



*VI international scientific conference
Brussels. Belgium
21-22.04.2026*

DIALOGUE OF TIMES: PAST, PRESENT, FUTURE

Proceedings of the VI International Scientific and Practical Conference

21-22 April 2026

BRUSSELS. BELGIUM

2026

UDC 001.1

BBC 1

VI International Scientific and Practical Conference «Dialogue of times: past, present, future», April 21-22, 2026, Brussels. Belgium. 172 p.

ISBN 978-91-65424-69-2

DOI <https://doi.org/10.5281/zenodo.19823915>

Publisher: «SC. Scientific conferences»

Main organization: 

Editor: Hans Muller

Layout: Ellen Schwimmer

The conference materials are in the public domain under the CC BY-NC 4.0 International license.

The publisher is not responsible for the materials published in the collection. All materials are provided in the author's edition and express the personal position of the participant of the conference.

The sample of the citation for publication is Gugin Aleksandr, Lisnievska Yuliia ANTI-ADVERTISING IN THE HOTEL BUSINESS // VI International Scientific and Practical Conference «Dialogue of times: past, present, future», April 21-22, 2026, Brussels. Belgium. Pp.9-11, URL: <https://sconferences.com>

Contact information

Website: <https://sconferences.com>

E-mail: info@sconferences.com

Content

Arts

Gulnar Alfi Verdiyeva FORMATION CHARACTERISTICS OF UZBEKISTAN'S NATIONAL MUSICAL INSTRUMENTS	4
--	---

Biological sciences

Ixtiyor Akramov, Begali Alikulov ANTIMICROBIAL ACTIVITY OF ENDOPHYTIC BACTERIA KRASCHENINNIKOVIA EWERSMANNIANA	8
--	---

Economic sciences

Maya Karimova I., Aslan Agayev R. IMPROVEMENT OF THE ENTERPRISE MANAGEMENT SYSTEM BASED ON INTEGRATED STANDARDIZATION AND RISK MANAGEMENT	11
S.R. Guliyeva REGIONAL DEVELOPMENT POLICY AND THE EXPERIENCE OF DEVELOPMENT AGENCIES IN AZERBAIJAN	16

Mathematical sciences

Rustemova Karashash Zhorabekovna, Shinikulova Gulnur Nurbekovna, Abdimanapova Perizat Bakhytovna, Tattibekov Konysbek Satievich SPECTRAL PROBLEM OF STABILITY FOR COUETTE FLOW BETWEEN CYLINDERS	22
Rustemova Karashash Zhorabekovna, Shinikulova Gulnur Nurbekovna, Tattibekov Konysbek Satievich, Nurmakhanova Asel Kasenovna ADJOINT OPERATOR APPROACH TO MAGNETOHYDRODYNAMIC COUETTE FLOW	27

Medical sciences

Bruno Gorana THE ROLE OF PHYSIOTHERAPY IN FALL PREVENTION AMONG OLDER ADULTS: A NARRATIVE REVIEW	32
Yeva Garbar, Valentyna Slipchuk MOLECULAR MIMICRY OF Tl ⁺ : THE MECHANISM OF ITS TOXIC EFFECTS AND ITS CONSEQUENCES FOR THE HUMAN NERVOUS SYSTEM	35
Ludmyla V. Fomina, Leonid M. Bulat, Olena I. Haidash, Oksana V. Zviahina, Artem O. Turzaiev TRANSFORMATION OF PARAMEDIC TRAINING IN UKRAINE UNDER CURRENT CHALLENGES: MILITARY EXPERIENCE AS A DRIVER FOR NEW EDUCATIONAL MODELS	37
Ulvi Hasanov, Rafiq Hajiyev METHODS OF EFFECTIVE QUALITY OF MEDICAL DEVICES	40
Harets Vira Ivanivna, Mirzebasov Maksym Abdulakhovich, Yanchevskiy Oleksandr Valeriiovich, Ludmyla V. Fomina, Valerii O. Kushnir MODERN APPROACHES TO MEDICAL REHABILITATION: CONTINUITY OF REHABILITATION CARE FROM CHILDHOOD TO ADULTHOOD	46
Kamenova B.S. ASSESSMENT OF THE QUALITY OF CARE AND PATIENT SATISFACTION WITH NURSING SERVICES IN A DISTRICT HOSPITAL	50
Arman Khozhayev, Aigul Buleshova, Nadira Chermukhambetova, Bayan Uataeva, Aigulya Izbakieva, Gulmira Doshanova, Roza Agibaeva, Shakhinur Turdiyeva, Aigerim Tleuke, Karakoz Zeidalieva, Umida Turganalieva MODERN STRATEGIES IN CHEMOTHERAPY AND TARGETED THERAPY: EFFICACY, SAFETY, AND THERAPEUTIC OPTIMIZATION	53

Pedagogical sciences

Abdraaly Rabiga Baktybekkyzy PEDAGOGICAL POTENTIAL OF INTEGRATING DIGITAL EDUCATIONAL ECOSYSTEMS INTO THE FORMATION OF PROFESSIONAL AND METHODOLOGICAL COMPETENCE OF FUTURE ENGLISH LANGUAGE TEACHERS	65
Badyrova Aikerim Nurlankyzy BARRIERS AND PROSPECTS FOR IMPLEMENTING BLENDED LEARNING IN TEACHING ENGLISH AS A FOREIGN LANGUAGE IN SMALL-CLASS RURAL SCHOOLS OF THE REPUBLIC OF KAZAKHSTAN: AN ANALYTICAL REVIEW	71
Feyzullayeva Seadet Teyfuq GUIDING AND BINARY LECTURES OF THE LEARNING PROCESS TO A QUALITY EFFECT	77
Kozhakul Nursat HELP OF AI-TOOLS IN WRITING ENGLISH AS A FOREIGN LANGUAGE	83
Mukasheva Raushana Nurbaevna THE ROLE OF TEXT-BASED ACTIVITY STRATEGIES IN THE DEVELOPMENT OF STUDENTS' CRITICAL AND ANALYTICAL THINKING	90

Okhap Aida INTEGRATING DIGITAL TOOLS AND INTERACTIVE TECHNIQUES TO BOOST UNIVERSITY STUDENTS' COMMUNICATIVE COMPETENCE	94
Orazaly Diana EXPLORING MEDIA LITERACY AND CRITICAL THINKING SKILLS AMONG UNIVERSITY STUDENTS: A SURVEY ON THEIR APPROACHES TO ANALYSING NEWS AND INFORMATION	101
Yessetova Ainur T., Mashimbayeva Ainur Zh., Utebayeva Botagoz T. LANGUAGE TRAINING IN THE MUSIC EDUCATION SYSTEM: A COGNITIVE-COMMUNICATIVE APPROACH	108
Kydyrali Zhanna Nurlankyzy, Smanova Gaziza Leskhankyzy DEVELOPING SCHOOLCHILDREN'S CREATIVE ABILITIES THROUGH THE COMMUNICATIVE APPROACH IN ENGLISH LESSONS	114
Zhumabay Zhazira Bekzhankyzy TEACHER-IN-THE-LOOP ARTIFICIAL INTELLIGENCE IN PERSONALIZED ENGLISH LANGUAGE TEACHING THROUGH THE LENS OF PEDAGOGICAL ROLES, AFFORDANCES, AND RISKS	118

Philological sciences

Nabiyeva Zulaykho KEY MOTIFS AND THEMES IN THE CHIVALRIC NOVEL HAVELOK THE DANE	132
---	------------

Physical sciences

Antonov Alexander Alexandrovich TIME TRAVELS ON EARTH IS ALREADY AVAILABLE TO PEOPLES	135
---	------------

Technical sciences

T.E. Mammadova CYBERSECURITY AND CYBER DEFENSE	154
Ulduz Mammadov, Nihat Huseynli OPTIMIZATION OF THE NATURAL GAS ABSORPTION PROCESS	157
D.T. Muhamediyeva, D.M. Yusupova, D.T. Yusupov, Sh.Z. Yuldashev CALCULATION BASED ON OPTIMIZATION OF ARITHMETIC OPERATIONS ON Z-NUMBERS	164
D. M. Yusupova ADVANCED MATH CLASSROOM MODEL OF Z-NUMBERS-BASED PYTHON MATH MODULE	166
Zhanuzakova Nazerke Kazybekovna, Kasymov Samat Kairatovich FUNCTIONAL MEAT PRODUCTS AS A PROMISING DIRECTION OF THE FOOD INDUSTRY	169

Arts

FORMATION CHARACTERISTICS OF UZBEKISTAN'S NATIONAL MUSICAL INSTRUMENTS

Gulnar Alfi Verdiyeva

Associate Professor of the Department of Music History and Theory, Faculty of Musical Art, Azerbaijan State University of Culture and Arts, PhD in Art Studies

ÖZBEKİSTAN MİLLİ MÜZİK ALETLERİNİN OLUŞUM ÖZELLİKLERİ

Verdiyeva Gülnar Elfi

Azerbaycan Devlet Kültür ve Sanat Üniversitesi Müzik Sanatı Fakültesi, Müzik Tarihi ve Teorisi Anabilim Dalı Doçenti, Sanat Bilimleri Felsefe Doktoru

ОСОБЕННОСТИ ФОРМИРОВАНИЯ НАЦИОНАЛЬНЫХ МУЗЫКАЛЬНЫХ ИНСТРУМЕНТОВ УЗБЕКИСТАНА

Вердиева Гюльнар Алфы гызы

Доцент кафедры Истории и теории музыки, факультета Музыкального искусства Азербайджанского Государственного Университета Культуры и Искусств. Доктор философии по искусствоведению

Abstract

The article examines the formation characteristics of Uzbekistan's national musical instruments from historical, theoretical, and practical aspects. Uzbek national musical instruments have ancient historical roots and have been shaped under the influence of folklore and professional musical art. Their systematic scientific study began in 1919, with researchers such as H.F.Eichhorn, V.A.Uspensky, and V.M.Belyaev making significant contributions to this field. In 1934, new types of ghijak, rubab, and doyra were created, and a typological classification of the instruments was carried out. In the works of Uzbek composers, national instruments are harmonized with European instruments, demonstrating the unity of Eastern and Western musical traditions. The folk-professional musicians of the 20th century contributed to the development of these instruments and their transmission from generation to generation.

Özet

Makale, Özbekistan milli müzik aletlerinin oluşum özelliklerini tarihsel, teorik ve pratik açılardan incelemektedir. Özbek milli müzik aletleri, kadim tarihsel köklere sahip olup folklor ve profesyonel müzik sanatının etkisiyle şekillenmiştir. Bunların sistematik bilimsel olarak incelenmesi 1919 yılında başlamış, H.F.Eychhorn, V.A.Uspenski, V.M.Belyayev gibi araştırmacılar bu alanda önemli çalışmalar yapmışlardır. 1934 yılında gıcak, rubap ve doyranın yeni türleri oluşturulmuş, aletlerin tipolojik sınıflandırması gerçekleştirilmiştir. Özbek bestecilerinin eserlerinde milli aletler, Avrupa aletleriyle uzlaştırılarak Doğu-Batı müzik geleneklerinin birliğini sergilemektedir. 20. yüzyıl halk-profesyonel müzisyenleri bu aletlerin gelişimine ve nesilden nesile aktarılmasına katkılar sağlamışlardır.

Аннотация

В статье исследуются особенности формирования национальных музыкальных инструментов Узбекистана в историческом, теоретическом и практическом аспектах. Узбекские национальные музыкальные инструменты имеют древние исторические корни и сформировались под влиянием фольклора и профессионального музыкального искусства. Их систематическое научное изучение началось с 1919 года, значительный вклад в эту область внесли такие исследователи, как Г.Ф.Эйхгорн, В.А.Успенский, В.М.Беляев. В 1934 году были созданы новые разновидности гиджака, рубаба и дойры, проведена типологическая классификация инструментов. В произведениях узбекских композиторов национальные инструменты гармонично сочетаются с европейскими инструментами, демонстрируя единство восточных и западных музыкальных традиций. Народно-профессиональные музыканты XX века внесли вклад в развитие этих инструментов и их передачу из поколения в поколение.

Keywords: *Uzbekistan, musical instruments, ghijak, range, performance capabilities, types of instruments, stringed bowed instruments, percussion instruments.*

Anahtar Kelimeler: *Özbekistan, müzik aletleri, gıcak, ses aralığı (diapazon), icra olanakları, alet türleri, yaylı çalgılar, vurmali çalgılar.*

Ключевые слова: *Узбекистан, музыкальные инструменты, гуджак, диапазон, исполнительские возможности, разновидности инструментов, струнные смычковые, ударные инструменты.*

GİRİŞ: Özbek milli müzik aletlerinin oluşumu, yüzyıllar boyu devam eden tarihî-kültürel gelişimin, etnik birlik ve coğrafi çevrenin etkisi sonucunda ortaya çıkmış karmaşık ve çok yönlü bir süreçtir. Bu aletler yalnızca bir icra aracı değil, aynı zamanda Özbek halkının dünya görüşünün, estetik zevkinin ve geleneksel yaşam tarzının açık bir tecessümüdür. Arkeolojik kazılar, eski minyatürler ve edebî kaynaklar göstermektedir ki, müzik aletleri bu bölgede kadim dönemlerden beri var olmuş ve giderek gelişip günümüzdeki çeşitli biçimlerine ulaşmıştır. Özbek halkının müzik mirasında, Doğu'nun diğer birçok halkında olduğu gibi iki büyük katmanı ayırmak mümkündür: folklor ve profesyonel müzik sanatı. Her iki katmanın gelişimi, farklı müzik aletlerinin gelişmesine sebep olmuştur. Folklor müziğinde basit yapıları aletler baskınken, profesyonel müzik sanatında ve makom icrasında daha karmaşık, zengin teknik olanaklara sahip aletler oluşmuştur. Böylece, maddi abidelerden günümüze ulaşmış zengin enstrüman fonu, Özbek müzik kültürünün sürekli gelişimini kanıtlamaktadır.

ANA METİN: XV-XVI. yüzyıl kaynaklarında ve minyatürlerinde bir dizi Özbek milli müzik aletinin adı zikredilerek tasviri verilmiştir. Özbek milli müzik aletlerinin ilk araştırmacısı Herman von Eichhorn olmuştur. O, Orta Asya müzik aletlerinin iki büyük koleksiyonunu toplayarak ilk koleksiyonu 1972 yılında Moskova'ya, ikincisini ise 1973 yılında Avusturya dünya sergisine göndermiştir. İkinci koleksiyonun Moskova ve Sankt-Peterburg şehirlerinde sergilenmesi sipariş edilmiş ve burada Orta Asya halklarına ait otuz yedi tür enstrüman yer almıştır. [Eichhorn G.F., 1885. 16 s.]

İ.Akbarov şöyle yazmaktadır: "Özbek milli müzik aletlerinin sistematik olarak incelenmesi 1919 yıllarından itibaren başlamıştır" [Akbarov İ. 1961. 344 s.]

1919 yılında Özbekistan Milli Konservatuarı bünyesinde V.A.Uspenski'nin liderliğinde milli aletlerin incelenmesi ve geliştirilmesi için bilimsel araştırma kabinesi kurulmuştur. Uspenski'nin temel amacı, Özbek milli aletlerinin tını özelliklerini araştırmak, diatonik, eksik kromatik ses düzenine sahip olan aletlerin ses aralığını genişleterek, onlara ek perdeler bağlatıp teknik imkânlarını artırmak suretiyle bestecilerin eserlerinden tam anlamıyla yararlanabilecek düzeyde geliştirmektir.

Müzik aletlerinin incelenmesi çalışmaları 1928 yılında Semerkant'ta açılan Musiki ve Koreografi Enstitüsü'nde A.A.Mironov'un liderliğinde devam ettirilmiştir. Mironov, henüz devrimden önce Alman müzikçi ustalara başvurarak Özbek tanburunu yaratmaya çalışmış, 1930 yılında ise Moskova müzik araştırmacılarını bu işe dâhil etmiştir. Ancak, ne Alman ne de Rus müzisyenlerin yarattıkları tanbur enstrümanı Özbekistan müzik pratiğinde uygulanamamıştır. Özbek milli aletlerinin incelenmesinde V.M.Belyayev özel bir faaliyet göstermiştir. Onun "Özbekistan Halk Çalgı Aletleri" kitabında bütün milli aletler bilimsel bir şekilde araştırılarak tasvir edilmiştir.

1934 yılında Özbek müzisyenleri-Şorahim Sourmanov, Matyusub Harratov ve Osman Zurapov Taşkent'te Bilimsel Araştırma Enstitüsü'nün deney atölyesi bünyesinde yorulmadan çalışarak gıcakın iki küçük, iki orta, bir büyük türünü; Kaşgar rubabının yüksek sese sahip iki türünü; doyranın büyük ve küçük türlerini yaratmışlardır. Böylece, Özbek milli müzik aletlerinin tipolojik açıdan farklı gruplara sınıflandırılması mümkün olmuştur:

Yaylı çalgılar: gıcak, sato, kobuz, setor

Tezeneli çalgılar: dombra, dutar, tanbur, ud, rubap

Telli vurmali çalgılar: çeng

Nefesli-dilli çalgılar: sızızgı, balaban, zurna, goşna

Nefesli-ağızlıkları çalgılar: nay, hacir-nay

Bakır nefesli çalgılar: karnay

Vurmali çalgılar: doyra, nağara, çindavul, sefail, kaşık.

Özbek halkının en sevilen müzik aleti olan gıcak, Orta Asya'dan başlayarak Kuzey Kafkasya'ya kadar bütün Türk halklarında yaygın olarak kullanılmakta ve ağırlıklı olarak Özbekler, Türkmenler, Tacikler ve Uygurlar tarafından icra edilmektedir. Enstrüman, dairesel bir gövdeden, uzun bir sap, perdelerin bulunduğu başlık ve bir yaydan oluşmaktadır. Gıcakta, tel yatağı eğik değil, düz bir konumda yer alır; bu yapı, tellerin aynı düzlemde bulunmasını sağlayarak yayın tüm teller üzerinde engelsiz hareket etmesine olanak tanır, seslerin daha pürüzsüz bir şekilde art arda gelmesine, hassas entonasyona ve

enstrümana özgü yumuşak tınının oluşmasına neden olur. Eskiden gıcak üç telli olup teller şu şekilde akort edilirdi: *mi bemol-la bemol-I oktav, re bemol-II oktav. Ses aralığı bir buçuk oktav hacmindeydi. Ancak, Özbek müzisyenlerinin uzun arayışlarından sonra enstrüman geliştirilerek farklı türleri oluşturulmuş ve dördüncü tel eklenerek ses aralığı küçük oktavdaki "sol" sesinden dördüncü oktavdaki "la" sesine ulaştırılmıştır. Bu konuda A.F.Eichhorn şöyle yazıyordu: "Gıcak enstrümanında, yaylı çalgılara özgü bütün yay tekniklerini icra etmek mümkündür: detaşe, legato, staccato, pizzicato, arco, glissando, vibrato. Bununla birlikte, bütün süslemeler (melizmalar) gıcakta güzel seslenir: forşlag, mordent, gruppetto"* [Eichhorn G.F., 1885. 16 s.]

Türk bilgini B. Ögel'e göre: "Gıcak sözüyle aynı anlamı taşıyan hicak sözü Türklerin arkaik sözlerinden olup, Türkün kemençesi anlamında kullanılır." [B.Ögel, 2010]

Günümüzde Özbekistan halk çalgıları orkestra ve topluluklarında, profesyonel müzik yaratıcılığında uygulanan gıcak enstrümanı, yüksek ve orta öğrenim müzik kurumlarında öğretilmektedir.

Özbeklerin vurmali müzik aleti olan doyra, İran, Irak, Türkiye, Suriye, Tacikistan ve tüm Yakın Doğu'da yaygın olarak kullanılmaktadır. Bu enstrüman ağırlıklı olarak Özbek makam icrasında kullanılır. Enstrümanın gövdesi dairesel formda olup-bir tarafı açık, diğer tarafına ise deri gerilmiş ahşap bir kasnaktan oluşmaktadır. Doyranın çapı küçük bir değişikliklerle 30-35 cm, genişliği ise 40 cm'dir. Enstrümanın iç tarafına 60-70 metal halka takılır. Doyrada icra edilen ritmik figürasyonlar, çeşitlilikleri ve renklilikleriyle farklılaşarak doğaçlama karakteri taşır.

Özbek halkının kadim nefesli müzik aleti olan zurnanın (surnay) ses aralığı (diapazonu) birinci oktavın "re" sesinden üçüncü oktavın "re" sesine kadar olsa da, işlek ses aralığı ikinci oktavın "si" sesine kadardır. Öyle ki, yüksek bölgede icracılık karmaşık nefes tekniği gerektirdiğinden ve sesin devamlılığı zorlaştığından, konser icrasında en çok kullanılan ses aralığı ikinci oktavın "si" sesine kadardır.

Karnay, İran, Tacikistan ve Özbekistan'da yaygın olarak kullanılan metal nefesli bir enstrümandır. Karnayın uzunluğu 2 metre olup, gövdesi düz, uç kısmı ise boruya benzer bir formdadır. Tını ve bölge (register) bakımından trombon enstrümanına yakındır. Ses aralığı büyük oktavın "sol" sesinden ikinci oktavın "sol" sesine kadar olup, B (si) sesinde akort edilir. Enstrüman için en rahat tonalite B majör ve ona yakın olan akraba tonalitelerdir. Staccato vuruşu karnay enstrümanında oldukça ağır seslenir ve hava esas olarak alt bölgelerde çok harcanır ki bu özellik, enstrümanda legato vuruşunun icrasını zorlaştırır. Enstrümanda geniş melodik çizgiler zor icra edildiğinden çoğu durumda kısa, akıcı, görkemli epizodlar ve uzun sesler ona emanet edilir. Genellikle görkemli karakterli eserlerde, heyecan verici ve haber verici bir enstrüman olarak işlev görür. Günümüzde karnay enstrümanı Özbek halkının düğün törenlerinde ve şenliklerinde kullanılmaktadır. Enstrüman ilk biçimini koruyarak günümüze ulaşmış olup, onun ses ve ifade imkânları oldukça renklidir. Karnayda hem yüksek ve parlak, hem de ince ve nazik melodileri icra etmek mümkündür.

Özbek topluluklarının karakteristik özelliği, unison (eşsesli) icra tarzıdır. Ses tınısı, dinamik renkler, bölge özellikleri ve icracılık tekniği gibi akustik-yapısal özelliklerin yakınlığına göre Özbekistan'da iki ana tip topluluk grubu oluşmuştur:

1. Keskin sesli enstrümanlar topluluğu, ağırlıklı olarak açık havada, meydanlarda, sokaklarda icra eder. Bu enstrümanlar, büyük geleneksel bayramları, çeşitli törenleri, sokak gösterisi etkinliklerini eşlik eder.

2. Yumuşak ve nazik sesli enstrümanlar topluluğu ise ağırlıklı olarak profesyonel müzik sanatında uygulanır.

Özbek bestecilerinin farklı türlerdeki eserlerinde: M.Nasimov "Büyük Vatan", H.İzamov "Benim Özbekistan'ım", "Savaşçı Kızlar", M.Leviyev "Beyaz Altın" kantatı, S.Babayev "Pamuk Bayramı", M.Azraf "Kahramanlık", "Zafere Alkış" senfonileri, M.O.Steinberg Özbek konulu "Senfonik Rapsodisi" ve b. eserlerde Özbek milli müzik aletleri Avrupa aletleriyle birlikte yer alarak Doğu ve Batı müzik geleneklerinin sentezini oluşturmakta, zengin tını renkleri ve özgün ifade araçlarıyla eserlerin sanatsal etki gücünü daha da artırmaktadır. [Vahidov S., 1976. 138 s.]

1950-60'lı yıllarda Özbekistan'da senfonik eserler ve bale türü özellikle gelişmiştir. D.Zakirov ve B.Giyenko'nun "Aynise" balesi, Muşel'in "Keşmir Efsanesi", "Balerina" baleleri, A. Akbarov'un "Arzu" baleleri sahnelenmiştir. Bu eserlerde Özbek milli müzik aletleri, Avrupa senfoni orkestrasının enstrümanlarıyla birlikte yer alarak besteci eserlerini yüksek düzeyde milli renklilikle zenginleştirmiştir. Doğu melodikasının ince nüanslarını Avrupa armonisiyle birleştiren bu sentez, Özbek bale sanatının dünya düzeyinde tanınmasına güçlü bir ivme kazandırmıştır.

20. yüzyıl halk-profesyonel müzisyenlerinden: Ahmedcan Umurzakov, İmamcan İkrarov, Muhittin Kari-Yakubov, Matyusuf Harratov, Nabican Hasanov, Tahtasin Celilov, Usta Alim Kamilov, Fahraddin Sadikov, Şorahim Şoumarov, Yunus Recebi, Özbekistan'ın müzik kültürünün oluşmasında önemli

hizmetlerde bulunmuşlardır. Bu sanatçılar, yaratıcılıklarında dutar, tanbur, doyra, gıcak, zurna gibi Özbek milli müzik aletlerini ustalıklıca icra ederek, hem geleneksel makamların hem de modern temalı eserlerin nesilden nesile aktarılmasını sağlamışlardır.

Onların her biri, kendi enstrümanın ses imkânlarını daha da zenginleştirmiş, icracılık ekollerinin temelini atmış ve böylece Özbek milli enstrümantal müziğinin gelişimine eşsiz katkılar vermişlerdir.

SONUÇ: *Özbek milli müzik aletleri, kadim tarihi köklere sahip olmakla birlikte, yüzyıllar boyu devam eden evrim sürecinde şekillenmiş, gelişmiş ve günümüzdeki seviyeye ulaşmıştır. 20. yüzyılın başlarından itibaren başlayan bilimsel araştırmalar sayesinde Özbek milli müzik aletleri sistematik bir şekilde incelenmiş, sınıflandırılmış ve teknik imkanları genişletilmiştir. Gıcak, doyra, zurna, karnay, dutar, tanbur gibi aletler, kendine özgü yapı, tını ve icra özellikleriyle öne çıkmaktadır. Özbek milli müzik aletleri, yalnızca geleneksel folklor ve makam icrasında değil, aynı zamanda modern besteci yaratıcılığında senfonik eserlerde, balelerde ve kantatlarda Avrupa aletleriyle sentez içinde başarıyla uygulanarak Doğu-Batı müzik geleneklerinin birliğini sergilemektedir. 20.yüzyıl halk-profesyonel müzisyenlerinin faaliyetleri, bu aletlerin gelişimine ve nesilden nesile aktarılmasına eşsiz katkılar sağlamıştır. Böylece, Özbek milli müzik aletleri, ülkenin zengin kültürel mirasının ayrılmaz bir bileşeni olarak bugün de yaşamakta ve gelişmektedir.*

Kullanılan Literatür

1. Bahaeddin Ö., *Türk Mitolojisi: Kaynakları ve Açıklamaları ile Destanlar*, I. C., Ankara: Türk Tarih Kurumu, 2010.
2. Акбаров И. Вопросы музыкальной культуры Узбекистана. Ташкент: Гос. изд. худ. лит. УзССР, 1961. 344 с.
3. Алавия М. *Узбекские народные песни*. Ташкент: Изд-во Фан, 1959. 316 с.
4. Вахидов С. *Узбекская советская песня*. Ташкент: Изд-во лит. и искусство, 1976. 138 с.
5. Эйхгорн Г.Ф. *Полная коллекция музыкальных инструментов народов Центральной Азии*. СПб.: Изд-во Музыка, 1885. 16 с.

Biological sciences

ANTIMICROBIAL ACTIVITY OF ENDOPHYTIC BACTERIA KRASCHENINNIKOVIA EWERSMANNIANA

Ixtiyor Akramov

*Institute of Biochemistry, Samarkand State University
named after Sharof Rashidov, Samarkand, Uzbekistan*

Begali Alikulov

*Institute of Biochemistry, Samarkand State University
named after Sharof Rashidov, Samarkand, Uzbekistan*

Introduction. Microorganisms are found in almost all regions of the Earth's surface. A wide variety of microorganisms have been isolated and studied from the internal tissues of many terrestrial and marine plants. Such microorganisms are found on the surfaces and tissues of most parts of plants, including roots, stems, leaves, fruits, and seeds. When microorganisms colonize the internal parts of a plant and the plant tissue is healthy, the relationship between the microorganism and its host plant can change from latent pathogenesis to mutualistic symbiosis [1,2].

The associations of endophytic organisms with host plants are diverse and complex, and we are only beginning to understand these interactions. Endophytic microorganisms often contribute to the normal health and development of their hosts in exchange for a relatively privileged location. Microbial endophytes have been isolated from the tissues of algae, mosses, ferns, grasses, other plants, and trees that grow in tropical, temperate, boreal, and arctic environments [3,4].

Many endophytic microorganisms produce secondary metabolites that have good antibacterial and antifungal effects that inhibit the growth of harmful and pathogenic microorganisms. These metabolites, such as alkaloids, phenols, flavonoids, peptides, steroids and terpenoids, have been isolated from endophytic bacterial and endophytic fungal strains. Alkaloids are active compounds that have the property of inhibiting the growth of pathogenic microorganisms. Clavicipitaceae sp endophytic fungi have been found to produce alkaloids in various plants [5]. Antifungal proteins such as iturin A, bacillomycin, and fengycin isolated from *Bacillus* spp. were evaluated for their activity against the pathogenic fungus *Fusarium moniliforme* [6]. An antifungal protein, designated Efe-AfpA, isolated from *Epichloe festucae*, has shown resistance against the pathogen *Sclerotinia homoeocarpa*, which causes dollar spot disease [7]. In addition, many endophytic microorganisms have been shown to inhibit the growth of pathogens by producing lipopeptides and antibiotics. Jiao et al. reported that *Bacillus amyloliquefaciens* strain has biocontrol activity against the pathogen *Erysiphe cichoracearum* through the production of lipopeptides, and that substances such as fengycin, iturin, and surfactin produced by *Bacillus* sp. have been shown to inhibit the growth of pathogenic fungi. [8].

Material and method. The bacterial streaking method was used to study the antagonistic activity of high salinity-tolerant endophytic bacterial isolates [9]. Endophytic bacterial strains were tested against 5 pathogenic bacteria *Escherichia coli*, *Staphylococcus aureus*, *Bacillus subtilis*, *Pseudomonas aureginosa*, *Candida albicans* by diffusion method in LB medium at 37°C for 72 hours. Each pathogenic bacteria, which was initially grown for 24 hours, was spread on the surface of LB agar medium using sterile cotton swabs and 6 mm wells were created and endophytic bacterial strains were added in a volume of 100 µl. As a negative control, sterile medium broth was added instead of endophytic bacteria, and as a positive control, ampicillin was used in the wells. After 24 hours, the incubation zones were observed and the incubation zones were evaluated by measuring [10].

Results and Discussion. The antimicrobial properties of 34 endophytic bacterial isolates isolated from plants were also studied. The antibacterial properties of endophytic bacteria are due to the numerous metabolites produced by them. It was noted that 34 endophytic bacteria have varying degrees of antimicrobial activity against the opportunistic pathogens *Escherichia coli*, *Bacillus subtilis*, *Staphylococcus aureus*, *Pseudomonas aureginosa*, and *Candida albicans*.

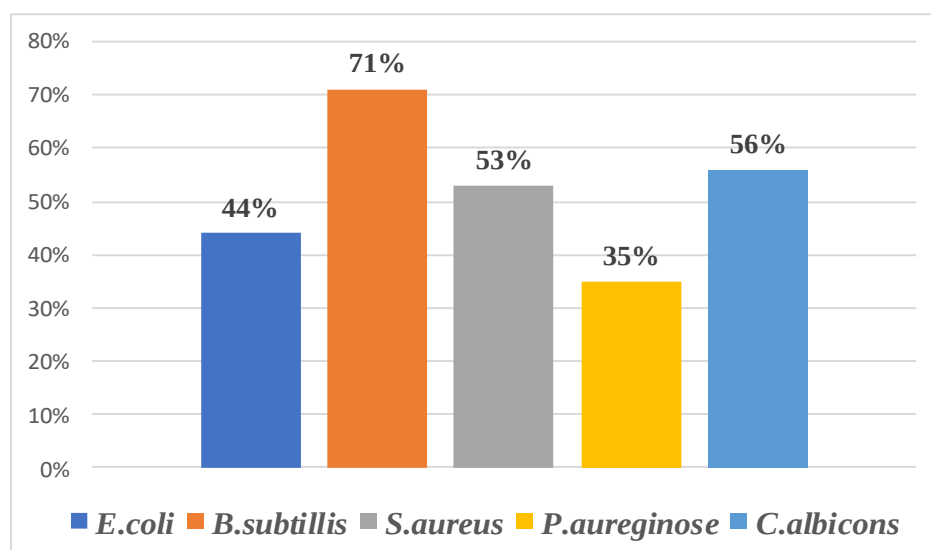


Figure 1. Number of endophytic bacterial isolates with antagonistic activity against various pathogens (in %)

Looking at the data recorded in Figure 1, 4 bacterial isolates were found to have antimicrobial activity against all pathogens. 14 bacterial isolates were found to have antimicrobial activity against *E. coli*, 21 bacterial isolates were found to have antimicrobial activity against *B. subtilis*, 18 bacterial isolates were found to have antimicrobial activity against *S. aureus*, 12 bacterial isolates were found to have antimicrobial activity against *P. aureginose*, and 19 bacterial isolates were found to have antimicrobial activity against *C. albicon*. Also, 6 endophytic bacterial isolates were found to have no antimicrobial activity.

Conclusion. In this study, the antagonistic activities of 34 endophytic bacterial isolates isolated from the roots, stems, and leaves of the *Krascheninnikovia ewersmanniana* plant against various pathogenic microorganisms *Escherichia coli*, *Staphylococcus aureus*, *Bacillus subtilis*, *Pseudomonas aureginosa*, and *Candida albicans* were studied. As a result of the studies, it was noted that 44% of the endophytic bacterial isolates had antimicrobial activity against pathogens *E. coli*, 71% *B.subtilis*, 53% *S.aureus*, 35% *P.aureginose*, and 56% *C.albicans*.

References

1. Lacava P.T., Azevedo J.L. (2013). Biological Control of Insect-Pest and Diseases by Endophytes. *Advances in Endophytic Research* 231–256.
2. Santoyo G., Moreno-Hagelsieb G., Orozco-Mosqueda M.del.C., Glick B.R. (2016). Plant growth-promoting bacterial endophytes. *Microbiological Resarch*. 183; 92-99.
3. Tadych M., James F. (2019). White Endophytic Microbes Reference Module in Life Sciences. *Encyclopedia of Microbiology (Fourth Edition)*, 123-136.
4. Mushtaq S., Shafiq M., Tariq M.R., Sami A., Nawaz-ul-Rehman M.Sh., Bhatti M.H.T., Haider M.S., Sadiq S., Abbas M.T., Hussain M., Shahid M.A. (2023). Interaction between bacterial endophytes and host plants. *Frontiers in Plant Science. Sec. Plant Symbiotic Interactions* 13; 3389
5. PanASKione D.G., Beaulieu W.T., Cook D. (2014). Bioactive alkaloids in vertically transmitted fungal endophytes. *Functional Ecology*. 28; 299–314.
6. Gond S.K., Bergen M.S., Torres M.S., White J.F.Jr. (2015). Endophytic *Bacillus* spp. produce antifungal lipopeptides and induce host defence gene expression in maize. *Microbiological Research*. 172; 79–87.
7. Tian Z., Wang R., Ambrose K.V., Clarke B.B., Belanger F.C. (2017). The *Epichloë festucae* anti-fungal protein has activity against the plant pathogen *Sclerotinia homoeocarpa*, the causal agent of dollar spot disease. *Scientific Reports*. 7; 5643.
8. Jiao R., Cai Y., He P., Munir S., Li X., Wu Y., Wang J., Xia M., He P., Wang G., Yang H., Karunarthna S.C., Xie Y., He Y. (2021). *Bacillus amyloliquefaciens* YN201732 produces lipopeptides with promising biocontrol activity against fungal pathogen *Erysiphe cichoracearum*. *Frontiers in Cellular and Infection Microbiology*. 11; 598999.

9. Lim, S.M.; Yoon, M.; Choi, G.J. (2017). Diffusible and volatile antifungal compounds produced by an antagonistic *Bacillus velezensis* G341 against various phytopathogenic fungi. *Plant Pathol. J.* 33; 488–498.

10. Mohamad O.A., Li L., Ma J.B., Hatab S., Xu L., Guo J-W., Rasulov B.A., Liu Y-H., Hedlund B.P., Li W-J. (2018). Evaluation of the antimicrobial activity of endophytic bacterial populations from Chinese traditional medicinal plant licorice and characterization of the bioactive secondary metabolites produced by *Bacillus atrophaeus* against *Verticillium dahliae*. *Frontiers in Microbiology.* 9; 924.

Economic sciences

IMPROVEMENT OF THE ENTERPRISE MANAGEMENT SYSTEM BASED ON INTEGRATED STANDARDIZATION AND RISK MANAGEMENT

Maya Karimova İ.¹

Aslan Agayev R.²

¹Azerbaijan State Oil and Industry University,
Department of Instrumentation Engineering./ assistant professor

²Azerbaijan State Oil and Industry University,
Department of Instrumentation Engineering./ Student/

Abstract

The contemporary corporate environment is shaped by a rapidly evolving technological landscape, intensifying competitive dynamics, and increasingly complex regulatory requirements. In this context, organizations face significant challenges in simultaneously pursuing strategic priorities such as maintaining operational effectiveness, ensuring regulatory compliance, and exercising systematic risk oversight. Corporate governance systems respond to these challenges by serving as structured methodological frameworks for decision-making, resource management, and process optimization.

The primary objective of this research is the development of an advanced enterprise governance model incorporating integrated standardization mechanisms and risk management methodologies. The standardization approach entails aligning organizational procedures with unified quality benchmarks, thereby reducing inter-departmental variability and enhancing overall performance indicators. The risk management component encompasses the systematic identification, assessment, and mitigation of factors that pose potential threats to operational continuity and strategic objectives. The integration of both strategies enables the formation of a more transparent, resilient, and managerially effective organizational structure.

To this end, the study conducts a critical analysis of existing governance practices, identifies methodological gaps, and advances practical implementation recommendations. The findings indicate that a proactive and systematic approach to operational uncertainty, combined with the consistent alignment of internal corporate procedures with external regulatory requirements, plays a decisive role in enhancing governance effectiveness. The research ultimately concludes that the adoption of an integrated standardization and risk management framework enables organizations to consolidate long-term sustainability, minimize operational losses, and improve decision-making quality, thereby securing a sustained competitive advantage in dynamic market environments.

Keywords: Enterprise management, standardization, risk management, organizational efficiency, process improvement, strategic planning

INTRODUCTION

Enterprises face a wide range of challenges in today's rapidly changing business environment, which requires efficient and flexible management methods. Traditional management practices are often inadequate within the complex operational landscape shaped by globalization, technological advancement, market volatility, and increasingly stringent regulatory requirements. In this context, the sustainability and efficiency of an organization largely depend on the strength of its management system. In addition to ensuring operational continuity, a well-organized management system provides a foundation for strategic decision-making, resource optimization, and continuous organizational development. One of the most important tools for improving management systems is comprehensive standardization. By establishing consistent procedures, performance indicators, and quality standards across all departments, organizations can minimize errors, reduce variability, and increase overall operational efficiency. Furthermore, standardization facilitates compliance with national and international regulations, resulting in an accountable and transparent organizational structure. At the same time, risk management has emerged as a crucial element of modern business management [4–8]. Enterprises are always vulnerable to various internal and external risks such as operational disruptions, technical failures, financial uncertainty, and strategic misalignment. By integrating risk management into the management system, organizations can proactively identify potential threats, assess their impact, and implement mitigation

measures. This proactive strategy minimizes losses, enhances organizational resilience, and reduces the likelihood of operational failures. A comprehensive approach to corporate governance is achieved through the integration of risk management and comprehensive standardization. While risk management ensures preparedness and adaptability to uncertainties, standardization guarantees efficiency and uniformity. When combined, they create a dynamic management framework that enhances competitiveness, promotes sustainable development, and improves overall organizational performance in an increasingly unpredictable business environment.

Relevance: The main objective of this research is to explore practical ways of improving enterprise management systems by combining the use of comprehensive standardization with holistic risk management. The specific objectives of the study include identifying gaps in management practices, examining the effectiveness of existing standardization procedures, and assessing the organization's ability to anticipate and mitigate risks. By doing so, the research aims to provide useful recommendations for the development of an integrated and robust management framework that improves operational performance, ensures compliance with internal and external standards, and strengthens organizational flexibility in a changing business environment. This study also aims to understand how the integration of risk management and standardization enhances overall organizational effectiveness. It examines how proactive risk management approaches minimize potential losses and prevent disruptions, while also highlighting the importance of standardized procedures in reducing variability and errors. The ultimate goal of the study is to demonstrate that enterprises adopting an integrated approach can achieve sustainable development, improved decision-making, and competitive advantage in increasingly complex and unpredictable markets.

Purpose of the research: Enterprises constantly struggle with operational efficiency, regulatory compliance, and risk management in today's intense and rapidly evolving business environment. The effectiveness of the management system is essential for organizations to successfully address these issues. The purpose of this research is to investigate ways to improve enterprise management systems by combining comprehensive standardization with holistic risk management approaches. In addition to emphasizing the potential to increase process efficiency, consistency, and resilience, this study aims to identify areas where existing management methods may be inadequate [2–3]. By examining the role of standardized procedures, the study seeks to demonstrate how consistent operational methods can reduce variability, prevent errors, and ensure compliance with internal and external quality standards. The research also highlights the importance of proactive risk management, which enables businesses to anticipate potential risks, minimize disruptions, and safeguard their strategic objectives.

Problem statement: Today's business environment is more complex and unpredictable than ever before. Traditional management approaches often fail in a context characterized by rapid technological advancements, globalization, changing market demands, and strict regulatory constraints. Many enterprises suffer from fragmented management systems that fail to successfully integrate operational procedures, quality standards, and risk mitigation methods. This lack of integration can lead to inefficiency, inconsistent performance, and increased vulnerability to both internal and external threats [5–7].

Risk management is often reactive rather than proactive, and standardization efforts are frequently limited to isolated procedures without being connected to other critical areas. As a result, businesses face issues such as missed opportunities for strategic expansion, financial losses, operational disruptions, and non-compliance with regulations. Therefore, the absence of an integrated framework that combines comprehensive standardization with systematic risk management represents a significant problem in ensuring a robust, effective, and flexible enterprise management system.

To address this issue, a comprehensive strategy is required that incorporates risk assessment and mitigation into daily operations in addition to aligning procedures with established standards. By doing so, enterprises can achieve consistent quality, reduce vulnerabilities, and improve their ability to handle unexpected challenges. This study aims to explore ways to bridge the gap between standardization and risk management in order to provide a framework for improved enterprise governance that promotes sustainable growth and competitive advantage (Fig. 1).

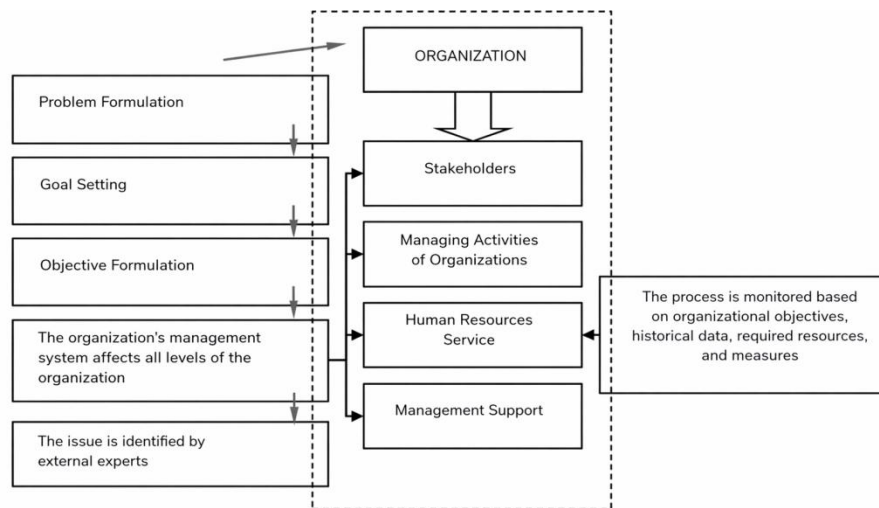


Figure 1. Structure of the management solution model for organizing management

As a result, businesses often deal with fragmented management systems, a lack of standardization, and reactive risk management, all of which lead to operational disruptions, inefficiency, and increased vulnerability to both internal and external threats. To overcome these challenges, an integrated strategy that combines proactive risk management with standardized procedures is required to establish a more effective, robust, and flexible management system.

Solution to the problem: The adoption of a comprehensive strategy that integrates complex standardization with proactive risk management is essential for addressing the problems found in enterprise management systems. The proposed approach aims to create an integrated management structure that enhances operational efficiency, ensures compliance, and strengthens organizational resilience [5] (Fig. 2).

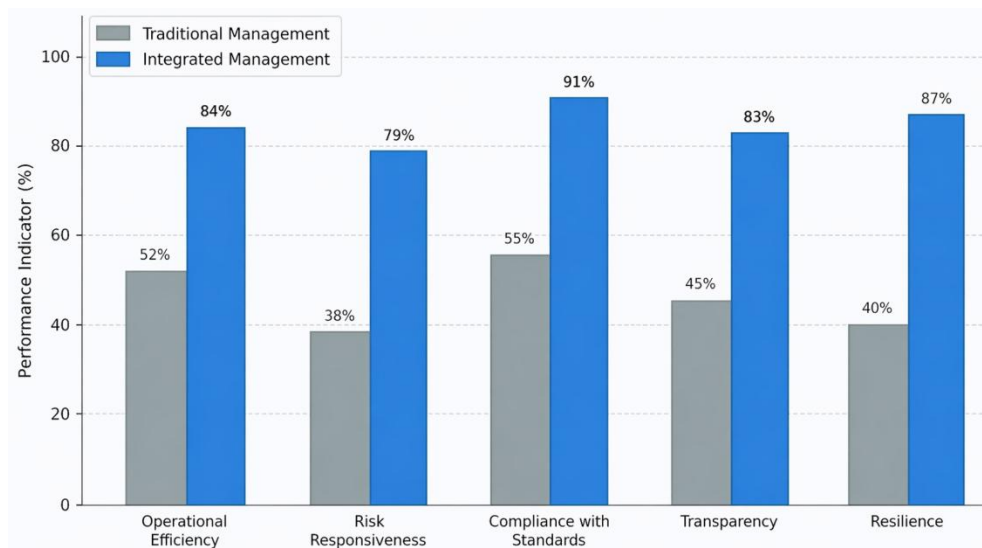


Figure 2. Comparative bar chart of traditional and integrated management

The evaluation of existing management methods is the first step. This involves assessing areas where procedures are not standardized or where risks are not effectively managed, as well as examining current workflows to identify gaps and inconsistencies. By understanding the current operational state, enterprises can identify critical areas that require improvement.

The implementation of comprehensive standardization is the second stage. Standardization ensures that all departmental processes comply with unified protocols and quality standards. In addition to improving productivity, it reduces errors, increases transparency, and facilitates compliance with industry and regulatory requirements. The development of performance metrics, standard operating procedures (SOPs), and consistent reporting systems are examples of standardization.

The integration of risk management into daily activities is the focus of the third stage. This involves identifying potential internal and external risks, assessing their impact and likelihood, and implementing mitigation plans. Through proactive risk management, enterprises can reduce operational disruptions, protect strategic objectives, and anticipate challenges before they arise (Fig. 3).

