гипспен бірдей беріктік көрсетеді. Екі жағдайда да мәселе су қажеттілігіне тіреледі, ал шешімі оны технологиялық тәсілдермен азайтуда жатыр. Қаратау фосфогипсі үшін бұл нәтижелерді бастапқы бағдар ретінде қолдануға болады, бірақ жергілікті шикізатты міндетті түрде өз алдына зерттеу қажет.

Пайдаланылған әдебиеттер

1. Pedreño-Rojas M.A., Fořt J., Černý R., Rubio-de-Hita P. Life cycle assessment of natural and recycled gypsum production in the Spanish context // Journal of Cleaner Production. - 2020. - Vol. 253. - 120056. https://doi.org/10.1016/j.jclepro.2020.120056
2. Rashad A.M. Phosphogypsum as a construction material // Journal of Cleaner Production. - 2017. - Vol. 166. - P. 732-743. https://doi.org/10.1016/j.jclepro.2017.08.049
3. Alfimova N.I., Pirieva S.Yu., Elistratkin M.Yu., Nikulin I.S., Titenko A.A. Binders from gypsum-containing waste and products based on them // IOP Conference Series: Materials Science and Engineering. - 2020. - Vol. 945. - 012057. https://doi.org/10.1088/1757-899X/945/1/012057
4. Levickaya K., Alfimova N., Nikulin I., Kozhukhova N., Buryanov A. The Use of Phosphogypsum as a Source of Raw Materials for Gypsum-Based Materials // Resources. - 2024. - Vol. 13, No. 5. - Art. 69. https://doi.org/10.3390/resources13050069
5. Alfimova N.I., Titenko A.A., Nikulin I.S., Galdun Yu.V., Pirieva S.Yu., Elistratkin M.Yu. Raw mixture for modified citrogypsum articles and method of their production. Patent RF No. 2693808. - 2018.
6. Bilal E., Bellefqih H., Bourgier V. et al. Phosphogypsum circular economy considerations: A critical review from more than 65 storage sites worldwide // Journal of Cleaner Production. - 2023. - Vol. 414. - 137561. https://doi.org/10.1016/j.jclepro.2023.137561
7. Seraya N., Litvinov V., Daumova G., Zhusipov N., Idrisheva Z., Aubakirova R. Production Waste Management: Qualitative and Quantitative Characteristics and the Calculation of the Hazard Class of Phosphogypsum // Processes. - 2023. - Vol. 11. - 3033. https://doi.org/10.3390/pr11103033
8. Zhou J., Sheng Z., Li T., Shu Z., Wang Y. Preparation of hardened tiles from waste phosphogypsum by a new intermittent pressing hydration // Ceramics International. - 2016. - Vol. 42. - P. 7237-7245. https://doi.org/10.1016/j.ceramint.2016.01.117

Philosophical Sciences

UDC 141.33:297.1

ONTOLOGICAL AND EPISTEMOLOGICAL FOUNDATIONS OF THE CONCEPT OF "TARIQA" IN ARAB-ISLAMIC PHILOSOPHY: IN THE CONTEXT OF AL-GHAZALI, IBN ARABI, AND NEUROTHEOLOGY

Temurbayev A.S.
Master's Student,a Department of Philosophy and Theory of Culture, Karaganda Buketov University, Karaganda, Kazakhstan

Abstract. In Arab-Islamic philosophy, the concept of tariqa denotes more than merely religious practice or moral and ethical precepts. It is conceptualized as a complex philosophical system that characterizes spiritual self-perfection, the cognition of existence, and the path of ascension toward the Divine. Within the Sufi tradition, tariqa is defined as a unique cognitive and experiential path that bridges sharia (the exoteric law) and haqiqa (the esoteric truth). This path is intrinsically tied to the purification of the inner self, spiritual maturation, and the comprehension of the profound essence of human existence. Consequently, tariqa transcends practical spiritual experience, functioning as a philosophical category endowed with deep ontological and epistemological substance that encompasses questions of being and knowledge.