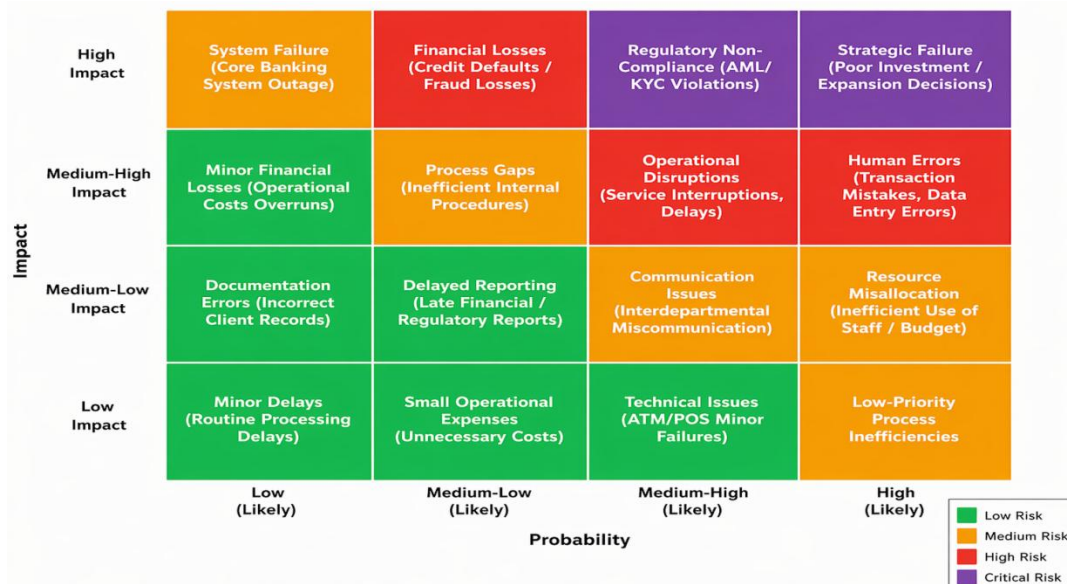


Figure 3. Risk assessment matrix

Finally, the strategy includes continuous monitoring and improvement. Processes should be adjusted in response to performance outcomes, emerging risks, and changes in the business environment. Management systems should be regularly evaluated. Through this cyclical process, the enterprise can remain agile, resilient, and maintain high performance even under conditions of uncertainty.

CONCLUSION

Enterprises face various challenges in today's complex and dynamic business environment, which can affect overall organizational resilience, operational efficiency, and regulatory compliance. This study highlights that reactive risk management, fragmented management systems, and the lack of standardization are major causes of organizational weaknesses and inefficiencies. Enterprises can create an integrated management system that ensures consistency and quality across processes, while improving the organization's ability to anticipate and mitigate potential risks by combining comprehensive standardization with proactive risk management. While risk management methods help prevent disruptions, minimize losses, and protect strategic objectives, standardized procedures reduce errors, increase transparency, and enable compliance with both internal and external standards (Fig. 4).

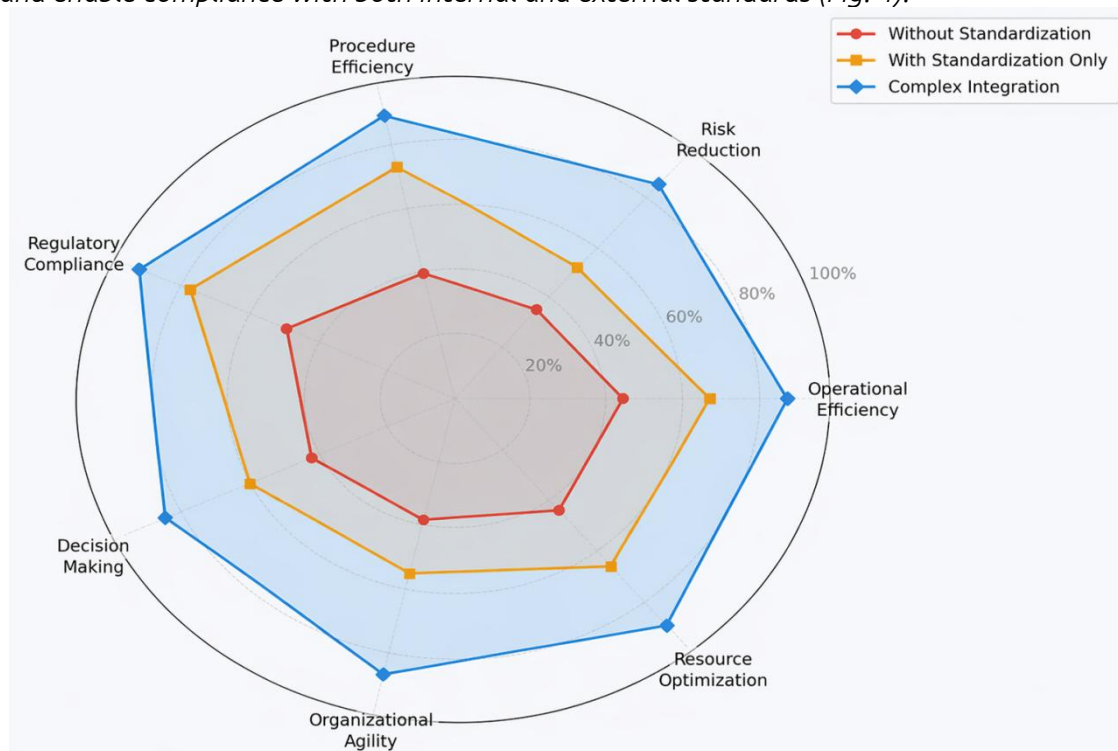


Figure 4. Radar Chart: Comparison of Three Scenarios

The proposed strategy places strong emphasis on continuous evaluation and improvement, ensuring that management systems remain adaptable in response to changing market conditions and emerging threats. Ultimately, enterprises that implement this comprehensive framework can enhance their competitive advantage, achieve sustainable development, and improve decision-making processes. This study demonstrates that the development of effective, robust, and future-ready corporate management systems requires the integration of standardization and risk management.

References

1. International Organization for Standardization. (2015). ISO 9001:2015 — Quality management systems: Requirements. ISO. <https://www.iso.org/standard/62085.html>
2. International Organization for Standardization. (2018). ISO 31000:2018 — Risk management: Guidelines. ISO. <https://www.iso.org/standard/65694.html>
3. Kerzner, H. (2017). *Project management: A systems approach to planning, scheduling, and controlling* (12th ed.). Wiley.
4. Jeston, J., & Nelis, J. (2014). *Business process management: Practical guidelines to successful implementations* (3rd ed.). Routledge.
5. Chapman, C., & Ward, S. (2011). *How to manage project opportunity and risk: Why uncertainty management can be a much better approach than risk management* (3rd ed.). Wiley.
6. Goetsch, D. L., & Davis, S. B. (2014). *Quality management for organizational excellence: Introduction to total quality* (8th ed.). Pearson.
7. Hillson, D. (2012). *Practical project risk management: The ATOM methodology* (2nd ed.). Management Concepts.

REGIONAL DEVELOPMENT POLICY AND THE EXPERIENCE OF DEVELOPMENT AGENCIES IN AZERBAIJAN

S.R. Guliyeva

PhD in Economics, Associate Professor,
Azerbaijan Academy of Labour and Social Relations,
Department of Finance and Accounting

Abstract

Regional development has re-emerged as a central pillar of economic policy in both advanced and emerging economies, driven by deepening spatial inequalities, urban–rural divides and differentiated access to infrastructure, services and opportunities. This article examines regional development policy through the dual lens of theory and practice, with particular emphasis on the evolution of regional development agencies and the specific experience of Azerbaijan. Rather than treating regions as passive recipients of national policies, the study approaches them as active loci of resources, capabilities and institutional experimentation.

The analysis first reviews how the transition from agricultural to industrial and then post-industrial economies has reshaped the objectives and instruments of regional policy. Concepts such as agglomeration, localisation economies, human capital and innovation capacity are discussed as key determinants of territorial competitiveness. Building on the work of classical and new regional development theorists, the paper highlights how the shift from centralised planning to strategy-based, place-sensitive governance has increased the demand for flexible intermediary institutions at the regional level.

A second line of inquiry focuses on the global diffusion of regional development agencies, tracing their emergence from early examples such as the Tennessee Valley Authority in the United States to the diverse models found across the European Union and transition economies. The comparative overview underlines the variety of legal forms, degrees of autonomy and functional mandates that these agencies may assume, ranging from project implementation and investment promotion to analytical, advisory and capacity-building roles.

Against this background, the article analyses Azerbaijan's regional development policy architecture and the institutional role of its regional development agencies. Particular attention is paid to policy priorities such as infrastructure upgrading, economic diversification, support for small and medium-sized enterprises, human capital development, innovation promotion and environmental sustainability. The discussion also considers persistent inter-regional disparities in economic activity, social services and quality of life, and reflects on how agency-based instruments can be used to address them more systematically.

The study concludes that the long-term success of regional development in Azerbaijan depends on aligning territorial policies with local resource endowments, strengthening coordination between central and local actors, and enhancing the strategic, analytical and partnership-building functions of regional development agencies within an integrated, evidence-based framework.

Keywords: *Regional development; regional development agencies; centralised and decentralised governance; regional policy; regional resources; inter-regional inequality; sustainable development; human capital; infrastructure; innovation and localisation.*

Introduction

Regional development is a system of purposive policies and actions aimed at ensuring balanced progress in the economic, social and cultural spheres at territorial and local levels. Within this policy framework, the specific natural, economic, demographic and social resources of regions are taken into account, and the improvement of living standards, the expansion of employment and the efficient use of resources are defined as key objectives. The essence of regional development is linked to the reduction of socio-economic inequalities within a country, the mitigation of inter-regional imbalances and the achievement of sustainable development.

In the contemporary context of globalisation, as cities and regions gradually gain greater prominence within the global economy, governance approaches shift from rigid centralisation towards more flexible, strategy-based and locally anchored regional development models. New concepts of regional development policy, the establishment of regional development agencies, the strengthening of local

governance institutions and the introduction of innovation-oriented approaches have therefore moved to the forefront of policy debates.

1. Theoretical foundations and planning of regional development

In the planning process, better utilisation of regional resources, preservation of ecological balance and the application of sustainable development principles are critical aspects. Each of these approaches constitutes a foundational element of regional development and helps to ensure that a territory experiences balanced and sustainable growth over time. Regional development is of major importance for both developed and developing countries. The rapid transformation of the global economy, driven by globalisation and accelerated technological change, generates new opportunities but also introduces various risks.

In this context, diverse development models and the role of localisation factors have come to the forefront as tools for converting existing threats into potential opportunities. Cities and regions now play an important role in the global economy, and as a result, governance concepts are shifting from purely centralised approaches to more strategic and locally based systems of management. In this regard, the notion of a "new regional development policy" is associated with the emergence of more differentiated and sophisticated approaches. Global strategies tailored to the needs and potential of specific regions, and the application of various development methods, generate significant effects on regional development. Regional development agencies act as key institutions in this field, and their role in the transition from classical to new regional development approaches is particularly significant.

The implementation and evolution of regional development policy can be analysed in more depth through the experience of Turkey. In this context, the role of regional development within national economic development models can be more clearly understood with reference to Alvin Toffler's "Three Waves Theory". In the first-wave economy, development is based on agriculture and natural resources, reflecting a pre-capitalist structure in which rural labour predominates. After the Second World War, regional development problems became a major component of public policy as states sought to broaden social welfare and reduce inequalities arising within the market system. As a result of this shift, regional development theories entered various branches of economics, and large-scale plans involving state intervention began to be implemented.

In the post-industrial era, from the 1970s onwards, new realities prompted fresh approaches in economic policy. Among these, new regional development plans in countries such as Italy, Germany, Scotland, Wales, India, Brazil and Turkey attracted attention due to their more proactive orientation. These approaches aim to promote regional development by employing mechanisms that mobilise internal potential and dynamism. In essence, the application of diverse economic, social and cultural approaches serves to make regional development more effective. In the framework of new regional development thinking, a range of institutional, economic, cultural and social development models are applied.

2. New regional development approaches and the role of agencies

In the field of economic development, particular emphasis is placed on industrial parks, region-specific investment support programmes and comprehensive development initiatives. Cultural development and social programmes are also managed as integral components of this approach, and increasingly innovative, development-oriented structures are created. This paradigm is linked to the introduction of new institutional mechanisms and optimised governance structures for managing regional development.

Two main governance approaches can be distinguished in the implementation of regional development policy:

- **Centralised approach.** *In this model, regional development policy is implemented through a central state body. It is more prevalent in countries undergoing transition, where decision-making power remains largely concentrated at the national level.*

- **Decentralised (or de-centralised) approach.** *This model is more common in developed countries and regions, where regional bodies operate with a greater degree of autonomy. In the United States, the European Union and other developed economies, this approach is widely applied, and regional institutions often play an active role in shaping and implementing policy.*

Ultimately, successful implementation of regional development requires both well-designed development agencies and appropriately structured regional policies. Where these approaches are used effectively, they contribute to the reduction of economic imbalances and the alleviation of inter-regional inequalities.

3. (If there is an implicit section) Regional policy, localisation and sustainable development

Although not explicitly numbered as a separate section in the text, the discussion of localisation, sustainable development and the changing role of regions provides an implicit third dimension. Regional development policy increasingly focuses on:

- fostering localised learning and innovation systems;
- strengthening industrial clusters and networks;
- improving the quality of human capital;
- integrating environmental sustainability into regional strategies.

In this perspective, regions are not merely administrative units, but complex socio-economic and spatial systems where knowledge, technology, institutions and social capital interact.

4. Formation and institutional-legal features of regional development agencies worldwide

The history of regional development agencies (RDAs) demonstrates how institutional innovations have accompanied the evolution of regional policy. The first widely recognised example of a development agency is the Tennessee Valley Authority (TVA), established in the United States in 1930. Following the Second World War, the need to promote regional development in Europe led to the establishment of various agencies, and the regional development policies adopted by the European Union gradually created a more structured framework.

In the mid-twentieth century, economic crises in Europe spurred the creation of development agencies in countries such as France and Ireland, with the aim of revitalising regional economies and supporting structural change. During the 1970s, the number of such agencies increased in Germany, the United Kingdom, Italy and the Netherlands. In the 1980s, amid financial crises and budget pressures, regional development policies were increasingly linked to the European Union's objective of reducing regional disparities through Structural Funds. This period also saw a substantial rise in the number of agencies in Central and Eastern Europe.

For many transition economies, including Bulgaria, Poland, Slovakia, the Czech Republic, Hungary, Sweden, Slovenia, Estonia, Romania and Portugal, the 1990s and early 2000s were a turning point in terms of setting up regional development institutions. From 2006 onwards, their number increased further, reaching 26 agencies in some European contexts. The key role of the European Union's Structural Funds strengthened the position of RDAs by expanding their areas of activity and enhancing their powers in project implementation, investment promotion and regional planning. In 1991, the European Association of Development Agencies (EURADA) was created, and by 2014 it brought together nearly 150 member agencies. Overall, there are currently more than 500 development agencies operating worldwide.

Common features of regional development agencies globally

Research on development agencies shows that, as a natural consequence of differences in legal, administrative and structural arrangements across countries, RDAs possess diverse legal statuses. In some cases, even within the same country or region, agencies with different legal forms may coexist. A broad assessment reveals that:

- in unitary states, agencies are more often subordinated to a specific ministry or central authority;
- in federal states, where sub-national units have stronger policy-making and implementation powers, agencies tend to enjoy greater autonomy and often operate as public or private companies.

In most countries, these agencies are non-profit legal entities and typically take one of the following organisational forms:

- Inter-municipal agency – e.g., Belgium
- Non-profit associations – e.g., Austria, Bulgaria, Sweden, Portugal, Hungary, Romania
- Limited liability companies – e.g., Germany, the Netherlands
- State entities – e.g., Germany, Belgium, Spain
- Private entities – e.g., Spain, Turkey
- State-owned or semi-state limited liability companies – e.g., the Netherlands, Italy
- Foundations – e.g., the Czech Republic
- Limited companies – e.g., Austria, Belgium, Czech Republic, Sweden, Italy, Hungary, Portugal, Slovenia
- Joint-stock companies – e.g., Czech Republic, Portugal.

This diversity shows that there is no single "one-size-fits-all" model for RDAs; instead, their design is adapted to national governance traditions, legal frameworks and regional development priorities.

5. Main directions of regional development policy and functions of regional development agencies in Azerbaijan

In Azerbaijan, regional development policy aims to ensure balanced economic and social development across the country, reduce inter-regional disparities and maximise the potential of each region. This policy is aligned with long-term national development strategies and covers several main directions:

- **Infrastructure development.** *Modernisation of transport, energy, telecommunication and social infrastructure.*
- **Economic diversification.** *Promotion of agriculture, industry, tourism and small and medium-sized enterprises, and reduction of regional dependence on a single sector.*
- **Human resource development.** *Improvement of education, healthcare and vocational training systems, and enhancement of the quality of human capital.*
- **Innovation and technology.** *Support for innovative projects, as well as the creation of tech-parks and business incubators in the regions.*
- **Ecological balance.** *Efficient use of natural resources and protection of the environment.*

Measures implemented in these directions are designed to increase economic activity in the regions, expand access to social services and reduce regional inequality.

Regional development agencies established in Azerbaijan play an important intermediary role in the implementation of state regional policies. Their main functions can be summarised as follows:

1. **Project implementation.** *Cooperating with state bodies and international partners in the design and execution of regional projects.*
2. **Finance and investment.** *Attracting investment to regions and ensuring the efficient allocation of financial resources.*
3. **Analysis and strategy.** *Assessing regional needs and preparing appropriate development strategies and programmes.*
4. **Training and consultancy.** *Organising training programmes and providing technical assistance for local businesses and civil society organisations.*
5. **International cooperation.** *Representing regions at the international level and creating opportunities for external cooperation and exchange.*

Through these functions, agencies contribute to mobilising regional development potential, supporting local initiatives and strengthening coordination between central government bodies and local structures.

6. Regional development indicators and inter-regional disparities in Azerbaijan

The analysis of regional development is based on evaluating socio-economic indicators across different geographical areas, determining their levels of development and identifying disparities between them. This, in turn, helps to design measures aimed at reducing such disparities. Regional development is a particularly relevant issue in Azerbaijan, as different parts of the country exhibit different levels of development, which can lead to unbalanced growth.

Differences between urban and rural areas, varying levels of development in agriculture and industry, as well as unemployment and social inequality, are among the principal issues examined in studies of regional development. Baku and its surrounding areas have more advanced infrastructure and services compared to other regions, especially mountainous and remote areas, where ensuring development and addressing social problems remain major challenges. This makes it crucial to ensure economic and social balance at the national level.

One of the key aspects to consider in the analysis of regional development is the efficient use of local resources and natural wealth. Each region has its own specific natural and economic resources; therefore, development projects must be designed in line with local characteristics. For instance, in regions specialising in agriculture, priority should be given to measures aimed at developing the agrarian sector, while in industrial centres, the implementation of new technologies and innovations is essential for economic development.

The social dimension of regional development is also of great importance. Differences in the level of development of education, healthcare, culture and infrastructure constitute one of the main reasons for social disparities between regions. These inequalities adversely affect people's living conditions and development opportunities. Consequently, a comprehensive approach to regional development should pursue progress not only in economic, but also in social domains.

Table 1.1. Regional development indicators in Azerbaijan

Region	Level of Economic Development	Population Growth	Infrastructure	Education and Health Services	Social Inequality
Baku	High	High	High	High	Low
Ganja	Medium	Medium	Medium	Medium	Medium
Sumgayit	Medium	Medium	High	Medium	Medium
Mingachevir	Low	Low	Low	Low	High
Lankaran	Medium	Medium	Medium	Medium	Medium
Sheki	Low	Low	Low	Low	High

Source: State Statistical Committee of the Republic of Azerbaijan. (2020). *Socio-Economic Development Indicators by Regions*. Baku: Azerbaijan State Publishing House.

The table reflects different aspects of regional development in various parts of Azerbaijan. It shows, for each region, the level of economic development, population growth, infrastructure conditions, the state of education and healthcare services, and the level of social inequality. Baku stands out as the most developed region in terms of economic development and infrastructure, with both high population growth and relatively low social inequality. Other major cities such as Ganja and Sumgayit have a medium level of development, although differences in infrastructure remain.

In less developed regions such as Mingachevir and Sheki, socio-economic indicators are at a lower level and social inequality is higher. Lankaran, while generally exhibiting a medium level of development, has a more balanced social situation compared to some other cities. The promotion of regional development should not be limited to increasing economic growth; social and cultural factors must also be taken into account. Ensuring balance between more and less developed regions is of particular importance.

In this context, infrastructure improvement, enhancement of the quality of healthcare and education services and the reduction of social inequalities are among the main objectives for achieving long-term sustainable development. In Baku and Sumgayit, although infrastructure and economic development are relatively advanced, challenges related to high population density and urbanisation persist, making it necessary to further improve social and cultural services and enhance quality of life.

In regions such as Mingachevir, Sheki and Lankaran, the continued presence of underdeveloped sectors increases the urgency of establishing infrastructure and services that meet basic needs. Diversification of the local economy and the development of sectors such as agriculture can help improve social welfare in these areas. The overall goal is to minimise economic and social disparities across all regions of Azerbaijan and to eliminate inequalities. This requires accurately assessing the development needs of each region and designing appropriate development strategies.

To ensure the long-term sustainability of regional development, it is also crucial to protect natural resources, maintain ecological balance and improve living conditions in rural areas.

Conclusion

Regional development policy in Azerbaijan and the regional development agencies involved in its implementation play a strategic role in restructuring the country's socio-economic space and reducing inter-regional inequalities. The study shows that the characteristic features of regional development — including geographical location, natural resources, economic structure, demographic indicators, socio-cultural environment and institutional frameworks — are key factors determining each region's development trajectory and priorities. It is neither appropriate nor effective to apply identical approaches to mountainous and plains areas, urban and rural territories, or industrial and agrarian regions. Hence, regional policy must be differentiated and tailored to local specificities and resource potential.

International experience demonstrates that, when properly established, regional development agencies can serve as flexible intermediaries in the implementation of state policy, enhancing the effectiveness of place-based instruments for investment attraction, project management, innovation and support for entrepreneurship. The TVA example in the United States, the system of structural funds and regional agencies in the European Union and the transition experiences of Central and Eastern European countries all confirm the importance of regional institutions in promoting economic revitalisation, structural change and social stability. In this context, there is a need to expand the analytical, coordination, investment and training functions of agencies in Azerbaijan and to strengthen, to a certain extent, their institutional and financial autonomy.

The analysis of regional development in Azerbaijan shows that, compared with Baku and other large cities, some regions (such as Mingachevir and Sheki) lag behind in terms of economic activity, infrastructure provision and the level of social services, while indicators of social inequality are higher. This situation calls for more targeted and balanced planning of infrastructure projects, social programmes,

investments in human capital and measures for economic diversification across regions. Modernisation of the agricultural sector in areas with high agrarian potential and the development of innovation, services and processing industries in urban and industrial centres can increase employment and help to reduce income disparities.

Ultimately, successful regional development requires the harmonisation of geographical, economic, social and ecological factors, effective coordination of governance at central and local levels and systematic support for public participation and local initiatives. Continuous improvement of regional development strategies in Azerbaijan, strengthening of statistical and analytical capacities, development of comprehensive indicator systems and expansion of monitoring mechanisms will facilitate the formation of a more balanced and inclusive development model. In this regard, the findings of the study provide recommendations that can inform both academic debates on regional development and practical policy design and management decisions.

References

1. Dunning, J. H. (1998). *Location and the Multinational Enterprise*. John Wiley & Sons.
2. Binns, T., & Nel, E. (2002). Sustainable rural development in South Africa: An analysis of the effectiveness of the new local government system. *Urban Forum*, 13(1), 53–74.
3. Rodríguez-Pose, A. (2018). The revenge of the places that do not matter (and what to do about it). *Cambridge Journal of Regions, Economy and Society*, 11(1), 189–209.
4. Scott, A. J. (2006). Entrepreneurship, innovation and industrial development: Geography and the creative field. *Journal of Economic Geography*, 6(5), 573–598.
5. World Bank. (2009). *World Development Report 2009: Reshaping Economic Geography*. The World Bank.
6. Rauscher, M. (2012). *Regional Economic Development: Analysis and Policy*. Springer Science & Business Media.
7. Maskell, P., & Malmberg, A. (1999). Localised learning and industrial competitiveness. *Cambridge Journal of Economics*, 23(2), 167–185.
8. Krugman, P. (1991). *Geography and Trade*. MIT Press.
9. Pomerantz, M., & Tsukamoto, Y. (2002). *Sustainable Development and Regional Policies in East Asia*. Springer.
10. Asheim, B. T., & Gertler, M. S. (2005). The geography of innovation: Regional innovation systems. In J. Fagerberg, D. C. Mowery, & R. R. Nelson (Eds.), *The Oxford Handbook of Innovation* (pp. 291–317). Oxford University Press.
11. Hacızadə, E. M. (2005). Regional development strategy: Scientific-empirical view and new conceptual justifications. *Dirçəliş (Revival)*, No. 86–87, Baku. [Published in Azerbaijani]
12. Əliyeva, R. Ə. (2013). *State Regulation of the Economy [İqtisadiyyatın dövlət tənzimlənməsi]*. Textbook, Baku. [Published in Azerbaijani]
13. Khaltaeva, S. R., & Badmaev, Z. V. (2005). Accounting for the functions of stimulating innovation processes in the formation of a regional innovation system. *Bulletin of Buryat State University, Issue 2a*, 124–128. [Published in Russian]

Mathematical sciences

SPECTRAL PROBLEM OF STABILITY FOR COUETTE FLOW BETWEEN CYLINDERS

Rustemova Karashash Zhorabekovna

candidate of physical and mathematical sciences, assistant professor

Shinikulova Gulnur Nurbekovna

Master of Physics

Abdimanapova Perizat Bakhytovna

PhD, assistant professor

Tattibekov Konysbek Satievich

*candidate of physical and mathematical sciences, associate Professor,
Almaty Technological University, Almaty, Republic of Kazakhstan*

СПЕКТРАЛЬНАЯ ЗАДАЧА УСТОЙЧИВОСТИ ТЕЧЕНИЯ КУЭТТА МЕЖДУ ЦИЛИНДРАМИ

Рустемова Карашаш Жорабековна

к.ф.-м.н., ассистент профессор

Шиникулова Гульнур Нурбековна

Магистр физики

Абдимананова Перизат Бахытовна

PhD, ассистент профессор

Таттибеков Конысбек Сатиевич

к.ф.-м.н., доцент,

Алматинский технологический университет, г. Алматы, Республика Казахстан

Abstract

This article investigates the spectral problem related to the stability of Couette flow in a system of two rotating cylinders. The flow of a viscous incompressible fluid is considered, described by the Navier–Stokes equations in cylindrical coordinates. The original nonlinear problem is transformed by decomposing the operator into linear and nonlinear parts, followed by linearization in the neighborhood of the basic Couette flow. The resulting linear system is used to formulate a spectral stability problem.

It is shown that for certain parameter values a deviation from the basic flow occurs, leading to instability associated with the formation of Taylor vortices. The spectral problem is reduced to an operator eigenvalue problem involving a compact operator, which ensures the discreteness of the spectrum. Special attention is given to the formulation of the stability problem and its mathematical representation.

The proposed approach allows the analysis of solution behavior near critical regimes and provides a basis for numerical spectral computations. The results are important for understanding the mechanisms of transition to turbulence in flows between rotating cylinders.

Аннотация

В статье исследуется спектральная задача, связанная со стабильностью течения Куэтта в системе двух вращающихся цилиндров. Рассматривается течение вязкой несжимаемой жидкости, описываемое уравнениями Навье–Стокса в цилиндрической системе координат. Исходная нелинейная задача преобразуется с использованием разложения оператора на линейную и нелинейную части, после чего выполняется линеаризация в окрестности основного течения Куэтта. Полученная линейная система используется для построения спектральной задачи устойчивости.

Показано, что при определённых значениях параметров возникает отклонение от основного течения и формируется неустойчивость, связанная с возникновением вихрей Тейлора. Спектральная задача сведена к задаче для компактного оператора, что позволяет доказать дискретность спектра. Особое внимание уделено постановке задачи устойчивости и её математической формализации.

Предложенный подход позволяет исследовать поведение решения вблизи критических режимов и является основой для численного анализа спектра. Работа имеет значение для

понимания механизмов перехода к турбулентности в течениях между вращающимися цилиндрами.

Keywords: flow stability, Couette flow, rotating cylinders, Navier–Stokes equations, spectral problem, linearization, Taylor vortices, compact operator, hydrodynamic stability.

Ключевые слова: устойчивость течения, течение Куэтта, вращающиеся цилиндры, уравнения Навье–Стокса, спектральная задача, линеаризация, вихри Тейлора, компактный оператор, гидродинамическая устойчивость.

Введение. Исследование устойчивости течений вязкой жидкости является одной из ключевых задач гидродинамики, имеющей как теоретическое, так и прикладное значение. Особый интерес представляет течение Куэтта между вращающимися цилиндрами, которое служит классической моделью для изучения перехода от ламинарного режима к вихревым и турбулентным структурам.

Данная система широко используется для анализа гидродинамической устойчивости, так как при определённых условиях в ней возникают вихри Тейлора, являющиеся типичным примером неустойчивости вязкого течения. Математическое описание таких процессов основано на уравнениях Навье–Стокса, решение которых в общем случае представляет значительные трудности из-за нелинейности и сложности граничных условий.

В настоящей работе рассматривается задача устойчивости течения Куэтта между вращающимися цилиндрами. Основное внимание уделяется переходу от нелинейной постановки к линеаризованной спектральной задаче, которая позволяет исследовать устойчивость основного течения. Для этого используется разложение операторов и анализ малых возмущений.

Постановка задачи. Рассмотрим задачу Навье–Стокса в декартовой системе координат в области между двумя бесконечными цилиндрами с радиусами r_0, r_1 , периодическую вдоль оси цилиндров:

$$\begin{cases} -\Delta v + \text{Re } v \cdot \nabla v + \nabla p = 0, \\ \text{div } v = 0, \end{cases}$$

$$-v^1 \sin \phi + v^2 \cos \phi \Big|_{x^2+y^2=r_0^2} = 1, \quad -v^1 \sin \phi + v^2 \cos \phi \Big|_{x^2+y^2=r_1^2} = 0,$$

$$v^3 \Big|_{\partial C} = 0, \quad v(x, y, z) = v(x, y, z + T), \quad p(x, y, z) = p(x, y, z + T).$$

Пусть внутренний цилиндр вращается с угловой скоростью $1/r_0$, а внешний цилиндр неподвижен. Перейдём к цилиндрическим координатам $\{r, \phi, z\}$ и новым компонентам скорости $\{v^r, v^\phi, v^z\}$:

$$\begin{cases} x = r \cos \phi, \\ y = r \sin \phi, \\ z = z, \end{cases} \quad \begin{cases} v^1 = v^r \cos \phi - v^\phi \sin \phi, \\ v^2 = v^r \sin \phi + v^\phi \cos \phi, \\ v^3 = v^z. \end{cases}$$

После стандартных преобразований получаем следующие уравнения:

$$\begin{cases} -\Delta v^r + \frac{v^r}{r^2} + \frac{2v_\phi^\phi}{r^2} + \operatorname{Re}\left(\frac{v^\phi v_\phi^r}{r} - \frac{v^{\phi^2}}{r} + v^r v_r^r + v^z v_z^r\right) + p_r = 0, \\ -\Delta v^\phi + \frac{v^\phi}{r^2} + \frac{2v_\phi^r}{r^2} + \operatorname{Re}\left(\frac{v^\phi v_\phi^\phi}{r} - \frac{v^\phi v^r}{r} + v^r v_r^\phi + v^z v_z^\phi\right) + \frac{p_\phi}{r} = 0, \\ -\Delta v^z + \operatorname{Re}\left(\frac{v^\phi v_\phi^z}{r} + v^r v_r^z + v^z v_z^z\right) + p_z = 0, \\ (rv^r)_r + v_\phi^\phi + (rv^z)_z = 0, \\ v^\phi|_{r=r_0} = 1, \quad v^\phi|_{r=r_1} = 0, \quad v^r|_{\partial\Omega} = v^z|_{\partial\Omega} = 0, \end{cases} \quad (1)$$

$$v(r, \phi, z) = v(r, \phi, z + T), \quad p(r, \phi, z) = p(r, \phi, z + T),$$

$$\text{где } \Delta = \frac{1}{r^2} \frac{\partial^2}{\partial \phi^2} + \frac{\partial^2}{\partial r^2} + \frac{1}{r} \frac{\partial}{\partial r} + \frac{\partial^2}{\partial z^2}.$$

Будем рассматривать только решения, не зависящие от ϕ , то есть $\frac{\partial v}{\partial \phi} = 0$. Для определённости положим $\phi = 0$. При таких ограничениях уравнения (1) принимают вид:

$$\begin{cases} -\Delta v^r + \frac{v^r}{r^2} + \operatorname{Re}\left(-\frac{1}{r} v^{\phi^2} + v^r v_r^r + v^z v_z^r\right) + p_r = 0, \\ -\Delta v^\phi + \frac{v^\phi}{r^2} + \operatorname{Re}\left(\frac{1}{r} v^\phi v^r + v^r v_r^\phi + v^z v_z^\phi\right) = 0, \\ -\Delta v^z + \operatorname{Re}(v^r v_r^z + v^z v_z^z) + p_z = 0, \\ (rv^r)_r + (rv^z)_z = 0, \\ v^\phi|_{r=r_0} = 1, \quad v^\phi|_{r=r_1} = 0, \quad v^r|_{\partial\Omega} = v^z|_{\partial\Omega} = 0, \\ v(r, z) = v(r, z + T), \quad p(r, z) = p(r, z + T), \end{cases} \quad (2)$$

где $\Delta = \frac{\partial^2}{\partial r^2} + \frac{1}{r} \frac{\partial}{\partial r} + \frac{\partial^2}{\partial z^2}$. - вектор скорости $v = \{v^r(r, z), v^\phi(r, z), v^z(r, z)\}$, определённый в плоской области $\Omega = [0, T] \times [r_0, r_1]$ (рис. 1). Полученная система является исходной для дальнейшего исследования.

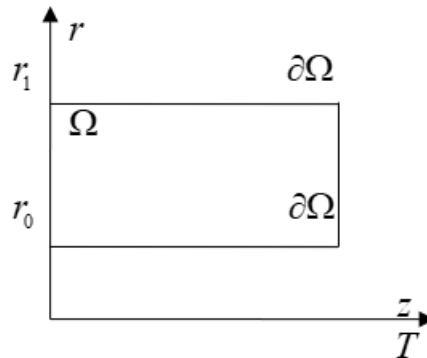


Рисунок 1. Область Ω

Разделим оператор в (2) на линейную и нелинейную части; тогда получаем более компактную форму исходной системы.

$$\begin{cases} L(v) + \operatorname{Re} N(v, v) + G(p) = 0, \\ \operatorname{div} v = 0, \end{cases} \quad (3)$$

$$v^\phi|_{r=r_0} = 1, \quad v^\phi|_{r=r_1} = 0, \quad v^r|_{\partial\Omega} = v^z|_{\partial\Omega} = 0,$$

$$v(r, z) = v(r, z + T), \quad p(r, z) = p(r, z + T).$$

Основная часть. Пусть w является некоторым решением задачи (2). Подставим его в (2) и добавим возмущение $(v - w) + w$. Обозначим его как $u = v - w$ и, сохраняя только линейные члены по u , принимая w за решение, получаем следующие уравнения:

$$\begin{cases} -\Delta u^r + \frac{u^r}{r^2} + \operatorname{Re} \left[-\frac{1}{r} (w^\phi u^\phi + u^\phi w^\phi) + (w^r u_r^r + u^r w_r^r) + (w^z u_z^r + u^z w_z^r) \right] + p_r = 0, \\ -\Delta u^\phi + \frac{u^\phi}{r^2} + \operatorname{Re} \left[\frac{1}{r} (w^\phi u^r + u^\phi w^r) + (w^r u_r^\phi + u^r w_r^\phi) + (w^z u_z^\phi + u^z w_z^\phi) \right] = 0, \\ -\Delta u^z + \operatorname{Re} [(w^r u_r^z + u^r w_r^z) + (w^z u_z^z + u^z w_z^z)] + p_z = 0, \\ (ru^r)_r + (ru^z)_z = 0, \\ u|_{\partial\Omega} = 0, \quad u(r, z) = u(r, z + T), \quad p(r, z) = p(r, z + T). \end{cases}$$

или в более компактной форме:

$$\begin{cases} L(u) + \operatorname{Re} [N(u, w) + N(w, u)] + G(p) = 0, \\ \operatorname{div} u = 0, \end{cases}$$

$$u|_{\partial\Omega} = 0, \quad u(r, z) = u(r, z + T), \quad p(r, z) = p(r, z + T).$$

Полученные уравнения представляют собой линеаризацию нелинейной задачи (3) в окрестности решения w .

$$\begin{cases} w^r = 0, \\ w^\phi = \frac{r_0}{r_1^2 - r_0^2} \left(\frac{r_1^2}{r} - r \right), \\ w^z = 0. \end{cases} \quad (4)$$

При достаточно больших значениях Re у задачи (3) существует решение, отличное от течения Куэтта, называемое вихрем Тейлора [5]. Спектральная задача, связанная со стабильностью течения Куэтта, имеет вид:

$$\begin{cases} L(u) + \operatorname{Re} [N(u, w) + N(w, u)] + G(p) = \lambda u, \\ \operatorname{div} u = 0, \end{cases} \quad (5)$$

$$u|_{\partial\Omega} = 0, \quad u(r, z) = u(r, z + T), \quad p(r, z) = p(r, z + T).$$

Исключая нулевые члены, получаем:

$$\begin{cases} -\Delta u^r + \frac{u^r}{r^2} + \operatorname{Re} \frac{2w^\phi u^\phi}{r} + p_r = \lambda u^r, \\ -\Delta u^\phi + \frac{u^\phi}{r^2} + \operatorname{Re} \left(\frac{w^\phi u^r}{r} + u^r w_r^\phi \right) = \lambda u^\phi, \\ -\Delta u^z + p_z = \lambda u^z, \\ (ru^r)_r + (ru^z)_z = 0, \end{cases} \quad (6)$$

$$u|_{\partial\Omega} = 0, \quad u(r, z) = u(r, z + T), \quad p(r, z) = p(r, z + T).$$

Полученную задачу можно свести к стандартной спектральной задаче для некоторого компактного оператора, откуда следует дискретность спектра.

Заключение. В работе рассмотрена задача устойчивости течения Куэтта между вращающимися цилиндрами на основе уравнений Навье–Стокса в цилиндрической системе координат. Показано, что исходная нелинейная задача может быть приведена к линейной спектральной задаче в окрестности основного решения.

Построенная спектральная постановка позволяет исследовать условия потери устойчивости и возникновения вторичных течений, таких как вихри Тейлора. Установлено, что спектр соответствующего оператора является дискретным, что открывает возможность для его численного анализа.

Полученные результаты подтверждают эффективность используемого подхода для исследования гидродинамической устойчивости. Разработанная методика может быть применена к более сложным задачам, связанным с переходом к турбулентности и анализом устойчивости вращательных течений.

Список литературы

1. Бабенко К.И. и др. Об устойчивости и бифуркации течения Куэтта между вращающимися цилиндрами. Препринт ИПМ АН СССР. № 99. М., 1981.
2. Chizhonkov E. V., Ivanchikov A.A. On numerical stabilization of solutions of Stokes and Navier-Stokes equations by the boundary conditions // Russ. J. Numer. Anal. Math. Modelling. 2004. 19, № 6. 477-494.
3. Graham I.G., Spence A., Vainikko E. Parallel iterative methods for Navier-Stokes equations and application to eigenvalue computation // Concurrency and Computation: Practice and Experience. 2003. 15. 1151-116.
4. Иванчиков А. А. Численное решение некоторых спектральных задач для уравнений Стокса // Вычисл. Методы и программирование. 2003. 4, № 2. 58-74.
5. Темам Р. Уравнения Навье–Стокса. Теория и численный анализ. М. : Мир, 1981.
6. Рустемова К.Ж., Абдимананова П.Б., Мажит Ж.Б., Тамтибеков К.С. Аналитические решения двумерных уравнений Навье–Стокса // VI International Scientific and Practical Conference «The future of intelligence: human, artificial, collective», April 14-15, 2026, Bern. Switzerland. P.15-17;
7. Рустемова К.Ж., Абдимананова П.Б., Шиникулова Г.Н., Мажит Ж.Б. Некоторые особенности уравнений Навье–Стокса и их решений // VI International Scientific and Practical Conference «The future of intelligence: human, artificial, collective», April 14-15, 2026, Bern. Switzerland. P.18-22.

ADJOINT OPERATOR APPROACH TO MAGNETOHYDRODYNAMIC COUETTE FLOW**Rustemova Karashash Zhorabekovna***candidate of physical and mathematical sciences, assistant-professor***Shinikulova Gulnur Nurbekovna***Master of Physics***Tattibekov Konysbek Satievich***candidate of physical and mathematical sciences, associate Professor***Nurmakhanova Asel Kasenovna***PhD, assistant professor,**Almaty Technological University, Almaty, Republic of Kazakhstan***ПРИМЕНЕНИЕ МЕТОДА СОПРЯЖЁННЫХ ОПЕРАТОРОВ К ЗАДАЧЕ
МАГНИТОГИДРОДИНАМИЧЕСКОГО ТЕЧЕНИЯ КУЭТТА****Рустемова Карашаш Жорабековна***к.ф.-м.н., ассистент-профессор***Шиникулова Гульнур Нурбековна***Магистр физики***Таттибеков Конысбек Сатиевич***к.ф.-м.н., доцент***Нурмаханова Асель Касеновна,***PhD, ассистент профессор,**Алматинский технологический университет, г. Алматы, Республика Казахстан***Abstract**

This article investigates the problem of magnetohydrodynamic Couette flow arising from the motion of an electrically conducting fluid between two parallel plates in the presence of an external uniform magnetic field. The classical configuration is considered, where one plate remains stationary while the other moves with a constant velocity, generating a shear flow within the fluid. Special attention is given to the influence of electromagnetic forces that emerge due to the interaction between the conducting medium and the magnetic field, significantly affecting the velocity distribution and overall flow structure.

The governing equations of the problem are derived, including the continuity equation and the momentum equation with an additional term representing volumetric electromagnetic forces. By introducing dimensionless variables, the problem is reduced to a generalized form involving key parameters such as the Hartmann number and a coefficient associated with the pressure gradient. This transformation enables a more comprehensive analysis of how physical parameters influence the flow behavior.

The boundary value problem is further reduced to a system of first-order differential equations, which is solved using the adjoint operator method. This approach allows for the accurate determination of missing initial conditions and transforms the problem into a well-posed Cauchy problem. A computational algorithm is presented, and a numerical example is provided for specific values of the dimensionless parameters.

The obtained results are compared with an exact analytical solution, demonstrating high accuracy and reliability of the proposed method. The study confirms the effectiveness of the adjoint operator method in solving magnetohydrodynamic problems and highlights its potential applicability to more complex physical and engineering systems.

Аннотация

В данной статье исследуется задача магнитогидродинамического течения Куэтта, возникающего при движении электропроводящей жидкости между двумя параллельными пластинами в присутствии внешнего однородного магнитного поля. Рассматривается классическая постановка, в которой одна из пластин неподвижна, а другая движется с постоянной скоростью, что приводит к формированию сдвигового течения. Особое внимание уделяется учету электромагнитных сил, возникающих в результате взаимодействия проводящей среды с магнитным полем, что существенно влияет на структуру потока и распределение скоростей.

В работе выполнен вывод основных уравнений, описывающих рассматриваемый процесс, включая уравнение неразрывности и уравнение движения с дополнительным членом, соответствующим объемным электромагнитным силам. Путем введения безразмерных переменных задача приведена к обобщенной форме, содержащей ключевые параметры, такие как число Хартмана и коэффициент, связанный с градиентом давления. Это позволяет провести более глубокий анализ влияния физических параметров на характер течения.

Краевая задача сведена к системе дифференциальных уравнений первого порядка, для решения которой применяется метод сопряженных операторов. Данный подход позволяет корректно определить недостающие начальные условия и эффективно решить задачу в форме задачи Коши. Приведен алгоритм вычислений и рассмотрен численный пример при фиксированных значениях безразмерных параметров.

Полученные результаты сопоставлены с точным аналитическим решением, что демонстрирует высокую точность и надежность используемого метода. Проведенное исследование подтверждает эффективность метода сопряженных операторов при решении задач магнитогидродинамики и его применимость к более сложным инженерным и физическим моделям.

Keywords: magnetohydrodynamics, Couette flow, electromagnetic forces, viscous fluid, boundary value problem, adjoint operator method, differential equations, dimensionless parameters.

Ключевые слова: магнитогидродинамика, течение Куэтта, электромагнитные силы, вязкая жидкость, краевая задача, метод сопряжённых операторов, дифференциальные уравнения, безразмерные параметры.

Введение. Магнитогидродинамика является важным разделом механики сплошных сред, изучающим поведение электропроводящих жидкостей в магнитных и электрических полях. Подобные задачи имеют широкое применение в инженерии, энергетике, металлургии и астрофизике. Одной из классических моделей является течение Куэтта, которое описывает движение жидкости между двумя параллельными пластинами, одна из которых движется относительно другой.

Учет магнитного поля существенно усложняет задачу, так как в уравнения движения добавляются силы электромагнитной природы. Это приводит к необходимости использования более сложных математических методов для анализа и решения соответствующих уравнений.

В данной работе рассматривается магнитогидродинамическое течение Куэтта в однородном магнитном поле. Основное внимание уделяется приведению исходной задачи к удобной для решения форме, введению безразмерных параметров, а также применению метода сопряженных операторов для нахождения решения краевой задачи.

Постановка задачи. Магнитогидродинамика изучает движение жидкости в электрических и магнитных полях. Для анализа этой задачи необходимо учитывать уравнения и законы гидродинамики совместно с основными соотношениями электромагнетизма.

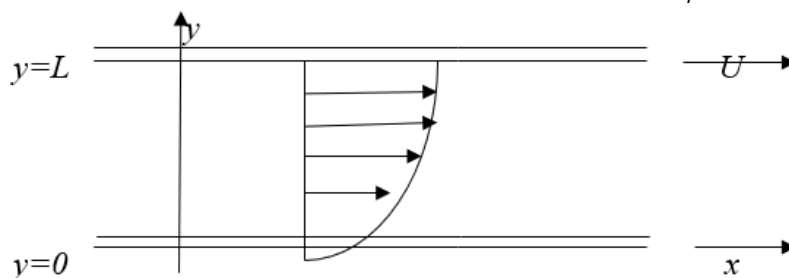


Рисунок 1. Течение Куэтта

Для понимания взаимодействия электрических, магнитных и гидродинамических сил рассмотрим задачу, называемую течением Куэтта. Рассмотрим жидкость, протекающую между двумя параллельными пластинами, одна из которых неподвижна, а другая движется в своей плоскости со скоростью U , в однородном магнитном поле, направленном вдоль оси u_0 (рис. 1).

Запишем уравнения неразрывности и изменения импульса:

$$\frac{du}{dx} = 0, \quad (1)$$

$$\rho \frac{du}{dx} = -\frac{\partial p}{\partial x} + \rho \nu (\frac{\partial^2 \rho}{\partial x^2} + \frac{\partial^2 u}{\partial y^2}) - \sigma B_0^2 u, \quad (2)$$

$$0 = -\frac{\partial p}{\partial y}, \quad (3)$$

где u, p, ρ, ν, σ — соответственно скорость жидкости, давление, плотность, кинематическая вязкость и проводимость, а B_0 — напряженность внешнего магнитного поля. Дополнительный член $\sigma B_0^2 u$ в уравнении (2) физически соответствует объемным электрическим силам. За исключением этого члена, основные уравнения совпадают с уравнениями, описывающими течение Куэтта ньютоновской жидкости.

Уравнение (1) показывает, что скорость u не зависит от x . Аналогично, уравнение (3) показывает, что плотность не зависит от y . С учетом этого уравнение (2) можно записать в виде:

$$d^2 u / dy^2 - [\sigma B_0^2 / (\rho \nu)] u = [1 / (\rho \nu)] dp / dx, \quad (4)$$

Граничные условия записываются следующим образом:

$$u = 0 \text{ при } y = 0, \quad u = U \text{ при } y = L.$$

Если ввести безразмерные переменные $\bar{u} = u / U$, $\eta = y / L$, то уравнение (4) и граничные условия принимают вид:

$$d^2 \bar{u} / d\eta^2 - M^2 \bar{u} = P, \quad (5)$$

$$\bar{u}(0) = 0, \quad \bar{u}(1) = 1, \quad (6)$$

где M и P — две безразмерные величины, определяемые следующим образом:

$$M = [\sigma / (\rho \nu)]^{1/2} B_0 L \text{ — число Гартмана,}$$

$$P = (1 / U) (dp / dx) L^2 / (\rho \nu) \text{ — коэффициент, используемый при пересчете давления.}$$

Решение. Краевая задача, определяемая уравнением (5) и условиями (6), решается методом сопряженных операторов.