The doctrines of Al-Ghazali and Ibn Arabi hold paramount significance in shaping the theoretical and philosophical framework of tariqa in Arab-Islamic philosophy. Although these two thinkers explicate the Sufi worldview from distinct perspectives, they share a common ultimate objective: legitimating human spiritual perfection and the path to Divine proximity. Al-Ghazali approaches tariqa primarily through a moral-ethical and spiritual-practical lens, emphasizing inner soul cultivation and spiritual purification. Conversely, Ibn Arabi articulates tariqa at a profound metaphysical and cosmological level, linking it directly to the comprehensive structure of being. From this viewpoint, their teachings can be interpreted as unified spiritual-philosophical inquiries directed toward a single goal yet executed through divergent methodologies—metaphorically described as "two different vessels sailing toward the same destination."

This article examines the ontological and epistemological foundations of tariqa in Arab-Islamic philosophy through the works of Al-Ghazali and Ibn Arabi. Furthermore, a comparative analysis of their philosophical perspectives is conducted to delineate similarities and divergences, thereby clarifying the essence and role of tariqa within the Sufi worldview.

The problem of tariqa continues to be extensively analyzed in both classical and contemporary scholarship. Ibn Arabi’s Al-Futuhat al-Makkiyya (The Meccan Revelations) and Fusus al-Hikam (The Ringstones of Wisdom) serve as primary sources for understanding the ontological structure of tariqa. Meanwhile, Al-Ghazali’s Ihya 'Ulum al-Din (The Revival of the Religious Sciences) thoroughly illuminates the ethical, spiritual, and psycho-epistemological foundations of the spiritual path. Modern scholars also investigate this subject from diverse angles. For instance, William Chittick analyzes the Sufi cognitive path through the lens of Ibn Arabi's metaphysics, whereas Andrew

Newberg endeavors to validate the scientific basis of Sufi experiences by researching the neurobiological mechanisms underlying spiritual states (neurotheology). Nevertheless, comprehensive research integrating the ontological and epistemological principles of tariqa into a unified philosophical framework remains limited.

This study utilizes philosophical hermeneutics, content analysis, and comparative-historical methodologies. The hermeneutic approach enables the unraveling of deep semantic layers inherent in classical Sufi concepts such as tariqa, fana (annihilation), and baqa (subsistence). The comparative-historical method serves to elucidate the distinctive characteristics of the cognitive models proposed by Al-Ghazali and Ibn Arabi and to evaluate the convergences and divergences in their philosophical frameworks.

1. Theoretical and Philosophical Foundations in Classical Thought

In Arab-Islamic philosophy, Al-Ghazali and Ibn Arabi stand among the most influential thinkers who established the ontological and epistemological foundations of tariqa [10, p. 125]. Although both philosophers approach the Sufi worldview via distinct pathways, their underlying objective remains unified: anchoring human spiritual perfection and the attainment of ultimate Truth (haqiqa). Their respective philosophical trajectories can be metaphorically described as "two different vessels sailing toward the same destination": Al-Ghazali elucidates tariqa from a moral-ethical paradigm, whereas Ibn Arabi elaborates it at metaphysical and cosmological levels [10, p. 126].

In Al-Ghazali’s doctrine, tariqa is primarily conceived as a spiritual pathway dedicated to disciplining the ego (nafs) and purifying the soul—a process known in Sufi tradition as tazkiyat al-nafs [11, p. 5]. Within Ghazali’s epistemological framework, the highest mode of cognition is kashf (intuitive spiritual unveiling) [11, p. 8]. In his view, ultimate reality cannot be reached solely through rational reasoning. Genuine cognition is realized through the divine light (nur) cast by God into a purified heart [10, p. 127]. Accordingly, Al-Ghazali demarcates rational knowledge ('ilm) from spiritual-intuitive illumination (ma'rifa), positioning ma'rifa as the apex of epistemology [11, p. 8]. For Al-Ghazali, tariqa must strictly harmonize with sharia; he rigorously opposes any spiritual path that strays beyond the boundaries of sacred law [10, p. 128]. He asserts that sharia constitutes the exoteric foundation leading to truth, and any departure from it risks spiritual deviation [11, p. 9]. Ontologically, Al-Ghazali structures reality into a hierarchical framework comprising three primary domains: Mulk (the physical realm), Jabarut (the realm of divine power), and Malakut (the spiritual realm) [3, p. 432]. This structural hierarchy reflects the soul's ascension from the material world to higher spiritual realms.