Сначала запишем уравнение (5) в виде системы дифференциальных уравнений первого порядка:

$$du_1 / d\eta = u_2 = (0)u_1 + (1)u_2 + (0), \quad (7)$$

$$du_2 / d\eta = M^2 u_1 + P = (M^2)u_1 + (0)u_2 + (P), \quad (8)$$

с начальными условиями $u_1(0) = 0$, $u_1(1) = 1$, где $u_1 = \bar{u}$.

Система (7)–(8) в векторно-матричной форме записывается как:

$$\dot{u} = A(\eta)u + F(\eta), \quad (9)$$

где точка обозначает дифференцирование по независимой переменной η и

$$u = \begin{bmatrix} u_1 \\ u_2 \end{bmatrix}, \quad A = \begin{bmatrix} 0 & 1 \\ M^2 & 0 \end{bmatrix}, \quad F(\eta) = \begin{bmatrix} 0 \\ P \end{bmatrix}.$$

Введем сопряженную систему:

$$-\dot{X} = A^T X, \quad (10)$$

где

$$X = \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}, \quad A^T = \begin{bmatrix} 0 & M^2 \\ 1 & 0 \end{bmatrix}.$$

Таким образом, сопряженная система имеет вид:

$$dx_1 / d\eta = -M^2 x_2, \quad (11)$$

$$dx_2 / d\eta = -x_1. \quad (12)$$

Процедуру, обозначенную формулами (7) и (8), можно реализовать следующим образом. Умножив уравнения (7), (8), (11) и (12) соответственно на переменные x_1 , x_2 , u_1 , u_2 и сложив результаты, получим:

$$d(x_1 u_1 + x_2 u_2) / d\eta = P x_2. \quad (13)$$

Интегрируя (13) от 0 до 1, получаем:

$$x_1(1)u_1(1) + x_2(1)u_2(1) - [x_1(0)u_1(0) + x_2(0)u_2(0)] = \int_0^1 Px_2 d\eta. \quad (14)$$

Поскольку одно из начальных условий отсутствует, соотношение (14) и сопряженную систему (11), (12) следует использовать только один раз. Подставим известные граничные значения в (14):

$$x_1(1) + x_2(1)u_2(1) - x_2(0)u_2(0) = \int_0^1 Px_2 d\eta. \quad (15)$$

Теперь недостающее начальное условие $u_2(0)$ системы (7), (8) можно найти из (15):

$$u_2(0) = [1/x_2(0)] \left[x_1(1) + x_2(1)u_2(1) - \int_0^1 Px_2 d\eta \right]. \quad (16)$$

Здесь $u_1(1)$ — неизвестная величина, а $x_1(1)$, $x_2(1)$ — начальные условия для интегрирования системы (11), (12), которые можно выбрать произвольно. Если принять $x_2(1) = 0$, то второй член в правой части (16) обращается в нуль независимо от $u_2(1)$. Самый простой выбор — $x_1(1) = 1$. Тогда (16) принимает вид:

$$u_2(0) = [1/x_2(0)] \left[1 - \int_0^1 Px_2 d\eta \right]. \quad (17)$$

Таким образом, решение системы (7)–(8) состоит из следующих шагов:

1. Не учитывая уравнения (11) и (12), интегрируем назад от $\eta = 1$ к $\eta = 0$ с начальными условиями $x_1(1) = 1$, $x_2(1) = 0$;

2. Зная x_1 и x_2 , вычисляем $u_2(0)$ по формуле (17);

3. Поскольку известны $u_1(0)$ (задано) и $u_2(0)$, решаем систему (7)–(8) как задачу Коши.

В качестве примера рассмотрим случай $M=2$, $P=4$. Решения x_1 и x_2 , полученные на первом шаге, приведены в таблице 1.

η	x_1	x_2
1.00	1.0000	0.0000
0.90	1.0200	0.1007
0.80	1.0810	0.2054
0.70	1.1853	0.3183
0.60	1.3372	0.4440
0.50	1.5428	0.5875
0.40	1.8103	0.7546
0.30	2.1505	0.9520
0.20	2.5769	1.1875
0.10	3.1067	1.4707
0.00	3.7612	1.8129

Из этого находим $x_2(0) = 1.8129$.

Подставляя значения из таблицы 1 в (17), получаем:

$$u_2(0) = \frac{1 - 0.6904 \cdot 4}{1.8129} = -0.9717.$$

Теперь систему (7)–(8) можно проинтегрировать как задачу Коши с начальными условиями:

$$u_1(0) = 0, \quad u_2(0) = -0.9717$$

Результаты приведены в таблице 2. Там же указаны значения u_1 , вычисленные по точной формуле.

$$u_1 = \frac{shM\eta}{shM} + \frac{P}{M^2} \left[\frac{2sh(M\eta/2)sh(M(\eta-1)/2)}{ch(M/2)} \right]$$

Полученные с помощью метода сопряжённых операторов			Точные
η	u_1	u_2	u_1
0.0	0.0000	-0.9717	0.0000
0.1	-0.0778	-0.5885	-0.0777
0.2	-0.1185	-0.2289	-0.1185
0.3	-0.1238	0.1214	-0.1239
0.4	-0.0940	0.4767	-0.0941
0.5	-0.0279	0.8511	-0.0279
0.6	0.0773	1.2596	0.07772
0.7	0.2257	1.7186	0.2256
0.8	0.4233	2.2466	0.4332
0.9	0.6781	2.8648	0.6779
1.0	1.0000	3.5979	1.0000

Как видно, результаты совпадают.

Заключение. В результате проведенного исследования была рассмотрена задача магнитогидродинамического течения Куэтта и получена ее математическая модель с учетом воздействия магнитного поля. Путем введения безразмерных переменных задача была приведена к более удобному виду, что позволило выделить ключевые параметры, влияющие на поведение системы.

Для решения краевой задачи был применен метод сопряженных операторов, позволивший эффективно определить недостающие начальные условия и свести задачу к задаче Коши. Проведенный численный пример показал хорошее совпадение полученных результатов с точным аналитическим решением, что подтверждает точность и надежность метода.

Таким образом, предложенный подход может быть успешно использован для анализа аналогичных задач магнитогидродинамики и может служить основой для дальнейших исследований в данной области.

Список литературы

8. Бабенко К.И. и др. Об устойчивости и бифуркации течения Куэтта между вражающимися цилиндрами. Препринт ИПМ АН СССР. № 99. М., 1981.
9. Иванчиков А. А. Численное решение некоторых спектральных задач для уравнений Стокса // Вычисл. Методы и программирование. 2003. 4, № 2. 58-74.
10. Рустемова К.Ж., Абдимананова П.Б., Мажит Ж.Б., Тамтибеков К.С. Аналитические решения двумерных уравнений Навье–Стокса // VI International Scientific and Practical Conference «The future of intelligence: human, artificial, collective», April 14-15, 2026, Bern. Switzerland. P.15-17;
11. Рустемова К.Ж., Абдимананова П.Б., Шунукулова Г.Н., Мажит Ж.Б. Некоторые особенности уравнений Навье–Стокса и их решений // VI International Scientific and Practical Conference «The future of intelligence: human, artificial, collective», April 14-15, 2026, Bern. Switzerland. P.18-22.

Medical sciences

THE ROLE OF PHYSIOTHERAPY IN FALL PREVENTION AMONG OLDER ADULTS: A NARRATIVE REVIEW

Bruno Gorana

Msc., Lecturer

University "Aleksandër Moisiu" Durrës

Faculty of Education

Lifelong Learn Center

<https://orcid.org/0009-0000-6499-9157>

Abstract

Falls among older adults represent a major public health concern due to their association with increased morbidity, mortality, and reduced quality of life. Physiotherapy plays a crucial role in preventing falls through targeted interventions such as strength training, balance exercises, and functional mobility programs. This narrative review aims to examine the current evidence regarding physiotherapeutic approaches in fall prevention among the elderly. Relevant literature was identified through searches in databases including PubMed and Google Scholar, focusing on studies published in recent decades. The findings suggest that physiotherapy interventions significantly reduce fall risk by improving muscle strength, postural stability, and gait performance. Multifactorial programs that combine exercise with patient education appear to be the most effective. Despite strong evidence supporting physiotherapy, variability in intervention protocols highlights the need for standardized guidelines. In conclusion, physiotherapy is an essential component in fall prevention strategies and should be widely implemented in geriatric care.

Introduction

The global population is aging rapidly, leading to an increase in age-related health conditions and functional impairments. Among these, falls are one of the most common and serious problems affecting older adults. It is estimated that approximately one-third of individuals aged 65 years and older experience at least one fall per year, making falls a leading cause of injury, hospitalization, and loss of independence (Bachmann et al., 2010).

Falls in older adults are multifactorial in nature and are often associated with decreased muscle strength, impaired balance, gait disturbances, and neurological or sensory deficits (Avin et al., 2015). In addition to physical consequences such as fractures—particularly hip fractures—falls can also lead to psychological effects, including fear of falling, which further reduces mobility and quality of life.

Physiotherapy has emerged as a key non-pharmacological intervention in the prevention of falls. It focuses on improving physical function through targeted exercise programs, balance training, and functional rehabilitation. Evidence suggests that structured physiotherapy interventions can significantly reduce fall risk and improve overall functional capacity in older adults (Kosse et al., 2013).

This narrative review aims to explore the role of physiotherapy in fall prevention among older adults, highlighting the most effective interventions and identifying gaps in current research.

Methodology

This narrative review was conducted through a comprehensive search of electronic databases, including PubMed, Google Scholar, and ScienceDirect. Keywords such as "falls," "elderly," "physiotherapy," "balance training," and "fall prevention" were used in various combinations to identify relevant studies.

Articles published between 2000 and 2025 were considered. Priority was given to systematic reviews, randomized controlled trials, and clinical guidelines related to physiotherapy interventions in older adults. Additional sources were identified through reference lists of selected articles.

Studies focusing on pharmacological treatments or non-rehabilitation interventions were excluded. The selected literature was analyzed and synthesized thematically to provide an overview of current evidence regarding physiotherapy in fall prevention.

4.1 Causes of falls in older adults

Falls in older adults are typically caused by a combination of intrinsic and extrinsic factors. Intrinsic factors include age-related physiological changes such as decreased muscle strength (sarcopenia), impaired balance, reduced flexibility, and slower reaction times. Neurological conditions, visual impairments, and cognitive decline also contribute significantly to fall risk (Avin et al., 2015).

Extrinsic factors involve environmental hazards such as poor lighting, slippery floors, uneven surfaces, and inappropriate footwear. Additionally, polypharmacy and the use of certain medications (e.g., sedatives) may increase the likelihood of falls.

The interaction between these factors makes fall prevention complex and highlights the need for multifactorial interventions.

4.2 Consequences of falls

Falls can have serious physical, psychological, and social consequences for older adults. Physically, falls are a leading cause of fractures, particularly hip fractures, which are associated with high morbidity and mortality rates (Bachmann et al., 2010).

Psychologically, many older adults develop a fear of falling after an initial incident. This fear can lead to reduced physical activity, social isolation, and further functional decline. In severe cases, falls may result in long-term disability and loss of independence, increasing the need for institutional care.

Therefore, preventing falls is essential not only for physical health but also for maintaining quality of life and autonomy in older individuals.

4.3 Role of physiotherapy in fall prevention

4.3.1 Strength training

Muscle weakness, particularly in the lower limbs, is a major risk factor for falls. Physiotherapy programs that include resistance and strengthening exercises have been shown to improve muscle power and functional mobility in older adults (Kosse et al., 2013).

4.3.2 Balance training

Balance impairments are strongly associated with fall risk. Specific balance exercises, such as standing on one leg, tandem walking, and dynamic stability training, can significantly improve postural control and reduce falls (Avin et al., 2015).

4.3.3 Gait training

Gait abnormalities, including reduced speed and instability, increase the likelihood of falls. Physiotherapists use gait training techniques to improve walking patterns, coordination, and safety during ambulation.

4.3.4 Multifactorial interventions

The most effective fall prevention strategies combine multiple approaches, including strength training, balance exercises, and patient education. These programs address both physical and behavioral risk factors and have demonstrated superior outcomes compared to single interventions (Crocker et al., 2013).

4.3.5 Patient education

Educating older adults about fall risks and preventive strategies is an essential component of physiotherapy. This includes advice on home safety, appropriate footwear, and lifestyle modifications.

4.4 Modern approaches in physiotherapy

Recent advances in technology have introduced new approaches to fall prevention. Telerehabilitation and digital health interventions allow remote monitoring and guidance, increasing accessibility to physiotherapy services (Kraaijkamp et al., 2021).

Additionally, the use of virtual reality and sensor-based training systems has shown promising results in improving balance and engagement in older adults (Spanakis et al., 2022).

Discussion

This narrative review highlights the significant role of physiotherapy in the prevention of falls among older adults. The findings from the analyzed literature consistently demonstrate that physiotherapy interventions—particularly those focused on strength, balance, and functional mobility—are effective in reducing fall risk and improving overall physical performance.

One of the key observations is that multifactorial interventions yield the most favorable outcomes. Programs that integrate strength training, balance exercises, gait re-education, and patient education address both intrinsic and extrinsic risk factors. This aligns with previous research emphasizing that falls are multifactorial in nature and require comprehensive management strategies (Crocker et al., 2013; Avin et al., 2015).

Moreover, advancements in technology, such as telerehabilitation and virtual reality, are expanding the scope of physiotherapy. These innovations offer new opportunities for delivering personalized rehabilitation programs, especially for older adults with limited access to healthcare facilities (Kraaijkamp et al., 2021; Spanakis et al., 2022).

However, despite strong evidence supporting physiotherapy, several limitations exist in the current literature. There is considerable variability in intervention protocols, duration, and intensity across

studies, making it difficult to establish standardized guidelines. Additionally, some studies have small sample sizes or lack long-term follow-up, limiting the generalizability of their findings.

Future research should focus on developing standardized, evidence-based physiotherapy protocols and exploring long-term outcomes of fall prevention programs in diverse populations of older adults.

Conclusion

Falls among older adults represent a major health concern with significant physical, psychological, and social consequences. This review demonstrates that physiotherapy plays a crucial role in fall prevention through targeted interventions aimed at improving strength, balance, and functional mobility.

Multifactorial physiotherapy programs appear to be the most effective approach, addressing the complex and multifaceted nature of fall risk. In addition, emerging technologies offer promising tools to enhance rehabilitation outcomes and accessibility.

In conclusion, physiotherapy should be considered a fundamental component of fall prevention strategies in geriatric care. Greater efforts are needed to standardize intervention protocols and promote the widespread implementation of physiotherapy programs for older adults.

References

1. Bachmann, S., Finger, C., Huss, A., Egger, M., & Stuck, A. E. (2010). Inpatient rehabilitation specifically designed for geriatric patients. *BMJ*, 340, c1718. <https://www.bmj.com/content/bmj/340/bmj.c1718.full.pdf>
2. Avin, K. G., Hanke, T. A., Kirk-Sanchez, N., et al. (2015). Management of falls in community-dwelling older adults. *Physical Therapy Journal*, 95(6), 815–834. <https://academic.oup.com/ptj/article-pdf/95/6/815/31635008/ptj0815.pdf>
3. Kosse, N. M., Dutmer, A. L., Dasenbrock, L., Bauer, J. M., & Lamothe, C. J. (2013). Effectiveness of early physical rehabilitation programs. *BMC Geriatrics*, 13, 107. <https://link.springer.com/content/pdf/10.1186/1471-2318-13-107.pdf>
4. Crocker, T., Young, J., Forster, A., Brown, L., & Ozer, S. (2013). Physical rehabilitation for older people in long-term care. *Age and Ageing*, 42(6), 682–688. <https://academic.oup.com/ageing/article-pdf/42/6/682/13695795/aft133.pdf>
5. Spanakis, M., Xylouri, I., & Patelarou, E. (2022). High-tech physiotherapy interventions in elderly. *International Journal of Environmental Research and Public Health*, 19(15), 9233. <https://www.mdpi.com/1660-4601/19/15/9233>
6. Kraaijkamp, J. J. M., van Dam van Isselt, E. F., et al. (2021). eHealth in geriatric rehabilitation. *Journal of Medical Internet Research*, 23(8), e24015. <https://www.jmir.org/2021/8/e24015/>
7. Ricci, N. A., Aratani, M. C., Doná, F., & Macedo, C. (2010). Vestibular rehabilitation in older adults. *Brazilian Journal of Physical Therapy*. <https://www.scielo.br/j/rbfis/a/qj4BMtwJFg84byFnyQcG3nJ/?format=pdf>
8. Hoenig, H., & Siebens, H. (2004). Geriatric rehabilitation. https://www.newfrontiers.americangeriatrics.org/chapters/pdf/rasp_12.pdf
9. Lubbe, A. L., van Rijn, M., Groen, W. G., & Hilhorst, S. (2023). Quality of geriatric rehabilitation. *Age and Ageing*. <https://academic.oup.com/ageing/article-pdf/52/3/afad032/49715089/afad032.pdf>
10. Guccione, A. A., Avers, D., & Wong, R. (2011). *Geriatric Physical Therapy*. Elsevier.

MOLECULAR MIMICRY OF Tl^+ : THE MECHANISM OF ITS TOXIC EFFECTS AND ITS CONSEQUENCES FOR THE HUMAN NERVOUS SYSTEM

Yeva Garbar

student of Educational and Scientific Institute of Medicine,
specialty I2 "Medicine",
Bogomolets National Medical University,
Kyiv, Ukraine

Valentyna Slipchuk

Doctor of Sciences in Pedagogy, Professor,
Professor of the Department of Medical Biochemistry
and Molecular Biology,
Bogomolets National Medical University,
Kyiv, Ukraine

Introduction. Despite restrictions on the use of thallium compounds in the agricultural sector, the problem of thallium poisoning remains acute due to extensive human activity. The release of thallium into ecosystems as a result of industrial use of the element leads to its persistent bioaccumulation in food chains and cases of serious poisoning.

The main material. Thallium is a trace element in the periodic table, located in the 6th period, Group III (or Group 13 according to the current IUPAC classification), with atomic number 81; it is characterized by high toxicity, significant reactivity, and high bioavailability [1, p. 1; 2, p. 1; 3, p. 1]. The element dissolves rapidly in water and acids, after which it exhibits two oxidation states, Tl^+ and Tl^{3+} . The first form is considered the most dangerous due to its ionic radius, which is close to that of K^+ (0.176 nm for Tl^+ and 0.160 nm for K^+), and its identical valence (+1). These properties lead to rapid accumulation of the toxin by cells [1, p. 1-3; 2, p. 1; 3, p. 1-2].

The highest concentrations of thallium are found in crookesite, lorandite, hutchinsonite, and urbaite, but on an industrial scale, it is obtained during the processing of non-ferrous metal ores. After the element was discovered in 1861, it was used in pesticides and therapeutic agents for tuberculosis, malaria, syphilis, gonorrhea, ringworm, and other conditions. Over time, these uses were banned in many countries around the world. Today, the element is still found in diagnostic agents, used in the creation of costume jewelry, green fireworks, optical technologies, measuring instruments (scintimeters), and photovoltaic cells, and is employed in the gravitational enrichment of minerals [1, p. 2; 2, p. 1-3; 3, p. 2].

Tl_2O is released into the Earth's atmosphere as a result of the metallurgical industry, volcanic eruptions, and soil erosion. It is estimated that approximately 5 tons of thallium enter ecosystems annually due to human activities. The highest concentrations of this toxin are found in urban areas and industrial regions. The deposition of thallium compounds on sediment leads to excessive bioaccumulation of the element in organisms of the hydrosphere and lithosphere. It is important to note that Tl^+ ions are the most common form in ecosystems due to their thermal stability. The food chain, starting with producers, is considered the typical mechanism for the transfer of the element to higher trophic levels [1, p. 2-3; 2, p. 2]. For example, crops grown on polluted land can lead to thallium poisoning in humans [1, p. 3].

Thallium enters the body through ingestion, percutaneous absorption, inhalation, and other routes. It typically occurs in the form of salts (Tl_2SO_4), oxides (Tl_2O , Tl_2O_3), or hydroxides ($TlOH$). The lethal dose of the element is 10–15 mg/kg, and with chronic exposure, it is 0.1–100 mg/kg. The body may be more sensitive to thallium due to age, physical characteristics, and other factors [1, p. 3; 2, p. 1-3; 3, p. 3; 4, p. 30]. In many cases, the toxin is successfully absorbed by the body. This process is most effective when the compounds come into contact with mucous membranes: between 80% and 100% of the thallium is absorbed [2, p. 3; 3, p. 3; 4, p. 30; 5, p. 115]. A key characteristic of the substance in the context of poisoning is the striking similarity of its physical and chemical properties to those of potassium. Tl^+ effectively replaces K^+ in the sodium-potassium ATPase mechanism, exhibiting an affinity for the pump that is many times higher than that of potassium. At this stage, the imbalance of particles causes depolarization of the cell membrane and disrupts the ionic balance, particularly that of Ca^{2+} . The element has a similar effect on mitochondria: by penetrating transport systems similar to the sodium-potassium pump, thallium causes a decrease in mitochondrial membrane potential. The mitochondria swell and become vacuolated [1, p. 4-5; 2, p. 7-8; 3, p. 2-3; 4, p. 31; 5, p. 114]. It is important to note that thallium is capable of forming complexes with sulfhydryl groups (-SH, which are characteristic of certain proteins and membrane components), thanks to its empty d-orbital [1, p. 4; 2, p. 7; 4, p. 31; 5, p. 114]. Inside the cells, the

toxin inhibits cysteine-containing pyruvate kinase and pyruvate dehydrogenase, disrupting energy metabolism [1, p. 4; 2, p. 7; 3, p. 3; 4, p. 31-32; 5, p. 114]. When Tl^+ interacts with glutathione, the latter is inactivated, leading to an excess of reactive oxygen species, such as the superoxide radical $O_2^{\cdot-}$ and the hydroxyl radical $OH^{\cdot}$ (oxidative stress) [1, p. 4; 2, p. 8; 4, p. 31-32; 5, p. 114]. In addition, contact between the toxin and phospholipid anions leads to disruption of the function of membrane receptors, enzymes, and channels. Researchers also report that the ribosomal complex is destroyed under the influence of Tl^+ [5, p. 114]. The combination of structural and metabolic abnormalities leads to the release of apoptotic factors, such as cytochrome C [1, p. 4].

Exposure to a toxin typically triggers neurological symptoms within 2 to 5 days, especially in cases of chronic poisoning [2, p. 5; 3, p. 5; 4, p. 33; 5, p. 115]. In the early stages, peripheral neuropathy is observed: weakness, pain, paresthesia, and hyporeflexia, primarily in the lower extremities. The upper body is affected only over time [2, p. 5-6; 3, p. 5; 4, p. 33; 5, p. 115]. Sometimes the cranial nerves (pairs 2, 3, 4, and 6) are damaged, causing the person to suffer from ptosis, nystagmus, ophthalmoplegia, amblyopia, and optic nerve atrophy [3, p. 5; 4, p. 34; 5, p. 116]. Equally characteristic are changes in mental health and circadian rhythms. Insomnia, anxiety, apathy, impaired emotional self-regulation, depression, delirium, psychosis, and hallucinations may develop [2, p. 6; 3, p. 5; 4, p. 33-34; 5, p. 116]. Depending on the amount of thallium absorbed by the body, choreoathetosis, ataxia, and amnesia may occur [2, p. 6; 3, p. 5; 5, p. 116].

Conclusions. The toxic effects of thallium are based on its physical and chemical similarity to potassium: Tl easily penetrates cells and triggers a cascade of destructive processes. These include mitochondrial damage and the inhibition of energy metabolism enzymes and glutathione. For the nervous system, this has fatal consequences, manifesting as acute neuropathies and cognitive-psychiatric disorders. Its high bioavailability and potential for bioaccumulation in tissues make thallium one of the most dangerous toxins of our time.

References

1. Moura, Alexandre Varão, Lucas Aleixo Leal Pedroza, José Domingos Santos da Silva, et al. (2026). Thallium: An overview of its distribution in the environment and its cellular and molecular toxicity. *Toxicology Letters*, 418, 111857. <https://doi.org/10.1016/j.toxlet.2026.111857>.
2. Fujihara, J., Nishimoto, N. (2024). Thallium - poisoner's poison: An overview and review of current knowledge on the toxicological effects and mechanisms. *Current Research in Toxicology*, 6, 100157. <https://doi.org/10.1016/j.crtox.2024.100157>.
3. Galván-Arzate, S., Santamaría A. (1998). Thallium toxicity. *Toxicology Letters*, 99, (1), 1-13. [https://doi.org/10.1016/S0378-4274\(98\)00126-X](https://doi.org/10.1016/S0378-4274(98)00126-X).
4. Hoffman, R. S. (2003). Thallium Toxicity and the Role of Prussian Blue in Therapy. *Toxicological Reviews*, 22, 29-40. <https://doi.org/10.2165/00139709-200322010-00004>
5. Cvjetko, P., Cvjetko, I. & Pavlica, M. (2010). Thallium Toxicity in Humans. *Archives of Industrial Hygiene and Toxicology*, 61(1), 111-119. <https://doi.org/10.2478/10004-1254-61-2010-1976>

TRANSFORMATION OF PARAMEDIC TRAINING IN UKRAINE UNDER CURRENT CHALLENGES: MILITARY EXPERIENCE AS A DRIVER FOR NEW EDUCATIONAL MODELS

Ludmyla V. Fomina

Doctor of Medical Sciences, Professor,
Professor of the Department of Anatomy,
National Pirogov Memorial Medical University, Vinnytsya.

Leonid M. Bulat,

Doctor of Medical Sciences, Professor,
Professor of the Department of Clinical Disciplines,
Private Higher Education Institution
"Dnipro Institute of Medicine and Public Health".

Olena I. Haidash,

Candidate of Medical Sciences (PhD), Associate Professor,
Associate Professor of the Department of Clinical Disciplines,
Private Higher Education Institution
"Dnipro Institute of Medicine and Public Health"

Oksana V. Zviahina,

Doctor of Philosophy (Medicine), Associate Professor,
Associate Professor of the Department of Clinical Disciplines,
Private Higher Education Institution
"Dnipro Institute of Medicine and Public Health"

Artem O. Turzaiev

Lecturer of the Department of Clinical Disciplines,
Epidemiologist, Private Higher Education Institution
"Dnipro Institute of Medicine and Public Health"

**ТРАНСФОРМАЦІЯ ПОДГОТОВКИ ПАРАМЕДИКІВ В УКРАЇНІ В УМОВАХ СУЧАСНИХ ВИ-
ЗОВІВ: ВОЄННИЙ ОПИТ КАК СТИМУЛ ДЛЯ СОЗДАНИЯ НОВЫХ ОБРАЗОВАТЕЛЬНЫХ МОДЕЛЕЙ**

Фоміна Людмила Василівна,

д. мед. наук, професор, професор кафедри анатомії
Вінницького Національного Медичного Університету
ім. М.І. Пирогова,

Булат Леонід Мойсейович,

д. мед. наук, професор, професор кафедри клінічних дисциплін
Приватний заклад вищої освіти
«Дніпровський інститут медицини та громадського здоров'я»

Гайдаш Олена Ігорівна

к. мед. наук, доцент, доцент кафедри клінічних дисциплін
Приватний заклад вищої освіти
«Дніпровський інститут медицини та громадського здоров'я»

Звягіна Оксана Володимирівна

доктор філософії (медицина), доцент, доцент кафедри клінічних дисциплін
Приватний заклад вищої освіти
«Дніпровський інститут медицини та громадського здоров'я»

Турзаєв Артем Олександрович

викладач кафедри клінічних дисциплін, лікар-епідеміолог
Приватний заклад вищої освіти
«Дніпровський інститут медицини та громадського здоров'я»

Abstract

The study examines the transformation of paramedic training approaches in Ukraine under current challenges. Particular attention is paid to the impact of practical experience gained in high-demand medical settings on the development of new educational models. Analytical and systemic approaches, as well as a synthesis of international and national practices, were applied. The necessity of shifting from traditional educational approaches to competency-based models with an emphasis on autonomy, rapid

decision-making, and functioning under resource-limited conditions is substantiated. The findings can be used in the development of modern paramedic training programs.

Анотація

У роботі розглянуто трансформацію підходів до підготовки парамедиків в Україні в умовах сучасних викликів. Особливу увагу приділено впливу практичного досвіду надання медичної допомоги в умовах підвищеного навантаження на формування нових освітніх моделей. Використано аналітичний та системний підходи, а також узагальнення сучасних міжнародних і національних практик. Обґрунтовано необхідність переходу від традиційних освітніх підходів до компетентнісно-орієнтованих моделей навчання з акцентом на автономність, швидкість прийняття рішень та роботу в умовах обмежених ресурсів. Отримані результати можуть бути використані при розробці сучасних освітніх програм з парамедицини.

Keywords: *paramedicine; medical education; emergency medical services; educational models; competency-based approach; pre-hospital care; simulation training*

Ключові слова: *парамедицина; медична освіта; екстрена медична допомога; освітні моделі; компетентнісний підхід; догоспітальна допомога; симуляційне навчання.*

Сучасний етап розвитку системи охорони здоров'я України характеризується необхідністю адаптації до умов підвищеного навантаження на службу екстреної медичної допомоги. У цих умовах відбувається переосмислення ролі парамедиків як ключових фахівців догоспітального етапу, здатних забезпечити своєчасне та ефективне надання допомоги.

Традиційні моделі підготовки медичних кадрів, орієнтовані переважно на теоретичні знання, демонструють обмежену ефективність у ситуаціях, що потребують швидкого прийняття рішень та роботи в умовах невизначеності [1,2]. Це зумовлює необхідність перегляду підходів до навчання парамедиків із акцентом на формування практичних компетентностей.

Практичний досвід, отриманий у процесі надання медичної допомоги в умовах високої інтенсивності навантаження та складних клінічних сценаріїв, став важливим фактором трансформації підходів до підготовки парамедиків. Зокрема, відзначається зміщення акценту від суворого дотримання алгоритмів до розвитку клінічного мислення, адаптивності та автономності прийняття рішень.

Одним із ключових елементів нової освітньої парадигми є інтеграція принципів тактичної медицини та менеджменту масових уражень у навчальні програми. Це дозволяє формувати навички роботи в умовах обмежених ресурсів, що є критично важливим для сучасної практики [3,4].

Важливу роль відіграє впровадження симуляційного навчання, яке забезпечує можливість відпрацювання клінічних сценаріїв у контрольованих умовах. Такий підхід сприяє формуванню не лише технічних навичок, але й стресостійкості, командної взаємодії та ефективної комунікації [5].

Крім того, компетентнісний підхід до навчання дозволяє системно оцінювати рівень підготовки парамедиків та забезпечувати відповідність освітніх програм сучасним вимогам практики.

Таким чином, трансформація підготовки парамедиків в Україні є закономірним процесом, обумовленим як глобальними тенденціями розвитку медичної освіти, так і національним практичним досвідом, який формує нові вимоги до професійної підготовки фахівців.

Висновки

1. Сучасні виклики системи охорони здоров'я зумовлюють необхідність трансформації підходів до підготовки парамедиків.

2. Практичний досвід надання медичної допомоги в умовах підвищеного навантаження виступає важливим фактором формування нових освітніх моделей.

3. Компетентнісно-орієнтовані підходи, симуляційне навчання та інтеграція міждисциплінарних знань є ключовими складовими ефективної підготовки.

4. Адаптація освітніх програм до сучасних умов дозволяє підвищити якість догоспітальної медичної допомоги.

5. Отримані результати можуть бути використані при розробці нових навчальних програм у сфері парамедицини.

Перспективи подальших досліджень

Подальші дослідження доцільно спрямувати на оцінку ефективності впроваджених освітніх моделей у підготовці парамедиків та їх впливу на клінічні результати. Перспективним є також розробка стандартизованих підходів до інтеграції практичного досвіду у навчальні програми. Представлені результати можуть слугувати основою для подальших наукових робіт у межах формування сучасної системи підготовки парамедиків.

References

1. World Health Organization. *Prehospital trauma care systems*. Geneva: WHO; 2005.
2. International Federation for Emergency Medicine. *IFEM Core Curriculum for Emergency Medicine*. 2011.
3. Butler FK Jr, Holcomb JB, Shackelford SA. *Tactical combat casualty care: evolving concepts and battlefield experience*. *Mil Med*. 2017;182(S1):16–23.
4. Kotwal RS, Montgomery HR, Kotwal BM, et al. *Eliminating preventable death on the battlefield*. *Arch Surg*. 2011;146(12):1350–1358.
5. McGaghie WC, Issenberg SB, Barsuk JH, Wayne DB. *Simulation-based medical education: an ethical imperative*. *Acad Med*. 2014;89(8):1137–1141.

METHODS OF EFFECTIVE QUALITY OF MEDICAL DEVICES

Ulvi Hasanov

Azerbaijan State University of Oil and Industry,
Instrumentation engineering department, master

Rafiq Hacıyev

Azerbaijan State University of Oil and Industry, Instrumentation engineering department, PhD of technical sciences, docent

20 Azadlig Ave., AZ1010 Baku, Azerbaijan, phone: 0099412 4934538

TİBBİ CİHAZLARIN EFFEKTİV KVALİMETRİYA METODLARI

Ulvi Hasanov

Azərbaycan Neft və Sənaye Universiteti,
Alətlər mühəndisliyi kafedrası, magistr

Rafiq Hacıyev

Azərbaycan Neft və Sənaye Universiteti, Cihaz mühəndisliyi kafedrası, texnika üzrə fəlsəfə doktoru, dosent

20 Azadlıq prospekti, AZ1010 Bakı, Azərbaycan

ЭФФЕКТИВНЫЕ КВАЛИМЕТРИЧЕСКИЕ МЕТОДЫ МЕДИЦИНСКИХ УСТРОЙСТВ

Ульви Гасанов

Азербайджанский нефтяной и промышленный университет,
кафедра инструментальной технологии, магистрант

Рафик Гаджиев

Азербайджанский нефтяной и промышленный университет, кафедра инструментальной инженерии, доктор технических наук, доцент

проспект Азадлиг, 20, AZ1010, Баку, Азербайджан

Abstract

Reliable techniques are required to evaluate the efficacy and caliber of medical devices because medical technology is developing so quickly. Qualimetry provides a systematic way to assess these devices against particular criteria, guaranteeing their efficacy, security, and adherence to rules. The benefits and drawbacks of several qualitative and quantitative methods for evaluating medical devices are highlighted in this study. The findings are meant to assist manufacturers, regulators, and medical practitioners in making educated decisions about the selection and usage of medical devices.

The qualitative and quantitative methods of evaluating medical devices are reviewed in this work. Qualitative methods include expert opinion, adherence to regulatory requirements, and user feedback, whereas quantitative approaches rely on rating systems, statistical analysis, and quantifiable performance indicators. Healthcare providers and manufacturers can make well-informed decisions on device selection, investment, and maintenance by combining these tactics.

The results of the study emphasize how crucial it is for healthcare facilities to employ efficient qualimetric techniques in order to lower risks, enhance device performance, and guarantee patient safety. This study provides suggestions for future developments in health technology evaluation and expands our understanding of optimal practices in medical device review. They are able to choose, invest in, and maintain devices with knowledge.

Xülasə

Tibbi texnologiyanın sürətli inkişafı səbəbindən tibbi cihazların effektivliyini və keyfiyyətini qiymətləndirmək üçün etibarlı üsullar lazımdır. Kvalimetriya bu cihazları xüsusi standartlara uyğun qiymətləndirmək üçün metodik üsul təklif edir, onların effektivliyinə, təhlükəsizliyinə və qaydalara riayət olunmasına zəmanət verir. Bu tədqiqat tibbi avadanlığın qiymətləndirilməsinə bir neçə keyfiyyət və kəmiyyət yanaşmalarının üstünlüklərini və çatışmazlıqlarını vurğulayır. Nəticələr istehsalçılara, tənzimləyicilərə və tibb işçilərinə tibbi cihazların istifadəsi və seçimi ilə bağlı yaxşı məlumatlı seçimlər etməkdə kömək etmək üçün nəzərdə tutulub.

Bu işdə tibbi cihazların qiymətləndirilməsinə həm keyfiyyət, həm də kəmiyyət yanaşmaları nəzərdən keçirilir. Kəmiyyət yanaşmaları qiymətləndirmə sistemlərinə, statistik təhlillərə və

kəmiyyətlə ölçülə bilən fəaliyyət göstəricilərinə əsaslanarsa da, keyfiyyət metodlarına ekspert qiymətləndirmələri, tənzimləyici standartlara riayət edilməsi və istifadəçi daxiletmələri daxildir. Səhiyyə təminatçıları və istehsalçılar bu strategiyaları birləşdirərək cihaz seçimi, investisiya və texniki xidmətlə bağlı yaxşı məlumatlı qərarlar qəbul edə bilərlər. Tədqiqatın nəticələri səhiyyə müəssisələrinin riskləri azaltmaq, cihazın performansını artırmaq və xəstələrin təhlükəsizliyini təmin etmək üçün səmərəli kvalimetriya üsullarından istifadə etməyin nə qədər vacib olduğunu vurğulayır.

Аннотация

В связи с быстрым развитием медицинских технологий необходимы надежные методы оценки эффективности и качества медицинских изделий. Квалиметрия предлагает методический подход к оценке этих изделий на соответствие конкретным стандартам, обеспечивая их эффективность, безопасность и соответствие нормативным требованиям. В данном исследовании освещаются преимущества и недостатки нескольких качественных и количественных подходов к оценке медицинских изделий. Результаты призваны помочь производителям, регулирующим органам и медицинским работникам принимать обоснованные решения относительно использования и выбора медицинских изделий.

В данной статье рассматриваются как качественные, так и количественные подходы к оценке медицинских изделий. Количественные подходы основаны на системах рейтингов, статистическом анализе и количественно измеримых показателях эффективности, тогда как качественные методы включают экспертную оценку, соблюдение нормативных стандартов и учет мнения пользователей. Сочетание этих стратегий позволяет медицинским учреждениям и производителям принимать обоснованные решения о выборе, инвестировании и обслуживании медицинских изделий.

Результаты исследования подчеркивают, насколько важно для медицинских учреждений использовать эффективные методы качественной метрологии для снижения рисков, повышения производительности оборудования и обеспечения безопасности пациентов.

Keywords: *Medical devices, qualimetry, quality assessment, evaluation methods, healthcare technology.*

Açar sözlər: *Tibbi cihazlar, kvalimetriya, keyfiyyətin qiymətləndirilməsi, qiymətləndirmə üsulları, səhiyyə texnologiyası.*

Ключевые слова: *Медицинские приборы, квалиметрия, оценка качества, методы оценки, медицинские технологии.*

Introduction

Medical devices, ranging from basic diagnostic tools like stethoscopes and blood pressure monitors to highly sophisticated systems like MRI scanners and robotic surgical instruments, are an essential part of modern healthcare. The accuracy and reliability of these devices are critical to the effectiveness of medical care, so assessing their quality is a top priority for healthcare professionals. Quality assessment and quantification, or qualimetry, provides an organized way to methodically review scientific medical products. Both qualitative and quantitative methods are used to determine whether a gadget meets accepted performance, safety, and usability requirements.

In addition to guaranteeing that medical equipment operate as intended, good quality assurance enhances clinical efficacy and patient outcomes. [3–8]. The evaluation of medical devices has become more difficult in recent years due to their rapid technological advancement. Healthcare organizations require dependable techniques to assess increasingly complex devices before to purchase, throughout regular usage, and while contemplating updates. Adopting devices that are dangerous, ineffective, or incompatible with current therapeutic practices is a risk that arises from improper evaluation.

Medical devices are an integral aspect of contemporary healthcare, ranging from simple diagnostic equipment like stethoscopes and blood pressure monitors to extremely complex systems like MRI scanners and robotic surgical instruments. Healthcare professionals place a high premium on evaluating the quality of these devices since their accuracy and dependability are essential to the efficacy of healthcare. [2–7]. The rapid technical improvement of medical gadgets has made evaluating them more difficult in recent years. Reliable techniques are needed by healthcare organizations to assess increasingly complicated devices before to purchase, during regular usage, and while contemplating updates.

Adopting devices that are harmful, useless, or incompatible with existing healthcare processes is dangerous if they are not thoroughly assessed. This study's goal is to investigate efficient qualimetry techniques for medical equipment, emphasizing both conventional and contemporary assessment

approaches. Healthcare practitioners, manufacturers, and regulators can guarantee the safe, effective, and efficient use of medical technology in clinical practice by making well-informed decisions based on their knowledge of these techniques.

Significance

The assessment of medical devices is becoming more crucial in contemporary healthcare due to the growing complexity and variety of accessible technology. The use of improper or insufficiently evaluated equipment can lead to inaccurate diagnosis, inefficient treatments, and even severe patient damage. As a result, using efficient qualimetry techniques is essential to guaranteeing that devices fulfill strict specifications for accuracy, safety, and usability.

Budgetary restrictions and growing expenses are another issue facing global healthcare systems. Inadequate due diligence when choosing medical equipment can lead to wasteful use of resources and monetary losses. Qualimetry, which offers an organized method to assess devices before to purchase, during routine maintenance, and while replacing equipment, can help healthcare organizations make evidence-based and economical decisions.

Research Objective

This study's primary goal is to examine and assess efficient qualimetric techniques for medical devices with an emphasis on their practical uses in healthcare environments. Healthcare businesses need to select equipment that is not only cutting edge but also safe, dependable, and economical due to the rapid advancement of medical technology. The study's goal is to gain a thorough understanding of how various assessment techniques might aid in addressing these issues. The specific goal of this study is to identify and categorize qualitative and quantitative techniques used to evaluate medical devices, such as expert assessments, user reviews, rating systems, and statistical performance analysis.

Examine the benefits and drawbacks of these methods in actual healthcare environments, considering factors like safety, accuracy, usability, and regulatory compliance. Examine how integrating various evaluation techniques might enhance the evaluation procedure as a whole and guarantee that medical equipment satisfy strict standards for dependability and quality. Give manufacturers, regulators, and healthcare providers helpful guidance on how to apply efficient qualimetric methods to support informed decision-making. Stress the value of ongoing evaluation and observation in order to adjust to new technological advancements and evolving healthcare requirements.

1. Theoretical Foundations Of Medical Device Quality Assessment

In contemporary healthcare, medical gadgets are vital for patient monitoring, diagnosis, and therapy. Despite its significance, it can be challenging to guarantee that every device utilized in healthcare facilities satisfies the essential standards for quality, safety, and efficacy. The proliferation of devices, each with distinct features, capabilities, and restrictions, has been made possible by the quick speed at which technology is developing. Although this diversity has helped to provide cutting-edge healthcare technologies, it has also made it more challenging for medical personnel to select the best and most dependable equipment.

As of right now, there isn't a generally recognized method for evaluating a medical device's quality that incorporates both practical usability considerations and objective performance metrics. Based on insufficient assessments, anecdotal evidence, or marketing information from manufacturers, many healthcare organizations make bad or even hazardous decisions. Misdiagnoses, unsuccessful therapies, and elevated hazards to patient safety can occasionally result from poorly studied equipment. Furthermore, purchasing inappropriate or faulty equipment can lead to large financial losses, resource waste, and a decline in the general standard of healthcare. [1]

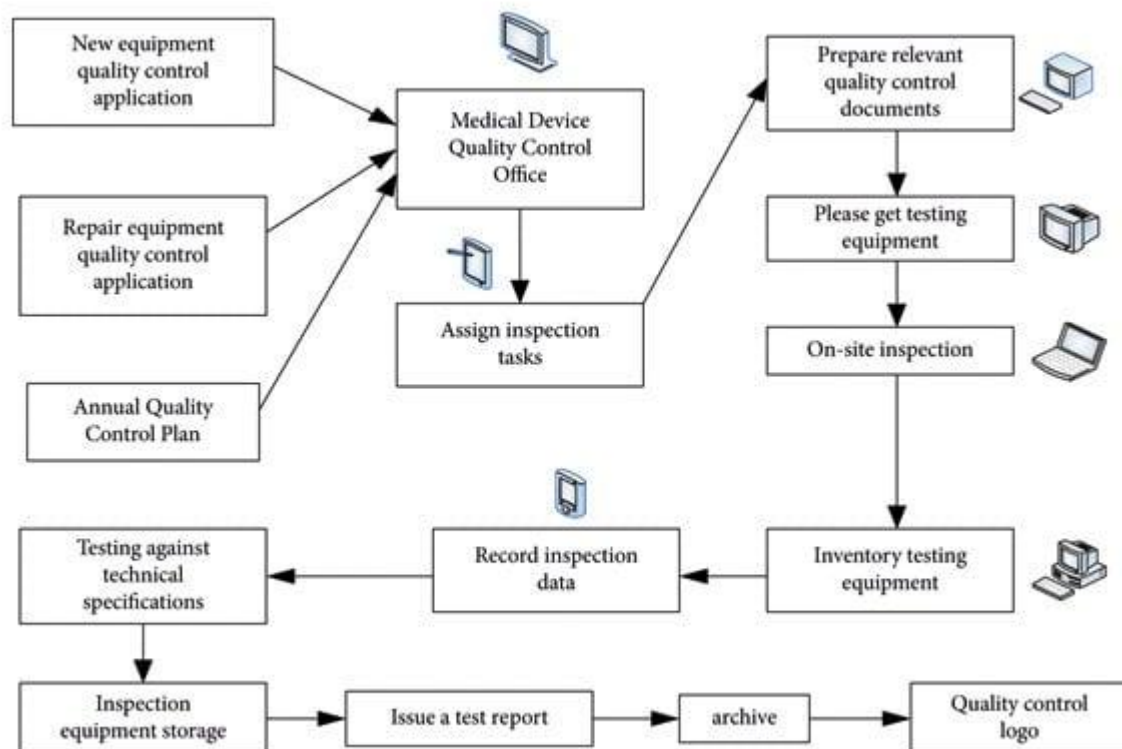


Figure 1. Quality Assessment of Medical Devices

2. The Role Of Reliability And Safety Indicators In Medical Devices

Another issue is the constantly shifting regulatory landscape. National and international standards for medical equipment are constantly changing in response to new safety laws and technological advancements. Although these laws must be understood by manufacturers and healthcare providers, it is still challenging to implement consistent and effective assessment techniques across various institutions. Devices may not fulfill current requirements in the absence of strict assessment methods, raising dangers to workers and patients [4-6]. Furthermore, it is becoming more and more crucial to integrate qualitative and quantitative assessment approaches.

Examples of qualitative approaches that shed light on practical usability and operational problems include expert assessments, user reviews, and compliance audits. Quantitative techniques including statistical analysis, performance measurements, and rating systems offer quantifiable and objective indicators of device quality.

These interconnected operational, technical, and human issues highlight the necessity of an all-encompassing plan to develop laser-based remote sensing for aviation applications. Improving predictive maintenance techniques, decreasing aircraft downtime, and ultimately guaranteeing the safety and dependability of contemporary aircraft under the increasingly demanding conditions of contemporary aviation all depend on resolving these problems in addition to boosting the precision of fault detection.

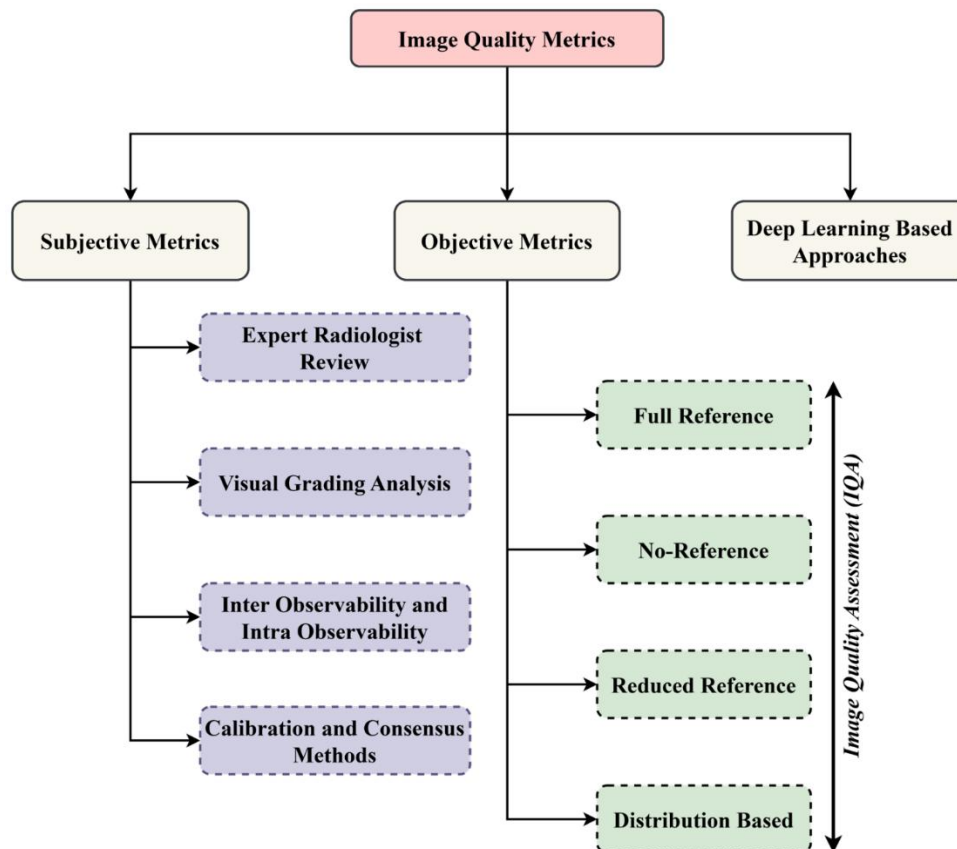


Figure 2. Categorization of image quality metrics.