In the philosophy of Ibn Arabi, tariqa is conceptualized as a metaphysical journey of cognition that unlocks the profound mysteries of existence [8, p. 47]. Central to his doctrine is the concept of Wahdat al-Wujud (the Oneness of Being) [10, p. 126]. According to this doctrine, absolute existence belongs solely to the Supreme Reality (Allah), while creation represents various manifestations or self-disclosures (tajalliyat) of the Absolute [10, p. 129]. Ibn Arabi outlines the ontology of existence across five primary realms: Hahut, Lahut, Jabarut, Malakut, and Nasut, representing progressive degrees of divine manifestation in the cosmos [12, p. 310]. A cornerstone of Ibn Arabi’s philosophy is the archetype of Al-Insan al-Kamil (the Perfect Human) [10, p. 129]. The Perfect Human serves as the complete mirror of Divine names and attributes, functioning as the ontological bridge—the barzakh—between the Creator and creation [8, p. 54]. Epistemologically, Ibn Arabi equates knowledge with being, describing ma'rifa as a process of becoming the reality itself [11, p. 7]. Thus, grasping ultimate Truth is not merely an intellectual acquisition, but an ontological transformation of human existence.

2. Comparative Analysis

Comparative scholarly analysis reveals notable convergences and divergences between these two thinkers. First, their ultimate goal remains shared: both acknowledge the primacy of spiritual

experience (dhawq) over rational intellect ('aql) in reaching ultimate Truth, noting the inherent limits of pure rationalism [7, p. 1125]. Second, their methodological orientations differ. Al-Ghazali structures tariqa along a practical-ethical axis, viewing spiritual maturation as a phased progression through defined spiritual stations (maqamat). Ibn Arabi interprets tariqa at a metaphysical-symbolic tier, treating it as a process of comprehending divine self-disclosures (tajalli) throughout existence [10, p. 130]. Third, they differ regarding the functional role of sharia. For Al-Ghazali, sharia is the irreplaceable foundation of the spiritual path. For Ibn Arabi, while essential, it also serves as an entry gateway or "shell" (qishr) prioritizing the realization of inner truth [11, p. 10]. Together, Al-Ghazali's psycho-ethical synthesis and Ibn Arabi's profound metaphysical doctrine complement one another, forming a comprehensive philosophical framework of tariqa within Arab-Islamic thought [10, p. 131].

3. Modern Interpretations and Neurotheology

Among contemporary scholars, William Chittick stands out for his deep exploration of Ibn Arabi's philosophy. He frames the Sufi path of knowledge not merely as a religious practice, but as a fundamental ontological project aimed at self-discovery and the reorientation of human existence toward the Divine [1, p. 586]. Analyzing Wahdat al-Wujud, Chittick demonstrates that the primary purpose of the spiritual journey is dissolving the illusion of dualism between God and creation [8, p. 47]. Chittick highlights Ibn Arabi's "Metaphysics of Imagination," arguing that cognition extends beyond rational thinking through kashf (unveiling) and dhawq (tasting/experiencing). Thus, knowing God is an existential metamorphosis rather than mere information gathering. Chittick describes tariqa as a dynamic spiritual ascension where fana (annihilation of ego) is not absolute negation, but the realization that True Being belongs exclusively to God [8, p. 54]. Furthermore, he examines Al-Insan al-Kamil as the ontological goal of tariqa, serving as the ultimate mediation between creation and Creator [1, p. 592; 14, p. 1175].

In modern interdisciplinary research, neurotheology has emerged as a key field exploring religious experience. American neuroscientist Andrew Newberg has contributed significantly by systematically analyzing the correlations between brain activity, spirituality, and neurobiology [1, p. 586]. Newberg's scientific endeavor seeks to analyze spiritual phenomena through empirical methods without proving or disproving theological validity [1, p. 586]. Utilizing neuroimaging techniques such as fMRI and EEG, Newberg and his colleagues demonstrated that spiritual practices—such as meditation, prayer, contemplation, and Islamic dhikr—produce measurable neural changes [1, p. 586]. These findings indicate that mystical experiences possess concrete neurobiological correlates rather than being mere subjective artifacts [1, p. 586].

Neurotheological studies demonstrate that intense spiritual focus increases prefrontal cortex activity (governing attention) while elevating alpha and theta brainwave power associated with meditative states [1, pp. 586, 590]. Concurrently, activity in the Default Mode Network (DMN)—linked to ego-centric thoughts—decreases [1, p. 590]. This neurobiological attenuation provides a scientific analog for the Sufi state of fana (ego dissolution) [1, p. 592]. Newberg also considers religion through an evolutionary lens, contrasting fundamentalist neural mechanisms (linked to early survival imperatives) with mystical neural pathways representing advanced cerebral processing [3, p. 432]. In Islamic philosophy, Newberg's concepts are increasingly cited to illuminate how practices like dhikr and muraqaba (meditation) foster neuroplasticity, emotional stability, and psychological well-being [1, p. 587].