3. Benefits of a Qualimetry System in Medical Devices

By merging several signs into a single evaluation, a qualimetry system offers an organized method for assessing the quality of medical devices. Its primary benefit is that it lessens subjectivity. Qualimetry makes the review process more clear and uniform by using quantifiable criteria rather than solely depending on expert opinion.

Comparing several gadgets on a same scale is another significant advantage. Direct comparison is challenging since medical technologies frequently differ in terms of performance, function, and design. Decision-makers can determine which gadget works better under particular situations by using a qualimetric technique, which standardizes these differences[10].

Additionally, qualimetry technologies facilitate improved decision-making in healthcare environments. They assist managers, engineers, and physicians in selecting the most dependable and efficient equipment by simplifying and quantifying complex technical and clinical data. When resources are scarce and investments need to be justified, this is very helpful. These technologies also enhance quality control over the course of a medical device's lifecycle. Qualimetric evaluation can identify flaws early on and direct improvements throughout the development, implementation, and maintenance phases. This enhances patient safety in addition to improving performance.

Lastly, the application of qualimetry is in line with both contemporary quality management techniques and international standards. In an area where accuracy, dependability, and safety are crucial, it promotes a methodical approach to monitoring and assessment.

5. Problems and Solutions

The challenge of establishing universal evaluation standards is one of the primary issues in applying qualimetry methodologies to medical equipment. Applying a single defined set of indicators is difficult since medical devices vary greatly in their function, complexity, and field of usage. For instance, therapeutic or monitoring equipment has different performance requirements than diagnostic equipment. Evaluations may become uneven as a result, and device comparisons may become less trustworthy[12].

The absence of reliable and comprehensive data is another problem. Although measurable factors are crucial to qualimetric analysis, data collection is not always methodical in actual clinical situations. Certain metrics, such long-term dependability or user satisfaction, are challenging to measure and could be impacted by outside variables. This may result in insufficient findings and lower the assessment's overall accuracy.

Enhancing data gathering is also crucial. Data consistency and dependability can be guaranteed by using digital monitoring systems and established reporting procedures. By offering useful insights that are sometimes absent from purely technical evaluations, incorporating clinical user feedback into the review process can further enrich the analysis.

A versatile, multi-level qualimetry framework should be created in order to overcome these obstacles. Evaluation methods can be tailored to certain medical device categories rather than depending on a single universal model. This method increases the precision of comparisons and permits more pertinent indications.

Lastly, the gap between theory and practice can be closed through increased cooperation between engineers, physicians, and quality management experts. Technical performance and practical usability are taken into consideration when using a multidisciplinary approach.

Conclusion

In summary, the use of efficient qualimetry techniques in the assessment of medical equipment is essential to guaranteeing the dependability and quality of healthcare systems. The demand for organized, impartial, and flexible assessment methods is growing as medical technology advances. Qualimetry offers a useful paradigm that unifies safety indicators, clinical efficacy, and technological characteristics into a single evaluation method.

It becomes evident throughout the conversation that although qualimetric approaches have many benefits, there are difficulties in putting them into practice. Their efficacy may be constrained by problems such the absence of established criteria, challenges in gathering data, and the disconnect between technical and clinical viewpoints. These difficulties are not insurmountable, though. Qualimetry may be used more effectively and precisely with the creation of adaptable models, better data systems, and more robust interdisciplinary cooperation.

Furthermore, the function of qualimetry in medical device evaluation is strengthened by the incorporation of contemporary technology and conformity to international standards. It aids in both the assessment process and ongoing development, assisting in the long-term identification of shortcomings and performance optimization.

In general, qualimetry should be viewed as a thorough approach to quality control in medical devices rather than merely as a measurement technique. When used appropriately, it improves patient safety, decision-making, and the efficient use of medical resources. It therefore has great potential to advance medical device evaluation from both a scientific and practical standpoint.

References

1. Bloemen B., Oortwijn W. *Assessing medical devices: a qualitative study from the validate perspective* // *International Journal of Technology Assessment in Health Care*, 2024.
2. Markiewicz K., van Til J.A., IJzerman M.J. *Medical devices early assessment methods: systematic literature review* // *International Journal of Technology Assessment in Health Care*, 2014.
3. Simunovic A. et al. *Quality analysis of manufacturer's incident reports regarding medical devices* // *Journal of Pharmaceutical Policy and Practice*, 2023.
4. Lepasepp T.K., Hurst W. *Industry 4.0 technologies within medical device manufacturing: a systematic review* // *Future Internet*, 2021.
5. Alexander K., Clarkson P.J. *Good design practice for medical devices and equipment* // *Journal of Medical Engineering & Technology*, 2000.
6. Jamshidi A. et al. *Medical devices inspection and maintenance: a literature review*, 2014.
7. *Worldwide trends in clinical investigations of medical devices: a scoping review* // *Trials Journal*, 2025
8. Kheir O. et al. *Efficient quality management in MedTech start-ups based on ISO 13485*, 2021.
9. Argotti Y., Baron C., Esteban P. *Quality quantification in systems engineering from the qualimetry perspective*, 2019.
10. Азгальдов Г.Г. *Квалиметрия: теория и практика оценки качества*. – Москва.
11. ISO 13485:2016. *Medical devices — Quality management systems — Requirements for regulatory purposes*.
12. ISO 14971:2019. *Medical devices — Application of risk management to medical devices*.
13. IEC 62304. *Medical device software — Software life cycle processes*.

MODERN APPROACHES TO MEDICAL REHABILITATION: CONTINUITY OF REHABILITATION CARE FROM CHILDHOOD TO ADULTHOOD

Harets Vira Ivanivna

Doctor of Medical Sciences, Professor,
Professor of the Department of Social, Humanitarian and Biomedical Disciplines
Private Higher Education Institution "Dnipro Institute of Medicine and Public Health"

Mirzebasov Maksym Abdulakhovich

Candidate of Medical Sciences, Associate Professor,
Associate Professor of the Department of Clinical Disciplines
Private Higher Education Institution "Dnipro Institute of Medicine and Public Health"

Yanchevskiy Oleksandr Valeriiovich

Doctor of Philosophy in Medicine, Associate Professor,
Associate Professor of the Department of Clinical Disciplines
Private Higher Education Institution "Dnipro Institute of Medicine and Public Health"

Ludmyla V. Fomina,

Doctor of Medical Sciences, Professor,
Professor of the Department of Anatomy,
National Pirogov Memorial Medical University, Vinnytsya.

Valerii O. Kushnir,

Colonel of the Medical Service, PhD,
surgeon dermato-oncologist, Medical Center "Angiolight"

СОВРЕМЕННЫЕ ПОДХОДЫ К МЕДИЦИНСКОЙ РЕАБИЛИТАЦИИ: НЕПРЕРЫВНОСТЬ РЕАБИЛИТАЦИОННОЙ ПОМОЩИ ОТ ДЕТСТВА ДО ВЗРОСЛОЙ ЖИЗНИ

Гарець Віра Іванівна

д. мед. наук, професор, професор кафедри соціально-гуманітарних та біомедичних дисциплін
Приватний заклад вищої освіти
«Дніпровський інститут медицини та громадського здоров'я»

Мірзебасов Максим Абдулахович

к. мед. наук, доцент, доцент кафедри клінічних дисциплін
Приватний заклад вищої освіти
«Дніпровський інститут медицини та громадського здоров'я»

Янчевський Олександр Валерійович

доктор філософії (медицина), доцент, доцент кафедри клінічних дисциплін
Приватний заклад вищої освіти
«Дніпровський інститут медицини та громадського здоров'я»

Фоміна Людмила Василівна,

д. мед. наук, професор, професор кафедри анатомії
Вінницького Національного Медичного Університету ім. М.І. Пирогова

Кушнір Валерій Олександрович

полковник медичної служби,
доктор філософії, лікар хірург дерматоонколог,
Медичний центр "Ангіолайт"

Abstract

The thesis considers the continuity of medical rehabilitation from childhood to adulthood as one of the key principles of a modern rehabilitation care system. Particular attention is paid to the importance of early identification of functional disorders, a multidisciplinary approach, family-centered care, and the staged transfer of clinically significant information from pediatric services to adult healthcare. The importance of proper documentation of the patient's functional status from childhood for further clinical follow-up, social adaptation, and expert assessment in adulthood is emphasized. It is noted that current challenges stimulate the search for new organizational solutions in rehabilitation and create conditions for the development of advanced rehabilitation care models in Ukraine.

Анотація

У тезі розглянуто безперервність медичної реабілітації від дитячого віку до дорослого життя як один із ключових принципів сучасної системи відновної допомоги. Акцентовано увагу на значенні раннього виявлення функціональних порушень, мультидисциплінарного підходу, сімейно-центрованої допомоги та поетапної передачі клінічно значущої інформації від педіатричної служби до дорослої ланки охорони здоров'я. Підкреслено важливість належного документування функціонального стану пацієнта з дитячого віку для подальшого клінічного супроводу, соціальної адаптації та експертної оцінки у дорослому віці. Відзначено, що сучасні виклики стимулюють пошук нових організаційних рішень у сфері реабілітації та створюють для України передумови для розвитку передових моделей реабілітаційної допомоги.

Keywords: medical rehabilitation; pediatrics; continuity of care; multidisciplinary approach; functional status; family medicine.

Ключові слова: медична реабілітація; педіатрія; безперервність допомоги; мультидисциплінарний підхід; функціональний стан; сімейна медицина; Україна.

Медична реабілітація в сучасних умовах набуває особливого значення як один із базових напрямів збереження функціональної спроможності населення, профілактики інвалідизації та підтримання якості життя пацієнтів різного віку [1]. Перебування населення України в умовах тривалого суспільного та безпекового напруження змусило у відносно короткі терміни переглянути низку підходів, які протягом десятиліть сприймалися як усталені. Це повною мірою стосується і сфери реабілітації, що сьогодні має розглядатися не як окремий етап після лікування, а як безперервний, поетапний і функціонально орієнтований процес, який доцільно починати з дитячого віку та логічно продовжувати у дорослому житті [1,6,7].

Саме дитячий вік є тим періодом, коли своєчасне виявлення порушень розвитку, функціональних обмежень і факторів ризику дозволяє найбільш ефективно впливати на подальший стан здоров'я людини. У педіатричній практиці реабілітація має особливу цінність, оскільки спрямована не лише на корекцію вже наявного дефіциту, а й на збереження потенціалу розвитку дитини, формування навичок самообслуговування, підтримання рухової активності, когнітивного та комунікативного функціонування [2,3]. Такий підхід є особливо важливим для дітей із неврологічною, ортопедичною, сенсорною, орфанною патологією, наслідками травм, розладами розвитку та іншими станами, що можуть супроводжуватися тривалими функціональними обмеженнями [2]. За тематичну основу педіатричного блоку також використано наданий Вами матеріал про реабілітацію в педіатрії

Сучасна педіатрична реабілітація повинна ґрунтуватися на принципах раннього втручання, мультидисциплінарності, сімейно-центрованої допомоги та оцінки функціонування дитини не лише в межах діагнозу, а й у межах її повсякденної активності та участі в житті суспільства [2,3]. Саме тому особливого значення набуває використання біопсихосоціальної моделі, зокрема підходів, близьких до Міжнародної класифікації функціонування, обмежень життєдіяльності та здоров'я, яка дозволяє описувати стан пацієнта більш повно і клінічно змістовно [2]. Для дитини важливо не лише зафіксувати захворювання, але й оцінити її реальні можливості, бар'єри середовища, потребу в підтримці та динаміку змін у процесі реабілітації [2,3].

Однак не менш важливою за ранній початок реабілітації є її наступність. Однією з актуальних задач сучасної системи охорони здоров'я є забезпечення поетапної та змістовної передачі інформації про стан пацієнта від педіатричної служби до дорослої ланки, насамперед до сімейної медицини та профільних спеціалістів [4,5]. Перехід із дитячого віку у дорослий не повинен супроводжуватися втратою важливих клінічних відомостей, функціональних оцінок, результатів попередньої реабілітації, інформації про досягнуті ефекти, обмеження, засоби корекції та індивідуальні особливості пацієнта [4]. Навпаки, саме в цей період має забезпечуватися безперервність медичного маршруту, яка дозволяє не починати оцінку "з нуля", а спиратися на накопичені дані та будувати подальшу тактику на основі вже відомої функціональної історії [4,5].

У цьому контексті особливого значення набуває належне документування функціонального стану пацієнта з дитячого віку. Йдеться не лише про фіксацію нозологічного діагнозу, а про системне відображення ступеня функціональних порушень, рівня активності, потреби у допоміжних засобах, переносимості навантажень, особливостей адаптації, участі в освітньому

процесі, а також динаміки реабілітаційного потенціалу [2,4]. Такий підхід має значення для клінічного ведення пацієнта, для побудови індивідуалізованої програми відновлення, для освітньої та соціальної адаптації, професійної орієнтації, а в певних випадках — і для належної експертної оцінки стану здоров'я у дорослому віці [2,4].

Слід підкреслити, що в сучасних умовах питання якості медичної документації та безперервності передачі інформації стосується всіх громадян незалежно від статі. З огляду на зміну суспільних ролей, підвищення загальних вимог до функціональної спроможності населення та особливості державних безпекових потреб, об'єктивна оцінка стану здоров'я, працездатності та рівня функціонування набуває ширшого значення як для чоловіків, так і для жінок [1,6]. У зв'язку з цим особливо важливо, щоб відомості про стани, які беруть початок у дитячому віці або суттєво впливають на функціонування в подальшому, були відображені повно, послідовно і зрозуміло для наступних ланок медичної системи, включаючи питання експертного супроводу [2,4].

Водночас реабілітація від дитинства до дорослого віку не може бути ефективною без мультидисциплінарного підходу. У педіатричному сегменті це означає співпрацю педіатра, дитячого невролога, ортопеда, фізичного терапевта, ерготерапевта, логопеда, психолога, соціального працівника та родини [3]. У дорослому віці до цього маршруту долучаються лікарі загальної практики — сімейної медицини, фахівці фізичної та реабілітаційної медицини, вузькі спеціалісти залежно від профілю патології та потреб пацієнта [1,4,5]. Саме така командна модель дозволяє бачити не фрагмент проблеми, а людину в цілому — з її клінічними, функціональними, психологічними та соціальними потребами [1,3].

Для України особливу актуальність має формування такої системи реабілітації, яка була б здатна поєднувати ранній старт допомоги, поетапність спостереження, функціонально орієнтоване документування та тривалий супровід пацієнта [6,7]. Сьогодні наша держава накопичує унікальний клінічний досвід роботи з тяжкими травматичними ушкодженнями, стійкими функціональними втратами, ампутаціями, поєднаними порушеннями та потребою в довгостроковому відновленні [6]. Попри всю складність цього досвіду, саме він може стати основою для пошуку найбільш ефективних, доказових і організаційно вивірених рішень. За умов належної систематизації, освітнього осмислення та впровадження сучасних стандартів це відкриває для України реальну перспективу стати однією з країн, що формують передові моделі реабілітаційної допомоги [1,6,7].

Таким чином, сучасна медична реабілітація має розглядатися як єдиний безперервний процес, що починається з дитячого віку і триває в дорослому житті [1,2,4]. Її ефективність визначається не лише якістю окремих методів відновлення, а й здатністю системи забезпечити раннє виявлення порушень, безперервність маршруту пацієнта, належне документування функціонального стану, міждисциплінарну взаємодію та адаптацію до актуальних потреб суспільства [1–7]. Саме такий підхід є клінічно виправданим, освітньо значущим і стратегічно важливим для подальшого розвитку реабілітаційної медицини в Україні [1,6].

Перспективи.

Перспективним є подальше вдосконалення системи безперервної реабілітаційної допомоги із забезпеченням наступності між педіатричною та дорослою ланками охорони здоров'я. Особливе значення має стандартизація документування функціонального стану пацієнтів, впровадження мультидисциплінарного маршруту супроводу та посилення ролі сімейної медицини в довготривалому спостереженні. Подальший розвиток цього напрямку може стати підґрунтям для формування в Україні сучасної та конкурентоспроможної моделі реабілітаційної допомоги.

Якщо треба, я одразу піджену це ще й під більш формальний стиль збірника, щоб обидві тези були стилістично абсолютно однакові.

References

1. World Health Organization. Rehabilitation [Internet]. Geneva: WHO; 2024 [cited 2026 Apr 17]. Available from: <https://www.who.int/news-room/fact-sheets/detail/rehabilitation>
2. World Health Organization. International classification of functioning, disability and health: children & youth version: ICF-CY. Geneva: WHO; 2007.
3. McCarthy E, Guerin S. Family-centred care in early intervention: a systematic review of the processes and outcomes of family-centred care and impacting factors. *Child Care Health Dev.* 2022;48(1):1-32.

4. Cassidy M, Doucet S, Luke A, Goudreau A, MacNeill L. Improving the transition from paediatric to adult healthcare: a scoping review on the recommendations of young adults with lived experience. *BMJ Open*. 2022;12(12):e051314.
5. Kingsnorth S, Lindsay S, Maxwell J, Bayley M, McArthur C. Bridging pediatric and adult rehabilitation services for young adults with childhood-onset disabilities: evaluation of the LIFEspan model of transitional care. *Front Pediatr*. 2021;9:728640.
6. World Health Organization Regional Office for Europe. Financing rehabilitation services in Ukraine: a situation assessment and policy options [Internet]. Copenhagen: WHO Regional Office for Europe; 2025 [cited 2026 Apr 17]. Available from: <https://www.who.int/europe/publications/i/item/WHO-EURO-2025-12703-52477-81012>
7. World Health Organization. Rehabilitation in emergencies factsheet [Internet]. Geneva: WHO; 2024 [cited 2026 Apr 17]. Available from: <https://www.who.int/publications/m/item/rehabilitation-in-emergencies-factsheet>

ASSESSMENT OF THE QUALITY OF CARE AND PATIENT SATISFACTION WITH NURSING SERVICES IN A DISTRICT HOSPITAL

Kamenova B.S.
2nd year Master's student
Al-Farabi Kazakh National University
Almaty, Kazakhstan

ОЦЕНКА КАЧЕСТВА УХОДА И УДОВЛЕТВОРЕННОСТИ ПАЦИЕНТОВ ОРГАНИЗАЦИЕЙ МЕДИЦИНСКОЙ ПОМОЩИ НА УРОВНЕ РАЙОННОЙ БОЛЬНИЦЫ

Каменова Баян Сатыбалдиевна
магистрант 2 курса
Казахский национальный
университет имени аль-Фараби
Алматы, Казахстан

Abstract

This study presents the results of an assessment of nursing care quality and patient satisfaction in a district hospital. The research includes analysis of socio-demographic characteristics, factors influencing satisfaction, and identification of strengths and weaknesses in nursing care. The findings indicate a high level of patient satisfaction, particularly in terms of nurses' kindness, respect, and attentiveness. However, lower satisfaction levels were observed regarding the clarity and completeness of information provided to patients about treatment and procedures. The results can be used to improve healthcare quality and implement patient-centered approaches.

Аннотация

В статье представлены результаты исследования, направленного на оценку качества сестринского ухода и уровня удовлетворенности пациентов медицинской помощью в районной больнице. Исследование охватывает анализ социально-демографических характеристик пациентов, факторов, влияющих на удовлетворенность, а также выявление сильных и слабых сторон сестринского ухода. Полученные данные свидетельствуют о высоком уровне удовлетворенности пациентов, особенно в аспектах внимательного и уважительного отношения медицинского персонала. В то же время выявлены недостатки в информировании пациентов о проводимом лечении и диагностике. Результаты исследования могут быть использованы для совершенствования качества медицинских услуг и внедрения пациент-ориентированных подходов.

Keywords: quality of care, nursing care, patient satisfaction, district hospital, healthcare quality assessment

Ключевые слова: качество медицинской помощи, сестринский уход, удовлетворенность пациентов, районная больница, оценка качества, здравоохранение

Введение

Качество медицинской помощи и удовлетворенность пациентов являются ключевыми показателями эффективности системы здравоохранения. Особую роль в формировании положительного опыта пациентов играет сестринский уход, который включает не только выполнение медицинских процедур, но и эмоциональную поддержку, информирование и взаимодействие с пациентами. В условиях районных больниц, где ресурсы могут быть ограничены, оценка качества ухода приобретает особую значимость [1].

Материалы и методы.

Дизайн исследования и выборка Исследование носило описательный, поперечный характер. В исследовании приняли участие 135 пациентов, проходивших краткосрочную госпитализацию в районной больнице. Сбор данных проводился непосредственно перед выпиской пациентов.

Инструменты исследования

Для оценки удовлетворенности пациентов использовался стандартизированный опросник, включающий шкалу оценки качества сестринского ухода и анкету социально-демографических характеристик.

Шкала включает 19 пунктов, оценивающих различные аспекты сестринской деятельности: внимание, уважение, доброту, компетентность, навыки и удовлетворение потребностей пациентов. Дополнительно включены 4 вопроса общего восприятия качества ухода и лечения.

Ответы оценивались по 5-балльной шкале Ликерта:

1 - отлично, 2 - очень хорошо, 3 - хорошо, 4 - удовлетворительно, 5 - плохо.

Общий балл варьируется от 19 до 95, при этом более низкие значения соответствуют более высокому уровню удовлетворенности.

Дополнительно использовалась анкета из 16 вопросов для оценки факторов, влияющих на удовлетворенность (уровень дохода, состояние здоровья, социальные характеристики) [3].

Статистический анализ

Анализ данных проводился с использованием программы SPSS (версия 21.0). Применялись методы описательной статистики (средние значения, стандартные отклонения, частоты, проценты). Нормальность распределения проверялась с помощью теста Колмогорова–Смирнова. Поскольку уровень значимости превышал 0,05, использовались параметрические методы анализа: t-тест для сравнения двух групп, однофакторный дисперсионный анализ (ANOVA), корреляционный анализ Пирсона

Результаты исследования

Средний возраст пациентов составил $47,94 \pm 19,66$ года. Наибольшую долю составили пациенты в возрасте 18–35 лет (37,8%).

Большинство респондентов: женщины - 77,0%, состояли в браке - 74,8%, имели высшее образование - 33,2%, имели средний уровень дохода - 52,1%, домохозяйки - 31,3%

61,6% пациентов были госпитализированы через приемное отделение, а 66,6% - впервые за последние два года.

Средняя продолжительность госпитализации составила $4,38 \pm 5,75$ дня.

Таблица 1 – Характеристики пациентов (N = 135)

Переменные	Количество	Процент
Возраст (лет)		
18-35	51	37,8
36-55	38	28,1
56 и более	46	34,1
Пол		
женский	104	77,0
мужской	31	23,0
Семейное положение		
женатый	101	74,8
одинок	14	10,4
в разводе	5	3,7
вдова/вдовец	15	11,1

Оценка удовлетворенности пациентов.

Результаты показали высокий общий уровень удовлетворенности пациентов сестринским уходом. Наиболее высокий уровень удовлетворенности отмечен по показателю: «Внимание и забота медсестер (вежливость, уважение, доброжелательность)» - $1,38 \pm 0,66$.

Наиболее низкий уровень удовлетворенности: «Информирование пациентов (ясность и полнота объяснений о лечении и обследованиях)» - $1,74 \pm 0,86$

Общий средний балл удовлетворенности составил: $1,61 \pm 0,65$

Минимальные и максимальные значения варьировались от 1 до 4,05.

Обсуждение

Полученные результаты демонстрируют высокий уровень удовлетворенности пациентов, что свидетельствует о хорошем качестве сестринского ухода в районной больнице. Особенно высоко пациенты оценивают личностные качества медицинского персонала, такие как доброжелательность, уважение и внимательность [2]. В то же время выявленные недостатки в информировании пациентов указывают на необходимость совершенствования коммуникационных навыков медицинских работников. Это соответствует данным международных исследований, где недостаток информации также является одной из основных причин неудовлетворенности пациентов.

Заключение

Исследование показало, что в целом пациенты удовлетворены качеством сестринского ухода в районной больнице. Основными сильными сторонами являются внимательное и уважительное отношение медицинского персонала [4].

Вместе с тем, необходимо улучшить систему информирования пациентов о лечении и диагностических процедурах. Полученные результаты могут быть использованы для разработки мероприятий по повышению качества медицинской помощи и внедрения пациент-ориентированных подходов.

Список литературы

1. Aiken LH, Clarke SP, Sloane DM. Hospital staffing, organization, and quality of care: cross-national findings. *Int J Qual Health Care*. 2002;14(1):5–13.
2. World Health Organization. Quality of care: a process for making strategic choices in health systems. Geneva: WHO; 2006.
3. Heather K. S. Laschinger, Hall LM, Pedersen C, Almost J. A psychometric analysis of the patient satisfaction with nursing care quality questionnaire (PSNCQQ). *J Nurs Care Qual*. 2005;20(3):220–230.
4. Batbaatar E, Dorjdagva J, Luvsannyam A, Savino MM, Amenta P. Determinants of patient satisfaction: a systematic review. *Perspect Public Health*. 2017;137(2):89–101.

UDC: 616-006+615.03

MODERN STRATEGIES IN CHEMOTHERAPY AND TARGETED THERAPY: EFFICACY, SAFETY, AND THERAPEUTIC OPTIMIZATION

Arman Khozhayev

Professor of the S.N. Nugmanov

Department of Oncology, Oncologist,

Asfendiyarov Kazakh National Medical University, Almaty, Kazakhstan

Aigul Buleshova

Nurse, Chemotherapy Department,

Almaty Oncology Center, Almaty, Kazakhstan

Nadia Chermukhambetova

Nurse, Chemotherapy Department,

Almaty Oncology Center, Almaty, Kazakhstan

Bayan Uataeva

Nurse, Chemotherapy Department,

Almaty Oncology Center, Almaty, Kazakhstan

Aigulya Izbakieva

Nurse, Chemotherapy Department,

Almaty Oncology Center, Almaty, Kazakhstan

Gulmira Doshanova

Nurse, Chemotherapy Department,

Almaty Oncology Center, Almaty, Kazakhstan

Roza Agibaeva

Nurse, Chemotherapy Department,

Almaty Oncology Center, Almaty, Kazakhstan

Shakhinur Turdiyeva

Nurse, Chemotherapy Department,

Almaty Oncology Center, Almaty, Kazakhstan

Aigerim Tleuke

Nurse, Chemotherapy Department,

Almaty Oncology Center, Almaty, Kazakhstan

Karakoz Zeidalieva

Nurse, Chemotherapy Department,

Almaty Oncology Center, Almaty, Kazakhstan

Umida Turganalieva

Nurse, Chemotherapy Department,

Almaty Oncology Center, Almaty, Kazakhstan

Abstract

Cancer remains one of the leading causes of death worldwide, making its treatment a major priority in modern medicine. Advances in chemotherapy, targeted therapy, and clinical pharmacology in oncology have significantly improved the efficacy and safety of cancer treatment, enabling a more individualized approach to patient care. The study of pharmacokinetics and pharmacodynamics of anticancer drugs, drug interactions, and metabolism is essential for optimizing treatment regimens and minimizing toxicity. Modern anticancer therapy, guided by principles of clinical pharmacology, increasingly integrates pharmacogenomic and molecular data, contributing to the development of personalized medicine and improving patients' quality of life.

Keywords: oncology, chemotherapy, targeted therapy, anticancer therapy, clinical pharmacology, pharmacokinetics, pharmacodynamics, pharmacogenomics, biomarkers, personalized medicine, drug development, toxicity.

Oncology is a field in which dosage errors, treatment delays, or inappropriate therapy selection can have disastrous consequences. Clinical pharmacology (CP), serving as a bridge between laboratory pharmacology, clinical trials, and practical oncology, plays a critical role. It ensures: 1) informed dose and administration selection; 2) assessment of interactions and toxicity; 3) individualization of therapy based

on the patient and tumor.

Cancer remains one of the leading causes of death worldwide. According to the World Health Organization (WHO, 2024), more than 20 million new cases of malignant neoplasms are registered annually, and the projected increase in incidence requires continuous improvement in therapeutic approaches. Therefore, clinical pharmacology in oncology plays a key role in ensuring the rational, safe, and personalized use of anticancer drugs. Modern CP integrates knowledge of pharmacokinetics (PKs), pharmacodynamics (PDs), pharmacogenomics (PGs), and drug-drug interactions (DDIs) to optimize dosing, improve treatment efficacy, and reduce the risk of toxicity. Advances in molecular genetic technologies have enabled a shift from empirical cytostatic drug administration to personalized treatment strategies that take into account the patient's genetic and metabolic characteristics. Particular attention is paid to studying the mechanisms of drug resistance, DDIs, and biomarkers of treatment efficacy.

CP is a key element of modern oncology, especially with the growth of new treatment modalities. Dose optimization, monitoring, and understanding PKs and PDs in populations with specific characteristics will help improve efficacy and safety. Thus, CP in oncology represents a fundamental basis for the development of individualized treatment regimens aimed at improving patient survival and quality of life, as well as the rational use of pharmaceutical resources in the healthcare system.

According to Kruse M. et al. [1] every drug development (DD) is a complex and long journey. CP is an essential discipline in modern DD. With its applications, computational modelling, and simulation techniques, it can significantly contribute to the efficiency in DD today. CP is the science of studying the effects of drugs in humans and their optimal clinical use in patients. There are two major components that help us understand a drug's behaviour; the first is how a drug moves within the body (PK) and the other is what a drug does to the body's functions (PD). Understanding both aspects of CP is an essential part of DD. When PK and PD are integrated in a model, the model can describe how the drug effect will change with time when a certain dosing regimen is used. Ultimately, a goal of what is often a lengthy and costly DD process is to ensure that the right patient receives the right drug at an optimal dose, given at the right time. CP provides a toolset that enables drug developers to make decisions that facilitate this process and help clinicians finding the right dose.

Research shows that the overall DD process is an iterative continuum of activities and not strictly linear in nature. Not all studies are always necessary to be conducted for every molecule and in fact the physicochemical nature of the drug determines which studies are required for a submission. Some studies may be waived if an adequate plan is set out and sufficient information is collected during other studies, e.g. on QTc assessment or a renal impairment study may be waived if the unchanged drug and its major active metabolites are eliminated primarily via non-renal and non-hepatic routes. The trend for an increasing number of biologically derived products with their different PK, PD, physiological, and pharmacological properties compared to chemically derived products has led to differences in requirements for small and large molecules. Ultimately, the size of the molecule and the specificity of its target binding determine the clinical development programme. In recent years, efforts have been made to increase the output and reduce the attrition rate of drugs, particularly before investing in timely and costly Phase 3 trials. Too often, DD has continued beyond the early phases due to pressure on research teams to be successful and a poorly informed decision-making process with a hesitancy in 'killing a drug' that is unlikely to meet its primary endpoints. While any drug must be safe and efficacious to benefit a patient, this information is not available during the early phase of clinical development. Safety may only be available in healthy volunteers, or a few patients and studies usually are not designed to assess efficacy outcomes. PK and PD data are the instruments to understand the drug's behaviour in the body and its target engagement. For obtaining high-quality PK and PD data, the right study design is key. It should not only reflect the most appropriate dosing scheme with adequate PK and PD sampling times but also the conditions, restrictions, and other factors (e.g. disease, genetics) potentially influencing these outcome variables. Hereby, the early identification of intrinsic differences between races, sexes, age groups, and other covariates potentially affecting a drug's concentration and its pharmacology can be used to improve study designs in the future and inform interactions with regulatory bodies. Moreover, for the developer, a thorough early characterisation of PD effects can potentially avoid or simplify expensive clinical studies. One example is the capture of quality electrocardiograms in early single and multiple ascending dose studies to assess a drug's potential on QT prolongation which could avoid a thorough QT study at a later development stage. A concept where PK is most instrumental in DD is establishing bioequivalence for generic products. To receive approval, applicants have to demonstrate that a proposed drug product is bioequivalent, i.e. has the same rate and extent of absorption, to a reference product. To solely rely on PK is based on the principle that systemic exposure is a surrogate for effects of the drug (efficacy, safety).

Efficacy does not need to be determined if the exposure is comparable between the generic and the reference drug. Ultimately, such 'abbreviated development' saves a lot of resources and avoids unnecessary replication of prior work performed for the reference drug. Conceptually, PK, PD, and biomarkers (PD or non-PD) can be considered 'surrogates' for the clinical efficacy and safety of a drug once their relationship is known and predictable. The most extreme example is the aforementioned bioequivalence concept in generic DD where PK is the only surrogate for its safety and efficacy. Rationale DD therefore requires a thorough understanding of these parameters and its relationship to the safety and efficacy [1].

As noted by Papachristos A. et al. [2], accelerated clinical development of anticancer drugs is crucial to ensure patients' access to the most safe and effective treatments. At the same time, the development process should be designed to ensure that the optimal dose and schedule are administered. Therefore, pharmacological methods such as PGs, PKs, and PDs must be integrated to inform oncology DD and dose optimization. Drugs' safety and effectiveness are evaluated in randomized, dose-ranging trials in most therapeutic areas. However, this is only sometimes feasible in oncology, and dose-ranging studies are mainly limited to Phase 1 clinical trials. Moreover, although new treatment modalities (e.g., small molecule targeted therapies, biologics, and antibody-drug conjugates) present different characteristics compared to cytotoxic agents (e.g., target saturation limits, wider therapeutic index, fewer off-target side effects), in most cases, the design of Phase 1 studies and the dose selection is still based on the Maximum Tolerated Dose (MTD) approach used for the development of cytotoxic agents. Therefore, the dose was not optimized in some cases and was modified post-marketing (e.g., ceritinib, dasatinib, niraparib, ponatinib, cabazitaxel, and gemtuzumab-ozogamicin). The Food and Drug Administration (FDA) recognized the drawbacks of this approach and, in 2021, launched Project Optimus, which provides the framework and guidance for dose optimization during the clinical development stages of anticancer agents. Since dose optimization is crucial in clinical development, especially of targeted therapies, it is necessary to identify the role of pharmacological tools such as PGs, therapeutic drug monitoring, and PDs, which could be integrated into all phases of DD and support dose optimization, as well as the chances of positive clinical outcomes.

In their work, the authors point out that the choice of dose selection is an ongoing challenge in developing new anticancer agents. The design of early clinical studies based on the pharmacological characteristics of the drug is essential to ensure a successful development plan, but it is not always feasible, as it requires rapid approval following a sequential Phase 1-3 trial. In a majority of cases, experience shows that a personalized approach in dosing based on the characteristics of each patient and each drug could improve the safety and efficacy of the treatment. In clinical trials, the current approach is to follow the standard 3+3 design to assess dose-limiting toxicities. This approach is valuable and informative for the old cytotoxic agents, but it is problematic for the newer modalities such as tyrosine kinase inhibitors, biologics, and antibody-drug conjugates (ADCs). As a result, there are many cases of approved drugs requiring dose modifications later based on post-marketing studies requested by the FDA or performed by the research community. A new paradigm for designing clinical trials that will precisely assess and define the optimal dose of new anticancer agents will accelerate drug approval and allow for more successful and safer drugs to enter the market [2].

Malhi V. et al. indicate that [3], the clinical development journey of novel pharmaceuticals is a complex multistage process, which continues to evolve as our understanding of disease biology deepens, new therapeutic entities and classes of drugs are designed, and regulatory mechanisms adapt to the changing therapeutic landscape. One of the objectives of clinical pharmacology is to characterize PKs by understanding the absorption, distribution, metabolism, and excretion (ADME) pathways of the drug in the body. Another major objective is to determine how drug concentrations are altered by intrinsic and extrinsic factors. Intrinsic factors are inherent to a person and include age, sex, race, genomics, and organ function, whereas extrinsic factors are external influences that may affect drug exposure, such as concomitant medications or the type of food ingested around the time of drug administration. Finally, the main goal of clinical pharmacology is to justify the dose based on the relationship between exposure and biological response, which can be assessed in terms of efficacy, safety, or PDs biomarkers.

In their work, the authors describe the clinical pharmacology characterization of giredestrant, a highly potent nonsteroidal oral selective estrogen receptor (ER) antagonist and degrader. Giredestrant was designed to optimize ER antagonism and degradation, while minimizing off-target toxicity. Several oral selective estrogen receptor degraders are in clinical development, all with distinct physicochemical and PKs properties. Variations in these characteristics, such as unfavorable PK attributes [including non-linear PKs, food effects, or drug-drug interactions (DDIs) with combination partners] may affect dosing, efficacy, and safety. This first-in-human phase Ia/Ib dose-escalation/-expansion study was designed to

evaluate the safety, PKs, PDs, and preliminary antitumor activity of giredestrant. In particular, the PKs were evaluated by characterizing the ADME of giredestrant, and generated signal-seeking data on the impact of certain intrinsic factors (including race and organ dysfunction) and extrinsic factors (including the effect of food and DDIs) on giredestrant exposure. This multicenter nonrandomized open-label dose-escalation and -expansion phase Ia/Ib study evaluated the safety, PKs, PDs, and preliminary antitumor activity of giredestrant alone and in combination with palbociclib in patients with ER-positive (ER+) human epidermal growth factor receptor 2 (HER2)-negative locally advanced/metastatic breast cancer. In brief, eligible patients had advanced or metastatic ER+/HER2-negative breast cancer that had recurred or progressed while being treated with adjuvant endocrine therapy (ET) for ≥ 24 months and/or ET in the incurable, locally advanced, or metastatic setting and derived a clinical benefit from therapy (i.e., tumor response or stable disease for ≥ 6 months); had not received any other ET, targeted therapy, or chemotherapy within the preceding 2 weeks; and were postmenopausal women (or premenopausal/perimenopausal women simultaneously receiving luteinizing hormone-releasing hormone agonists). To enroll a racially diverse population, the study was performed globally at sites in Europe, North America, Asia, and Australia. In the single-agent dose-escalation stage, giredestrant was administered orally once daily on days 1-28 of each 28-day cycle at 10, 30, 90, or 250 mg. A single dose was administered on cycle 1 day -7, followed by a 7-day PK lead-in for all single-agent giredestrant dose-escalation cohorts. In addition, a combination cohort in the dose-escalation stage explored giredestrant 100 mg once daily (days 1-28) in combination with palbociclib 125 mg once daily (days 1-21), repeated every 28 days. In the expansion stage, single-agent expansion cohorts evaluated giredestrant at doses of 30, 100, and 250 mg once daily. A combination expansion cohort evaluated giredestrant 100 mg with palbociclib 125 mg [3].

In the single-agent dose-escalation stage, PK samples were collected at cycle 1 day -7 predose and then at 0.5, 1, 1.5, 2, 3, 4, 6, 8, 24, 28, 72, 96, and 168 hours after dosing to characterize the single-dose PK profile and estimate the terminal half-life. Samples to determine the steady-state PK profile were collected at cycle 2 day 1 (after 28 days of daily giredestrant) predose and at 0.5, 1, 1.5, 2, 3, 4, 6, and 8 hours after dosing. Metabolite identification was conducted following the first dose (cycle 1 day -7) and at steady state (cycle 2 day 1) in 6 patients (3 patients at 90 mg and 3 at 250 mg). Plasma samples were pooled across patients and timepoints. The cytochrome P450 (CYP) 3A induction potential of giredestrant was evaluated in vivo by assessing 4 β -hydroxycholesterol (4 β -HC), an endogenous biomarker formed by CYP3A metabolism in humans. 4 β -HC concentration was measured at cycle 1 day -7, cycle 2 day 1, cycle 3 day 1, and cycle 4 day 1 predose in 7 patients (5 patients at 30 mg and 2 at 90 mg). Analysis was conducted ad hoc, in compliance with the informed consent, in patients from whom there was sufficient plasma volume remaining for the assessment after completion of prespecified analyses. Giredestrant concentrations in urine samples were measured at cycle 1 day 1 predose and cycle 2 day 1 at 0-8 hours postdose. Urine samples were collected from 13 patients (7 patients at 30 mg, 5 at 100 mg, 1 at 250 mg). PK parameters for giredestrant were calculated from the plasma concentration-time data according to standard noncompartmental analysis methods using Phoenix WinNonlin (version 8.3.4; Certara USA, Inc.). Noncompartmental analyses were conducted in PK-evaluable patients, defined as those having at least one nonzero postdose plasma concentration. Patients with dose reductions, sparse PK samples, incomplete PK profiles, or incorrect dosing information during PK sampling were not included in the noncompartmental analysis. The concentrations of giredestrant in plasma were measured using validated liquid chromatography with tandem mass spectrometry (LC/MS-MS) assays. Giredestrant and its internal standard [(13C8, 15N) GDC 9545] were extracted from human plasma by supported liquid extraction (SLE). Giredestrant concentrations were calculated using a standard curve with a 1/x2 linear regression over concentration ranges of 1 to 1,000 ng/mL or 0.1 to 100 ng/mL. The concentrations of giredestrant in urine were measured using a qualified LC/MS-MS assay. Giredestrant and its internal standard were also extracted from human urine by SLE. Giredestrant concentrations were calculated using a standard curve with a 1/x2 linear regression over a concentration range of 0.25 to 250 ng/mL. Concentrations of 4 β -HC were measured using an LC/MS-MS assay that was developed and validated in human plasma. 4 β -HC and its internal standard 4 β -HC-d7 were extracted from human plasma by SLE. 4 β -HC concentrations were calculated using a standard curve with a 1/x2 linear regression over a concentration range of 4 to 100 ng/mL. For plasma, urine, and 4 β -HC assays, the mass spectrometer was operated in positive electrospray ionization mode under optimized conditions with multiple reaction monitoring of analytes and internal standards. The precision and accuracy of assays were satisfactory throughout the study. For metabolite identification, plasma samples were extracted by protein precipitation. Parent and metabolites were analyzed by LC and high-resolution MS. The metabolite structures were proposed on the basis of fragmentation patterns and comparison with those of the parent. In the

single-agent dose-escalation stage, giredestrant was taken under fasted conditions (fasted for ≥ 6 hours overnight) until cycle 4 day 1. To explore whether giredestrant had a potential food effect, patients in the single-agent dose-expansion cohorts were able to take giredestrant with or without food, and were asked to complete a food diary at cycle 2 day 1. Patients who had reported fasting for longer than 6 hours before giredestrant dosing were considered as fasted. The study was conducted in accordance with the protocol and the consensus ethical principles derived from international guidelines including the Declaration of Helsinki and Council for International Organizations of Medical Sciences International Ethical Guidelines for Health-Related Research Involving Humans, relevant International Conference on Harmonisation Good Clinical Practice guidelines, and applicable laws and regulations. All patients provided written informed consent [3].

In the work of Lazarou G. et al. [4] the authors say that application of contemporary molecular biology techniques to clinical samples in oncology resulted in the accumulation of unprecedented experimental data. These “omics” data are mined for discovery of therapeutic target combinations and diagnostic biomarkers. It is less appreciated that omics resources could also revolutionize development of the mechanistic models informing clinical pharmacology quantitative decisions about dose amount, timing, and sequence. In their study, they demonstrate how mechanistic models of cancer immunotherapy in humans can be informed by state-of-the-art molecular and cell biology data on clinical tumor biopsies and samples of healthy peripheral blood and tissue, which have recently become available. Mechanistic models expand the applicability of these data beyond target identification and biomarker discovery – they allow quantitative predictions of dose amount sequence and timing. Although there are still gaps in quantitative knowledge, which necessitate incorporation of machine-learning predictions and model assumptions, the authors that the recent publication of landmark omics resources in immuno-oncology (IO) will motivate further effort and that much more data will be available soon. They also hope that increasing adoption of mechanistic modeling to integrate these data will direct experimental work, especially in areas where absolute reference data are needed. Our colleagues convinced that, as new omics data accumulate, confidence in virtual trial simulations with clinical Quantitative Systems Pharmacology (QSP) models integrating these data will increase, and that these models will be making increasing impact in development of new cancer immunotherapies.

Ramasubbu M.K. et al. [5] emphasize that QSP is an innovative and integrative approach combining physiology and pharmacology to accelerate medical research. By considering receptor-ligand interactions of various cell types, metabolic pathways, signaling networks, and disease biomarkers simultaneously, QSP provides a holistic understanding of interactions between the human body, diseases, and drugs. Integrating knowledge across multiple time and space scales enhances versatility, enabling insights into personalized responses and general trends. QSP consolidates vast data into robust mathematical models, predicting clinical trial outcomes and optimizing dosing based on preclinical data. QSP operates under a “learn and confirm paradigm,” integrating experimental findings to generate testable hypotheses and refine them through precise experimental designs. An interdisciplinary collaboration involving expertise in pharmacology, biochemistry, genetics, mathematics, and medicine is vital. QSP’s utility in DD is demonstrated through integration in various stages, predicting drug responses, optimizing dosing, and evaluating combination therapies. In addition to its prominent role in DD, QSP extends its applications to inform health care and life sciences. It can align with increasingly significant technologies such as physiological monitors, wearable devices, personalized medicine, and artificial intelligence-informed health care. By leveraging QSP, health-care professionals and researchers can gain valuable insights into the intricate relationships between interventions and patient physiology, ultimately contributing to more effective and personalized health-care strategies. This broader utility of QSP showcases its potential to revolutionize various aspects of health care and life sciences beyond traditional DD.

The authors' analysis found that integrating QSP approaches in DD has shown promising results in various aspects of the field. By mechanistically modeling drug PK and PD alongside disease pathophysiology, QSP provides valuable insights and has the potential to address key challenges in the DD process. QSP has demonstrated its ability to identify optimal targets and biomarkers for specific diseases, improve therapeutic effectiveness through drug combination strategies, predict human response doses based on preclinical data, and repurpose existing drugs for new indications. In addition, QSP can facilitate individualized dosing regimens based on patient characteristics, leading to the adoption of personalized medicine and potentially enhancing treatment outcomes. Training and fostering multidisciplinary expertise at scale are essential to proposing, developing, and effectively communicating QSP modeling analyses. Pharmacologists, with their clinical research training and understanding of pathology and pharmacotherapy, can play a vital role in bridging the gap between physiologists and modeling engineers. They

can act as interpreters, utilizing the expertise of QSP teams to support decision-making in the clinical trial process and the development of novel molecules [5].

Ramasubbu M.K. et al. [5] citing the works of Bai J.P.F. [6,7], they note that over the years, there has been growing awareness of QSP approaches within regulatory authorities as modeling techniques become more prevalent in DD. Regulatory agencies, including the FDA, have issued recommendations that should be applied to all QSP modeling practices. These recommendations are designed to ensure the reliability and transparency of QSP models and include the following key points: 1) achieving the appropriate qualification and validation of a QSP model relies on finding a suitable balance between the available data for model calibration/validation and ensuring alignment with the underlying physiological mechanisms involved; 2) model reproducibility and transparency are crucial aspects that allow reviewers to access all parameters and equations utilized in the model, facilitating the replication and interpretation of simulation outcomes; 3) the QSP model should incorporate relevant PD indicators and clinical endpoints of the drug candidate, with the level of molecular granularity in detail based on the intended use (whether it's for preclinical or clinical stages); utilizing a preclinical model for late-stage clinical development can lead to identifiability and uncertainty issues, so appropriate modifications or the development of a new clinical-oriented model may be necessary; 4) similar to clinical trials, predetermined quantitative and statistical criteria should be established to guide the decision-making process when accepting QSP model extrapolation; these criteria should be dependent on the specific decision risk being made. Over the past few years, there has been a significant rise in the number of regulatory submissions documenting the utilization of QSP modeling: 1) landscape analysis revealed a consistent and substantial increase in QSP submissions from 2013 to 2020, with a total of 157 identified submissions, of which 57 were recorded in 2020 alone; 2) QSP submissions were observed across all stages of DD, with the majority being in the investigational new drug stage, indicating widespread utilization of QSP in early DD; 3) QSP models found application in various therapeutic areas, including oncology, infectious diseases, neurology, nephrology, and cardiology, with oncology being the most prominent area of interest among the submissions; 4) the versatility of QSP applications was evident in the submissions, as they addressed a wide range of efficacy and safety-related questions; efficacy-focused inquiries primarily centered around dosing strategies, encompassing Phase I dose-finding and escalation, Phase II dose-range studies, and Phase III dose selection; safety applications covered liver toxicity, plasma ion concentration, cardiotoxicity, and bone mineral density.