References

1. Atamimi, M. (2025). Mysticism, Sufism, and neurotheology: The link between spirituality and modern science. Jurnal Iman dan Spiritualitas, 5(4), 585–598.
2. Newberg, A., & Waldman, M. R. (2009). How God Changes Your Brain: Breakthrough Findings from a Leading Neuroscientist. New York: Ballantine Books.
3. Bilalov, M., Akaev, V., Enikeev, A., & Agaeva, M. (2019). Roots of ontological and epistemological contradictions in Islam. European Proceedings of Social and Behavioural Sciences, 76, 430–436.
4. Saraei, M., Newberg, A. B., Hosseini, S. R., et al. (2023). Comparing three states of dhikr, meditation, and contemplation on God: An fMRI study. Religion, Brain & Behavior, 13(1), 5–17.
5. Fatima, H. A., & Ullah, S. (2023). An analytical study of the relationship between spirituality, Sufism, muraqaba, and neuro-linguistic programming. Islamic Studies Research Journal Abhath, 8(31).
6. Mahmood, S. (2023). Neuroscientific Study of Religion: What Neuroimaging Research Reveals About Cognitive Pathways.
7. Benketfi, Z. (2025). Deductive paths leading to the cognition of Almighty Allah in Sufism: Investigating epistemological origins and foundations. Pegem Journal of Education and Instruction, 15(4), 1122–1137.
8. Rozi, S. (2022). Spiritual philosophy of Ibn al-'Arabi: Between external and internal dimensions. Jurnal Fuaduna, 6(1), 45–60.
9. Mannopov, I. S. (2025). Philosophical foundations of the Yasawi order. American Journal of Philological Sciences, 5(09), 88–92.
10. Anrivika, G. I., & Rahman, M. T. (2024). Investigating the Divine: A modern comparative analysis of Sufi thought in the works of Imam al-Ghazali and Ibn Arabi. Integritas Terbuka: Peace and Interfaith Studies, 3(2), 125–132.
11. Suparna, A., Rohanda, R., & Kodir, A. (2025). Epistemology of Ibn Arabi and al-Ghazali's Sufism. Syifa al-Qulub, 9(2), 1–10.
12. Lambden, S. (2020). From Nasut to Hahut: Studies in Islamic Cosmology and Mysticism. Hurqalya Publications.
13. Chittick, W. C. (1989). The Sufi Path of Knowledge: Ibn al-'Arabi's Metaphysics of Imagination. Albany: State University of New York Press.

Geographic Sciences

Dünyanın Ən Sakit Yerləri Və Akustik Ekologiya

Şəfəq Əliyeva Məmməd qızı
Azərbaycan Dövlət Pedaqoji Universitetinin Şəki filialı,müəllim

Müasir dünyada urbanizasiya, sənayeləşmə və nəqliyyat şəbəkələrinin genişlənməsi Yer kürəsinin ən ucqar nöqtələrini belə fəth edib. Biz çox vaxt havanın, suyun və torpağın çirklənməsindən danışırıq, lakin gözlə görünməyən, lakin planetin ekoloji tarazlığına ciddi zərbə vuran başqa bir təhlükəni unuduruq: **səs çirkliliyi**. Bu gün antropogen (insan mənşəli) küy artıq sadəcə şəhərlərin deyil, meşələrin, okeanların və səhraların da akustik xəritəsini dəyişdirir. Bu kontekstdə yaranan yeni elmi istiqamət – **Akustik Ekologiya** – bizə səssizliyin sadəcə "heç nəyin eşidilməməsi" deyil, qorunmalı olan tükənən bir təbii resurs olduğunu xatırladır.

Akustik Ekologiya Nədir və Səs Landşaftı (Soundscape) Necə Dəyişir?

Akustik ekologiya canlı orqanizmlərin öz mühitləri ilə səs vasitəsilə qurduğu münasibətləri öyrənir. Bu elmin banisi olan ekoloq və bəstəkar R. Murray Schafer yer üzündəki səsləri üç əsas qrupa ayırır:

Geofoniya: Təbiətin qeyri-canlı səsləri (küləyin vıyıldaması, dalğaların sahili döyməsi, ildırım çaxması).