Chelliah V. et al. [8] in their work say that DD in oncology commonly exploits the tools of molecular biology to gain therapeutic benefit through reprogramming of cellular responses. In IO the aim is to direct the patient's own immune system to fight cancer. After remarkable successes of antibodies targeting programmed cell death protein 1 (PD1)/programmed death ligand-1 (PD-L1) and cytotoxic T-lymphocyte antigen-4 (CTLA4) receptors in targeted patient populations, the focus of further development has shifted toward combination therapies. However, the current DD approach of exploiting a vast number of possible combination targets and dosing regimens has proven to be challenging and is arguably inefficient. In particular, the unprecedented number of clinical trials testing different combinations may no longer be sustainable by the population of available patients. Further development in IO requires a step change in selection and validation of candidate therapies to decrease development attrition rate and limit the number of clinical trials. QSP proposes to tackle this challenge through mechanistic modeling and simulation. Compounds' PKs, target binding, and mechanisms of action as well as existing knowledge on the underlying tumor and immune system biology are described by quantitative, dynamic models aiming to predict clinical results for novel combinations. In light of the unprecedented number of ongoing and planned clinical trials and preclinical programs for IO combination therapies and the emergence of examples of late-stage attrition, there is an urgent need to improve the process of selecting candidate therapies and improve the design of trials to increase the chances of success and terminate low-value programs prior to clinical testing. QSP models integrate existing mechanistic knowledge on disease and drug PK/PD in a quantitative framework allowing simulation of virtual trials, where candidate drug combinations are evaluated *in silico* before being tested in the clinic. Although development of full-scale platform models allowing virtual screening of large numbers of candidate therapies became possible only recently, the current QSP approaches capitalize on the legacy of 3 decades of progress in mathematical and systems biology. Recently developed QSP models have started to demonstrate their potential in actual DD case studies that indicate both feasibility and benefit of the approach. Based on these early results, our colleagues predict that QSP models will increasingly be used in IO DD and that it will soon become standard practice to run virtual trials ahead of and in parallel with clinical trials to more quickly bring better therapeutics to patients with cancer.

Liu SN, Li C. in their study [9] note that ADCs are important molecular entities in the treatment of cancer. These conjugates combine the target specificity of monoclonal antibodies with the potent anti-cancer activity of small-molecule therapeutics. The complex structure of ADCs poses unique challenges to characterize the drug's PKs and PDs since it requires a quantitative understanding of the PK and PD properties of multiple different molecular species (e.g., ADC conjugate, total antibody and unconjugated cytotoxic drug). As a result, clinical pharmacology strategy of an ADC is rather unique and dependent on the linker/cytotoxic drug technology, heterogeneity of the ADC, PK and safety/efficacy profile of the specific ADC in clinical development. In the course of the study, the authors state that ADCs represent a rapidly evolving area of oncology DD and hold significant promise. The complex structure of ADCs poses unique challenges to clinical pharmacology strategy in supporting development and approval of ADCs, since it requires a quantitative understanding of the PK and PD properties of multiple different molecular species (e.g., ADC conjugate, total antibody and unconjugated payload) in the systemic circulation and/or tissues of interest (e.g., tumors). Integration of diverse clinical pharmacology approaches, ranging from dedicated clinical pharmacology studies (e.g., DDI, QTc-interval, renal/hepatic impairment study) to mechanistic and/or empirical models (e.g., physiologically based pharmacokinetic, population PK modeling for one- or two- analytes, exposure-response analysis) can provide insights into the PK, PD and ADME properties of an ADC and inform development decision and clinical dose and schedule selection. An additional consideration for clinical development includes the thorough assessment of immunogenicity on ADC PK, efficacy, and safety. As the field continues to evolve, the selection of suitable ADC targets and the identification of a target population remain critical challenges. Efforts to further optimize "next-generation" ADCs using engineered antibodies, innovative linkers, conjugation methods, and novel payloads are rapidly advancing. Despite the great success of ADCs, it is worth noting that the therapeutic window for ADCs remains relatively narrow with the MTD often reached before ADCs achieve the maximum efficacious dose. Additionally, the toxicities associated with the ADCs might dictate the number of treatment cycles that the patients can tolerate and often result in dose delay, dose reductions or study discontinuation. The future success of ADCs in part will depend on our ability to overcome these developmental challenges, especially by developing clear strategies to optimize the dose and schedule of ADCs and identifying predictive biomarkers to assess response, optimize patient selection, and inform potential combination therapies.

Huang W. et al. [10] in their work concerning the prospects of CP perspectives for adoptive cell therapies in oncology indicate that adoptive cell therapies (ACTs) have shown transformative efficacy in oncology with five US FDA approvals for chimeric antigen receptor (CAR) T-cell therapies in hematological malignancies, and promising activity for T cell receptor T-cell therapies in both liquid and solid tumors. CP can play a pivotal role in optimizing ACTs, aided by modeling and simulation toolboxes and deep understanding of the underlying biological and immunological processes. Close collaboration and multilevel data integration across functions, including chemistry, manufacturing, and control, biomarkers, bioanalytical, and clinical science and safety teams will be critical to ACT development. As ACT is comprised of alive, polyfunctional, and heterogeneous immune cells, its overall physicochemical and pharmacological property is vastly different from other platforms/modalities, such as small molecule and protein therapeutics. In this work, researchers first describe the unique kinetics of T cells and the appropriate bioanalytical strategies to characterize cellular kinetics. They then assess the distinct aspects of CP for ACTs in comparison to traditional small molecule and protein therapeutics. Additionally, authors provide a review for the five FDA-approved CAR T-cell therapies and summarize their properties, cellular kinetic characteristics, dose-exposure-response relationship, and potential baseline factors/variables in product, patient, and regimen that may affect the safety and efficacy. Finally, they probe into existing empirical and mechanistic quantitative techniques to understand how various modeling and simulation approaches can support CP strategy and propose key considerations to be incorporated and explored in future models.

As our colleagues note the central tenet of pharmacology necessitates deep understanding of drug kinetics as it is critically related to efficacy and toxicity. At the apparent level, the kinetic profiles of both small molecules and protein therapeutics (SMs/PTs) and ACTs are multiphasic; however, the underlying mechanisms are fundamentally different. Due to the unique properties and kinetics of ACTs, several traditional CP considerations/lessons learned from SM/PT are either unknown or less applicable. Some examples include: (1) the impact of renal and hepatic impairment on cellular kinetics has not been reported; (2) the effect from food, formulation, and acid reducing agents are not relevant due to the intravenous administration of ACT; (3) the traditional half-life driven dosing frequency may not be suitable as the memory cells can be reactivated; and (4) the concept of dose proportionality is less applicable because the drug can be generated *de novo* by cellular expansion driven by many factors (e.g., host immune status

and tumor immunogenicity) that are unrelated to dose [10].

ACT is a complex and novel modality that has shown tremendous promise for treating cancer, with five FDA-approved CAR T cell therapies so far. Along with the technology and regulatory guidance, the CP aspect of this new treatment modality is still evolving. As the core purpose of CP is to determine the best dose/product (i.e., what) for the most appropriate patient (i.e., who) with the optimal conditioning/administration regimen (i.e., how), it is critical to understand the complex interaction between T cells and host biology/disease to identify key factors that we can control and relate to safety and efficacy. Several control points include product characteristics (i.e., dose, fitness, phenotype, and subset of both apheresis product and infusion product), patient characteristics (i.e., demographic information, tumor type, tumor burden, and tumor microenvironment), and regimen characteristics (timing and type of conditioning therapy, comedications, single vs. multiple infusion, and intravenous vs. regional injection). The large number of ACT control points demonstrate the uniqueness of this therapeutic modality compared with SM/PT, necessitating close collaboration of CP with biomarker, bioanalytical, chemistry, manufacturing, and control, and clinical science and safety teams. As our understanding of these control points improves and/or more homogenous cellular products are developed, clinical pharmacologists will have opportunities to better guide dose selection (first-in-human), escalation/expansion (phase I), and determination (pivotal) to optimize ACT development. To ensure optimal clinical development, clinical pharmacologists can contribute by applying quantitative methodologies, including: (1) translational PK/PD modeling to optimize product, patient, and regimen characteristics before the first-in-human study; (2) real-time statistical/machine learning approaches to forecast severe toxicity probability and mitigate risk during the clinical study; and (3) nonlinear mixed-effect and QSP modeling to gain deep insight and design future studies more appropriately with optimal selection of dose, patient, and regimen. Given the complexity and cost of delivering these therapies, initial studies may generate rich, robust, and multilevel datasets of T cell, biomarker, safety, and efficacy data, but in a relatively small number of patients. Therefore, integration of data across internal ACTs and externally published ACTs will be critical to drawing conclusions and informing decision making. As the field evolves and additional key drivers of safety and efficacy are elucidated, banking and preserving tissues may prove valuable as samples can be re-assayed for new biomarkers or other characteristics. These quantitative methodologies and infrastructure are anticipated to transfer well to the next generation of cell therapies, including T cell receptor (TCR)-T, Natural killer NK-T, and off the shelf/allogeneic cell systems and individualized therapies targeting tumor-specific private neo-antigens [10].

Advances in IO have provided a variety of novel therapeutics that harness the innate immune system to identify and destroy neoplastic cells. It is noteworthy that acceptable safety profiles accompany the development of these targeted therapies, which result in efficacious cancer treatment with higher survival rates and lower toxicities [11]. Kast J. et al. in their study say that ACT has shown promising results in inducing sustainable remissions in patients suffering from refractory diseases. Two main types of ACT include engineered CAR-T cells and TCR T cells. The application of these immuno-therapies in the last few years has been successful and has demonstrated a safe and rapid treatment regimen for solid and non-solid tumors. The authors emphasize that the clinical success of immunotherapy, which is due to the understanding of cancer immunobiology and effective application of this knowledge to eliminate cancerous cells, has changed the field of cancer therapy. Currently, immunotherapy is considered as one of the most important and effective approaches of cancer care. The success of genetically modified CAR-T cells has created substantial excitement among Biotech companies and researchers. In this regard, the scientific communities have produced tremendous efforts in developing abundant quantitative approaches for CAR-T cells that can assist the safety and efficacy evaluation of CAR-T cell products.

The prevalence of and factors associated with treatment modification at first cycle in older adults with advanced cancer receiving palliative treatment were reported by Mohamed M.R. et al. [12]. The authors say that treatment toxicities are common in older adults with cancer and consequently, treatment modifications are sometimes considered. They evaluated the prevalence and factors associated with treatment modifications at the first cycle in older patients receiving palliative systemic treatment. The aims of this study were 1) to examine the prevalence of treatment modifications at cycle 1 in a cohort of older adults with advanced cancer receiving palliative systemic treatment, and 2) to identify baseline factors, including socio-demographic variables, clinical variables, geriatric assessment (GA) domains, and physician beliefs that are associated with treatment modifications. As an exploratory analysis, we also investigated the possible moderation effect of chronological age on the association of baseline factors with treatment modifications.

Our colleagues collected the following baseline information after patients provided informed consent and before they started a new line of palliative cancer treatment. Socio-demographic variables included age (continuous variable), gender, race (White, Black, and others), education (less than high school, high school graduate, and some college or more), and income ($\leq \$50,000$ and $> \$50,000$ /declined to answer). Clinical variables included cancer type (gastrointestinal, lung, others), cancer stage (stage III, stage IV), line of palliative treatment (first versus second-line or greater), and physician-reported Karnofsky Performance Score (KPS) (40-60, 70-80, and 90-100). GA domains were captured using validated tools with established cut-offs for impairment including comorbidity, functional status, physical performance, cognition, social support, polypharmacy, psychological health, and nutritional status. Variables to assess physician beliefs about the prognosis of the disease included answers to the following questions: "How do you think cancer treatment will affect the patient's quality of life?" (Improve versus no change or decrease), and "What would you estimate the patient's overall life expectancy to be?" (0-12 months versus > 12 months). Treatment modification at cycle 1 (at the beginning of the treatment course) was defined as any change in dose or agents of the planned regimen from the standard treatment guidelines (National Comprehensive Cancer Network [NCCN] guidelines) or published phase II/III clinical trials. Standard treatment "full dose" means regimens that meet the standard guidelines for dose and scheduling according to NCCN or published phase II/III trials. The planned regimens (individual drugs, doses, and schedule) were captured at the beginning of the study from the primary oncology team and reviewed by a blinded research team including at least two oncology clinicians and an information analyst. Modifications were classified as 1) dose reduction (i.e. chemotherapy dose lower than the established regimen); 2) modified schedule to administer chemotherapy less frequently than the established regimen (e.g. patient receives only Day 1 and Day 15 of a regimen with established schedule of Day 1, 8, 15); or 3) modified regimen (e.g. one or more chemotherapy agents are intentionally left out of a poly-chemotherapy regimen). The composite binary variable of treatment modification (standard versus non-standard) was constructed as the presence of any of these types of treatment modifications and served as the dependent variable in bivariate and multivariate analyses [12].

Descriptive statistics were performed to describe independent and dependent variables. Subsequently, bivariate analyses were conducted to evaluate the association between each of the baseline variables and treatment modification (standard or non-standard) at cycle 1. The researchers constructed multivariable cluster-weighted generalized estimating equations (GEE) model with a binary distribution, logit link, and robust standard errors to examine the independent associations of baseline covariates with treatment modification at cycle 1 accounting for correlations among patients from the same practice. The mean age of participants ($n=369$) was 77.2 years (standard deviation 5.2 years; range 70-94). Overall, 54.7% were males, 94% were non-Hispanic Whites, and the majority (87.8%) had stage IV cancer. The most common cancer types were lung ($n=116$, 31.4%) and gastrointestinal ($n=114$, 30.9%). At the time of enrollment, 74.5% ($n=275$) were scheduled to receive first-line chemotherapy, and 25.5% ($n=94$) were scheduled to receive second-line or later treatment. Of 369 patients, 240 (65.0%) received standard regimens at cycle 1 according to NCCN guidelines or published clinical trials, and 129 (35.0%) received a modified treatment regimen. Of those patients with treatment modification, 79% ($n=292$) received a regimen with a dose reduction, 12% ($n=44$) received a different combination of agents (modified regimen), and 9% ($n=33$) received a modified schedule. The mean age of patients who received a modified regimen was 78.6 years, compared to 76.6 years in patients who received standard regimens ($p<0.01$). Patients who received treatment modifications were more likely to have functional impairments (66.4% versus 52.9%, $p=0.01$) and had physician-estimated life expectancies of < 12 months (43.4% versus 33.1%, $p=0.04$). Treatment modifications at cycle 1 were also more likely in patients reporting lower incomes (57.8% of patients with yearly incomes $\leq \$50,000$, compared to 42.2% of patients with incomes $> \$50,000$ and those who declined to answer [$p = 0.02$]). In addition, patients who received a modified treatment regimen were more likely to be receiving second line or later treatment (32.6% versus 21.7%, $p=0.02$). There were no significant differences between groups (i.e. patients received standard vs treatment modification) across race, gender, education, cancer type, KPS, other impaired GA domains, or physician estimated impact of treatment on quality of life. In multivariable GEE regression, authors found that each additional year of age was associated with 10% increased odds of treatment modification at cycle 1. [odds ratio (OR) 1.1, 95% confidence interval (CI) 1.0-1.2]. Receipt of second or greater line of chemotherapy (OR 1.8, CI 1.1-3.0), functional impairment (OR 1.6, CI 1.1-2.3), and lower income (OR 1.7, CI 1.1-2.4) were also associated with increased odds of treatment modification at cycle 1. A significant moderation effect was found between patients' age and physician-estimated life expectancy for cycle 1 treatment modification ($p=0.02$). In adjusted models and after stratification of the study

population by age group (70-74 ($n=136$), 75-79 ($n=114$), and ≥ 80 ($n=118$)), researchers found that among patients aged 70-74 years, those who had an estimated life expectancy of more than one year had 2.5 times the odds of receiving standard of care doses compared to those who had a life expectancy of less than one year (CI 1.1-5.4). Among patients aged 75-79 years and patients ≥ 80 years, those who had life expectancies greater than one year had 1.3 (CI 0.6-3.1) and 1.2 (CI 0.5-2.6) times the odds of receiving standard of care doses compared to those had life expectancies of less than one year. Increasing age did not moderate the associations of functional status, physical performance, or cognition with treatment modification at cycle 1 ($p>0.05$). Summarizing the results of the study, the authors note that in this large, nationwide study of older adults with advanced cancer receiving palliative treatment, our colleagues observed that 35% received a modified treatment regimen at cycle 1. Increasing age, lower income, functional impairment, and receipt of prior lines of treatment were associated with increased odds of treatment modification. Additionally, researchers observed chronologic age as a moderator in the relationship between life expectancy and treatment recommendations, suggesting that life expectancy is weighted more or less heavily in treatment decisions depending on chronologic age. The rate of treatment modification in this population emphasizes the importance of developing evidence-based treatment regimens for older adults with advanced cancer and GA impairments. Future studies should evaluate the longitudinal effect of cycle 1 treatment modifications in the advanced cancer setting on both cancer and patient-reported outcomes [12].

Shebley M. et al. in their work describe aspects of DD in pediatric oncology [13]. The authors point out that pediatric DD is a challenging process due to the rarity of the population, the need to meet regulatory requirements across the globe, the associated uncertainty in extrapolating data from adults, the paucity of validated biomarkers, and the lack of systematic testing of drugs in pediatric patients. In oncology, pediatric DD has additional challenges that have historically delayed availability of safe and effective medicines for children. In particular, the traditional approach to pediatric oncology DD involves conducting phase 1 studies in children once the drug has been characterized and in some cases approved for use in adults. Because it may be unethical and infeasible to conduct DDI trials in pediatrics in general and in oncology patients in particular, drug interaction results in adults are typically extrapolated to pediatrics based on the dosing considerations described above (ie, intrinsic factors that influence drug clearance). However, due to known physiologic and developmental differences between adults and children (ie, drug-metabolizing enzyme ontogeny), DDIs are often extrapolated using modeling and simulation approaches such as physiologically based pharmacokinetic, when the ontogeny of drug elimination pathways is well understood such as in the case of CYP3A-mediated metabolism. Not only does this provide a more scientifically robust approach to provide DDI recommendations and dose adjustment in children, but it also provides a platform to simulate scenarios that are otherwise impossible to test clinically and ethically. Furthermore, some chemotherapy regimens differ even when the disease type is the same in children and adults, often due to the inability of older adults to tolerate a more intensive regimen (ie, PEG-L-asparaginase is always used in pediatric acute lymphocytic leukemia protocols but rarely in adult protocols). Therefore, DDI information on such combinations would be completely absent. It also may be impossible to adjust the chemotherapy dose (ie, lower dose/intensity) when introducing the new drug if DDI is suspected, since the new drug may not provide efficacy and the loss of benefit to the child from adjusting backbone therapy would leave the patients in a subtherapeutic window. This again highlights the need for a model-informed DD approach to provide the appropriate dosing instructions for concomitant drug administration in children.

As the authors note establishing an optimal starting dose of a convenient, age-appropriate formulation remains important for successful pediatric oncology DD. Use of modeling and simulation approaches must continue to advance to inform selection of safe and efficacious doses as early in the drug development process as possible and to avoid overexposing children to subtherapeutic doses. It is imperative that modeling and simulation approaches, together with identification and validation of additional PD end points, continue to evolve to enable development of the most effective therapies in the shortest amount of time. Additional research in both of these areas is warranted [13].

I would also like to dwell on such a fairly new direction in CP as chronopharmacology.

As Kaşkal M. et al. [14] emphasize in their work one of the goals of CP is to optimize patient treatment by adopting new treatment strategies which will increase the efficacy of the treatment and decrease the adverse effects of the drugs. In the literature, it has shown that the effectiveness and toxicity of medications can vary significantly based on when they are administered, making timing a crucial factor in treatment plans. Chronopharmacology a relatively new branch of CP focuses on adjusting drug administration times to enhance patient outcomes. Chronopharmacology is largely influenced by an

individual's circadian rhythm which refers to periodic changes in biological processes depending on the time of the day. The chronopharmacology influences clinical practice, and the accumulating knowledge in this field will likely lead healthcare providers to adopt new strategies for drug treatment regimens. Chronopharmacology is a branch of pharmacology that studies how the timing of drug administration affects the body's response to medication. It emphasizes the role of biological rhythms, such as the circadian rhythm, in influencing drug effectiveness and safety. The studies on chronopharmacology are divided into two main areas: chronopharmacokinetics and chronopharmacodynamics.

Chronopharmacokinetics investigates how the timing of drug intake impacts the processes of ADME of the drugs. Chronopharmacodynamics examines the change in the effects of drugs on cellular and tissue levels, depending on the administration time of the drug. Both of these disciplines form the core of chronopharmacology and are the main themes in the aspects of chronopharmacology. They are essential for guiding the optimal timing of drug treatment to enhance benefits and reduce adverse effects. The drugs used in oncology are considered highly effective due to their antineoplastic effect but they also exhibit a broad range of severe adverse effects. The adverse effect profiles of antineoplastic agents are an important topic of discussion, particularly in the context of chronopharmacology. The timing of drug administration has been shown to potentially influence both the efficacy and the side effects of these agents. By aligning the administration of antineoplastic drugs with the body's circadian rhythms, it may be possible to enhance their therapeutic effects while minimizing adverse reactions. Ongoing research is focused on identifying the optimal timing for these treatments, with the aim of improving patient outcomes and reducing the burden of side effects. In the course of the study, the authors state that chronopharmacology represents a significant step forward in the quest to optimize drug therapies. By integrating the principles of this discipline into clinical practice, healthcare providers can enhance the effectiveness of treatments, reduce adverse effects, and move closer to the goals of personalized medicine. Ongoing research and clinical trials will continue to refine these strategies, ultimately leading to more precise and effective treatment protocols across a wide range of medical fields [14].

Summarizing the above data, it can be concluded that CP in oncology is currently a key area of modern medicine, combining fundamental understanding of the mechanisms of action of anticancer agents with the principles of individualized therapy. The development of molecular technologies, PGs, and biomarkers has significantly improved the accuracy of drug selection and dosage, minimized toxicity, and improved patient prognosis.

Despite significant advances, issues of drug resistance, interindividual variability in PKs and PDs, and the need to optimize drug combinations remain pressing. Addressing these challenges requires further integration of CP with oncogenomics, bioinformatics, and clinical trials.

Thus, understanding the fundamentals of CP in oncology forms the basis for the rational use of anticancer drugs, facilitates the development of a personalized approach, and serves as the foundation for improving malignant tumor therapy in the future. The development of predictive models of therapy efficacy and toxicity will enable the implementation of a truly personalized approach, in which the choice of drug, dose, and treatment regimen is based on a combination of pharmacological, genetic, and clinical factors.

CP in oncology occupies a central place in modern anticancer treatment, providing a scientific basis for the selection, dosing, and combination of medications. Understanding the mechanisms of action of cytostatic, targeted, and immunomodulatory agents, as well as their PKs and PDs, not only improves therapy effectiveness but also significantly reduces the incidence and severity of toxic complications, which remain a leading problem in oncology practice.

In recent decades, there has been a shift from empirical chemotherapy selection to personalized medicine based on the analysis of the molecular and genetic characteristics of the tumor and the individual patient's metabolic characteristics. PGs and therapeutic drug monitoring are becoming integral elements of CP, opening up opportunities for precise dosing and predicting treatment response. The introduction of biomarkers into clinical practice facilitates patient stratification and the selection of optimal treatment regimens, which is particularly important when using targeted and immunotherapeutic agents.

Thus, CP serves as the scientific foundation for rational anticancer therapy. Its further development determines not only the increased effectiveness and safety of malignant tumor treatments but also the emergence of a new paradigm of oncological care – precise, individualized, and pathogenetically sound.

References

- 1 Kruse M, Stankeviciute S, Perry S. Clinical pharmacology-how it shapes the drug development journey. *Eur J Clin Pharmacol*. 2025 Apr;81(4):597-604. doi: 10.1007/s00228-025-03811-z.
- 2 Papachristos A, Patel J, Vasileiou M, Patrinos GP. Dose Optimization in Oncology Drug Development: The Emerging Role of Pharmacogenomics, Pharmacokinetics, and Pharmacodynamics. *Cancers (Basel)*. 2023 Jun 18;15(12):3233. doi: 10.3390/cancers15123233.
- 3 Malhi V, Agarwal P, Gates MR, Liu L, Wang J, De Bruyn T, Lam S, Eng-Wong J, Perez-Moreno P, Chen YC, Yu J. Optimizing Early-stage Clinical Pharmacology Evaluation to Accelerate Clinical Development of Giredestrant in Advanced Breast Cancer. *Cancer Res Commun*. 2023 Dec 15;3(12):2551-2559. doi: 10.1158/2767-9764.CRC-23-0324.
- 4 Lazarou G, Chelliah V, Small BG, Walker M, van der Graaf PH, Kierzek AM. Integration of Omics Data Sources to Inform Mechanistic Modeling of Immune-Oncology Therapies: A Tutorial for Clinical Pharmacologists. *Clin Pharmacol Ther*. 2020 Apr;107(4):858-870. doi: 10.1002/cpt.1786.
- 5 Ramasubbu MK, Paleja B, Srinivasann A, Maiti R, Kumar R. Applying quantitative and systems pharmacology to drug development and beyond: An introduction to clinical pharmacologists. *Indian J Pharmacol*. 2024 Jul 1;56(4):268-276. doi: 10.4103/ijp.ijp_644_23.
- 6 Bai JPF, Earp JC, Strauss DG, Zhu H. A Perspective on Quantitative Systems Pharmacology Applications to Clinical Drug Development. *CPT Pharmacometrics Syst Pharmacol*. 2020 Dec;9(12):675-677. doi: 10.1002/psp4.12567.
- 7 Bai JPF, Earp JC, Florian J, Madabushi R, Strauss DG, Wang Y, Zhu H. Quantitative systems pharmacology: Landscape analysis of regulatory submissions to the US Food and Drug Administration. *CPT Pharmacometrics Syst Pharmacol*. 2021 Dec;10(12):1479-1484. doi: 10.1002/psp4.12709.
- 8 Chelliah V, Lazarou G, Bhatnagar S, Gibbs JP, Nijssen M, Ray A, Stoll B, Thompson RA, Gulati A, Soukharev S, Yamada A, Weddell J, Sayama H, Oishi M, Wittemer-Rump S, Patel C, Niederalt C, Burghaus R, Scheerans C, Lippert J, Kabilan S, Kareva I, Belousova N, Rolfe A, Zutshi A, Chenel M, Venezia F, Fouliard S, Oberwittler H, Scholer-Dahirel A, Lelievre H, Bottino D, Collins SC, Nguyen HQ, Wang H, Yoneyama T, Zhu AZX, van der Graaf PH, Kierzek AM. Quantitative Systems Pharmacology Approaches for Immuno-Oncology: Adding Virtual Patients to the Development Paradigm. *Clin Pharmacol Ther*. 2021 Mar;109(3):605-618. doi: 10.1002/cpt.1987.
- 9 Liu SN, Li C. Clinical pharmacology strategies in supporting drug development and approval of antibody-drug conjugates in oncology. *Cancer Chemother Pharmacol*. 2021 Jun;87(6):743-765. doi: 10.1007/s00280-021-04250-0.
- 10 Huang W, Li J, Liao MZ, Liu SN, Yu J, Jing J, Kotani N, Kamen L, Guelman S, Miles DR. Clinical Pharmacology Perspectives for Adoptive Cell Therapies in Oncology. *Clin Pharmacol Ther*. 2022 Nov;112(5):968-981. doi: 10.1002/cpt.2509.
- 11 Kast J, Nozohouri S, Zhou D, Yago MR, Chen PW, Ahamadi M, Dutta S, Upreti VV. Recent advances and clinical pharmacology aspects of Chimeric Antigen Receptor (CAR) T-cellular therapy development. *Clin Transl Sci*. 2022 Sep;15(9):2057-2074. doi: 10.1111/cts.13349.
- 12 Mohamed MR, Kyi K, Mohile SG, Xu H, Culakova E, Loh KP, Flannery M, Obrecht S, Ramsdale E, Patil A, Dunne RF, DiGiovanni G, Hezel A, Burnette B, Desai N, Giguere J, Magnuson A. Prevalence of and factors associated with treatment modification at first cycle in older adults with advanced cancer receiving palliative treatment. *J Geriatr Oncol*. 2021 Nov;12(8):1208-1213. doi: 10.1016/j.jgo.2021.06.007.
- 13 Shebley M, Menon RM, Gibbs JP, Dave N, Kim SY, Marroum PJ. Accelerating Drug Development in Pediatric Oncology With the Clinical Pharmacology Storehouse. *J Clin Pharmacol*. 2019 May;59(5):625-637. doi: 10.1002/jcph.1359.
- 14 Kaşkal M, Sevim M, Ülker G, Keleş C, Bebitoğlu BT. The clinical impact of chronopharmacology on current medicine. *Naunyn Schmiedebergs Arch Pharmacol*. 2025 Jun;398(6):6179-6191. doi: 10.1007/s00210-025-03788-7.

Pedagogical sciences

PEDAGOGICAL POTENTIAL OF INTEGRATING DIGITAL EDUCATIONAL ECOSYSTEMS INTO THE FORMATION OF PROFESSIONAL AND METHODOLOGICAL COMPETENCE OF FUTURE ENGLISH LANGUAGE TEACHERS

Abdraly Rabiga Baktybekkyzy

1st year master's student, Zhanibekov University SKPU, Shymkent, Kazakhstan

Abstract

This article examines the pedagogical potential of integrating digital educational ecosystems into the formation of professional and methodological competence of future English language teachers. The study highlights how digital platforms, tools, and resources contribute to developing teaching skills, methodological awareness, and adaptability in modern educational environments. Special attention is given to interactive technologies, online collaboration, and personalized learning opportunities. The findings suggest that digital ecosystems enhance students' engagement, foster critical thinking, and support continuous professional development. The integration of such ecosystems is considered an essential factor in preparing future teachers for effective and innovative teaching practices in a rapidly evolving digital society.

Keywords: *digital educational ecosystem, future teachers, professional competence, methodological competence, English language teaching, digital technologies*

1. Introduction.

In the context of rapid digital transformation, the education system is undergoing significant changes that affect both teaching methods and learning environments. One of the key trends in modern pedagogy is the integration of digital educational ecosystems, which combine various digital tools, platforms, and resources into a unified learning environment. These ecosystems provide new opportunities for enhancing the quality of teacher education, particularly in the preparation of future English language teachers.

Professional and methodological competence is a fundamental component of teacher training. It includes not only subject knowledge but also the ability to apply effective teaching methods, adapt to diverse learning needs, and continuously develop professionally. In this regard, digital educational ecosystems play a crucial role by offering access to interactive resources, online communication tools, and innovative teaching strategies.

The integration of digital technologies into teacher education allows students to engage in active learning, collaborative projects, and reflective practices. Future English language teachers can benefit from authentic materials, virtual classrooms, and global communication opportunities, which contribute to the development of their linguistic and pedagogical skills. Moreover, digital ecosystems support personalized learning, enabling students to progress at their own pace and focus on their individual needs.

Despite the growing importance of digital tools, their effective integration requires a clear pedagogical framework and methodological support. Therefore, it is essential to explore the pedagogical potential of digital educational ecosystems and their impact on the formation of professional competence. This study aims to analyze the role of digital ecosystems in teacher education and to identify their advantages in preparing future English language teachers for the challenges of the modern educational landscape.

2. Theoretical Background

2.1 Definition of Digital Educational Ecosystems

The concept of digital educational ecosystems has emerged as a response to the rapid development of information and communication technologies in education. A digital educational ecosystem can be defined as an integrated and dynamic environment that combines digital tools, platforms, resources, and participants to support teaching and learning processes. It includes learning management systems (LMS), online collaboration tools, digital content repositories, and communication technologies that interact within a unified framework.

Unlike traditional educational environments, digital ecosystems are characterized by flexibility, adaptability, and interconnectivity. They enable continuous access to educational resources and support

both formal and informal learning. Moreover, such ecosystems promote learner autonomy and provide opportunities for personalized learning paths, which are particularly important in teacher education.

2.2 Key Components and Characteristics

Digital educational ecosystems consist of several essential components that ensure their effectiveness. These include technological infrastructure, digital content, communication tools, and pedagogical strategies. Technological infrastructure provides the foundation for the functioning of digital platforms, while digital content includes multimedia materials, interactive tasks, and online courses.

One of the key characteristics of digital ecosystems is interactivity, which allows students to actively engage in the learning process. Another important feature is scalability, enabling the system to accommodate a large number of users and resources. Additionally, digital ecosystems are characterized by accessibility, allowing learners to access materials anytime and anywhere. Collaboration is also a significant aspect, as digital tools facilitate communication and teamwork among students and educators.

2.3 Concept of Professional Competence in Teacher Education

Professional competence in teacher education refers to a complex set of knowledge, skills, attitudes, and values that enable teachers to perform their professional duties effectively. It includes subject knowledge, pedagogical skills, classroom management abilities, and the capacity for continuous professional development.

In the context of English language teaching, professional competence also involves linguistic proficiency and intercultural awareness. Future teachers must be able to apply theoretical knowledge in practice, design effective lessons, and respond to the diverse needs of learners. The development of professional competence is a continuous process that requires both formal education and practical experience.

2.4 Concept of Methodological Competence in English Language Teaching

Methodological competence is a key component of professional competence and refers to the ability to select, adapt, and apply appropriate teaching methods and strategies. In English language teaching, this includes knowledge of language acquisition theories, teaching approaches, and assessment methods.

Future English language teachers must be capable of designing lesson plans, choosing suitable materials, and implementing interactive teaching techniques. Methodological competence also involves the ability to evaluate learning outcomes and adjust teaching practices accordingly. The integration of digital technologies enhances methodological competence by providing access to innovative teaching tools and resources.

2.5 Review of Relevant Scientific Literature

The issue of integrating digital technologies into teacher education has been widely discussed in contemporary research. Scholars emphasize the importance of digital competence as an essential component of modern teacher professionalism. According to recent studies, digital educational ecosystems contribute significantly to the development of both professional and methodological competence.

Researchers highlight that digital tools improve student engagement, facilitate collaborative learning, and support the development of critical thinking skills. Furthermore, studies show that the use of online platforms and digital resources enhances the quality of language instruction by providing authentic materials and real-life communication opportunities.

However, some authors point out challenges related to the implementation of digital ecosystems, such as insufficient technical support and lack of training. Despite these limitations, the majority of researchers agree that digital educational ecosystems have strong pedagogical potential and play a crucial role in the modernization of teacher education.

3. Pedagogical Potential of Digital Educational Ecosystems

3.1 Opportunities for Interactive and Student-Centered Learning

Digital educational ecosystems provide extensive opportunities for implementing interactive and student-centered learning approaches. Unlike traditional teacher-centered models, digital environments encourage active participation, engagement, and autonomy among learners. Through the use of interactive platforms, simulations, and multimedia content, students become active participants in the learning process rather than passive recipients of information.

Future English language teachers benefit from these environments by experiencing innovative teaching methods firsthand. Tools such as quizzes, gamified applications, and virtual classrooms allow learners to receive immediate feedback and adjust their learning strategies accordingly. This interactive approach enhances motivation and supports deeper understanding of educational content. Moreover, student-centered learning within digital ecosystems promotes critical thinking, problem-solving, and independent learning skills, which are essential for modern educators.

3.2 Development of Digital Literacy and Teaching Skills

The integration of digital educational ecosystems significantly contributes to the development of digital literacy among future teachers. Digital literacy involves not only the ability to use technological tools but also the capacity to critically evaluate digital content, create educational materials, and apply technology effectively in teaching practice.

For future English language teachers, mastering digital tools is essential for designing engaging lessons and adapting to diverse learning environments. Digital ecosystems provide opportunities to develop skills such as creating multimedia presentations, managing online classrooms, and using learning management systems. Additionally, students learn how to integrate technology into lesson planning and assessment processes.

As a result, future teachers become more confident in using digital tools and are better prepared to meet the demands of modern education. The development of these competencies ensures their readiness for continuous professional growth in a technology-driven world.

3.3 Support for Collaborative and Communicative Competence

One of the key advantages of digital educational ecosystems is their ability to facilitate collaboration and communication. Online platforms enable students to interact with peers and instructors through discussion forums, group projects, and virtual meetings. These interactions promote the development of communicative competence, which is particularly important for future English language teachers.

Collaborative learning activities encourage the exchange of ideas, peer feedback, and collective problem-solving. Through participation in online discussions and teamwork, students develop essential interpersonal skills and learn how to communicate effectively in diverse contexts. Furthermore, digital tools allow for synchronous and asynchronous communication, making collaboration more flexible and accessible.

The development of communicative competence in digital environments also prepares future teachers to create interactive and inclusive classrooms. It enhances their ability to manage group work and foster meaningful communication among their future students.

3.4 Access to Authentic Materials and Global Resources

Digital educational ecosystems provide access to a wide range of authentic materials and global resources, which are crucial for effective English language teaching. These include online articles, videos, podcasts, interactive exercises, and real-life communication platforms. Exposure to authentic content helps learners develop language skills in realistic contexts and improves their cultural awareness.

Future English language teachers can use these resources to design engaging lessons that reflect real-world language use. Digital ecosystems also enable access to international educational platforms and communities, allowing students to interact with native speakers and educators from different countries.

Moreover, the availability of diverse resources supports differentiated instruction, as teachers can select materials that meet the needs and proficiency levels of their students. This flexibility enhances the quality of teaching and promotes more effective language acquisition.

4. Integration into Teacher Training

4.1 Strategies for Implementing Digital Ecosystems in Higher Education

The effective integration of digital educational ecosystems into teacher training requires well-structured strategies and institutional support. Higher education institutions must adopt a systematic approach that combines technological infrastructure with pedagogical innovation. One of the key strategies involves embedding digital tools and platforms into the curriculum rather than treating them as supplementary elements.

Blended learning models, which combine face-to-face instruction with online learning, are widely recognized as an effective approach to integrating digital ecosystems. These models allow students to benefit from both traditional and digital methods, enhancing flexibility and engagement. Additionally, project-based learning and problem-based learning can be supported through digital environments, encouraging students to apply theoretical knowledge in practical contexts.

Another important strategy is continuous professional development for both students and instructors. Training programs and workshops should be provided to ensure that all participants possess the necessary digital competencies. Institutional policies should also support innovation and encourage the use of digital technologies in teaching and learning processes.

4.2 Use of Online Platforms, LMS, and Digital Tools

Online platforms and learning management systems (LMS) play a central role in digital educational ecosystems. These systems provide a structured environment for organizing course materials, managing

assignments, and facilitating communication between students and instructors. Common LMS features include content delivery, assessment tools, discussion forums, and progress tracking.

Digital tools such as video conferencing applications, collaborative platforms, and interactive software further enhance the learning experience. They allow for synchronous and asynchronous communication, enabling students to participate in lectures, discussions, and group work regardless of their physical location.

For future English language teachers, the use of these tools is particularly valuable, as it helps them develop practical skills in managing digital classrooms. They learn how to design online lessons, monitor student progress, and provide feedback through digital channels. This experience prepares them for teaching in both traditional and online environments.

4.3 Examples of Digital Resources in English Language Teaching

A wide variety of digital resources can be effectively used in English language teaching within digital educational ecosystems. These include online dictionaries, language learning applications, educational websites, and multimedia content such as videos and podcasts. Interactive exercises and quizzes help reinforce vocabulary and grammar, while virtual simulations and role-playing activities support the development of speaking skills.

Authentic materials, such as news articles, interviews, and real-life communication platforms, are particularly valuable for language learning. They expose students to natural language use and diverse cultural contexts. Additionally, online communities and forums allow learners to engage in meaningful communication with speakers from around the world.

The integration of these resources enables future teachers to design dynamic and engaging lessons. It also encourages creativity and innovation in teaching practices, making the learning process more effective and enjoyable.

4.4 Role of Instructors in Guiding Digital Learning

In digital educational ecosystems, the role of the instructor shifts from a traditional knowledge transmitter to a facilitator and guide. Instructors are responsible for creating a supportive learning environment, selecting appropriate digital tools, and guiding students in their use. They must also help students develop critical thinking skills and digital literacy.

Effective instructors provide clear instructions, organize learning activities, and offer timely feedback. They also encourage collaboration and active participation, ensuring that students remain engaged in the learning process. In addition, instructors play a crucial role in monitoring students' progress and addressing individual learning needs.

Furthermore, instructors must continuously update their own digital competencies to keep pace with technological advancements. Their ability to integrate digital tools effectively has a direct impact on the quality of teacher training. Therefore, the success of digital educational ecosystems largely depends on the professional readiness and adaptability of instructors.

5. Impact on Professional and Methodological Competence

5.1 Improvement of Teaching Methodologies

The integration of digital educational ecosystems significantly contributes to the improvement of teaching methodologies among future English language teachers. By engaging with digital tools and platforms, students are exposed to a wide range of innovative teaching approaches that go beyond traditional methods. These include blended learning, flipped classrooms, and interactive instruction supported by multimedia resources.

Digital environments enable future teachers to experiment with various instructional strategies and adapt them to different learning contexts. They learn how to design engaging lesson plans, incorporate technology into teaching, and use data from digital platforms to assess student performance. As a result, teaching methodologies become more flexible, dynamic, and learner-centered, which enhances the overall quality of education.

5.2 Development of Reflective and Critical Thinking Skills

Digital educational ecosystems also play a crucial role in developing reflective and critical thinking skills. Through participation in online discussions, collaborative projects, and self-assessment activities, future teachers are encouraged to analyze their own learning processes and teaching practices.

Reflection is an essential component of professional growth, as it allows teachers to evaluate their strengths and identify areas for improvement. Digital tools such as e-portfolios, blogs, and discussion forums provide platforms for continuous reflection and feedback. In addition, access to diverse sources of information enables students to critically evaluate content, compare perspectives, and make informed decisions.

These skills are particularly important for English language teachers, who must be able to adapt their teaching strategies and respond to the needs of diverse learners.

5.3 Adaptation to Diverse Learning Environments

The use of digital educational ecosystems enhances the ability of future teachers to adapt to diverse learning environments. Modern classrooms are increasingly characterized by diversity in terms of students' backgrounds, learning styles, and proficiency levels. Digital tools provide opportunities for differentiated instruction, allowing teachers to tailor their teaching methods to individual needs.

For example, online platforms offer various types of content, including videos, texts, and interactive activities, which cater to different learning preferences. Teachers can also use digital assessment tools to monitor student progress and adjust instruction accordingly.

Moreover, experience with digital ecosystems prepares future teachers to work in both traditional and online learning environments. This adaptability is essential in the context of global educational changes and the increasing demand for дистанционное and hybrid learning.

5.4 Enhancement of Lifelong Learning Abilities

Digital educational ecosystems promote the development of lifelong learning abilities, which are essential for professional success in the modern world. Future English language teachers are encouraged to take responsibility for their own learning and continuously update their knowledge and skills.

Access to online courses, webinars, and professional communities allows teachers to engage in ongoing professional development. Digital environments support self-directed learning by providing flexible access to educational resources and opportunities for skill improvement.

As a result, future teachers develop a mindset of continuous learning and professional growth. They become more independent, motivated, and capable of adapting to changes in the educational landscape. This ability to engage in lifelong learning ensures that they remain effective and relevant in their profession.

6. Conclusion

The integration of digital educational ecosystems into teacher training represents a significant step toward the modernization of education and the improvement of teaching quality. As demonstrated in this study, digital ecosystems provide a dynamic and flexible learning environment that supports the development of both professional and methodological competence among future English language teachers.

The findings highlight that digital technologies enhance teaching methodologies, promote interactive and student-centered learning, and foster the development of critical thinking and reflective skills. In addition, digital ecosystems enable future teachers to adapt to diverse learning environments and support the formation of lifelong learning habits, which are essential in a rapidly changing educational landscape.

At the same time, the study identifies several challenges, including technical limitations, insufficient digital competence, and issues related to accessibility and digital inequality. These factors must be carefully addressed to ensure the effective implementation of digital ecosystems in higher education.

Overall, the pedagogical potential of digital educational ecosystems is substantial, and their integration into teacher education should be considered a strategic priority. Future research should focus on developing practical models for implementation, as well as exploring innovative approaches to digital pedagogy. By leveraging the opportunities offered by digital ecosystems, educational institutions can better prepare future English language teachers for the demands of modern education and contribute to the development of a more effective and inclusive learning environment.

References

1. Michael Fullan, M. (2013). *Stratosphere: Integrating technology, pedagogy, and change knowledge*. Pearson.
2. Ruben Puentedura, R. (2006). *Transformation, technology, and education*. Blog post. Retrieved from <http://hippasus.com>
3. Punya Mishra, P., & Matthew J. Koehler, M. J. (2006). *Technological pedagogical content knowledge: A framework for teacher knowledge*. *Teachers College Record*, 108(6), 1017–1054.
4. Neil Selwyn, N. (2016). *Education and technology: Key issues and debates*. Bloomsbury Academic.
5. UNESCO. (2018). *ICT competency framework for teachers*. Paris: UNESCO.
6. Mark Warschauer, M. (2000). *The changing global economy and the future of English teaching*. *TESOL Quarterly*, 34(3), 511–535.

7. Graham Stanley, G. (2013). *Language learning with technology: Ideas for integrating technology in the classroom*. Cambridge University Press.
8. Hayo Reinders, H., & Stephen Bax, S. (2014). Digital technology in language teaching. *The International Journal of Computer-Assisted Language Learning and Teaching*, 4(1), 1–8.
9. Larry Cuban, L. (2001). *Oversold and underused: Computers in the classroom*. Harvard University Press.
10. John Hattie, J. (2009). *Visible learning: A synthesis of over 800 meta-analyses relating to achievement*. Routledge.
11. Linda Darling-Hammond, L. (2017). Teacher education around the world: What can we learn from international practice? *European Journal of Teacher Education*, 40(3), 291–309.
12. David Nunan, D. (2003). *Practical English language teaching*. McGraw-Hill.

BARRIERS AND PROSPECTS FOR IMPLEMENTING BLENDED LEARNING IN TEACHING ENGLISH AS A FOREIGN LANGUAGE IN SMALL-CLASS RURAL SCHOOLS OF THE REPUBLIC OF KAZAKHSTAN: AN ANALYTICAL REVIEW

Badyrova Aikerim Nurlankyzy

Master's student

*Uzbekali Zhanibekov South Kazakhstan Pedagogical University
Shymkent, Kazakhstan*

Abstract

Small-class rural schools (MKS) constitute one of the most vulnerable and numerous segments of the education system of the Republic of Kazakhstan. According to official data from the Ministry of Education, approximately 73% of all state general secondary schools are located in rural areas, and more than half of them are small-class institutions with combined grades that educate around 40% of the country's school-age children. These schools face chronic challenges in delivering high-quality English as a foreign language (EFL) education, which is a key strategic component of the state trilingual education policy aimed at developing competence in Kazakh, Russian, and English.

Blended learning (BL), defined as a systematic integration of traditional face-to-face instruction with digital and online components, is increasingly viewed as one of the most promising innovative approaches. It offers the potential to mitigate the digital divide, personalize learning, and significantly enhance students' communicative competence in EFL. This analytical review provides a comprehensive systematization of the main barriers to the implementation of blended learning in EFL teaching within small-class rural schools and identifies realistic prospects based on current state initiatives as of 2026.

The barriers are classified into four interconnected categories: infrastructural-digital, personnel-related, methodological, and socio-cultural. Prospects are strongly associated with the pilot launch of the Qazaq Digital Mektebi project in September 2026 across seven regions, the successful scaling of regional experiences such as the Aktobe project included in the HundrED Global Collection 2026, and the active development of offline-capable digital content incorporating artificial intelligence elements.