Biofoniya: Canlı təbiətin səsləri (quşların oxuması, qurbağaların qurultusu, balinaların nəğmələri).

Antropofoniya: İnsanın və onun yaratdığı mexanizmlərin səsləri (təyyarə mühərrikləri, magistral yollar, tikinti küyləri).

Müasir coğrafiyada əsas problem antropofoniyanın həm geofoniyanı, həm də biofoniyanı tamamilə boğmasıdır. Səs dalğaları coğrafi sərhəd tanımır; meşənin dərinliyindəki bir heyvan kilometrlərlə uzaqdakı magistral yolun uğultusuna məruz qalır.

Səssizliyin Coğrafi Mühafizəçisi: "One Square Inch of Silence"

Dünyada antropogen səsdən tamamilə təmizlənmiş coğrafi zonaları tapmaq getdikcə çətinləşir. Bu sahədə ən unikal eksperimentlərdən biri ABŞ-ın Vaşinqton ştatındakı Olimpik Milli Parkında yerləşən "One Square Inch of Silence" (Səssizliyin Bir Kvadrat Düymü) nöqtəsidir.

Akustik ekoloq Gordon Hempton tərəfindən 2005-ci ildə təyin olunan bu nöqtə, planetin akustik ekologiyasını qorumaq üçün simvolik bir coğrafi abidədir. Hemptonun ideyasına görə, əgər biz yer kürəsində cəmi bir kvadrat düym ərazini tam səssiz (insan səsindən uzaq) saxlaya bilsək, bu səssizlik dalğası ətrafdakı minlərlə kvadrat kilometr ekosistemi reaktiv təyyarələrin və sənaye küyünün təsirindən qorumuş olacaq. Layihənin məqsədi federal hökuməti bu parkın üzərindən keçən hava yollarını dəyişdirməyə məcbur etməkdir. Bura daxil olduqda insan qulağı yalnız mamırların rütubəti sorma səsini, damcıları və quşların təbii tezliklərini eşidə bilir.

Dünyanın Ən Sakit Coğrafi Nöqtələri

Akustik xəritələşdirmə və peyk tədqiqatları nəticəsində dünyada təbii səs landşaftını qoruyub saxlamış bir neçə unikal yer müəyyən edilmişdir:

Məkan / Coğrafi Zona	Akustik Xüsusiyyəti	Təhlükə Amili
Haleakala Krateri (Havay)	Dünyanın ən sakit coğrafi relyeflərindən biridir. Kraterin daxili vulkanik süxurları səsi tamamilə udur, heç bir əks-səda yaratmır.	Turist helikopterlərinin səs kirliliyi.
Makmördo Quru Vadiləri (Antarktida)	Demək olar ki, sıfır rütubət və canlı orqanizmin olmaması bura unikal "mütləq səssizlik" bəxş edir. Səsi yalnız şiddətli küləklər pozur.	Elmi stansiyaların texniki avadanlıqları.
Sakit Okeanın Ortası (Nemo Nöqtəsi)	Quru torpaqdan ən uzaq nöqtə olduğu üçün okean səthində insan mənşəli səs minimumdur.	Gəmiçilik xətləri və yeraltı seysmik fəaliyyət.
Sinay Səhrası (Misir)	Qum təpələrinin səsi udma qabiliyyəti sayəsində gecələr akustik vakuum effekti yaranır.	Safari turları və motorlu nəqliyyat.

Okeanların Altındakı Səs Kabusu: Hidroakustik Çirlənmə

Səssizliyin coğrafiyası dedikdə yalnız quru sahələri nəzərdə tutulmur. Dünyanın 71%-ni əhatə edən okeanlar qaranlıq olduğu üçün oradakı canlılar (balinalar, delfinlər, balıqlar) dünyanı görməklə deyil, eşitməklə dərk edirlər. Okean biofoniyası canlıların çoxalması, miqrasiyası və ovlanması üçün həyati əhəmiyyət kəsb edir.

Lakin müasir yük gəmilərinin nəhəng pərləri, dəniz dibində neft-qaz axtarışı üçün istifadə olunan seysmik pnevmatik silahlar (airguns) və hərbi sonarlar okean səssizliyini cəhənnəmə çevirib. Seysmik silahların yaratdığı səs dalğaları hər 10 saniyədən bir təkrar olunmaqla minlərlə kilometr uzaqlıqdakı dəniz məməlillərinin qulaq pərdələrini partladır, onların istiqaməti itirməsinə və sahilə çırpılaraq kütləvi ölümünə səbəb olur. Okeanın "səssiz dünyası" artıq sənaye uğultusunun əsiridir.

Səs Çirkliliyinin İnsan Psixologiyasına Və Davranış Coğrafiyasına Təsiri

Səs ekologiyası yalnız yabanı təbiəti deyil, birbaşa insan coğrafiyasını və antropogen məkanların daxili strukturunu da idarə edir. Şəhər mühitində davamlı küyə məruz qalmaq insanda xroniki stress, yuxu pozğunluğu, koqnitiv funksiyaların zəifləməsi və yüksək qan təzyiqi kimi ciddi psixo-fizioloji problemlərə yol açır. Ümumdünya Səhiyyə Təşkilatının (ÜST) hesabatlarına görə, səs çirkliliyi Avropada hava çirkliliyindən sonra sağlamlığa ən çox zərər vuran ikinci ekoloji amildir.

Bu vəziyyət həm də sosial coğrafiyada qeyri-bərabərlik yaradır. "Akustik bərabərsizlik" adlanan bu fenomenə görə, gəlir səviyyəsi aşağı olan sosial qruplar adətən küy səviyyəsi yüksək olan magistral yolların, fabriklərin və aeroportların yaxınlığında yaşamağa məcbur olurlar. Digər tərəfdən, səssizlik artıq lüks bir əmtəəyə (commodity) çevrilir; varlı təbəqələr səssiz, yaşıllıq və izolyasiya olunmuş coğrafi rayonlara (şəhərkənarı koteclərə və ya qapalı rezidensiyalara) köçərək öz akustik rahatlıqlarını pulla satın alırlar. Beləliklə, səssizlik müasir dünyada sosial statusun coğrafi göstəricisinə çevrilmişdir.

Səssizliyin Xəritələşdirilməsi: Coğrafiyaçılar Nə Edir?

Müasir coğrafi informasiya sistemləri (COİS / GIS) artıq relyef və iqlim xəritələri ilə yanaşı "Səs Landşaftı Xəritələri" (Soundscape Mapping) hazırlayır. Alimlər həssas mikrofonları müxtəlif coğrafi zonalara yerləşdirərək günlərlə səs yazısı aparırlar. Bu xəritələr ekoloji deqradasiyanı izləməyə və şəhərlərdə və ya milli parklarda qanunla qorunan "Sakit zonalar" (Quiet Areas) elan edərək xüsusi səssizlik dəhlizləri formalaşdırmağa kömək edir.

Nəticə: Tükənən Resursu Qorumaq

Səssizlik boşluq deyil; səssizlik təbiətin öz səsini bizə eşitdirməsi üçün bir imkandır. Təmiz su və təmiz hava kimi, təbii səssizlik də insanın həm psixi sağlamlığı, həm də ekoloji zəncirin qorunması üçün əvəzedilməz resursdur. Coğrafi olaraq səssizliyin sərhədlərini qorumaq, gələcək nəsillərə təbii dünyanın əsl simfoniyasını miras qoymağın yeganə yoludur. Əks halda, bəşəriyyət öz yaratdığı küyün içində boğulmağa məhkum olacak.

Ədəbiyyat Siyahısı (References)

Schafer, R. M. (1977). The Soundscape: Our Sonic Environment and the Tuning of the World. Destiny Books.

Hempton, G., & Gross, J. (2009). One Square Inch of Silence: One Man's Quest to Preserve Quiet in a Noisy World. Free Press.

Krause, B. (2012). The Great Animal Orchestra: Finding the Origins of Music in the World's Wild Places. Little, Brown and Company.

World Health Organization (WHO). (2018). Environmental Noise Guidelines for the European Region. WHO Regional Office for Europe.

Pijanowski, B. C., et al. (2011). Soundscape Ecology: The Science of Sound in the Landscape. BioScience, 61(3), 203-216.

ISBN 978-1-62017-835-5

Proceedings of the 14th International Scientific Conference
«Interdisciplinary Science Studies» (October 15-16, 2026). Dublin, Ireland,
2026. 385p

editor@publisher.agency

https://publisher.agency

University of Dublin

Windgates 22

D02 DR53 Dublin, Ireland