The review proposes a practically adapted hybrid model for EFL that prioritizes offline components while minimizing dependence on constant high-speed internet. It effectively supports the development of all four language skills. The scientific novelty of the study lies in the detailed and context-specific analysis of blended learning applied to EFL in the unique socio-economic, infrastructural, and cultural conditions of Kazakhstani small-class rural schools amid the ongoing 2025–2026 national digital transformation policy.

Keywords: *blended learning, English as a foreign language (EFL), small-class rural schools, digital divide, educational inequality, Qazaq Digital Mektebi, trilingual education, Kazakhstan.*

Introduction

The education system of the Republic of Kazakhstan is undergoing profound digital transformation aimed at ensuring equitable access to quality education for all citizens, regardless of their place of residence. This process is driven by key national strategic documents, including the Concept for the Development of Preschool, Secondary, Technical and Vocational Education until 2029, the Digital Kazakhstan program, and recent presidential initiatives emphasizing the use of artificial intelligence to bridge urban-rural gaps. Despite considerable state investments in infrastructure, teacher training, and digital platforms, small-class rural schools with combined grades continue to represent the most vulnerable and numerous segment of the educational infrastructure.

These schools typically operate in remote and sparsely populated territories, where limited financial, material, technical, and human resources create persistent structural barriers to delivering modern, high-quality education. In such challenging contexts, the quality of English as a foreign language (EFL) instruction acquires exceptional strategic importance. English is not merely a school subject but a critical tool for students' future academic mobility, access to international knowledge resources, participation in global labor markets, and successful realization of the state trilingual policy, which aims to develop functional competence in Kazakh (state language), Russian (language of interethnic communication), and English (language of international communication).

However, EFL teaching in rural small-class schools is severely constrained by multiple factors: a chronic shortage of qualified English language specialists, insufficient access to up-to-date teaching

materials and authentic resources, and the organizational complexities of combined-grade classes, where learners of different ages, cognitive development levels, and language proficiency study together in the same classroom. Traditional face-to-face instruction, while valuable for building personal relationships and immediate feedback, often fails to provide the necessary volume, variety, repetition, and individualization of practice required for effective development of communicative competence across listening, speaking, reading, and writing skills.

Under these circumstances, blended learning emerges as a highly promising and practically viable pedagogical solution. Blended learning is understood as a deliberate, systematic, and pedagogically grounded combination of traditional classroom-based activities with digital, online, and offline technological components. This approach allows for flexible personalization of the learning process, increased student motivation through interactive and multimedia tools, more efficient use of limited classroom time, and better adaptation to the specific constraints of rural educational environments.

This analytical review seeks to address a significant research and practical gap in the existing literature by providing a detailed and multifaceted systematization of the key barriers that currently impede the widespread and effective adoption of blended learning in EFL instruction within small-class rural schools of Kazakhstan. Simultaneously, it outlines realistic prospects and opportunities grounded in the latest state-level digital initiatives, with particular emphasis on the pilot phase of the Qazaq Digital Mektebi project scheduled to begin in September 2026 in seven regions. The review pays special attention to the complex interplay between infrastructural limitations, teacher professional preparedness, methodological challenges, socio-cultural factors, and the overarching goals of trilingual education policy.

The primary objectives are: (1) to present a thorough and up-to-date characterization of the current state and distinctive features of small-class rural schools in Kazakhstan; (2) to classify and deeply analyze the multifaceted barriers to blended EFL implementation; (3) to critically evaluate existing and emerging digital initiatives at national and regional levels; (4) to propose a contextually adapted hybrid model suitable for the realities of rural small-class schools; and (5) to draw well-substantiated conclusions regarding the feasibility, potential impact, and necessary conditions for successful integration of blended learning in rural EFL education. The scientific novelty of this work lies in its focused, context-sensitive, and comprehensive examination of blended learning models applied specifically to English as a foreign language under the unique socio-economic, infrastructural, cultural, and policy realities of Kazakhstani small-class rural schools during the active phase of national digital transformation in 2025–2026.

Theoretical Foundations of Blended Learning in EFL

Blended learning has firmly established itself in global educational theory and practice as one of the most effective, flexible, and student-centered pedagogical models of the 21st century. It represents a harmonious integration of the proven strengths of traditional classroom-based instruction — including direct teacher guidance, immediate formative feedback, social interaction, emotional engagement, and development of soft skills — with the powerful advantages of digital technologies, such as high adaptability to individual learner needs and paces, access to vast multimedia and authentic resources, opportunities for repeated self-paced practice, continuous automated progress tracking, and scalability beyond physical classroom limitations.

In the specific field of teaching English as a foreign language, blended learning demonstrates particular pedagogical value and effectiveness. It enables the balanced, simultaneous, and integrated development of all four core language skills — listening, speaking, reading, and writing — while successfully accommodating diverse student proficiency levels, learning styles, motivational profiles, and cognitive abilities. Several well-established models have shown strong applicability in resource-constrained environments such as rural schools. The flipped classroom model shifts the delivery of theoretical content (grammar rules, vocabulary introduction, cultural background information) to independent study through short videos, audio recordings, or texts accessed via offline devices, thereby liberating precious classroom time for higher-order interactive communicative activities, role-plays, debates, pair work, and personalized teacher feedback.

The station rotation model organizes the lesson around several rotating learning stations: one station focuses on teacher-led pronunciation drills and speaking practice, another on digital or pre-downloaded listening and vocabulary exercises, and a third on collaborative group projects or creative tasks. The flex model, meanwhile, emphasizes digital content delivery as the primary mode while retaining teacher support and intervention on demand. These models are especially relevant and practical for small-class schools with combined grades, as they naturally support differentiated instruction, optimize the limited time and energy of multi-subject teachers, and allow for more efficient classroom management in multi-age groups.

A large body of international and comparative empirical research consistently demonstrates that thoughtfully designed blended learning programs in EFL contexts can lead to measurable improvements in language proficiency indicators ranging from 10% to 22%, alongside substantial gains in student motivation, autonomy, engagement, and confidence in using English for real communication. In the Kazakhstani educational landscape, blended learning approaches have been relatively well studied and implemented at the higher education level, where universities generally enjoy better technological infrastructure and access to qualified staff. However, the systematic adaptation, piloting, and scaling of these models to the specific realities of rural secondary education — marked by chronic issues of unstable internet connectivity, limited device availability, heavy teacher workloads across multiple subjects, and the pedagogical complexities of combined-grade teaching — remain significantly underdeveloped both in research and in practice. This persistent gap in theory, policy, and implementation underscores the relevance and timeliness of the present analytical review, which focuses explicitly on identifying context-specific barriers, proposing feasible adaptation strategies, and evaluating long-term prospects for EFL instruction through blended learning in Kazakhstani small-class rural schools.

Characteristics of Small-Class Rural Schools in Kazakhstan

Small-class rural schools represent a substantial, strategically vital, and numerically significant component of the national education system of Kazakhstan. According to the most recent official statistics released by the Ministry of Education for the 2025–2026 academic year, approximately 73% of all state general secondary schools are situated in rural areas. Moreover, more than 50% of these rural institutions function as small-class (малокомплектные) schools characterized by combined grades and relatively low student enrollments. Taken together, these schools currently provide education to roughly 40% of the total school-age population of the country. In several northern and central regions, the share of small-class schools rises even higher, reaching 60–64% of all rural educational institutions.

The operational realities of these schools are defined by a complex web of interconnected challenges. Teachers routinely shoulder heavy and multifaceted workloads, often teaching several subjects simultaneously while managing combined-grade classes that bring together students of markedly different ages, developmental stages, and levels of language proficiency within the same physical classroom. This organizational model creates considerable methodological and pedagogical difficulties, particularly in the domain of foreign language teaching, which inherently demands consistent individual attention, frequent and meaningful speaking practice, accurate pronunciation modeling, and carefully differentiated tasks tailored to each learner's current abilities and needs.

In addition to human resource pressures, the material and technical infrastructure in many small rural schools remains modest and frequently outdated. Common problems include aging equipment, irregular electricity supply, and unreliable or low-speed internet connections that severely restrict the possibilities for regular use of modern digital educational tools and platforms. English as a foreign language is formally introduced into the curriculum starting from primary school in accordance with national state standards. Nevertheless, the overall quality and effectiveness of EFL instruction in rural areas continue to lag noticeably behind that observed in urban schools. This quality gap is largely attributable to the acute and persistent shortage of qualified, specially trained EFL teachers. In a large number of cases, generalist teachers who lack specialized linguistic, phonetic, or communicative methodology training are responsible for delivering English lessons. Consequently, critical aspects such as accurate pronunciation modeling, organization of authentic communicative activities, integration of interactive and task-based methods, and development of intercultural competence often receive insufficient attention.

These deeply rooted structural, resource-related, and human-factor constraints position small-class rural schools as a clear national priority for targeted digital transformation and innovative pedagogical interventions. The thoughtful and contextually adapted integration of blended learning models in such environments could play a transformative role in narrowing long-standing educational inequalities, improving equitable access to quality EFL education, and advancing the broader strategic objectives of Kazakhstan's trilingual education policy.

Barriers to Implementing Blended Learning in EFL

The practical implementation of blended learning in English language teaching within small-class rural schools encounters a complex, multifaceted, and mutually reinforcing set of barriers. For analytical clarity, these obstacles can be systematically categorized into four primary groups that interact and amplify one another in rural contexts.

Table 1. Main Barriers to Blended EFL Implementation in Small-Class Rural Schools

Category	Specific Barriers	Impact on EFL Teaching	Severity
Infrastructural-Digital	Unstable or slow internet connection, acute shortage of computers and tablets, frequent power outages	Severely restricted access to video materials, interactive online exercises, authentic listening resources, and real-time communication platforms	High
Personnel	Insufficient digital literacy and competence among teachers, chronic shortage of qualified EFL specialists, excessively high teaching workloads across multiple subjects	Significant difficulties in effective integration of digital tools, accurate pronunciation modeling, and organization of meaningful speaking practice	High
Methodological	Lack of locally developed and culturally adapted EFL content that accounts for trilingual realities and Kazakh national culture, major challenges associated with teaching combined-grade classes	Markedly reduced effectiveness of communicative tasks, limited possibilities for individualized and differentiated instruction	High
Socio-Cultural	Generally lower student motivation toward digital learning formats, strong influence of household and agricultural responsibilities, widespread parental skepticism or limited understanding of digital education benefits	Decreased active participation in speaking and interactive activities, lower overall engagement and persistence in language learning	Medium

These barriers manifested with particular intensity during the nationwide transition to distance learning in previous years and continue to exert a constraining influence on the potential of blended learning formats in rural educational settings. Empirical observations and surveys frequently reveal that rural students experience substantially lower levels of reliable digital access and express lower satisfaction with online learning components when compared to their urban counterparts. Socio-cultural dimensions further complicate adoption: concerns regarding academic integrity in unsupervised digital work, feelings of isolation in remote communities, and insufficient peer interaction or parental support add additional layers of difficulty to the successful transition toward sustainable blended models.

Table 2. Comparative Overview of Digital Access and EFL-Related Indicators (Urban vs. Rural Small-Class Schools, synthesized from 2025–2026 studies)

Indicator	Urban Schools	Rural Small-Class Schools	Gap Level
Access to stable high-speed internet	High	Low	Significant
Availability of personal or shared devices per student	High	Low to Medium	Notable
Teacher digital and EFL-specific competence	High	Medium	High
Measured student EFL communicative competence development	Higher	Lower	Moderate to High
Student motivation and engagement in digital language learning	High	Medium to Low	Moderate

Prospects and Opportunities

Despite the considerable and deeply entrenched barriers outlined above, the year 2026 has brought concrete, tangible, and strategically important opportunities for meaningful advancement of blended learning in the rural school sector of Kazakhstan. The flagship national initiative is the pilot launch of the Qazaq Digital Mektebi project, officially scheduled to commence in September 2026 in seven designated pilot regions: North Kazakhstan, Kostanay, Akmola, Pavlodar, West Kazakhstan, Aktope, and East Kazakhstan. This ambitious project is specifically designed to address the needs of under-enrolled small-class schools. It envisages the creation and deployment of a national educational platform equipped with high-quality digital content, AI-powered tutors capable of providing interactive support in multiple subjects (including foreign languages), and crucially important offline functionality that allows usage in areas with limited or unstable internet connectivity. The initiative forms part of the broader national push toward large-scale integration of artificial intelligence in education and aligns directly with presidential directives on reducing urban-rural educational disparities.

A highly encouraging regional precedent that demonstrates practical viability is the Aktobe region project titled "Enhancing Rural Schools with Digital Solutions". This initiative successfully covered 134 small rural schools (plus 12 supporting anchor schools) and was selected for inclusion in the prestigious HundrED Global Collection 2026. The project achieved measurable improvements in overall educational performance through the thoughtful combination of digital resource provision, systematic teacher professional development programs, and the introduction of contextually adapted blended and hybrid learning models tailored to rural realities.

Collectively, these state-level and regional developments open a genuine and timely window of opportunity for the systematic introduction and scaling of blended EFL teaching. The ongoing creation

of fully offline-compatible teaching materials, development of low-bandwidth mobile applications, and deployment of simple AI-assisted tools can dramatically decrease dependence on constant high-speed internet access. Furthermore, the deliberate development of culturally relevant and locally grounded EFL content — incorporating elements of Kazakh history, national traditions, literature, folklore, contemporary social realities, and everyday life — carries strong potential to significantly boost student intrinsic motivation, foster a sense of cultural ownership of the learning process, and strengthen the connection between English language acquisition and the wider goals of trilingual education policy in Kazakhstan.

Proposed Adapted Blended Model for EFL in Small-Class Rural Schools

The proposed adapted hybrid model for EFL instruction in small-class rural schools strategically combines a dominant offline component (approximately 60–70% of instructional time) focused on teacher-guided communicative activities, role-plays, discussions, and pronunciation work suitable for combined-grade classes, with a carefully calibrated supplementary digital/hybrid component (30–40%). The digital portion includes pre-recorded video and audio materials distributed through USB drives or low-bandwidth platforms, mobile applications optimized for vocabulary acquisition and listening comprehension, and asynchronous tasks delivered via accessible tools such as Telegram bots or basic AI chat-bots for additional speaking practice. Implementation of the station rotation structure enables efficient and differentiated organization of the learning process even in multi-age classrooms with limited resources. This model is deliberately designed to be realistic, cost-effective, and feasible within the existing infrastructural constraints of rural schools while remaining highly effective for the systematic development of communicative competence and support of trilingual education objectives.

Discussion

The detailed and multi-dimensional analysis presented in this review clearly demonstrates that, in the absence of targeted, context-sensitive, and well-coordinated adaptation to the specific infrastructural, personnel, methodological, and socio-cultural realities of small-class rural schools, any attempt to introduce blended learning risks not only failing to achieve desired outcomes but potentially exacerbating existing educational inequalities between urban and rural student populations. At the same time, the current convergence of several powerful enabling factors — most notably the upcoming pilot launch of the Qazaq Digital Mektebi project with its emphasis on AI tutors and offline functionality, the continued operation and expansion of established national platforms such as Bilimland and Online Mektep, and the documented success of pioneering regional initiatives such as the Aktobe project — creates a genuine, timely, and strategically important window of opportunity for meaningful and sustainable progress throughout 2026–2027 and subsequent years.

Comparative international experience drawn from other countries confronting analogous challenges in rural and remote education systems (including selected regions of Central Asia, parts of South-east Asia, and certain developing contexts in Latin America and Africa) strongly confirms that carefully designed hybrid models, which maintain a robust offline foundation while intelligently incorporating digital and AI-supported elements and culturally resonant content, can successfully narrow the digital divide, improve language learning outcomes, and enhance overall educational equity. In the Kazakhstani context, the ultimate success of blended EFL implementation will hinge on several critical and interdependent factors: the provision of continuous, high-quality, and practically oriented professional development programs for rural EFL teachers focused on digital literacy, AI tool usage, and blended methodology; the systematic and accelerated creation of high-quality localized teaching and learning materials that authentically reflect Kazakh cultural heritage and contemporary realities; and the establishment of coordinated support mechanisms involving the Ministry of Education, regional education departments, school administrations, and local communities. Only through such a holistic and systemic approach can blended learning fulfill its considerable potential to transform EFL education in small-class rural schools and contribute meaningfully to the realization of Kazakhstan's long-term trilingual education goals.

Conclusion

Blended learning possesses substantial long-term pedagogical, technological, and social potential for significantly elevating both the quality and the equitable accessibility of English as a foreign language teaching and learning in small-class rural schools throughout the Republic of Kazakhstan. Realizing this considerable potential, however, necessitates a deep, nuanced, and evidence-based understanding of the existing challenges, followed by the systematic, coordinated, and sustained addressing of the identified infrastructural-digital, personnel-related, methodological, and socio-cultural barriers.

The ongoing national digital transformation process, which has gained additional momentum through the pilot introduction of the Qazaq Digital Mektebi project in 2026 — with its explicit focus on artificial intelligence tutors, offline functionality, and targeted support for under-enrolled rural schools

— creates genuinely favourable structural and policy conditions for the gradual, thoughtful, and effective integration of blended learning methodologies into everyday EFL practice in rural educational settings. When appropriately customized, rigorously piloted, and continuously refined to align with the unique infrastructural, human, cultural, and linguistic circumstances of small-class rural schools, blended learning can evolve into a powerful transformative instrument. It holds the capacity to make a tangible and lasting contribution toward reducing persistent educational inequalities, enhancing the overall quality of language education, and advancing the strategic national objectives of trilingual education policy across the vast and diverse rural territories of Kazakhstan. The successful realization of this vision will require not only technological innovation and policy support but also sustained collaboration among researchers, practitioners, policymakers, and local communities committed to building a more equitable and future-oriented education system.

References

1. Abdezova, A. (2025). How can Kazakhstan overcome the educational divide between urban and rural schools? Central European University. https://www.etd.ceu.edu/2025/abdezova_aisha.pdf
2. Grankina, V. (2026). Digital transformation of the educational process in schools of Kazakhstan. *Frontiers in Education*. <https://doi.org/10.3389/feduc.2026.1766616>
3. HundrED. (2026). Enhancing rural schools with digital solutions (Aktobe region innovation). <https://hundred.org/en/innovations/enhancing-rural-schools-with-digital-solutions>
4. Kerimbayev, N., Akramova, A., & Suleimenova, J. (2016). E-learning for ungraded schools of Kazakhstan: Experience, implementation, and innovation. *Procedia - Social and Behavioral Sciences*, 197, 2165–2171.
5. Ministry of Education of the Republic of Kazakhstan. (2026). Press releases on Qazaq Digital Mektebi project. <https://www.gov.kz/memleket/entities/edu>
6. Nurgaliyeva, S. et al. (2024). COVID-19 online learning challenges: Kazakhstan. *Frontiers in Education*. <https://doi.org/10.3389/feduc.2024.1448594>
7. Sariyeva, A., Zholdubayeva, A., Kurmanaliyeva, A., & Gerfanova, E. (2026). Digital inequality and socio-cultural barriers in distance learning in Kazakhstan: Urban-rural perspectives. *Journal of Culture and Values in Education*, 9(1), 59–85. <https://doi.org/10.46303/jcve.2026.3>
8. Times of Central Asia. (2026, April 2). Kazakhstan to launch digital schools project. <https://timesca.com/kazakhstan-to-launch-digital-schools-project/>
9. Yelubayeva, P. (2025). Addressing language education challenges in Kazakhstan for sustainable development. *European Journal of Language Policy*. <https://doi.org/10.3828/ejlp.2025.5>
10. Peng, Z., & Raman, A. (2026). Systematic literature review on the effects of blended learning in EFL education. *Contemporary Educational Technology*, 18(1), ep631. <https://doi.org/10.30935/cedtech/17924>
11. Kikbanova, A. (2026). Pedagogical system for hybrid training of future specialists in Kazakhstan. De Gruyter Brill.
12. OECD. (2025). Education at a Glance – Kazakhstan country notes.
13. UNICEF Kazakhstan. (2025). Annual report on education access and equity in rural areas.
14. Informburo.kz. (2026, January). Announcements regarding the Qazaq Digital Mektebi pilot launch and AI integration in education.
15. Qazinform. (2026). Official reports on AI in education and rural school modernization.
16. Prime Minister of Kazakhstan. (2026). Statements on rural school development and digital transformation initiatives.
17. Imanova, D., Akzhigitova, A., & Zabrodskaja, A. (2025). Language-in-education policy for English language teaching in public schools of Kazakhstan. *Education Sciences*.
18. Central Asia Program. (2025). Inequality between students of rural and urban schools in Kazakhstan: Causes and ways to address it.
19. KazTEA Proceedings (2024–2025). Collections on innovative methods in EFL teaching in Kazakhstan.

GUIDING AND BINARY LECTURES OF THE LEARNING PROCESS TO A QUALITY EFFECT

Feyzullayeva Seadet Teyfuq
 Azerbaijan State Pedagogical University Sheki
 Branch (Azerbaijan)

İSTİQAMƏTLƏNDİRİCİ VƏ BİNAR MÜHAZİRƏLƏRİN TƏLİM PROSESİNİN KEYFİYYƏTİNƏ TƏSİRİ

Feyzullayeva Səadət Teyfuq
 Azərbaycan Dövlət Pedaqoji Universitetinin Şəki
 filialı, (Azərbaycan)

As much as possible, children should not be taught, but they should be taught to think more.
 Outstanding German teacher A. Disterveq

Abstract

Lectures continue to maintain their position as the primary organizational form of instruction and a leading teaching method in higher education institutions. In the modern era, where artificial intelligence is rapidly integrating into education, lectures do not lose their relevance; however, they face the necessity of renewal. In this regard, there is an increasing need to use diverse and innovative types of lectures in teaching various subjects and topics.

In this article, the author analyzes the objectives and functions of lectures, as well as the main criteria applied to them. In particular, the content and organizational principles of guiding and binary lectures are examined. Along with analyzing the advantages of these lecture types, the requirements for their organization are explained and illustrated with specific examples.

Xülasə.

Mühazirələr ali məktəblərdə təlimin başlıca təşkili forması və əsas təlim metodu kimi öz mövqeyini saxlamaqdadır. Süni intellektin təlimə sürətlə inteqrasiya etdiyi bir dövrdə ali məktəblərdə mühazirələr öz əhəmiyyətini saxlayır, lakin yenilənmə zərurəti ilə qarşılaşır. Belə ki, müxtəlif fənlərin və mövzuların tədrisində fərqli və innovativ mühazirə növlərindən istifadə ehtiyacı yaranır. Müəllif bu məqalədə mühazirələrin məqsəd, vəzifə və kriteriyalarını təhlil edir. İstiqamətləndirici və ikili (binary or dual) mühazirələrin məzmunu və təşkili qaydalarına toxunur. Bu mühazirə növlərinin üstünlüklərini təhlil etməklə bərabər, təşkilinə verilən tələbləri açır, nümunələrlə onları şərh edir. Müəllif mühazirələri mənşəyinə, təsir istiqamətinə, keçirilmə xüsusiyyətinə, təşkilati xüsusiyyətlərinə, formasına, məqsədinə, növlərinə, tədqiqatın aparılması yollarına və s. əlamətlərinə görə təsnif etmişdir.

Keywords: lecture, e-learning, goals, task, criterion, guiding lecture, dual(binary) lecture, developmental training

Açar sözlər: mühazirə, elektron təhsil, məqsəd, vəzifə, kriteriyalar, istiqamətləndirici mühazirə, ikili(dual və ya binar) mühazirə, inkişafetdirici təlim

Bacardıqca uşaqlara az öyrətməli, amma daha çox düşünməyi öyrətməli.

Böyük alman pedaqoqu A.Disterveq

Mühazirələrin ali məktəblərin "qaynar qazanı" adlandırılması heç də təsadüfi deyil. Mühazirələr üçün böyük həcmli materialın olması, fundamentallıq, məntiqi əlaqələrin mürəkkəbliyi, isbat və ümumiləşmə, əsaslandırılmış üfüqi və şaquli inteqrasiya, vəziyyətin elmi təhlili, nəzəri və praktikliyin inkişafı, öyrənilən fənnin tələbələrə gələcək peşəsində əsaslandırılmış rolunun yer alması səciyyəvidir. Müzakirələrin aparıldığı mühazirələrdə həqiqətlər tapılır, yaranan yeni suallar tələbələrə davamlı olaraq axtarırlarına sövq edir. Həllini gözləyən problemlər isə mühazirələrin məqsədlərini müəyyən etmiş olur:

- Fundamental və tədbiqi biliklər analiz edilərək təhlillərlə birlikdə tələbələrə ötürülür, istiqamətləndirilir;
- Şəxsiyyətin hərtərəfli və davamlı inkişafı həyata keçirilir, yeni münasibətlər, baxışlar yadılır;
- Şəxsiyyətin tərbiyəsi davamlı olaraq həyat keçirilir;

Mühazirələrin [7.s.147] üç əsas funksiyası var: öyrədici, inkişafetdirici, tərbiyəetdirici. Təlim prosesində gözlənilən nəticələrin yüksək səviyyədə qazanılması üçün üç məqsədin kompleks halında həyata keçirilməsi vacibdir. Elə ona görə məqsəd və vəzifə vahid təşkil edir. Vəzifələr məqsədə çatmaq üçün görülməli işlərin cəmidir.

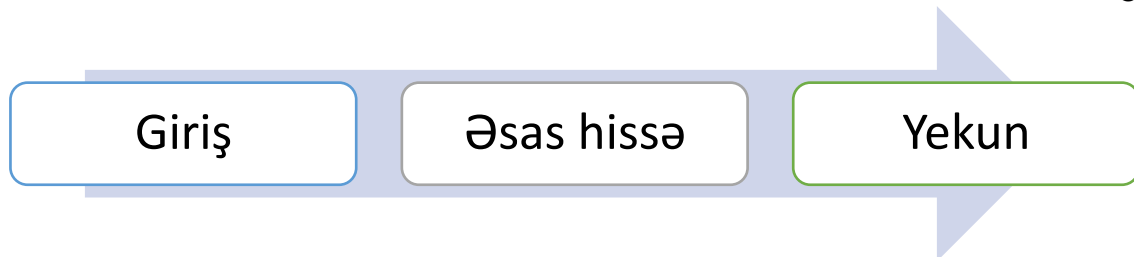
Vəzifələr məqsədin məzmununu, mahiyyətini dəqiq təsvir etməyə imkan verir. Mühazirə (F.N.İbrahimov) aşağıdakı **vəzifələri** daşıyır:

- **Informasiyalılıq**(dərslərdəki materialın, yeni informasiyaların, elmi biliklərin ötürülməsi);
- **Oreantasiyaedici**(elmə və gələcək peşəyə daxil olma(giriş), dərslərlə tanışlıq,davamlı işlənilməsi gərək olan nəzəri və tədbiqi problemlərin qoyuluşu);
- **Metodoloji**(elmin metodologiyası, tədqiqat metodları);
- **Maraqoyatma - stimulyasiyaedici**(fənnin müstəqil öyrənilməsinə,elmi –tədqiqat işlərinə ,özünütəhsilə, peşəkər yönə sözq etmə);
- **Tərbiyəedici**(lektorla ünsiyyət, diskussiya, qulaq asmaq mədəniyyəti, müxtəlif dəyərlərin dərk edilməsi və qəbul edilməsi, dünyagörüşünün formalaşdırılması);
- **Inkişafetdirici** (təfəkkür, diqqət, nitq, gələcək peşə ilə bağlı bacarıqların, analiz,sintez və s.qabiliyyətlərin inkişaf etdirilməsi);
- **Həyatla əlaqələndirmə**

Görkəmli psixoloq L.S.Viqotski yazırdı: "Təlimlə inkişafın qarşılıqlı mürəkkəb əlaqədə olmasına baxmayaraq təlim inkişafdan əvvəl başlayır, dərk etmə elmi anlayışın qarşısından keçir, anlayışlar dərk edildikcə şəxsiyyət inkişaf edir və tərbiyələnin".

Mühazirənin strukturu -giriş(problemin qoyuluşu),əsas hissə(problemin,sualın açılışı), yekun (nəticənin alınması)mərhələlərini özündə birləşdirir.

Sxem 1.



Sxem 1. Mühazirənin strukturu.

Mühazirələrin **növləri** müxtəlifdir və onlar mühazirənin məqsədi, mövzunun məzmunu, auditoriyanın psixoloji mühiti, öyrəncilərin sayı, müasir dövrün aktual çağırışları, texnologiyalarla təchiz olunma imkanları, auditoriyanın maraqlarına və s. görə seçilə bilər.Mühazirələri müxtəlif meyarlara görə təsnif edə bilərik.

Ümumi məqsədlərinə görə: öyrədici, tərbiyəedici, təşfiqat, təbliğat, inkişafetdirici[Şaripov F.V, Danilov A.İ., Artemova S.F., F.Rüstəmov, F.N.İbrahimov];

Didaktik vəzifələrinə görə: giriş, yeni bilik verən, təkrar, yekun-ümumiləşdirici şərh –mühazirə, tövsiyyə -mühazirə, mühazirə-vizuallaşdırma .

Tərbiyə prosesinə təsir istiqamətinə görə: şüura təsir edən, davranışa təsir edən və davranış stimula edən;

Keçirilmə xüsusiyyətinə görə: məlum ardıcıl mərhələləri və spontan ardıcılıqlı;

Təşkilati xüsusiyyətlərinə görə: lektor, öyrəncilərlə birlikdə(pedaqoq və tələbələr);

Formasına görə: kiçik və böyük qruplar, kollektiv;

Məzmununa görə: nəzəri bilik verən, bacarıq və vərdişlər formalaşdırıcı;

Təsirinə görə: emosional, dərk etmə, əqidə yaratma ;

Praktika ilə əlaqəsinə görə: nəzəri, praktik və nəzəri-praktik;

Təlim prosesindəki formasına görə: ənənəvi(klassik),fəal, interaktiv;

Formasına görə: ikili(binar və ya dualitik və ya mühazirə-diskussiya), mini, mətbuat-mühazirə, giriş mühazirə, şərh mühazirə,istiqamətləndirici, mühazirə-konfrans;

Tədqiqatın aparılması yollarına görə: induktiv, deduktiv,kombinə olunmuş

Aparılma formasına görə: canlı, onlayn və hibrid

Istiqamətlənmiş və ikili mühazirələr daha çox dioloji xarakter daşıyan və dioloji imkanları ilə seçilən mühazirə formalarıdır.

İstiqamətlənmiş mühazirələr. Dərsin əvvəlində müəllim mövzunu elan edir. Məsələn, mövzu "Ətraf mühit və sağlamlıq" adlanır. Sonra müəllim tələbələri qruplara ayırır və onlara təklif edir ki, mövzu üzrə bildiklərini yada salsınlar və siyahı hazırlasınlar. Bunun üçün ağ vərəqdə cədvəl çəkilir, vərəqin bir tərəfində "Ətraf mühit insan sağlamlığına necə təsir edir?", o biri tərəfində "İnsan ətraf mühitə necə təsir edir?" suallarını yazmaq lazımdır. Sualları belə də yazmaq olar: 1. Təbiət insana nə verir? Və İnsan təbiətə nə verir? Verilən vaxt ərzində qruplar bu suallarla əlaqədar fikir mübadiləsi edir və öz vərəqlərində qeydiyyat aparırlar.

Ətraf mühit insan sağlamlığına necə təsir edər bilər, hansı yeni biliklər əldə ediləcək?	Ətraf mühitə necə təsir edir?
1.	1.
2.	2.

Qruplarda iş bitdikdən sonra müəllim bütün siniflə müzakirə aparır, şagirdlərin fikirlərini ümumiləşdirir və lövhədəki cədvəldə qeyd edir. Tələbələrə bildirir ki, mühazirənin məzmunu ilə siyahını müzakirə edəcəklər, diqqətli olsunlar.

Müəllim mətnin I hissəsini 15-20 dəqiqə ərzində mühazirə edir. Yadda saxlamaq lazımdır ki, xüsusilə ixtiyari diqqətin vaxtı təqribən 15 dəq. dir. Mətnin çox olması diqqətin yayınmasına səbəb olur. Mühazirənin I hissəsi bitdikdən sonra müəllim tələbələrə xahiş edir ki, mövzu haqda öz fikirlərini indicə mühazirədə eşitdikləri informasiya ilə müqayisə edib qeydlərində düzəliş etsinlər və lövhədəki cədvəldə qruplar qeyd etdikdən sonra fikirlərini söyləsinlər. Yazdıqlarından hansı düz çıxdı, hansı səhvdir. Müəllim tələbələrə çatdırmalıdır ki, mühazirənin II hissəsində onları maraqlandıran, lakin I hissədə cavab tapmadıqları suallara rast gələcəklər.

Müəllim mühazirənin II hissəsini oxuyur. Mühazirə bitdikdən sonra o tələbələrə müraciət edir ki, yeni öyrəndiklərinizi cədvəldə qeyd edin [3, s.629].

Dərsin sonunda tələbələr 10-15 dəqiqəlik esse (sərbəst yazı) yazmaq tapşırılır. Yəni tələbələr yeni öyrəndikləri haqqında öz fikirlərini qısa şəkildə vərəqə qeyd edirlər. Əgər vaxt varsa, auditoriyada yazırlar, vaxt yoxdursa, evdə yazıb gətirirlər, müəllim yazıları yığır və onlarla tanış olur. Müəllim mütləq bu esselər haqqında öz fikrini bildirməlidir.

İkili mühazirələrin əsas xüsusiyyətləri :

- İkili mühazirələrdə öyrənmə materialı iki lektor tərəfindən çatdırılır;
- Müxtəlif baxışlar özündə birləşdirən mövzular üçün əlverişlidir;
- Hər lektor məzəni bir aspektdən izah edir, bi mövqeyi əsaslandırır;
- Lektorlar dialoji mədəniyyət nümayiş etdirməli və sonda problemin ortaq həllini göstərməlidirlər;

• Tələbəni diskussiya qanə etməsə, anlaşılmazlıqlar olsa sual verməyə imkan vardır ki, bu da onun sualın cavabındakı şəxsi mövqeyini tapmağa kömək edir;

İkili mühazirələrə binar və ya leksiya-diskussiyalar da deyilir. S.F.Artemova, L.A. Korolyovaya görə binar mühazirələr müxtəlif mövqeləri müdafiə edən iki pedaqoqun dialoqudur [1, s.5]. İkili mühazirələrdə üstün tərəflərdən biri də təlim prosesinin dioloq formasında qurulmasıdır. Bu isə fəal təlimin əsas xüsusiyyətlərindən biridir.

1980- ci illərdə Azərbaycan təhsilində bir yenilənmə prosesi baş verdi. Belə ki, təlim prosesində dialoqlara geniş yer verilməsi, sual-cavab metodundan geniş istifadə edilməsi, həmçinin təlim prosesində "Problem situasiya"ların yaradılması məsələləri meydana çıxdı. Buna "Fəal təlim" metodu deyə bilərik. 2000-ci ilin əvvəllərindən isə təhsilimizə interaktiv təlim metodu, interaktiv təlim forması daxil olmuşdur [4. S.247]. Professor F.N.İbrahimova görə problemli situasiyaların yaradılması mühazirələrin ilkin şərtlərindən biridir və müəllim sualvermə texnikalarından səmərəli istifadə edərək təfəkkür prosesini başlada, yönləndirə bilər. Məlum olduğu kimi fəal təlim təfəkkür prosesini stimullaşdırır, təfəkkürün fəallaşması isə sual vermə ilə başlayır [3.c.612].

Professor F.Rüstəmov binar mühazirələrin imkanlarını yüksək qiymətləndirir. Müəllif qeyd edir ki, belə mühazirələr iki müəllim və tələbə auditoriyası ilə birlikdə əməkdaşlıq şəraitində aparılır. Mühazirənin məzmunu dialoji ünsiyyət prosesində problem şəkilində şərh olunur [6.s.221]. Bütün texnoloji proses kimi ikili mühazirələr də üç mərhələdən ibarətdir: texnologiya hazırlıq, fəaliyyət prosesi və onun təhlili [6.c. 15].

İkili mühazirələrə verilən tələblər aşağıdakılardır:

- ✓ Müxtəlif baxışları özündə birləşdirən mövzuların olması;
- ✓ Mövzunun aktual və qoyulan problemin isbat olunması;
- ✓ Mövzunun qoyuluşunun problem səciyyəli olması;

- ✓ Müxtəlif mənbə və mövqelərin olması (yanaşma, təhlil, müdafiə etmə və s. imkanının olması);
- ✓ Dialoji mədəniyyət və problemi ortaq həll etmək qabiliyyəti;
- ✓ Lektorların cəld reaksiya vermə və impravizə etmə bacarığına malik olmaları;
- ✓ Lektorların kommunikasiya bacarıqlarının olması;
- ✓ Ekspert rolunda çıxış etmə bacarığı.

Mühazirənin digər təlim formalarından **üstünlüyü**:

- böyük həcmli materialın geniş auditoriyaya çatdırılması;
 - vaxta qənaət;
 - büdcəyə qənaət;
 - güclü təsir etmə - (lektorun canlı ünsiyyətin bütün üstünlüklərindən ən səmərəli formada istifadə etmək imkanı);
 - tələbənin fikrinin lektorun (daha doğrusu, öyrəniləcək materialın əsas fikri) fikri arxasınca apara bilməsi imkanı;
 - lektorun şəxsiyyətinin və peşəkarlığının üzə çıxması;
 - dialoji, dinləmə və mədəniyyəti, müqayisə etmə və öz fikrini müəyyən etmə bacarığının formalaşması;
 - mühazirə təfəkkürün bütün formalarının - məntiqi, tənqidi və yaradıcı inkişafı üçün əlverişlidir.
- İkili və istiqamətləndirici mühazirələr eyni zamanda onlayn formatda təşkil olunma üçün də əlverişlidir.

Mühazirənin bəlkə də ən çətin tərəfi ondadır ki, dərslər vaxtı auditoriyanın lektorun şəxsiyyətini tanıma imkanı digər təlim metodlarından çoxdur. Öz təcrübəmdən deyər bilərəm ki, mühazirə güzgü kimidir, müəllim özünü orada çox aydın görə bilir. Hər bir sahədə biliyin az olması, dərin və ya geniş olmaması, vizuallığın az olması, diqqətin düzgün paylanmaması, nitqindəki nöqsan və ya motivasiyanın zəifliyi tez özünü göstərir. Buraya fiziki hazırlığı da əlavə etsək yerinə düşər. **Ona görə lektor özünü davamlı tərbiyə və inkişaf etdirmək məcburiyyətində qalır.**

Mühazirənin müxtəlif növlərinin həyata keçirilməsi zamanı onlar üçün səciyyəvi olan çatışmazlıqları pedaqoqlar aradan götürməyə çalışmalıdırlar. Lektor öz fikrini monoloji nitq formasında tələbələrə passiv qəbul etməsinə imkan verməməlidir, nitqi emosional, aydın olmalı, **tədqiqatçılığa həvəsləndirmə** diqqət mərkəzində saxlanılmalıdır. Lektorun nitqi uzun monoloq formasında olmamalı və həmçinin diskussiyalara açıq şəraitin yaradılması imkanı diqqət mərkəzində saxlanılmalıdır. Mühazirələrin gedişi zamanı qeydlər aparmaq olar [5, s. 156.] Hazırda audio və video materiallardan, müxtəlif platformalardan istifadə ilə daha səmərəli mühazirələr qurmaq imkanları genişlənib.

Bir maraqlı məqam ondan ibarətdir ki, əsas faktların **hadisələrlə verilməsi** vacib məqamları yadda qalan edir. Lektor müxtəlif mənbələrdən danışacaq hadisələri götürə bilər: elmi nəşrlərdən, tarixdən, şəxsi təcrübəmizdən, müqəddəs kitablardan, fantaziyamıza əsasən.

Dini kitablarda veriləcək əsas fikrin ruhanilər, müqəddəs sayılan insanlar tərəfindən hekayə şəkilində insanlara çatdırılması təsadüfi deyil. Bütün dini kitablarda kamilliyin şərtlərində 3 amil var: elm, allaha inam, ağıl (Əbu Turxan). Bunlar da insanların fiziki, əqli və ruhi sağlamlığına imkan verir, onu daima təkmilləşdirir. Mühazirələrdə də lektor bilik vermək, şəxsiyyət formalaşdırmaq və tərbiyə etmək məqsədləri daşıyır.

Bəzi müəlliflərin əksinə olaraq F.N.İbrahimov hesab edir ki, mühazirənin mühüm yerlərinin tələbələrə qeydə alması onları diqqətli olmağa alışıdır. Mühazirədə məntiqi yadda saxlama tərzləri, isbatlar, faktların qruplaşdırılması, sistemə salınması, ümumiləşdirilməsi, müqayisələr üstünlük təşkil edir. Buna görə də mühazirə zamanı tələbələrə anlama dərəcəsini yoxlamaq məqsədi ilə suallarla onlara müraciət edilməsinə səmərəli üsul kimi baxmaq lazımdır.

Məlum olduğu kimi biliyin əsaslı mənimsənilməsinə və möhkəm yadda qalmasına kömək edən metodlardan biri də **təkrardır**. İcra etdiyi konkret didaktik vəzifəyə görə təkrarı üç əsas növə ayırmaq olar: yeni mövzunun mənimsənilməsinə xidmət edən təkrar, unutmanın qarşısını alan təkrar, ümumiləşdirici və sistemləşdirici təkrar.

Mühazirə aparan pedaqoq:

- Fakt və hadisələr arasındakı məntiqi əlaqələri müəyyən etməli;
- Nəzəriyyələri, fərziyyələrin, mühakimələrin köməyi ilə faktları sistemləşdirməli;
- Tədqiqatın nəticələrini müzakirəyə verməlidir.

Mühazirə aparan pedaqoqlara verilən tələblər müxtəlif müəlliflər tərəfindən qeyd olunub və əksəriyyəti üst-üstə düşür. Məsələn: fakt və hadisələrin məntiqi ardıcılığı tələbi Danilov A.İ. tərəfindən belə ifadə olunmuşdur: material struktura malik olmalı, məntiqi əlaqəyə əsaslanmalı və auditoriya üçün

anlaşılan olmalıdır[2, 23].

İstiqamətləndirici, ikili və digər növ mühazirələrin aşağıdakı hallarda təşkili tövsiyə olunur:

- Yeni təlim proqramında verilən təlim materialı dərslərdə olmadıqda;
- Dərslərdə öyrənilməsi çətinlik törədən mövzuların tədrisində;
- Kursun əsas problemləri ətrafında ziddiyyətli konsepsiyalar olduqda;
- Öyrənməyə motivasiyanın artırılması, peşəkar təfəkkür, dünyagörüşü formalaşdırmaq lazım gəldikdə, lektorun şəxsi emosionallığı və canlı şərhə ehtiyacı lazımdır;

■ Müasir texnologiyalarla mühazirənin vərəq və ya elektron formasını əldə etmək asandır. Belə olduqda mühazirə passiv formadan çıxır və fəal formaya keçərək problemlə – tədqiqat xarakteri daşmağa başlayır. Əvvəlcədən tələbələrə elektron və ya vərəq forması çatdırılır, onunla tanış olmaq tapşırıqlar və təlim prosesində problemlər həll olunur.

■ Tələbələr və işi çox sevən halda mühazirə təşkil etmək olar. Bu incəsənət kimidir. Sevməsən və qabiliyyətlər olmasa hər iki tərəf üçün uzun və üzücü prosesə çevriləcək.

Sonuncu fikrin üstündə qısaca dayanmaq istəyirəm. Hər şey paylaşanda azalır, təkcə bilik və sevgidən başqa. Bilik və sevgi paylaşıqca çoxalır. Bu baxımdan mühazirə ideal formadır. Verdiyən sevgi nə vaxsa mütləq özünə qaydır. Lektorun hər şeyi olub, üzündə təbəssümü və hərəkətlərində səmimiyyəti yoxdursa, demək onun heç nəyi yoxdur. Bu tələbələrin motivasiyası üçün vacibdir. Ancaq unutmayın ki, görüntü xarici amil olsa da kökü daxildir. Bilik, mədəniyyət, səmimiyyət, niyyət kimi keyfiyyətlər olmasa müsbət təsir bağışlamaz mümkünsüzdür. Qısa müddət təəssürat müsbət ola bilər. Necə deyirlər, su durulanda dibi aydın görünür. Əmin olun ki, "suyun durulması" üçün auditoriyanın kifayət qədər vaxtı var. Bu məqamda fəlsəfədə cavab axtarılan çox məşhur bir sualı xatırladım: söz əvvəl yaranıb, yoxsa materiya? Daha çox tədqiqatçı söz əvvəl yaranması fikrini dəstəkləyir. Ancaq mən elə düşünürəm ki, sevgi əvvəl yaranıb və bu sevgi sözün yaranmasına zəmin yaradıb. Deməli, lektor yaxşı alim, müəllim yox, həm də şəxsiyyət olmalıdır. **Qısa desək, mühazirə peşəkarların işidir.** Fikrimi M.C.Ruminin sözləri ilə aydınlıq gətirmək istəyirəm: "Nə olursansa ol, göründüyün qədər sən. Necə görünürsən görün, qarşıdakı sənə gördüyün qədər sən".

Məşhur Roma alimi M.F.Kvintilian öz pedaqoji təcrübəsini və müəllimin tərbiyə işində yerini nəzəri cəhətdən ümumiləşdirməyə çalışmışdır. O «natiqin tərbiyəsi haqqında» əsərində yazmışdır ki, müəllim yalnız yüksək təhsilli, bilikli olmaqla bərabər, uşaqları sevən və onları başa düşən bir adam olmalıdır.

Mühazirənin **keyfiyyətinin qiymətləndirilməsi standartları** müxtəlifdir. Mühazirənin keyfiyyətinin təhlili qiymətləndirməyə imkan yaradır. Buraya mühazirənin məzmununu, oxu metodikası, mühazirənin təşkili, mühazirə zamanı tələbələrlə işin nəzarətdə saxlanması, təlim prosesinin idarə olunması, müəllimin natiqlik qabiliyyəti, mühazirənin nə dərəcədə nəticəliliyinin olması kimi vacib amillərin analizi aiddir. Bu standartlar binar mühazirələr üçün də əsas götürülür. Əlavə olaraq dioloji mədəniyyət, diskussiya qabiliyyəti, bilikləri integrasiya edərək nəticə çıxartmaq bacarığı bu mühazirə forması üçün daha da vacibdir(cədvəl 1).

Cədvəl 1

Binar mühazirələrin standartları	
1	Mühazirənin oxu standartı
2	Mühazirə məzmununun standartı
3	Təşkilatçılıq standartı
4	Tələbələrlə işə rəhbərlik standartı
5	Natiqlik standartı
6	Nəticəlilik standartı
7	Yüksək dioloji təlim standartı
8	Bilikləri integrasiya edərək ümumiləşmə etmə(vahid tablo, trans integrasiya) standartı

Cədvəl 1. Binar mühazirə standartları

Son illər elektron təhsil sahəsində yaranan çatışmazlıqları da fərqli, daha mütəşəkkil yanaşmalarla aradan götürmək mümkündür. Heç kimə sirr deyil ki, zümrə nəslinin nümayəndələri daha çox elektron vasitələrdən istifadə edir. Bu yaxşıdır. Ancaq elektron təhsildə internet resurslarından nəzarətsiz istifadə zamanı bəzi arzuolunmaz hallarla rastlaşırıq. İnernetdən qısa məlumatların tez və asanlıqla əldə olunması elmlə fundamental məşğul olan beyin sahələrinin ləngiməsinə, ümumiləşməyə cavab verən sahələrin isə inkişafına səbəb olur. Bu uzun müddət davam etdikdə beyinin bu sahələrinin tənbelləşməsi baş verir. Neyrobioloq Cared Xorvat[9] öz tədqiqatları nəticəsində belə qənaətə gəlib ki, zümrə nəslinin daha çox internet resurslarından, elektron mətnlərdən istifadəsi, əsas hissələrin əl ilə yazılmaması biliyin uzunmüddətli yadaşa keçməsinə tormozlandırır. Bu fikir birmənalı qarşılanmasa da

geniş əks səda doğurdu. Eyni zamanda parlaq effektiv təqdimatlar asan və qısa müddətli dopomin istehsalını aktivləşdirir. Deməli, mühazirənin müəyyən hissələrinin yazılması **beyində yeni neyron əlaqələri yaradır** ki, bu da biliyin uzunmüddətli yaddaşa ötürülməsini təmin edir. Oxuyub, anlamaq, əl ilə yazmaq, təqdimat, nəticələrin çıxarılması ilə aparılan öyrənmə prosesində bilik kefiyyətli və uzun ömürlü olur. Digər tərəfdən **dopomin yeni öyrənməyə** sövq edir.

Deməli, elektron təhsil prosesində də inkişafetirici təlim prinsiplərinə əməl edərək təşkil olunmuş mühazirələrin yeri böyükdür. Hər işi internetlə görmək insanın təfəkkür prosesinin inkişafına mane olur. Lazım gəldikdə mühazirələrdə yazı ilə qeyd alma, mətlər üzərində iş kimi metodlardan da istifadə etmək ləzimdır. İstiqamətlənmiş mühazirə, ikili mühazirə və s. kimi mühazirə növlərində yuxarıda deyilənlər üçün daha geniş imkanlar var. Nəticə olaraq onu deyə bilərik ki, 1-elektron təhsildə (o cümlədən fəal mühazirələrdə) kitab və dəftərdən tam imtina yeni neyron əlaqələrinin yaranmasını ləngidir, təfəkkürün inkişafına mane olur, b – uzunmüddətli yaddaş atəfiya olur, çünki beyinin hazır məlumat alma imkanı olur, 3- dərin bilik yaradan mətinlərə diqqətin toplanması çətinləşir. Deməli, elektron resurların insanı inkişaf etdirməsinə şərait yaratmaq lazımdır, onu sadələşdirərək inkişafdan qalmasına deyil. Mühazirə üçün informasiyanın axtarılması, əlçatanlığı, mobilliyi üçün elektron resursların geniş imkanlarından lektor səmərəli istifadə edərək təlim prosesinin keyfiyyətini yüksəldə bilər.

Nəticə. Nəticə olaraq onu deyə bilərik ki, istiqamətlənmiş və ikili mühazirələr təlimin keyfiyyətinin yüksəldilməsi baxımından geniş imkanlara malikdir. Pedaqoqlar tərəfindən mühazirələrə verilən standartlara və inkişafetirici təlimin prinsiplərinə əsaslanaraq qurulan mühazirələr təlim prosesinin nəticəsinin yüksəlməsinə səbəb olur. Belə mühazirələrdə elektron resurslardan səmərəli istifadə edilməsi təlimin keyfiyyətinə müsbət təsir edir.

Müasir mühazirələrin təşkilində fəal təlimin prinsipləri, o cümlədən inkişafetirici prinsip əsas götürülməlidir. Eyni zamanda fəal təlimə cəlb olunan tələbələr öyrəndiklərini öz məqsədlərinə çatmaq üçün istifadə edə biləcəklər [Z.Veysova, 2009, s.6]. Müasir mühazirələr interaktiv olmalı və C.Dyu, L.C.Viqotski, Z.Veysova, F.N.İbrahimov, M.M.Mehdizadənin (1982), H.Əhmədov, Y.Kərimov, F.Rüstəmovun dediyi kimi öz ardınca inkişafı aparmalıdır.

Referenes

1. Artemova S.F., Korolyeva L.A. (2017). Psychological and pedagogical foundations of the professional activity of a teacher-researcher: methodological manual for lecture classes. /– Penza: PGUAS, – 18 p.
2. Danilov A.I. (2015). Requirements for lectures, seminars and practical classes.
3. İbrahimov F.N., Huseynzadə R.L. (2013). Pedagogy. Volume I. Baku: "Mutarcim". 708 p.
4. Huseynzadə R.L., Z.M. Azizova, S.H. Aliyev, U.M. Verdiyeva. (2021). -Pedagogy. Textbook. -Baku: Mutarcim, 488 p.
5. Mehdizadə M.M. (1982). Ways to improve the educational process in secondary schools. Baku: Maarif,.
6. Rustamov F.A. Dadashova T.Y. (2001). Higher school pedagogy. Textbook for higher school master's degree. Baku: "Nurlan", 568 p.
7. Sharipov F.V. (2012). Pedagogy and psychology of higher schools. – M.: Logos, – 448 p.
8. Veysova Z.A. (2009). Active (Interactive) learning. Tools for teachers. UNİCEF, 156 p.
9. <https://www.instagram.com/reel/DUtiJxDUwO/>

UDC 37.091.33:81'243

HELP OF AI-TOOLS IN WRITING ENGLISH AS A FOREIGN LANGUAGE**Kozhakul Nursat**Scientific Supervisor: **Duisenova M.M.**

PhD, Senior Lecturer

Uzbekali Zhanibekov South Kazakhstan Pedagogical University

Shymkent, Kazakhstan

Abstract

Artificial intelligence (AI) offers new possibilities for enhancing English language learning, particularly in writing. However, there is still limited understanding of how K–12 students use AI writing tools and how they perceive their effectiveness. This study addresses that gap by employing a mixed-methods design: 69 students completed a questionnaire, and 35 of them took part in semi-structured interviews. The results show that students are generally familiar with widely used tools such as Grammarly, ChatGPT, and Google Translate, while their awareness of other AI writing tools remains limited. From a sociocultural standpoint, these tools play a mediating role throughout different stages of the writing process, offering support that helps students generate ideas, expand their vocabulary, and improve textual accuracy. At the same time, although students recognize the advantages of AI writing tools, they express concerns about how relying on them might affect the development of their independent writing abilities in the long term. Based on these findings, the study suggests practical ways for secondary school teachers to effectively incorporate AI writing tools into traditional writing instruction.

Keywords: Artificial intelligence (AI), K12 education, English as a Foreign Language (EFL), writing skills, Sociocultural theory (SCT)

Introduction

The release and launch of different types of AI apps such as GPT has forced teachers and students around the globe to deal with the consequences of artificial intelligence for education. AI writing tools such as GPT pose distinct challenges for second language teachers. To respond to this, a five-part pedagogical framework is suggested: understand, access, prompt, corroborate, and incorporate. This framework aims to help learners use AI effectively while equipping them for the evolving technological environment beyond the classroom.

The emergence and rapid spread of GPT have compelled both teachers and researchers to confront the impact of artificial intelligence on education. Responses have varied widely, from enthusiasm about its potential to concern about its implications, particularly for writing instruction. For second language educators AI writing tools present specific challenges, as their ability to facilitate communication across languages regardless of a users proficiency may limit learners chances to develop essential language skills. (Greene, 2022; Roose, 2023) (Herman, 2022; Weissman, 2023)

These fears are reasonable and unavoidable; as with any technological innovation, there are numerous important factors involved in implementing new technologies that must be considered to best support student learning. From a teaching standpoint, AI generated writing can seem like an easy shortcut, allowing learners to produce native-like texts on any topic without having the necessary knowledge or language skills. From an ethical perspective, such tools can further obscure the boundary between acceptable use of learning support and academic dishonesty is problem that is already challenging for many second language learners. Given these concerns, it is not surprising that educators may feel a struggling to introduce AI-based tools in their classrooms. Although banning GPT and the same AI tools from education might seem like a simple solution, it is ultimately unrealistic. These technologies are already widespread and will remain present both inside and outside the classroom for the expected future. Their integration into platforms like Microsofts Bing, the release of advanced models such as GPT-4, and the development of comparable tools by companies like Apple and Google all indicate that AI-generated writing is not temporary but will continue to be widely available.

Literature review

In recent years, the rise of AI-powered writing tools—such as automated feedback systems, corpus-based resources, machine translation, and chatbots—has significantly reshaped the teaching of writing, shifting it from traditional practices toward more modern, technology- integrated approaches (Godwin-Jones, 2022). These tools function as mediators in the learning process by providing scaffolding through

contextual feedback, explanations, and error correction. Moreover, AI supports learners in operating within their Zone of Proximal Development (ZPD) by offering assistance that slightly exceeds their current abilities without overwhelming them. While Vygotsky (1978) emphasized the importance of social interaction with teachers and peers, AI tools extend this concept by enabling a form of "individualized interaction," where learners can practice and receive immediate feedback independently (Song & Song, 2023). This type of AI-mediated support also encourages the development of critical thinking and autonomous reasoning skills, which are essential for effective and independent writing (Darwin et al., 2024). Challenges and ethical concerns with AI writing tools

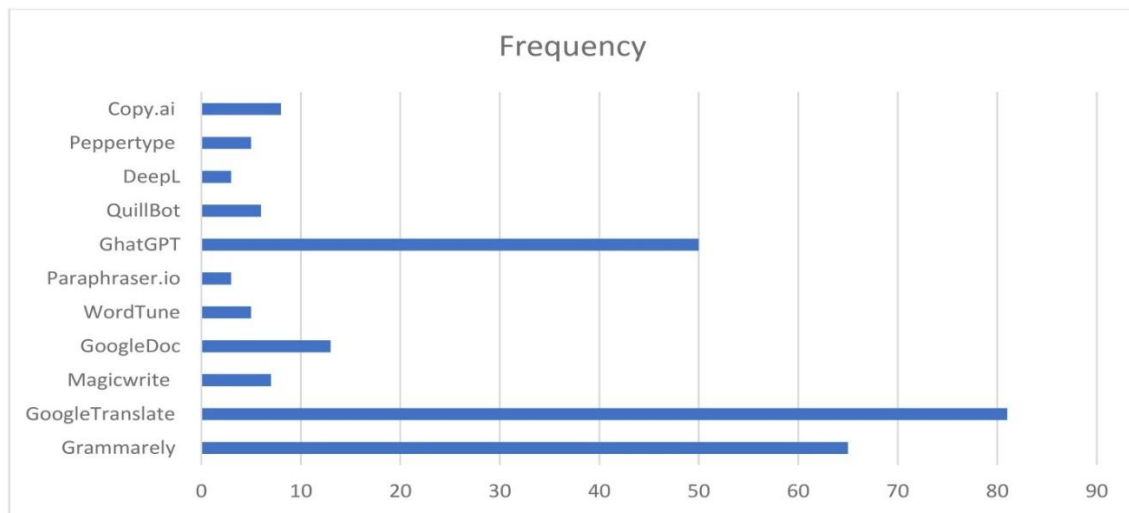
As AI writing tools become increasingly embedded in language learning environments, they also raise a number of challenges and ethical concerns that require careful attention (Crompton et al., 2024). One major issue is the risk of technical inaccuracies, as AI systems may generate incorrect or misleading information. Another limitation lies in their reliance on statistical language models, which can restrict their ability to fully grasp pragmatic and contextual aspects of language use (Godwin-Jones, 2024). As a result, AI may function as a culturally and linguistically limited partner, potentially leading to miscommunication or misunderstanding.

In addition, concerns about privacy persist, as both educators and students may be hesitant to share personal data with AI systems, while others worry that interaction with AI could reduce exposure to authentic emotional communication (Crompton et al., 2024). Finally, there is the risk that excessive dependence on AI tools may weaken students' capacity for critical thinking and creative expression, particularly if they rely on these technologies without active engagement in the learning process. Additional ethical issues relate to authorship, academic integrity, and plagiarism (Aljabret al., 2024; Al-Zhrani, 2024; Creely, 2024). The use of AI tools complicates the notion of authentic authorship, as it becomes increasingly difficult to determine whether a text is produced by a human or generated by AI. This ambiguity raises concerns about proper attribution and ownership of written work. Furthermore, excessive reliance on AI in academic contexts may undermine academic integrity, as students might submit AI-generated content that does not accurately reflect their own abilities. There is also the risk of "artificial plagiarism," where learners use AI-generated ideas or text without appropriate acknowledgment. The preceding discussion reviewed existing empirical studies on the effectiveness of AI writing tools in enhancing learners' writing skills. On the one hand, these tools offer clear advantages, such as providing immediate feedback, improving writing fluency, and assisting with grammar and spelling. On the other hand, several limitations have been identified, including the potential for overdependence, inaccuracies in AI-generated suggestions, and possible declines in critical thinking and creativity. Despite these concerns, the benefits of AI tools in second language writing may outweigh the drawbacks, particularly when they are used responsibly and in a balanced manner.

Methodology

This study was carried out in South Kazakhstan Pedagogical University during the second semester of 2025-2026 academic year. A total of 24 students aged between 18-19 all native Kazakh speakers participated in the research. These participants were selected using convenience sampling, as they were readily accessible and willing to take part. This approach was chosen because it is cost-effective and allows for quick data collection, which was important given the time limitations of the study (Creswell, 2009). Nonetheless, convenience sampling has notable drawbacks. Since participants are not randomly selected, the findings cannot be easily generalized to a wider population, which affects the external validity of the study. Additionally, this method may result in a sample that lacks sufficient diversity in terms of demographic factors such as age, gender, socioeconomic background, ethnicity, or geographic location.

The participants in this study were all female with zero males.(N=24). Most of the study samples were aware of AI-writing tools and their usage in academic writing (90%)(N=22).



Procedure, instruments, and analysis

Prior to the start of the study, participants were provided with a clear explanation of the research objectives, procedures, and any potential risks and benefits associated with their involvement. They were given a written informed consent form to complete and were informed that they could withdraw from the study at any point without any consequences. Participation was entirely voluntary, and all students submitted their written consent before the study began.

Data were collected through an online questionnaire distributed via Google Forms, with each student allowed to submit only one response. The students were asked to read these transcripts carefully, and to edit or remove text from their interview transcript, as appropriate. The majority of participants (N=20) responded, reviewed, and confirmed the transcripts, in order to guarantee their trustworthiness.

A descriptive quantitative approach was used to analyze the survey data, while thematic analysis was applied to the open-ended survey responses and semi-structured interview data (Braun & Clarke, 2006). The analysis followed an inductive, data-driven process. Initially, the researcher became familiar with the data through careful reading and repeated review to understand the overall content. All interview transcripts were examined multiple times to gain a comprehensive view of students' perceptions. Next, initial open codes were generated inductively, such as revising vocabulary, identifying synonyms, and paraphrasing. This stage involved labeling meaningful segments of the data with codes that captured their core ideas.

These codes were then refined and organized into broader themes through constant comparison, combining related codes into overarching categories like "vocabulary enrichment" and "content generation." NVivo 12 software was used to support and systematize the coding process.

Findings

The quantitative data collected from 24 students were analyzed using descriptive statistics, including mean scores and standard deviations. The results provide insights into students' perceptions of using AI tools (e.g., ChatGPT) to improve their English writing skills. Overall, the findings indicate that students had a positive attitude toward the use of AI in writing. Most participants agreed that AI tools helped them enhance their vocabulary, improve sentence structure, and generate ideas for writing tasks. The relatively moderate standard deviation values suggest that students' responses were fairly consistent, with no extreme variation. The highest mean score was observed for the statement related to vocabulary improvement, indicating that students found AI particularly useful for learning new words and expressions. Similarly, content generation and paraphrasing were also rated highly. In contrast, slightly lower mean scores were recorded for statements related to over-reliance on AI, suggesting some awareness among students about potential drawbacks.

NO	Statement	Mean	Std.deviation
1	AI tools help me to improve my vocabulary	4.45	0.58
2	AI helps me generate ideas for writing	4.30	0.62
3	AI improves my grammar and sentence structure	4.25	0.65
4	AI helps me in paraphrasing	4.40	0.60
5	Using AI makes writing easier	4.35	0.59
6	I feel more confident in writing when using AI	4.10	0.70
7	AI saves time during writing tasks	3.20	0.80

Similarly, participant S15 reported using ChatGPT during the pre-writing stage to generate ideas, stating that she consulted it for topic-related information before outlining and organizing her essay (Table 1). Other students highlighted their use of Google Translate to improve lexical choices during the writing process. For example, S8 explained that she previously struggled to find synonyms for frequently repeated words, but Google Translate helped her identify alternative vocabulary, thereby enhancing the quality of her writing. Likewise, S18 noted that she relied on Google Translate to check word meanings and ensure clarity, mentioning that she used it both to understand unfamiliar vocabulary and to verify whether her sentences made sense. Additionally, students valued the interactive and responsive features of tools such as ChatGPT and Grammarly, describing them as a form of continuous virtual support. As S22 expressed, engaging with these tools during writing tasks felt like having a personal tutor, helping her identify grammatical errors and offering improved vocabulary suggestions.

At the post-writing stage, most students reported using Grammarly to review and correct their grammatical errors. As S12 noted, she relied on Grammarly to check her final draft, emphasizing that it helped make her writing more polished and professional. Similarly, S9 described using Grammarly as a final step to refine the text and identify any remaining mistakes.

Overall, these responses indicate that students actively incorporated AI writing tools across different stages of the writing process to enhance content development and produce more accurate, error-free texts.

The impact of AI tool usage on students' academic writing skills

This section presents the findings on participants' perceptions of the impact of AI writing tools on their writing development, with particular attention to text accuracy, self-editing skills, academic integrity, content organization, and vocabulary repertoire. The analysis of the questionnaire provided important insights into students' views on how AI-powered tools contribute to their academic writing skills. The students' responses to items 4, 5, and 6 revealed more negative or cautious perceptions, highlighting the complex and multifaceted nature of their attitudes toward AI use. Overall, the findings indicate both areas of agreement and variation in opinion, suggesting that students hold nuanced views regarding the role of AI writing tools in supporting and shaping their writing development.

NO	statement	mean	Std.deviation
1	AI tools improved my overall writing ability	4.42	0.58
2	AI helped me generate better ideas for writing tasks	4.38	0.60
3	AI improved my vocabulary use	4.50	0.55
4	AI helped me reduce grammatical errors in my writing	4.45	0.57
5	AI improved the structure and organization of my essays	4.30	0.63
6	AI helped me write faster and more efficiently	4.40	0.59
7	AI increased my confidence in writing	4.25	0.56

The results show that students generally perceived AI writing tools as highly beneficial for improving their writing abilities (Table 2). The highest mean score was recorded for vocabulary development, indicating that AI tools were particularly effective in enhancing lexical

use. Students also reported improvements in grammar, idea generation, and writing efficiency. However, the relatively lower mean for over-reliance suggests that while students recognize the benefits of AI, some awareness of dependency issues also exists.

Discussion

The results of this study support recent research showing that AI writing tools are changing the way students approach and complete writing tasks (Warschauer & Xu, 2024). The study found that participants were mainly familiar with only a few tools, such as Google Translate, Grammarly, and ChatGPT. Their limited awareness of other AI tools may be explained by factors like usefulness, accessibility, and ease of use, as well as the fact that different tools are designed for specific writing purposes. Students likely prefer tools like ChatGPT, Google Translate, and Grammarly because they are simple to use, easy to access, and meet their current writing needs. Another reason for their limited familiarity with other tools could be concerns about using AI in academic work. Issues such as plagiarism, cheating, and misuse of AI tools may make students less willing to explore new platforms (Fryer et al., 2020).

The results of this study partly challenged Sociocultural Theory (SCT), which suggests that learning first happens through social interaction and then becomes internalized by the individual. In this case, the findings showed that too much reliance on AI tools might weaken students' self-regulation and reduce deep thinking. Many participants were unsure about how AI would affect their writing skills in the long term and were worried about issues like academic integrity. Similar concerns have been reported in other studies (Chen et al., 2020; Darwin et al., 2024; Fredholm, 2019; Lee et al., 2023). Students especially questioned whether AI tools really help them develop independent writing skills. While they recognized

the short-term benefits, such as improving their writing quickly, they were not confident about the long-term effects.

This supports Fredholm's (2019) findings. They also understood that AI tools should only be used as support, not as a replacement. Overusing them, they believed, could reduce their critical thinking and writing abilities. This idea is connected to "cognitive offloading" (Darwin et al., 2024), which means relying too much on technology can weaken thinking skills.

From a sociocultural perspective, the study showed that AI tools play a supportive role in the writing process by helping students work within their Zone of Proximal Development (Vygotsky, 1978). The participants were familiar with tools such as ChatGPT, Google Translate, and Grammarly, and used them at different stages of writing—for example, to generate ideas, check accuracy, expand vocabulary, and receive guidance. However, students mainly viewed these tools as useful for short-term improvements rather than for developing long-term writing skills. At the same time, they expressed concerns about overreliance on AI and related ethical issues. This suggests the importance of maintaining a balanced approach, where AI tools are used alongside traditional writing practices rather than replacing them.

Conclusion

While the findings of this study are valuable, several limitations should be noted. First, the small sample size ($N = 24$) limits how widely the results can be applied. A larger group of participants would provide more reliable results and improve the generalizability of the findings.

Second, the study relied on questionnaire data, which means the responses were self-reported. As a result, some participants may have answered in ways they thought were expected rather than reflecting their true opinions. Future research should combine questionnaires with semi-structured interviews and classroom observations to better understand how students actually use AI tools in writing. Third, the study did not include pre- and post-tests, so it could not measure the long-term effects of AI tools on writing skills. Future studies should use longitudinal designs with pre- and post-testing to explore these long-term impacts. Despite these limitations, the study highlights the important role of AI writing tools in supporting secondary school students' writing. The findings suggest that integrating AI tools into education is not only useful but increasingly necessary. For teachers and policymakers, this means providing proper training on how to use these tools effectively in the classroom. For example, teachers can combine traditional feedback with tools like Grammarly to give more detailed and timely responses to students' writing. AI tools can also support vocabulary development and help teachers identify common errors, making instruction more targeted and efficient.

The study also showed that students are familiar with only a limited number of AI tools. This indicates a need for training sessions that introduce a wider range of tools designed for different aspects of writing. During such training, teachers should also discuss ethical use and academic integrity. At the same time, it is important to avoid overreliance on AI, as this may reduce students' independence and motivation. A balanced approach is essential, where AI is used strategically alongside traditional writing practices. For instance, students can use AI tools at specific stages of writing, such as brainstorming or editing. Teachers can also encourage critical thinking by asking students to evaluate AI-generated texts, identify errors, and reflect on content quality. Additionally, AI can be used to support peer review and self-editing, promoting a more student-centered learning process.

Overall, although AI tools are effective in helping students identify and correct errors, they cannot replace the role of teachers. Human guidance remains essential for developing strong writing and critical thinking skills. Therefore, the most effective approach is one that combines the strengths of both AI tools and traditional teaching methods.

References

1. Greene, P. (2022). No, ChatGPT is not the end of high school English. But here's the useful tool it offers teachers. *Forbes*. <https://www.forbes.com/sites/petergreene/2022/12/11/no-chatgpt-is-not-the-end-of-high-school-english-but-heres-the-useful-tool-it-offers-teachers/?sh=14fbba314379> Search in Google Scholar
2. Herman, D. (2022). The end of high-school English. *The Atlantic*. <https://www.theatlantic.com/technology/archive/2022/12/openai-chatgpt-writing-high-school-english-essay/672412/> Search in Google Scholar
3. Weissman, J. (2023). ChatGPT is a plague upon education. *Inside Higher Ed*. <https://www.insidehighered.com/views/2023/02/09/chatgpt-plague-upon-education-opinion> Search in Google Scholar

4. Roose, K. (2023). Don't ban ChatGPT in schools. Teach with it. The New York Times. <https://www.nytimes.com/2023/01/12/technology/chatgpt-schools-teachers.html> [Search in Google Scholar](#)
5. Abu Ghali, M. J., Abu Ayyad, A., Abu-Naser, S. S., & Abu Laban, M. (2018). An intelligent tutoring system for teaching English grammar. *International journal of academic engineering research*, 2(2), 1–6.
6. Alenezi, W. (2024). Potentiality and apprehensions of artificial intelligence in education: Perspectives of education staff. *International Journal of Education in Mathematics, Science and Technology*, 12(4), 942–956. <https://doi.org/10.46328/ijemst.4177>
7. Zhao, X., Sbaffi, L., & Cox, A. (2023). The digitization of writing in higher Education: Exploring the use of Wordtune as an AI writing assistant. Center for Open Science.
8. Zhang, Z., & Hyland, K. (2018). Student engagement with teacher and automated feedback on L2 writing. *Assessing Writing*, 36, 90–102. <https://doi.org/10.1016/j.asw.2018.02.004>
9. Yan, D. (2023). Impact of ChatGPT on learners in a L2 writing practicum: An exploratory investigation. *Education and Information Technologies*, 28(11), 13943–13967. <https://doi.org/10.1007/s10639-023-11742-4>
10. Warschauer, M., & Xu, Y. (2024). Generative AI for language learning: Entering a new era. *Language Learning & Technology*, 28(2), 1–4. <https://hdl.handle.net/10125/73569>
11. Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.
12. Tsai, S. C. (2019). Using google translate in EFL drafts: A preliminary investigation. *Computer Assisted Language Learning*, 32(5-6), 510–526. <https://doi.org/10.1080/09588221.2018.1527361>
13. Song, C., & Song, Y. (2023). Enhancing academic writing skills and motivation: Assessing the efficacy of ChatGPT in AI-assisted language learning for EFL students. *Frontiers in Psychology*, 14, 1260843. <https://doi.org/10.3389/fpsyg.2023.1260843>
14. Oxford Reference. (2021). Artificial intelligence. <https://www.oxfordreference.com/view/10.1093/oi/authority.20110803095426960>
15. Osawa, K. (2024). Integrating Automated Written Corrective Feedback into E-Portfolios for second language Writing: Notion and Notion AI. *RELC Journal*, 55(3), 881–887. <https://doi.org/10.1177/00336882231198913>
16. O'Neill, M. (2019). Training students to use online translators and dictionaries: The impact on second language writing scores. *International Journal of Research Studies in Language Learning*, 8(2), 47–65. <https://doi.org/10.5861/ijrsl.2019.4002>
17. Mutsuda, P. (2003). Process and post-process: A discursive history. *Journal of Second Language Writing*, 12(1), 65–83.
18. Marzuki, Widiati, U., Rusdin, D., Darwin, Indrawati, I. (2023). The impact of AI writing tools on the content and organization of students' writing: EFL teachers' perspective. *Cogent Education*, 10(2), 1–17. <https://doi.org/10.1080/2331186X.2023.2236469>
19. Lim, L., Bannert, M., van der Graaf, J., Singh, S., Fan, Y., Surendrannair, S., Rakovic, M., Molenaar, I., Moore, J., & Gašević, D. (2023). Effects of real-time analytics-based personalized scaffolds on students' self-regulated learning. *Computers in Human Behavior*, 139(107547), 107547. <https://doi.org/10.1016/j.chb.2022.107547>
20. Kim, N.-Y., Cha, Y., & Kim, H.-S. (2019). Future English learning: Chatbots and artificial intelligence. *Multimedia Assist. Lang. Learn*, 22, 32–53. http://journal.kamall.or.kr/wp-content/uploads/2019/10/KimChaKim_22_3_02.pdf
21. Kim, H.-S., Kim, N. Y., & Cha, Y. (2021). Is it beneficial to use AI chatbots to improve learners' speaking performance? *The Journal of AsiaTEFL*, 18(1), 161–178. <https://doi.org/10.18823/asiatefl.2021.18.1.10.161>
22. Kang, E., & Han, Z. (2015). The efficacy of written corrective feedback in improving L2 written accuracy: A meta-analysis. *The Modern Language Journal*, 99(1), 1–18. <http://www.jstor.org/stable/43651875> (open in a new window) <https://doi.org/10.1111/modl.12189>
23. Hyland, K., & Hyland, F. (2006). Contexts and issues in feedback on L2 writing: An introduction. In K. Hyland & F. Hyland (Eds.), *Feedback in second language writing: Context and issues* (pp. 10–19). Cambridge University Press.
24. Godwin-Jones, R. (2024). AI in language learning: opportunities and threats. https://godwinjones.com/godwin-jones_AI_in_language_learning.pdf
25. Godwin-Jones, R. (2022). Partnering with AI: Intelligent writing assistance and instructed language learning. *Language, Learning and Technology*, 26(2), 5–24. <https://hdl.handle.net/10125/73474>

THE ROLE OF TEXT-BASED ACTIVITY STRATEGIES IN THE DEVELOPMENT OF STUDENTS' CRITICAL AND ANALYTICAL THINKING

Mukasheva Raushana Nurbaevna

Master of Science, Senior Lecturer
Almaty Technological University
Almaty, Republic of Kazakhstan

РОЛЬ СТРАТЕГИЙ ТЕКСТОВОЙ ДЕЯТЕЛЬНОСТИ В РАЗВИТИИ КРИТИЧЕСКОГО И АНАЛИТИЧЕСКОГО МЫШЛЕНИЯ ОБУЧАЮЩИХСЯ

Мукашева Раушана Нурбаевна

магистр наук, сеньор-лектор
Алматинский технологический университет
г. Алматы, Республика Казахстан

Abstract

The article examines the didactic potential of text-based activity strategies in the context of developing students' reading literacy. It substantiates the importance of the textual stage as a key phase of meaningful reading, ensuring the transition from the reproductive perception of information to its interpretation and critical comprehension. The paper presents a systematization of strategies for working with texts aimed at developing analytical, reflective, and communicative skills. It concludes that their integration into educational practice is essential for improving the quality of learning.

Аннотация

В статье рассматривается дидактический потенциал стратегий текстовой деятельности в контексте формирования читательской грамотности обучающихся. Обосновывается значимость текстовой стадии как ключевого этапа смыслового чтения, обеспечивающего переход от репродуктивного восприятия информации к ее интерпретации и критическому осмыслению. Представлена систематизация стратегий работы с текстом, направленных на развитие аналитических, рефлексивных и коммуникативных умений. Делается вывод о необходимости их интеграции в образовательную практику как условия повышения качества обучения.

Keywords: reading literacy, critical thinking, analytical thinking, text-based activity, meaningful reading, pedagogical strategies.

Ключевые слова: читательская грамотность, критическое мышление, аналитическое мышление, текстовая деятельность, смысловое чтение, педагогические стратегии.

Современные образовательные стандарты ориентируют педагогическую практику на формирование у обучающихся не только предметных знаний, но и универсальных когнитивных умений, среди которых особое место занимает способность к осмысленному чтению и интерпретации информации. В условиях возрастающего объема текстовых данных умение работать с текстом становится базовой компетенцией, определяющей успешность обучения и социальной адаптации личности [1].

Читательская грамотность в данном контексте рассматривается как интегративное качество, включающее навыки понимания, анализа, интерпретации и оценки текстовой информации. Существенную роль в ее формировании играет текстовая стадия работы с материалом, в рамках которой происходит углубленное осмысление содержания [2].

Цель настоящего исследования заключается в выявлении и научном обосновании эффективности стратегий текстовой деятельности как средства развития критического и аналитического мышления обучающихся.

Текстовая деятельность представляет собой сложный когнитивный процесс, включающий декодирование информации, ее интерпретацию и соотнесение с личным опытом читателя. В отличие от поверхностного чтения, направленного на извлечение фактов, данный вид деятельности предполагает активное включение обучающегося в процесс смыслопорождения [3].

На этом этапе особую значимость приобретают следующие аспекты:

- выявление авторской позиции;
- определение смысловой структуры текста;

- формирование личностного отношения к прочитанному;
- рефлексия собственных мыслительных действий.

Таким образом, текстовая стадия выступает как пространство взаимодействия текста и читателя, в котором осуществляется переход от восприятия к пониманию и интерпретации.

Анализ педагогической практики позволяет выделить несколько групп стратегий, каждая из которых направлена на развитие определенных аспектов читательской деятельности.

1. Стратегии диалогического взаимодействия.

К данной группе относятся методы, предполагающие сочетание индивидуальной и совместной деятельности обучающихся. Их ключевая особенность заключается в организации учебного диалога, в ходе которого происходит сопоставление различных интерпретаций текста.

Как правило, внедрение подобных стратегий предполагает двухступенчатый процесс: сначала происходит самостоятельное осмысление представленного материала, а затем следует коллективное обсуждение в парах или малых группах. Такой последовательный подход к организации учебной деятельности дает возможность каждому обучающемуся выработать свою точку зрения, после чего он может сравнить ее с позициями других участников.

Эффективность подобных стратегий обусловлена тем, что обучающийся сначала формирует собственное понимание текста, а затем подвергает его критической оценке в процессе обсуждения. Это способствует развитию аргументационных умений и навыков рефлексии [4].

2. Стратегии смыслового выделения.

Данные методы направлены на выявление ключевых элементов текста, формирующих его смысловое ядро. К ним относятся:

- определение ключевых слов;
- выделение опорных предложений;
- формулирование смысловых доминант.

Реализация данной стратегии предполагает последовательный процесс, начинающийся с ознакомительного анализа текста и идентификации ключевых элементов. Далее следует этап систематизации и обобщения выявленных единиц. Особый акцент делается на анализе лексических повторов и смысловых маркеров, служащих для установления композиционной структуры произведения.

Особую значимость приобретает способность обучающегося осуществлять смысловое сжатие информации, что позволяет не только лучше понять текст, но и воспроизвести его содержание в обобщенном виде [5].

3. Стратегии концептуализации.

Концептуализация предполагает преобразование текстовой информации в структурированную модель. Одним из наиболее эффективных инструментов в данном случае являются концептуальные карты, позволяющие визуализировать взаимосвязи между элементами содержания [6].

Применение подобных методов способствует:

- систематизации знаний;
- выявлению логических связей;
- развитию абстрактного мышления.

4. Стратегии аргументации и доказательства.

Важным компонентом работы с текстом является умение выделять основную мысль и обосновывать ее с опорой на текст. Для этого используются методы, предполагающие:

- формулирование тезиса;
- подбор аргументов;
- их логическую структуризацию.

Данные стратегии развивают навыки аналитического мышления и формируют способность к построению связного рассуждения.

5. Стратегии ранжирования информации.

Отдельное место занимают методы, ориентированные на оценку значимости информации. Обучающиеся не только выделяют факты, но и определяют степень их важности, выстраивая иерархию смысловых элементов.

Осуществление данной стратегии включает в себя идентификацию ключевых смысловых блоков (идей, аргументов) и их последующую ранжирование в соответствии с уровнем их значимости. Такой метод способствует формированию у обучающихся навыков критической оценки информации, сопоставления фактов и обоснования принятых решений.

Подобная деятельность способствует развитию критического мышления, так как требует осознанного выбора и обоснования собственной позиции.

6. Стратегии постановки вопросов.

Формирование умения задавать вопросы рассматривается как показатель глубины понимания текста. В процессе работы обучающиеся переходят от простых репродуктивных вопросов к более сложным — интерпретационным и оценочным. Это позволяет:

- выявлять скрытые смыслы;
- уточнять содержание;
- формировать исследовательскую позицию [2].

Реализация данной стратегии предполагает поэтапное формирование вопросов, ориентированных на различные сегменты текста. Последующая верификация сформулированных вопросов осуществляется в рамках парной или групповой деятельности. При этом ключевое значение придается адекватности вопросов содержанию исходного материала и четкости их формулировок.

7. Стратегии кодирования информации.

Кодирование представляет собой процесс преобразования текстовой информации в более компактную и структурированную форму. Он включает:

- выделение микротем;
- их объединение в смысловые категории;
- формулирование общей темы текста.

Работа организуется поэтапно: на начальном этапе обучающиеся анализируют содержание каждого абзаца, после чего осуществляется их группировка в более крупные смысловые сегменты с последующим выявлением взаимосвязей. Итогом данного процесса является формирование комплексного понимания материала и его логической структуры, а также совершенствование компетенций в области смыслового обобщения и структурирования информации.

8. Интегративные стратегии.

К данной группе относятся методы, сочетающие различные формы деятельности: индивидуальную, парную и групповую. Их применение обеспечивает постепенное углубление понимания текста за счет перехода от личной интерпретации к коллективному обсуждению.

Организация работы выстраивается поэтапно, от индивидуального погружения в материал к совместному поиску решений и формированию общего понимания. Такой подход гарантирует внимание к каждому обучающемуся и способствует развитию его познавательной активности.

Такие стратегии способствуют развитию коммуникативных навыков и формированию способности к коллективному смыслопорождению.

Анализ представленных стратегий позволяет утверждать, что их системное использование оказывает комплексное воздействие на развитие познавательной деятельности обучающихся. Они обеспечивают переход от пассивного восприятия текста к активной интерпретации и критической оценке [1].

Особое значение имеет вариативность применения данных стратегий, позволяющая учитывать индивидуальные особенности обучающихся и уровень их подготовки. Кроме того, сочетание различных методов обеспечивает более глубокое усвоение материала.

Таким образом, стратегии работы с текстом выступают эффективным инструментом формирования читательской грамотности, обеспечивая развитие критического и аналитического мышления обучающихся. Их использование позволяет повысить уровень понимания текстовой информации, сформировать навыки ее структурирования и интерпретации.

Перспективы дальнейших исследований связаны с разработкой методик интеграции данных стратегий в цифровую образовательную среду, а также с изучением их влияния на результаты обучения в различных предметных областях.

References

1. Sidorova, G.A., Kovaleva, G.S., Gosteva, Yu.N., et al. *Reading Literacy: Methodological Guidelines for the Development of Reading Literacy among Students in Grades 5–9 Using an Open Task Bank on a Digital Platform*. Moscow: Russian Academy of Education, 2021. 124 p.
 2. Mishatina, N.L., Mushtavinskaya, I.V. *Methods for Developing Reading Literacy "From Text to Meaning" (Based on Practical Experience): Teaching and Methodological Guide (St. Petersburg Vector for the Implementation of the Federal State Educational Standard of Basic General Education)*. St. Petersburg: KARO, 2023. 208 p.
 3. Karaulov, Yu.N. *The Russian Language and the Linguistic Personality*. 7th ed. Moscow: LKI Publishing House, 2010. 264 p.
 4. Smetannikova, N.N. *A Strategic Approach to Teaching Reading*. Moscow: School Library, 2005. 512 p.
 5. Volkov, B.S., Volkova, N.V. *Developmental Psychology*. In 2 parts. Part 2: *From Primary School Age to Adolescence*. Moscow: VLADOS, 2020. 344 p.
 6. *The Use of the "Cartography" Technique in Working with Texts. Series "Modern Technologies in University Education," Issue 1*. Belarusian State University, Center for Problems of Educational Development. Minsk: Propilej, 2023. 124 p.
- UDC 37.091.33:81'243

INTEGRATING DIGITAL TOOLS AND INTERACTIVE TECHNIQUES TO BOOST UNIVERSITY STUDENTS' COMMUNICATIVE COMPETENCE

Okhap Aida

Scientific Supervisor: **Polatova S.D.**

PhD, Senior Lecturer

Uzbekali Zhanibekov South Kazakhstan Pedagogical University

Shymkent, Kazakhstan

Abstract

The purpose of this study is to explore ways how to develop English as a foreign language learners' communicative competence through the use of multimedia-assisted language instruction. This paper tries to explore the impact of using authentic multimedia and effective instructional strategies in order to motivate university students' English language learning. This study also tried to find out students' perception and attitudes toward engaging in multimedia-assisted language learning materials and classroom activities for their English study. This paper investigates how the utilization of multimedia and technology-enhanced instructional strategies can foster learner motivation and autonomy in their EFL learning. This study first explains the notion of communicative competence which has been derived from the paradigm of communicative language teaching and then portrays how the integration of multimedia-enhanced language learning resources and instructional strategies can support university students to develop their communicative competence and integrated four English skills, especially presentation skills. In this study, EFL university students responded that they could develop their English communicative competence while they were engaging in the multimedia-assisted language learning. Participants of this study expressed that language learning materials using multimedia were very entertaining and informative for their English study. They evaluated their English learning experience through the use of multimedia as effective and motivating. The result of this study revealed that authentic multimodal English language learning materials and classroom activities using multimedia could be served as motivating factors to improve English as a foreign language learners' communicative competence as well as to boost their English language learning motivation and autonomous learning experience.

Keywords: *Multimedia-assisted language learning, Communicative competence, Learner motivation, EFL*

Introduction

Over the past several decades, developing English as a foreign language (EFL) learners' communicative competence has gained much attention among researchers and educators around the globe as the paradigm of English education has shifted from form-focused theoretical orientation into the direction of meaning-focused pedagogy. This change has been the result of constructivist movement which emphasizes the importance of social interaction in language learning and the value of meaningful context and cooperative learning community [1]. In the constructivist perspectives, the conventional pedagogical emphasis has moved away from the focus on teaching to the focus on learning; from teacher-directed to learner-initiated. For constructivists, the goal of education is to help learners transform and grow as proactive agents of their own learning process. This standpoint makes it possible for the learners to be transformed as the major agents in their learning. Accordingly, in the field of English as a foreign and second language education, the goals of classroom English language education based on constructivism are not just indoctrinating simple linguistic skills and English language pattern drills or emphasizing rote memorization. Instead, educators have tried to develop EFL learners' communicative competence, helping them understand the importance of meaningful social interaction, active communication, discovery of meaning, shared learning communities, and collaboration with peer during their English language learning process [2]. Recently, due to the development of innovative technology and the effort to seek out effective instructional techniques and strategies, multimedia assisted language learning (MALL) has been increasingly integrated in the field of English education [3]. MALL can be generally defined as any instructional practice that encourages English language learners to use authentic multimedia in order to enrich their English language learning experience. The accessibility and availability of well-resourced multimedia equipment and various multimodal English language learning and teaching materials in language classrooms have played a crucial role in developing the new trend for English as a foreign language learning and teaching [4]. The prevalent development of multimedia and new technology has made it possible

that English language educators and curriculum developers should rethink the use of the traditional English language teaching resources and instructional techniques, which has become somewhat old fashioned in the era of new digital technologies. The progresses in diverse educational technology have also led to a relentless search for more effective and reliable teaching methods and instructional strategies in the English language classrooms. By integrating new technology into English language classrooms, the pedagogical practices in which knowledge is transmitted have been dramatically transformed and enhanced. Because English language learners' perspectives and learning experiences have been greatly enriched by implementing authentic multimodal language learning resources and innovative technologies, it has been possible for English language learners to develop their English communicative competence and four integrated English language skills simultaneously [5]. Consequently, the evolving paradigm of EFL pedagogy and instructional environment using multimedia-assisted language learning have brought a paradigm shift away from the conventional EFL instructional practice to technology-enhanced language education [6]. Under the constructivists' perspectives, this paradigm shift has also transformed the role of teachers from a knowledge distributor to a facilitator or a guide who can help learners expand their capacity in solving problems, making educated decisions, and thinking critically. Under the premises of constructivism in EFL education field, the emphasis of the English language learning process has been transferred to learners, so English language learners can take the initiative in their own learning through the development of communicative competence, instead of depending on the teacher in conventional English language classrooms [7]. The purpose of this study is to develop EFL university learners' communicative competence using multimedia-assisted language learning and teaching. This study examines how the use of multimodal instructional English learning resources and effective classroom activities based on multimedia-assisted language teaching strategies can help develop English as a foreign language learners' communicative competence and four integrated English language skills in university English language instruction. This study also investigates how the integration of multimedia and technology enhanced instructional strategies can foster learner motivation and autonomy in university EFL learning. This study then examines how the use of MALL has influenced students' English language learning experience and interactional classroom dynamics. Since the computer and new educational technology were incorporated into language teaching, many educators and EFL learners have engaged in utilizing multimodal learning materials and educational technology such as learning management system, discussion boards, weblog, social networks, and internet on a daily basis. Accordingly, multimedia-assisted English language learning and teaching has been introduced into the field of English education as the plausible alternative of the traditional pedagogical framework [8]. The prevalent use of technology in English language learning and teaching corresponds with the introduction of sociocultural theory of learning based on constructivist perspectives. With the benefit of multimedia and computer related English language learning and teaching environments, a lot of educators and researchers embrace the notion that more meaningful learning occurs through social interaction with others in authentic and interactive communicative contexts [8]. In the current pedagogical framework of constructivism, classroom language learning activities are learner-centered, genuine, and organized in the supportive and meaningful context [9]. Classroom is not the only place for the English language learners to receive new information, especially with the current trends to integrate state-of-the-art technological skills into the conventional curriculum [10]. The pedagogical direction toward integrating multimedia and technology-assisted learning into English education makes it imperative for English teaching professionals to keep up with current English language teaching methods and to attain essential knowledges and skills of educational technology. Teachers serve as facilitators and guides while learners engage in constructing their own learning and meaning making. Learners activate new information and abilities upon pre-existing knowledge in more collaborative and autonomous manner. Students develop new information and knowledge according to their own needs and interests, taking initiatives in their own learning activities and outcomes. By integrating multimedia applications into English language learning, learners can be engaged in learning activities that can cultivate critical thinking skills. Various multimedia-facilitated language learning and teaching environment can provide English language learners with the salient support and successful learning experiences in order to develop English language learners' communicative competence. Interactive multimodal English language learning resources can offer authentic learning experiences for practicing all language skills, including speaking, listening, writing, and reading. Thanks to the development of information and communication technologies, schools around the world have attempted to implement various educational technology and state-of-the-art teaching techniques into EFL instruction both to boost digital native learners' learning motivation and to facilitate their language learning experience [11]. The use of authentic multimedia in language classrooms has some benefits because it can provide

language learners with genuine and self-motivated learning environment. Using authentic multimedia in language learning can also cultivate learner motivation and autonomy as well as learning interests. Research results showed that by the use of multimedia-related classroom techniques students could develop better oral skills and this technique could be regarded as an important tool in foreign language learning and teaching [12]. Studies have also reported the benefits of a mixture of audio, picture, and video language learning in comparison to text only materials in offering new knowledge [13] [14]. In terms of the modality principle, audio or video language learning materials simultaneously require both the visual working memory and auditory working memory, while text only language learning materials contain only the visual working memory. Multimedia language learning resources can be utilized as the supplement and improvement of traditional English language learning and teaching since they offer genuine aural and visual English learning resources that can be motivating and engaging [13]. These appealing features can help language learners study with the multimodal learning materials enthusiastically. Integrating multimodal language learning contents such as text, images, audios, or videos can trigger language learners' curiosity and increase participation in classroom learning activities. Classroom instructional practice using multimedia can create genuine environment for language learning through simulations, role plays, or class discussion. Multimedia technology can be an outstanding channel for maximizing learners' language output [15]. Learners can acquire auditory and visual stimulation, which can activate their language input into the level of long-term knowledge and can also provide learners with enhanced possibilities of accomplishing integrated English four language skills [16]. Figure 1 shows the benefits of multimedia-assisted language learning.

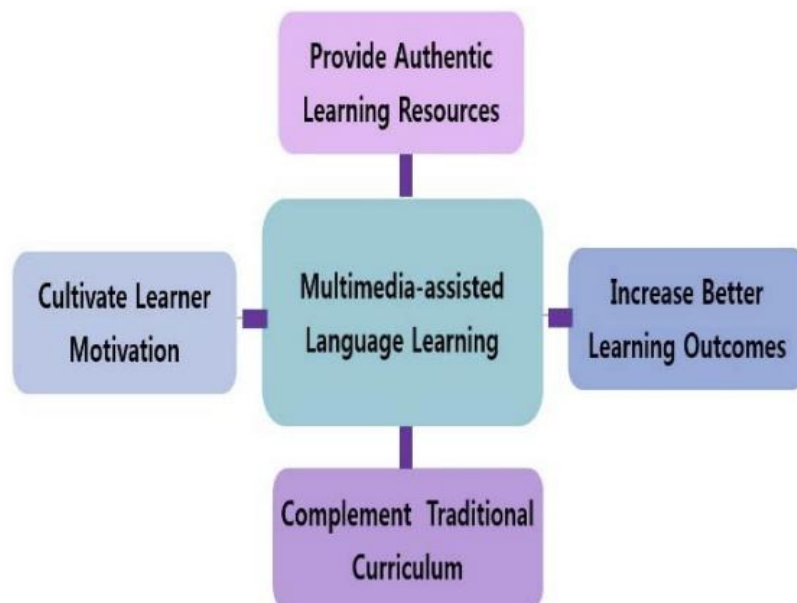


Figure 1: Benefits of Multimedia-assisted Language Learning

Since EFL settings may have environmental constraints such as students' diversity in English proficiency levels, socioeconomic disparity between urban and rural schools, diverse class sizes, and time constraints, the availability and accessibility of English learning resources such as audiovisual materials and more recently digital learning resources in EFL language classroom become significant in improving learner motivation and achievement. Integrating technology into English language education allows addition of multisensory features that can offer meaningful contexts to promote learning comprehension so as to broaden the learning ground of language and linguistics beyond the classrooms [17]. As a teaching technique to maximize the integration of new technology into EFL education, shadowing technique, which is integrated into multimedia-assisted language learning, has been regarded one of the most effective instructional techniques. This shadowing technique can be incorporated into language education in order to improve listening comprehension as well as speaking fluency [18]. This technique was originally created to train simultaneous language interpreters and then later it was pedagogically implemented in the realm of second or foreign language education. Shadowing is considered to be a dynamic and greatly cognitive practice in which language learners can track the aural form of the speech and articulate it as clearly as possible with the concurrent manner while they are listening to it [19]. Many language educators could see the benefits of the shadowing technique in cultivating communicative

competence of language learners since shadowing was proved to play a crucial role in boosting language learners' linguistic competence in both speaking and listening [20].

Developing Communicative Competence in EFL Education

In the field of English as a second or foreign language learning and teaching, communicative language teaching (CLT) has gradually become a dominant paradigm around the world as a new or innovative way of learning and teaching English, replacing the conventional way of form-focused English language learning and teaching. This approach was emerged as the reaction against grammar-based English language teaching approaches like audiolingual approach. The foremost pedagogical notion of communicative language teaching is to foster English language learners' communicative competence. The term communicative competence was coined by Hymes and referred to not only the implicit knowledge of a language and the ability to use it appropriately [21]. This concept was proposed as the disapproval at the concept of Chomsky's idealized ideas of purely linguistic competence. Chomsky proposed linguistic competence was as the only theoretical foundation of methodology of English language learning, teaching, and assessment [22]. However, the term communicative competence was suggested to alter Chomsky's notion of linguistic competence into a broader and more genuine concept of competence [23]. The newly proposed concept of communicative competence embraced language competence not only as an essential linguistic competence but also as the ability to utilize linguistic competence appropriately in various communicative contexts. Thus, the term communicative competence has brought the sociolinguistic perspectives into Chomsky's linguistic perspectives of language competence [24]. Having English communicative competence means that an English language user has sociocultural knowledge about when and how to speak the intended utterances properly beyond just having grammatical knowledge of English such as syntactic, morphological, phonetical, and phonological knowledge. The concept of communicative competence can be characterized by means of manifestation, interpretation, and negotiation of meaning in communication. Having communicative competence can be defined into several categories. According to the categorization, communicative competence has four sub-categories; grammatical competence, discourse competence, sociolinguistic competence, and strategic competence [25]. For grammatical competence, EFL learners should have knowledge about English phonological, orthographical, syntactical, and lexical aspects. Sociolinguistic competence includes knowledge of sociocultural implications of using English. It is related to the English language learners' ability to manage the communicative contexts in terms of communicative settings, topics, and functions in diverse sociolinguistic situations. In addition, it is the ability of understanding and creating different speech acts in different communicative contexts where various factors play an essential role, for example the relationship between interlocutors and their situation. Discourse competence is concerned with the English language learners' mastery of understanding and producing utterances in the types of listening, speaking, reading, and writing. To master this, English language learners should be able to understand rhetorical device for conversational organization, which includes cohesion and coherence in different genres of texts. Strategic competence has to do with compensatory strategies in conversational settings in case of linguistic, sociolinguistic, or discourse complications. This ability includes English language learners' effective use of tactics in terms of verbal and non-verbal resources to repair their linguistic errors that can arise in communication due to different events that may limit the communicative process. These strategies include using avoidance tactics, reference resources, and paraphrase, as well as using requests for repetition, clarification, or slower speech [26]. Using a language appropriately in communication means to know the relationship between the utterances and their contexts of using them appropriately. To be communicatively competent, all these features of communicative competence should be meaningfully interweaved into intercultural understanding, communicative context, and abundant exposure to language use as well as the knowledge of conversational contents. According to the perspective of constructivism, the English language learning and teaching filed meets the twenty-first century with the clear emphasis on meaningful social interaction. For communicative language teaching, it is crucial that English language learners should be engaged in doing authentic things with English and should make meaningful connection between the self and the world through the medium of language, not merely knowing about the language [27].

Method

The participants of this study were first-year undergraduate students enrolled at a university located in the southern part of Kazakhstan. They were studying at Pedagogical University and were members of Group 1703–35. The total number of participants was 30 students (18 female and 12 male), aged between 18 and 19 years. The English proficiency level of the students ranged from intermediate to upper-intermediate (B1–B2) according to the Common European Framework of Reference for Languages

(CEFR). The primary objective of the course was to develop students' communicative competence and improve their integrated language skills, with particular emphasis on speaking accuracy and fluency. Special attention was given to the correct use of English articles (a, an, the) in communicative contexts, as this area was identified as problematic for many learners. The objective of the course was to develop English communicative competence and to improve integrated four English language skills, especially presentation skill. The course format of this study was based on a blended learning framework, which utilized authentic multimodal English learning resources and materials from various Internet websites. For instructional strategy, the shadow-speaking method was used as a language learning and teaching technique. Since students in this study were expected to be tech-savvy digital natives, various digital devices such as smartphones, laptops, or pads were utilized for the implementation of technology-enhanced English language learning and teaching. For data collection and data analysis, five-Likert questionnaire survey and semi-structured interview were conducted. The data collecting tools for this study were designed to investigate the impact of using authentic multimedia in order to develop EFL university students' communicative competence and motivate their English language learning process. The data were also collected in order to find out EFL university students' perception and attitude of experiencing multimedia-assisted language learning and technology-enhanced classroom activities for their English study. During the research, the participants of this study were required to engage in classroom learning activities in order to improve their English-speaking skill, especially English presentation activities, through utilizing aural and visual English learning resources of news headlines from various Internet websites. While students of this study were participating in classroom activities of listening to the news headlines, they practiced to speak the news scripts using the shadow-speaking technique. Once they had enough practice of speaking the news headlines, they took part in simulating activities, in which they were asked as a new reporter to deliver the given news headlines.

Data Collection Instruments and Procedure

Data were collected in three stages: pre-test, while-activity, and post-test.

In the pre-test phase, students completed a diagnostic grammar test and a self-assessment questionnaire focusing on their use of English articles in communication. During the while-activity phase, students participated in interactive tasks designed to practice article usage in meaningful contexts. Classroom observations were conducted to evaluate engagement and performance. In the post-test phase, the same test and questionnaire were administered to measure improvement. A paired-samples t-test was used to determine the statistical significance of differences between pre- and post-test results.

Results

Table 1. Pre-Test Results

Skill	Mean	SD	N
Use of a/an	2.60	0.88	30
Use of the	2.47	0.91	30
Article distinction	2.53	0.90	30
Speaking use	2.40	0.95	30
Confidence	2.37	0.93	30

Note. Items rated on a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree).

The pre-test results indicate that students had low proficiency in the use of English articles ($M = 2.47$). The most problematic areas were confidence ($M = 2.37$) and speaking accuracy ($M = 2.40$), confirming that grammatical knowledge was not effectively transferred into communication.

Table 2. While-Activity Observation

Activity	Focus	Engagement
Role play	Linguistic	High
Discussion	Strategic	High
Grammar games	Linguistic	High
Pair work	Discourse	Moderate
Storytelling	Discourse	High
Error correction	Linguistic	Moderate

Table 2 shows that interactive activities increased engagement, especially in speaking-based tasks. Role plays and discussions were particularly effective in encouraging the practical use of articles.

Table 3. Post-Test Results

Skill	Pre	Post	Gain
Use of a/an	2.60	3.87	+1.27
Use of the	2.47	3.80	+1.33
Article distinction	2.53	3.90	+1.37
Speaking	2.40	3.83	+1.43
Confidence	2.37	3.73	+1.36

The post-test results demonstrate significant improvement across all areas. The overall mean increased from 2.47 to 3.83, indicating a substantial gain in students' communicative competence.

Discussion

The results demonstrate significant improvement in students' communicative competence and article usage. Interactive activities such as role-plays and discussions contributed to increased engagement and accuracy. Overall, the study confirms the effectiveness of communicative teaching methods.

Conclusion

This study examines the ways how to foster English as a foreign language learners' communicative competence through the use of multimedia-assisted language instruction and also to scrutinize the effect of using genuine multimedia assisted language learning resources and effective instructional strategies in order to motivate university students' English language learning. Overall, the findings of this study suggest that integrating multimedia resources and technology enhanced classroom activities into EFL university English instruction was beneficial for improving university students' English study and motivating their learning experience. To foster motivating and engaging pedagogical learning environment for tech-savvy digital native EFL university students, EFL educators and researchers should never stop relentless efforts to incorporate the most effective channel to promote English as a foreign language learners' communicative competence [29] [30]. The result of this study might provide insights about how to implement authentic multimedia and effective instructional strategies in order to motivate EFL university students' English language learning.

References

1. Vygotsky, L. S., *Mind in Society*, Cambridge: Harvard University Press, 1978.
2. Slavin, R., *Educational Psychology: Theory and Practice*, Boston: Allyn and Bacon, 2003.
3. Klassen, J., and Milton, P., "Enhancing English Language Skills using Multimedia: Tried and Tested", *Computer Assisted Language Learning*, Vol. 12, No. 4, 1999, pp. 281-294.
4. Rahini, M., and Hosseini, F., "The Impact of Computer-based Activities on Iranian High School Students' Attitudes towards Computer assisted Language Learning", *Procedia Computer Science*, Vol. 3, 2011, pp. 183-190.
5. Hu, Z., Li, M., and Zou, H., "Internet-assisted College English Teaching in China", *IERI Procedia*, Vol. 2, 2012, pp. 623-629.
6. Marina, S. T., "Facing the Challenges, Getting the Right Way Distance Learning", *Education at a Distance*, Vol. 15, 2001, pp. 1-8.
7. Jeong, K. O., "A Study on the Integration of Google Docs as a Web-based Collaborative Learning Platform in EFL Writing Instruction", *Indian Journal of Science and Technology*, Vol. 9, No. 39, 2016, pp. 1-7.
8. Wilhelm, J. D., and Friedemann, P. D., *Hyperlearning: Where Project, Inquiry, and Technology Meet*. York, ME: Stenhouse Publishers, 1998.
9. O'Neil, J., "Our Schools as Learning Organizations: A Conversation with Peter Senge", *Educational Leadership*, Vol. 52, No. 7, 1995, pp. 20-23.
10. Jonassen, D. H., *Computers as Mindtools for Schools*, Upper Saddle River, NJ: Prentice-Hall, 2000.
11. Jeong, K. O., "Integrating a Web-based Platform to Promote Creativity and Authenticity in Language Classrooms", *International Journal Knowledge and Learning*, Vol. 11, Nos. 2/3, 2016, pp. 127-136.
12. Razmia, M., Pouralib, S., and Nozad, S., "Digital Storytelling in EFL Classroom (Oral Presentation of the Story): A Pathway to Improve Oral Production", *Procedia-Social and Behavioral Sciences*, Vol. 98, 2014, pp. 1541- 1544.
13. Marzban, A., "Investigating the Role of Multimedia Annotations in EFL Reading Comprehension", *Procedia-Social and Behavioral Sciences*, Vol. 28, 2011, pp. 72-77.
14. Mayer, R., and Moreno, R., "Information Processing and Multimedia Usability", *Journal of Educational Psychology*, Vol. 91, 1998, pp. 358-368.

15. Hwang, W. Y., Shadiev, R., Hsu, J. L., Huang, Y. M., Hsu, G. L., and Lin, Y. C., "Effects of Storytelling to Facilitate EFL Speaking Using Web-based Multimedia System", *Computer Assisted Language Learning*, Vol. 2, No. 2, 2016, pp. 215-241.
16. Yi, L. X., "A Tentative Exploration on the Use of Multi-media in College English Education", *AASRI Procedia*, Vol. 1, 2012, pp. 282-286.
17. Ramasubbu, S., "How Technology Can Help Language Learning", retrieved from the website https://www.huffingtonpost.com/surenramasubbu/how-technology-can-help_b_7489002.html
- Zakeri, E., "The Effect of Shadowing on EFL Learners' Oral Performance in Terms of Fluency", *International Journal of English Language Teaching*, Vol. 2, No. 1, 2014, pp. 21- 26. [19] Nekoueizadeh, M., and Bahrani, T., "The Effect of Conversational Shadowing on Teaching and Learning Conditional Sentences", *International Journal of Language Learning and Applied Linguistics World*, Vol. 4, No. 1, 2013, pp. 253-267.
18. Murphey, T., "Exploring Conversational Shadowing", *Language Teaching Research*, Vol. 5, 2001, pp. 128-155.
19. Hymes, D., "Models of the Interaction of Language and Social Life", in J. J. Gumperz and D. Hymes (Eds.), *Directions in Sociolinguistics: The Ethnography of Communication*, Austin, TX: Holt, Rinehart and Winston, 1972, pp. 1-19.
20. Chomsky, N., *Aspects of the Theory of Syntax*, Cambridge, MA: The M.I.T. Press, 1965.
21. Savignon, S. J., *Communicative Competence: Theory and Classroom Practice. Texts and Contexts in Second Language Learning*, Reading, MA: Addison-Wesley Publishing Company, 1983.
22. Vesna, B., "Defining Communicative Competence", *Metodika*, Vol. 8, No. 1, 2007, pp. 94-103.
23. Canale, M., and Swain, M., "Theoretical Bases of Communicative Approaches to Second Language Teaching and Testing", *Applied Linguistics*, Vol. 1, No. 1, 1980, pp. 1-47.
24. Reinhold, P., *What Is the Matter With Communicative Competence?: An Analysis to Encourage Teachers of English to Assess the Very Basis of Their Teaching*, London, UK: LIT Verlag, 2005.
25. Savignon, S. J., *Interpreting Communicative Language Teaching*, New Haven, CT: Yale University Press, 2002.
26. *Morning Special*, Korea Educational Broadcasting System, Seoul, 2014.
27. Jeong, K. O., "Preparing EFL Student Teachers with New Technologies in the Korean Context", *Computer Assisted Language Learning*, Vol. 30, No. 6, 2017, pp. 489-509.

UDC 37.091.33:81'243

EXPLORING MEDIA LITERACY AND CRITICAL THINKING SKILLS AMONG UNIVERSITY STUDENTS: A SURVEY ON THEIR APPROACHES TO ANALYSING NEWS AND INFORMATION**Orazaly Diana**

1-year Master's Degree Student

Scientific Supervisor: **M.Yu. Shingareva**

PhD, associate professor

Uzbekali Zhanibekov South Kazakhstan Pedagogical University

Shymkent, Kazakhstan

Abstract

In today's media environment, young people encounter the challenge of navigating an intricate ecosystem filled with misinformation and disinformation. As the digital landscape continues to expand, the ability to critically evaluate news and information has become essential. Media literacy plays a pivotal role in equipping students with critical thinking skills to assess media content, identify biases, and discern credible information from falsehoods. This study investigates the application of critical thinking skills in media literacy among university students through a comprehensive survey. The survey assesses students' tendencies to analyse context, identify dependencies between diverse information sources, and interpret nuances in media content. Results indicate a significant proportion of students actively engage in higher-level critical thinking processes. However, a notable segment remains neutral or less engaged, highlighting opportunities for targeted educational interventions. The findings underscore the importance of fostering media literacy and critical thinking skills within higher education to enhance students' ability to navigate complex media environments effectively.

Keywords: media literacy, critical skills, news, information, survey, disinformation

Introduction

Critical thinking is important for making judgments about sources of information and forming your own arguments, emphasizing a rational and objective approach. As is generally known, critical thinking is referred to the ability to interpret, evaluate, and analyse facts and information that are available, to form a judgment or decide if something is right or wrong. Furthermore, as widely acknowledged, critical thinking implies the capacity to think clearly and rationally, understanding the logical connection between ideas, analysing assumptions, discerning hidden values, and evaluating evidence. More than just being curious about the world around you, critical thinkers make connections between logical ideas to see the bigger picture. Building your critical thinking skills means being able to advocate your ideas and opinions, present them in a logical fashion, and make decisions for improvement. Critical thinking is about questioning and learning with an open mind. Media literacy includes the ability to access and analyse media messages, as well as to create, reflect on, and take actions using the power of information and communication. Media literacy is the ability to critically assess, analyse and evaluate media messages across various platforms like TV, social media, websites, and advertisements. It helps individuals recognize biases, misinformation, and the motives behind what they see and hear, enabling them to engage with media more thoughtfully and responsibly. Media literacy and critical thinking are intertwined. A prerequisite of media literacy is being able to use critical skills mainly focusing in addressing questions, identifying biases, and forming reasonable arguments thus recognising and evaluating what you read, see, and hear. ML uses critical thinking especially in the age of online misinformation and disinformation. Using critical thinking in media literacy can empower people recognize false information and fake news, understand media influence in people's perception and opinions, make decisions based on credible information, choose between what is important and relevant and what is not, be aware of the importance of double-checking of the information. Helping students understand the links between critical thinking and analysing information presented in so many formats, seems to be one of the most challenges for teachers, educators, and parents.

Literature review

H. Siegel (1988) associates critical thinking with rationality, understood as effectiveness in achieving goals. What is important to Siegel is that someone who can be called a "critical thinker" does not have specific skills only but is also a certain kind of person [Siegel, 1988, 9]. He also states that "the defining characteristic of critical thinking is its focus on reasons and the power of reasons to warrant or justify

beliefs, claims, and actions. [Siegel, 1988, 22]. Siegel also asserts that his notion of critical thinking is able of influencing all educational activities and practice [Siegel, 1988, 137]. Thinking critically requires command of fundamental intellectual standards. Critical thinkers routinely ask questions that apply intellectual standards to thinking. The ultimate goal for these questions is to become so spontaneous in thinking that they form a natural part of our inner voice guiding us to better and better reasoning [Paul R. & Elder L. 2012, 92]. In forming beliefs, critical thinkers do not passively accept the opinions of the others. Rather they think through situations and issues for themselves. They carefully form principles of thought and action and do not mindlessly accept those presented to them [Paul R. & Elder L. 2012, 19]. The concept of media literacy emerged in the beginning of 20th century in Europe as a way of acknowledging the set of knowledge, skills, and habits of mind required for full participation in a contemporary media-saturated society. Media literacy constitutes a set of skills that help consumers of media content to think critically by examining the source of the media content through evaluation and analysis to capture what is behind the production of such media content [Alvarman & Hagood, 2000]. ML seeks to understand how media content shapes behaviour and values of the society. Critical media literacy is an educational response that expands the notion of literacy to include different forms of mass communication, popular culture, and news. It deepens the potential of literacy education to critically analyse relationships between media and audiences, information, and power. Along with this mainstream analysis, alternative media production empowers students to create their own messages that can challenge media texts and narratives [Douglas K. & Share J. 2007, 2]. The main aim of media literacy is to provide critical autonomy. Emphases in media literacy training range widely, including informed citizenship, aesthetic appreciation and expression, social advocacy, self-esteem, and consumer competence. Some may use media literacy as a vehicle to understand the economic infrastructure of mass media, as a key element in the social construction of public knowledge. (Aufderheide, 1993, 5). People have become info-obese, as they are bombarded with information in the form of text, audio, image, or video through media. The central role of media in individuals' lives makes media literacy a mandatory skill to possess. In compliance with media literacy, the crucial skill that the new century requires is critical thinking and it is a core element of media literacy [Erdem, 2018, 2]. Whereas digital literacy is an individual's ability to find, evaluate, and communicate information by utilizing typing or digital platforms using both technical and cognitive abilities [Gilmour, 2024, 6]

New age media in the era of constant media consumption

New age media is increasingly challenging the way people consume and interact with information. Information overload and over consumption of the news seem to be the main features characterizing the new era of media transformation and modernization. Digital advancements and technological innovations have transformed media's accessibility and engagement transforming it into a more rapidly accessible, instantly updated, personalized, and interactive device than ever before. New age media has been democratized and modernized in the recent years allowing broader participations and fostering interconnected networks thus allowing audience to actively participate, individually create and share the content. People influencing the audience and the public opinion often rival the traditional media which is currently facing many challenges such as declining audiences, limited interactivity, high-production costs, slower releases evidently being in "desperate" need of new upgraded digital landscapes.

A critical mind: Students Navigating the Landscape of Information and Disinformation

21st century students are constantly exposing to a vast number of digital platforms easily becoming consumers of both information and misinformation. They own amounts of credible and diverse information. They often create and share their own content, expressing their identity, sharing their personal experiences, inspiring their peers thus promoting new digital trends. Young people are playing a direct role in developing a new digital culture. In this sense, they are both producers and consumers of a vast amount of diverse, yet not always credible or verified, information. Without proper fact-checking skills, young people may unintentionally receive or share false or misleading information, which can quickly spread due to social media's rapid sharing and influencing nature. They may also lack experience or expertise needed to accurately interpret complex topics, leading to the oversimplification or distortion of facts. Without a proper media literacy education young people become more vulnerable to misinformation, disinformation, and manipulative content. Students may believe or spread false information seriously "threatening" their understanding of important issues as well as make choices based on unreliable source. Young people are often more vulnerable to fake news due to high social media use and sometimes limited media literacy. They can easily be influenced by false information because they may lack the skills to critically evaluate sources. A study by the Council of Europe found that – 2/3rds of EU citizens say they identify fake news at least once a week. Over 80% say it is an issue for their countries

and for democracy in general. And the students/citizens between the ages of 15-30 say they need critical thinking and information skills to help them combat fake news. (Council of Europe, 2018) In a Q&A with Dennis Kovtun the misinformation expert professor at University of Alberta, Timothy Caulfield clearly states that "Misinformation is a defining issue of our time. I think it is good news that more and more people, including governments, are taking this battle against misinformation seriously, because that is what it is required. Misinformation is killing people it is destroying our democracy. It is leading to stigma and discrimination. We have got to do pre-bunking – in other words, letting people know that misinformation is out there, we have got to debunk, we have got **to teach critical thinking skills**. We need to teach critical thinking throughout the life course - from kindergarten to elementary school to middle school to high school. And I think it should be taught regardless of what degree you take at university. In some capacity, we need to give people the skills to use critical thinking and media literacy. It is just become so fundamental to our society right now, especially in this incredibly chaotic information environment. And I also think it needs to be available to adults. (Kovtun, 2022)

4. A case study survey

This study investigates the application of critical thinking skills in media literacy among university students through a comprehensive survey. The survey did not distinguish between different types of media consumption such as TV, social media, or online news. Therefore, it does not provide specific insights into how students engage with or perceive each platform separately. However, it is reasonable to assume that students' media literacy may vary across platforms. For instance, social media often requires a critical eye to identify misinformation and bias due to its fast-paced, user-generated content, which can be less regulated. In contrast, traditional media like TV and reputable online news sites may have more established editorial standards, potentially making it easier for students to judge their credibility. Nonetheless, despite these differences, many students might lack the necessary skills to effectively evaluate sources, regardless of platform, highlighting the need for targeted media literacy education across all media types. This survey assesses students' tendencies to analyse context, identify dependencies between diverse information sources, and interpret nuances in media content. Results indicate a significant proportion of students actively engage in higher-level critical thinking processes. However, a notable segment remains neutral or less engaged, highlighting opportunities for targeted educational interventions. The findings underscore the importance of fostering media literacy and critical thinking skills within higher education to enhance students' ability to navigate complex media environments effectively.

Research questions:

1. How do young students assess the credibility of the media sources they consume?
2. Are they able to distinguish between factual news and false or misleading information?
3. Are students aware of the importance of cross-checking information, and do they practice it regularly? What types of filters do students commonly use when listening to news reports?
4. Do students determine which information they receive from media is relevant or important to them
5. How can students as media consumers be better equipped to critically analyse the information they receive?

Method

This study employs a quantitative descriptive research design using a structured Likert-scale survey instrument. The survey was designed to measure students' self-reported tendencies, attitudes, and practices related to critical thinking and media literacy.

Participants

The study involved 30 students enrolled in an English language course at the B1–B2 proficiency level. The sample comprised 17 female and 13 male students. All participants were secondary-level learners aged between 15 and 18 years. Participation was entirely voluntary and anonymous, with all data used exclusively for this research.

Table 1. Participant Demographics

Category	n	%
Female	17	56.7%
Male	13	43.3%
Total	30	100%

Instruments

The survey instrument consisted of 12 statements addressing key dimensions of media literacy and critical thinking: source verification, synthesis of information, analytical depth, sharing behaviour, and metacognitive awareness. Students rated their agreement with each statement using a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The survey was administered in English, in line with the instructional language of the course, and students received brief clarification of vocabulary where needed to ensure comprehension. The survey was completed individually during class time in approximately 20 minutes.

Table 2. Survey Instrument – Likert Scale (1 = Strongly Disagree, 5 = Strongly Agree)

Survey Question	1 SD	2 D	3 N	4 A	5 SA
1. I enjoy combining information from different sources to better understand a topic.	☐	☐	☐	☐	☐
2. When I learn something new, I like to share it with others.	☐	☐	☐	☐	☐
3. I believe analysing information in depth is a valuable and important skill.	☐	☐	☐	☐	☐
4. I usually form my opinions based on multiple sources, not just one.	☐	☐	☐	☐	☐
5. I regularly double-check information before accepting it as true.	☐	☐	☐	☐	☐
6. I often verify whether the information I read or hear is accurate.	☐	☐	☐	☐	☐
7. I am confident in my ability to identify the most important information in a media text.	☐	☐	☐	☐	☐
8. I compare different opinions and perspectives when forming my own view.	☐	☐	☐	☐	☐
9. I tend to remember and retain most of the information I hear or read.	☐	☐	☐	☐	☐
10. I often connect new information I encounter to things I already know.	☐	☐	☐	☐	☐
11. I pay attention to subtle details and nuances in news stories.	☐	☐	☐	☐	☐
12. I actively look for connections and relationships between different pieces of information.	☐	☐	☐	☐	☐

Data Analysis

Responses were tabulated using frequency counts and percentage distributions for each item. Descriptive statistics were calculated to identify the central tendencies and variation in responses. Items were grouped thematically to allow for cross-item analysis and pattern identification. Due to the small sample size ($n = 30$), results are presented as descriptive and exploratory rather than statistically inferential.

Results

The following section presents the frequency distribution of student responses across all 12 survey items. Results are summarized in Table 3, which reports the number of responses per Likert scale point (1–5) for each question along with a note on the dominant response pattern. Note: Q columns represent individual students ($n=30$ total); numbers shown are representative frequency distributions.

Table 3. Frequency Distribution of Survey Responses ($n = 30$)

Question	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Top Response (%)
Combining info from multiple sources	1	2	4	5	11	4	3	Agree/Strongly Agree – 53%
Sharing newly gained information	1	1	4	6	10	5	3	Agree/Strongly Agree – 57%
In-depth analysis is valuable	2	2	8	7	6	3	2	Neutral/Agree – 50%
Forming impressions from multiple sources	1	2	5	8	9	3	2	Agree/Strongly Agree – 60%
Double-checking information	1	1	4	7	10	4	3	Strongly Agree – 47%
Verifying information regularly	1	2	6	7	9	3	2	Agree/Strongly Agree – 53%
Extracting relevant key information	1	2	6	7	8	4	2	Agree/Strongly Agree – 50%
Comparing opinions across sources	2	2	5	8	8	3	2	Agree/Strongly Agree – 53%
Remembering information heard	3	3	8	7	5	2	2	Neutral – 37%
Connecting new info to prior knowledge	2	2	5	7	9	3	2	Agree/Strongly Agree – 57%
Attention to subtle details in news	1	2	6	7	9	3	2	Agree/Strongly Agree – 53%
Finding dependencies between information	2	2	7	7	7	3	2	Neutral/Agree – 47%

Note: Scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree. Frequency values are approximate based on proportional distribution across 30 respondents.

Discussion

The results indicate a generally positive orientation among B1–B2 English learners toward critical thinking and media literacy practices. A majority of students reported positive attitudes toward combining information from multiple sources (Item 1), double-checking facts (Items 5 and 6), and connecting new information to prior knowledge (Item 10). These findings align with research suggesting that learners at this proficiency level can successfully engage with complex critical thinking tasks when scaffolded appropriately (Paul & Elder, 2012).

The strong tendency to share information (Item 2), with over 57% of respondents choosing agreement or strong agreement, reflects the digital communication habits of contemporary young learners.

However, this enthusiasm for sharing must be balanced with rigorous fact-checking practices, particularly in environments where misinformation spreads rapidly via social media (Kovtun, 2022).

Item 3, concerning the value of in-depth analysis, produced a more distributed response pattern, with a considerable 37% selecting the neutral option. This may reflect ambivalence among some students about the perceived effort required for deep analysis or an uncertainty about their own analytical capabilities. Similar findings were observed in the original study by the authors of the uploaded document (*Criticalthinkinginmedialiteracy.docx*), where a significant portion of university students demonstrated neutrality toward analytical depth.

Item 9, addressing memory retention of information heard or read, showed the highest concentration of neutral responses (37%), which may reflect metacognitive limitations at this level — students may not have yet developed strong strategies for processing and retaining media content. This is consistent with research suggesting that active engagement strategies, such as note-taking, discussion, and reflection, are needed to improve retention (Erdem, 2018).

Notably, items related to comparing perspectives (Item 8) and finding dependencies between information (Item 12) showed more varied distributions, suggesting that while many students engage in these higher-order thinking skills, a substantial minority has yet to develop these habits. This highlights the pedagogical importance of modelling and practising these skills explicitly in the language classroom.

Analysis

Thematic Patterns

Cross-item analysis reveals three prominent thematic patterns in the data. First, a Source Verification Cluster (Items 4, 5, 6) shows that students who value multiple sources consistently also report higher rates of verification behaviour, suggesting a coherent critical disposition rather than isolated habits. Second, a Sharing and Synthesis Cluster (Items 1, 2, 10) shows strong positive alignment, indicating that students who enjoy combining information also tend to share and connect it to prior knowledge. Third, a Depth and Retention Gap (Items 3, 9, 12) reveals lower engagement with deeper analytical tasks, pointing to an area in need of instructional intervention.

Gender Considerations

Although the sample size does not permit robust statistical gender-based comparisons, the slight female majority (56.7%) in this study mirrors broader trends in language learning contexts. Future research with larger samples could explore whether gender differences emerge in media literacy practices among B1–B2 learners.

Proficiency Level Implications

The B1–B2 proficiency range represents a critical threshold in language development, where learners transition from controlled to more autonomous language use. This makes it an ideal stage for introducing authentic media texts and structured critical thinking tasks. The results of this study suggest that students at this level are ready and generally willing to engage with such tasks, though explicit instruction and practice are still required to address gaps in analytical depth and retention.

Findings

The following key findings emerged from the analysis of the survey data:

1. The majority of students (over 50%) demonstrated a positive orientation toward critical media practices, including source combination, verification, and analytical engagement.
2. A significant minority (approximately 17–25% depending on item) remained neutral or showed lower engagement, particularly on items related to in-depth analysis (Item 3) and information retention (Item 9).
3. Students demonstrated stronger engagement with practical verification behaviours (double-checking, using multiple sources) than with reflective or metacognitive practices (deep analysis, retention, dependency-finding).
4. The willingness to share newly gained information was high (57%), suggesting that these students are active participants in digital information ecosystems and thus particularly vulnerable to inadvertently spreading unverified content.
5. These findings are broadly consistent with prior research on media literacy and critical thinking in student populations, while also highlighting specific challenges associated with lower-proficiency language learners.

Key findings

The data collected indicate that majority of responders hold a positive attitude toward combining information from multiple choices. This suggest that many students recognize the value of synthesizing diverse information, like viewing it as a beneficial approach to comprehensive understanding and critical

thinking. Yet there is a minority that strongly disagrees with the possibility of checking information from different sources highlighting resistance or dislike toward multiple source integration, probably out of concern that this process may lead to confusion or misinformation. A primary factor contributing in this perception may be related to individuals' worries that comparing various sources might lead to conflicting information, making it harder to discern the truth. **Trust issues** also may play a role, students may have limited confidence in the reliability of multiple sources, preferring to stick to familiar or authoritative references. **Lack of digital literacy skills** may hinder their ability to effectively evaluate and synthesize information from different sources, leading to frustration or hesitation about the process. **Comfort with existing information** might also lead to reluctance, as changing habits can feel uncomfortable or threatening. Most respondents demonstrate attentive, analytical listening and a tendency to connect new information with prior knowledge, reflecting a deep engagement with content. However, a notable minority shows limited connection-making or superficial interpretation, which may hinder their understanding. As the analysis of the data collected indicates, a significant group enjoys identifying dependencies and connections, indicating strong critical thinking and curiosity in understanding relationships between pieces of information. A considerable number of individuals proactively seek out relationships and dependencies within information, reflecting strong critical thinking skills and a curiosity-driven mindset. They favour deep analysis over superficial understanding, which can lead to more nuanced insights and well-rounded perspectives.

To effectively enhance media literacy skills among university students, a comprehensive approach can be implemented by integrating multiple strategies. This includes attending interactive workshops and seminars that focus on critical analysis, fact-checking, and recognizing bias. Embedding media literacy modules within existing curricula would also contribute. Digital literacy campaigns utilizing posters, social media, and events can raise awareness and foster engagement. Assignments that require students to critically analyse news articles, social media content, or advertisements further reinforce these skills. Students may also be given the possibility to attend online modules and simulations which offer accessible, self-paced learning. Participating in discussions on media ethics, and the impact of misinformation in social life may also reinforce a deeper understanding and promote responsible media use. Students may also create their own media content critically reflecting on the media production process and the messages conveyed.

Conclusions

This study examined the critical thinking and media literacy practices of 30 B1–B2 English language learners using a 12-item Likert-scale survey. Results indicate that while the majority of students demonstrate encouraging critical engagement with media content, a meaningful minority exhibits gaps in analytical depth, retention, and dependency-finding — skills that are central to navigating the modern information landscape. These findings carry important implications for English language teaching practice. Media literacy should not be treated as a peripheral concern but as a core competency to be developed alongside linguistic skills. Educators are encouraged to incorporate authentic media texts, structured critical analysis tasks, and reflective discussion activities into B1–B2 level courses. Explicitly teaching students to question sources, verify information, and seek multiple perspectives should be woven into everyday instructional practice.

Future studies should employ larger and more diverse samples, include quantitative statistical analysis, and explore the longitudinal development of media literacy skills across proficiency levels. Mixed-methods approaches incorporating student interviews or focus groups would provide richer qualitative insight into the attitudes and barriers identified in this survey. Fostering critical thinking and media literacy in the English language classroom is not only pedagogically valuable — it is a social and civic necessity. Students equipped with these skills are better prepared to navigate the complex, often misleading information environments of the twenty-first century. In an era dominated by rapid information dissemination through social media, digital platforms, and online news sources, media literacy and critical thinking have become fundamental skills for students. Media literacy and critical thinking are crucial for empowering students to navigate the digital world in a more responsible and accurate way. Education in media literacy is essential to enable them to identify and challenge misinformation effectively. One of the primary goals of media literacy education is to enable students to identify and challenge misinformation effectively. Encouraging students to question sources, cross-check information, and seek multiple perspectives is vital for fostering a more critical approach. Instead of passively accepting information, students should be guided to analyse who is sharing the content, what their purpose might be, and what context surrounds the data. Enhancing skills such as critical thinking, contextual awareness, and active engagement could help bridge the gaps, fostering more comprehensive and nuanced understanding

across all groups. Promoting these skills is essential for cultivating more informed and thoughtful consumers of information. Using critical thinking skills encourage students to question the validity of the data they encounter and to seek collaboration from multiple perspectives. By integrating media literacy and critical thinking into education, we cultivate informed citizens who can participate actively and responsibly in democratic societies.

References

1. Alvermann, D. E., & Hagood, M. C. (2000). Critical media literacy: Research, theory, and practice in "new times." *Journal of Educational Research* 93(3), 193–205. <https://doi.org/10.1080/0022067000959870>
2. Aufderheide, P. (1993) *Media Literacy: A report of the media literacy conference on media literacy*, Washington D.C. Aspen Institute.
3. Council of Europe (2018) *Human rights, democracy, and the rule of law*, Activity report
4. Douglas K. & Share J. (2007) *Critical media literacy is not an option* *Learning Inquiry* 1(1):59-69 DOI: 10.1007/s11519-007-0004-2
5. Erdem C. (2018) *The relationship between media literacy and critical thinking: a theoretical and empirical review*, In book *Cutting-Edge Topics and Approaches in Education and Applied Linguistics*, Cambridge Scholars Publishing
6. Gilmour T. (2024) *Critical Thinking and Media Literacy in an Age of Misinformation*. Available from: <https://www.researchgate.net/publication/377325728>
7. Kovtun D. (2022) *Misinformation is killing people: A Q&A with misinformation expert Timothy Caulfield* University of Alberta prof named to Order of Canada CBC News · Posted: Dec 31, 2022, 10:00 AM EST | Last Updated: December 31, 2022
8. Siegel H. (1988) *Educating reason; Rationality, critical thinking, and education*, New York, Routledge
9. Paul R. & Elder L. (2012) *Critical Thinking: Tools for Taking Charge of Your Learning and Your Life*, Pearson Education

LANGUAGE TRAINING IN THE MUSIC EDUCATION SYSTEM: A COGNITIVE-COMMUNICATIVE APPROACH

Yessetova Ainur T.

*Candidate of Pedagogical Sciences, Associate Professor,
Kurmangazy Kazakh National Conservatory,
Almaty, Kazakhstan*

Mashimbayeva Ainur Zh.

*Candidate of Philology Sciences, Professor,
Kurmangazy Kazakh National Conservatory,
Almaty, Kazakhstan*

Utebayeva Botagoz T.

*Master of Pedagogical science, Interim Associate Professor,
Kurmangazy Kazakh National Conservatory,
Almaty, Kazakhstan*

ЯЗЫКОВАЯ ПОДГОТОВКА В СИСТЕМЕ МУЗЫКАЛЬНОГО ОБРАЗОВАНИЯ: КОГНИТИВНО-КОММУНИКАТИВНЫЙ ПОДХОД

Есетова Айнур Такеевна

*Кандидат педагогических наук, доцент,
Казахская национальная консерватория имени Курмангазы,
Алматы, Республика Казахстан*

Машимбаева Айнур Жакыпалиевна

*Кандидат филологических наук, профессор,
Казахская национальная консерватория имени Курмангазы,
Алматы, Республика Казахстан*

Утебаева Ботагоз Тлеулесовна

*Магистр педагогических наук, и.о. ассоц. профессора,
Казахская национальная консерватория имени Курмангазы,
Алматы, Республика Казахстан*

Abstract

The relevance of this study stems from the need to modernize language training in the system of higher music education amid the globalization of the academic and professional spheres, which requires specialists to master a foreign/non-native language as a tool for professional communication. The aim of this work is to provide a theoretical justification and systematization of a methodological model for professionally oriented language instruction for students in music programs. The methodological foundation of the study consists of interdisciplinary approaches, including the principles of Content and Language Integrated Learning (CLIL), English for Specific Purposes (ESP), Task-Based Learning, as well as discourse- and genre-oriented analysis of professional texts; methods of theoretical analysis, modeling of the educational process, and cognitive interpretation of students' language activities are employed. As a result, it has been established that integrating linguistic training with a professional musical context, as well as taking into account the cognitive characteristics of musicians (development of neuroplasticity, structuring abilities, and pattern analysis), contributes to improving the effectiveness of language acquisition and the development of professional communication skills. The proposed phased model of working with text (deconstruction—reconstruction—production) facilitates the transition from receptive perception to productive language activity. It is concluded that moving away from universal linguistic models in favor of professionally oriented and cognitively integrated strategies is a necessary condition for developing competitive specialists in the field of musical arts.

Аннотация

Актуальность исследования обусловлена необходимостью модернизации языковой подготовки в системе высшего музыкального образования в условиях глобализации академического и профессионального пространства, требующей от специалистов владения иностранным/неродным языком как инструментом профессиональной коммуникации. Целью работы является теоретическое обоснование и систематизация методологической модели профессионально-ориентированного обучения языку студентов музыкальных специальностей.

Методологическую основу исследования составляют междисциплинарные подходы, включающие принципы предметно-языкового интегрированного обучения (CLIL), обучения для специальных целей (ESP), обучения на основе задач (Task-Based Learning), а также дискурс- и жанрово-ориентированный анализ профессиональных текстов; используются методы теоретического анализа, моделирования образовательного процесса и когнитивной интерпретации языковой деятельности обучающихся. В результате установлено, что интеграция лингвистической подготовки с профессиональным музыкальным контекстом, а также учет когнитивных особенностей музыкантов (развитие нейропластичности, способности к структурированию и паттерн-анализу) способствует повышению эффективности освоения языка и формированию навыков профессиональной коммуникации. Предложенная поэтапная модель работы с текстом (деконструкция — реконструкция — продукция) обеспечивает переход от рецептивного восприятия к продуктивной языковой деятельности. Сделан вывод о том, что отказ от универсальных лингвистических моделей в пользу профессионально-ориентированных и когнитивно интегрированных стратегий является необходимым условием формирования конкурентоспособного специалиста в сфере музыкального искусства.

Keywords: higher music education, language training, CLIL, ESP, TBL, professional discourse, cognitive profile of a musician, language pedagogy, discourse analysis, interdisciplinary approach.

Ключевые слова: высшее музыкальное образование, языковая подготовка, CLIL, ESP, TBL, профессиональный дискурс, когнитивный профиль музыканта, лингводидактика, дискурс-анализ, междисциплинарный подход.

Introduction. In the modern system of higher music education, language training for students has become a key component in the development of professional competence. In the context of the globalization of cultural and academic spaces, foreign language proficiency is no longer merely a supplementary tool but a functionally essential instrument of professional communication for performing musicians, educators, and researchers. A musician's professional activity inevitably extends beyond national borders; a foreign/non-native language transforms from a general education subject into a tool for accessing the world's cultural heritage and academic professional discourse. However, in higher education pedagogical practice, there is a clear contradiction between the content of traditional curricula, which are oriented toward a general linguistic approach, and the real needs of students in creative fields. Standard teaching methods, often detached from the specifics of music education, fail to develop the skills necessary for analyzing complex musical material, working with scholarly and critical literature, and engaging in meaningful professional communication. In this context, there is a growing need to rethink the role of the language discipline: working with text must cease to be a mechanical process of translation or grammatical analysis and become a complex cognitive act. Professional musical texts possess a high degree of intertextuality and terminological richness, requiring students not only linguistic knowledge but also deep musical and aesthetic competence. In this framework, the text functions as a kind of musical score, where linguistic meanings are closely interwoven with concepts of musical art. It is essential to understand working with the text not as a mechanical process of translation or grammatical analysis, but as a complex cognitive act that shapes the professional competence of future specialists in the context of a global cultural space.

This paper is devoted to the analysis and systematization of methodological approaches aimed at integrating language teaching principles into the professional training system at music conservatories. The focus is on the application of professionally oriented teaching strategies, such as Task-Based Learning and discourse analysis, which enable the learning process to move beyond standard linguistic exercises into the realm of developing sustainable professional competence. The presented material substantiates the possibility of transforming the language discipline into a space of professional discourse, where language acquires the status of an organic extension of the specialist's creative and research toolkit.

Contemporary research in applied linguistics and cognitive science confirms the existence of stable connections between musical and linguistic information processing, allowing these systems to be viewed as partially overlapping cognitive domains. This becomes particularly significant in the context of educational models focused on Content and Language Integrated Learning (CLIL) and English for Specific Purposes (ESP). Thus, language training at a music conservatory requires a shift from universal models to professionally oriented and cognitively integrated approaches.

Methodological foundations of the study. *The methodological foundation of the study consists of interdisciplinary approaches that combine linguistics, musicology, and cognitive science.*

The examination of text in a professional context requires a clarification of the concept of musical discourse, which, according to the approaches of T.A. van Dijk (Van Dijk, 1997), functions as a socio-communicative event. The musical text in the broad sense, encompassing scholarly musicological articles, critical essays, and artistic narratives, possesses its own hierarchical structure. The theoretical basis for the parallelism between music and language is provided by F. Lerdahl and R. Jackendoff's generative theory of tonal music (Lerdahl, Jackendoff, 1983), in which the authors demonstrate the presence of common principles of recursion and hierarchical organization in music and natural language. From a linguistic perspective, work with such material draws on M.M. Bakhtin's ideas about the dialogic nature of text, where each utterance is a link in a continuous chain of verbal communication. The synthesis of linguistics and musicology allows us to view the verbalization of musical images as a process of recoding meanings, requiring students to master not only lexical but also conceptual tools. Musical thinking, characterized by reliance on auditory, rhythmic, and imagery-based associations, interacts directly with the mechanisms of linguistic analysis, as confirmed by research in neurolinguistics, which points to the activation of similar neural circuits when processing syntactic structures in music and speech (Patel, 2008). Thus, the text in a music conservatory functions as a cultural-linguistic artifact that unites linguistic form and professional content, requiring specific approaches to analysis that go beyond the scope of traditional academic teaching models.

Undoubtedly, the professionally oriented nature of the material is a defining factor that transforms the learning process itself. When working with musicians, we rely on the principles of English for Specific Purposes (ESP), where the key focus is on integrating language training into the learner's professional activities. In this context, working with texts ceases to be merely an exercise in developing language skills and becomes, in addition, a tool for professional practice. A methodological system adapted for music majors must be based on a set of approaches focused on the practical use of language in the professional field. One of the central methods is Task-Based Learning, conceptually grounded in the works of R. Ellis (Ellis, 2003). In this model, a professional text—such as a critical review or a concert program annotation—serves not as a didactic object for analyzing grammar, but as a basis for solving a specific communicative task. Students simulate real-life professional situations, which requires them not only to understand the lexical and grammatical structure of the text but also to be able to apply professional concepts to achieve a specific result, whether it be preparing a performance or conducting a scholarly analysis of a musical work. This ensures high motivation, as language is perceived as a necessary tool for a successful career, rather than as an abstract academic discipline.

Parallel to this effective tool is the genre-oriented approach developed in the research of J. Swales (Swales, 1990) within the framework of the analysis of discursive communities. This approach involves a detailed analysis of the rhetorical structure of texts specific to the music community. Students examine how information is organized in musicology research articles or biographical essays, identifying patterns in argumentation and terminology use. Such analysis allows students not merely to copy vocabulary, but to internalize the logic of constructing professional discourse characteristic of their specialized field. Working with such material allows students to see how a specific text genre reflects the professional values and standards accepted in the academic music community.

The sociocultural approach, based on E. Wenger's theory of communities of practice (Wenger, 1998), plays a significant role in the methodology. Within this paradigm, learning is viewed as a process through which students enter a professional community by mastering its specific language. Working with texts is transformed here into a social practice: discussing the material in groups, holding debates, and participating in professional dialogues transform the student from a passive consumer of information into an active participant in discourse. According to Hutchinson and Waters (Hutchinson & Waters, 1987), the creation of instructional materials based on professional texts requires the instructor to have a deep understanding of the specifics of the student's future work, which brings the educational process closer to the real demands of the music industry, making the learning process pragmatic and transparent for the student. Thus, the integration of TBL, genre analysis, and sociocultural practices forms a powerful methodological foundation that enables the preparation of a specialist capable of functioning freely in the international professional music sphere, using language as a full-fledged tool of their profession.

Methods. *The study employs the following methods: discourse analysis of professional music texts; genre analysis of academic and critical texts; simulation of professional communication situations; cognitive analysis of musicians' text perception; and a phased approach to text analysis (deconstruction → reconstruction → production).*

Results and Discussion. *The process of perceiving a professionally oriented text by music students is determined by the specifics of their cognitive profile, shaped by many years of performance practice. Cognitive psychology indicates that a musician's professional skills, including developed auditory attention and the ability to rapidly structure information, have a direct impact on linguistic activity. Musicians possess unique abilities to recognize patterns and hierarchical structures, which, when working with a text, allows them to effectively segment information and identify semantic dominants (Gardner's concept of "musical intelligence"). When reading musicological or critical texts, mechanisms analogous to score analysis are activated: the student intuitively or consciously seeks "themes," "climaxes," and "syntactic connections," which makes the reading process a unique form of interpretation.*

Schema theory plays an important role in this process; according to this theory, the learner's professional experience serves as a system of background knowledge that facilitates the decoding of complex texts. For a musician, the professional context serves as a powerful mnemonic tool: terms associated with specific performance techniques or aesthetic categories are memorized much more quickly if they are incorporated into a semantic network linked to practical experience. In the works of D. Levitin (Levitin, 2006), it is convincingly demonstrated that musical training promotes the development of neuroplasticity, which in turn improves working memory efficiency. This allows student musicians to more successfully handle tasks involving the retention and processing of large amounts of information during reading. Recent studies confirm that musical training positively correlates with the development of cognitive control and the speed of information processing in linguistic tasks (Bugos et al., 2026). This fact supports the hypothesis that the cognitive mechanisms formed during music education can and should be effectively utilized in the acquisition of a professionally oriented foreign/non-native language. However, when working with linguistic material, one must also consider the risk of transferring automatic responses: the habit of "holistic" music perception can lead to superficial reading of texts, where the student focuses on the general meaning while ignoring syntactic details or specific lexical nuances. In this regard, the teacher's pedagogical task consists of a conscious "de-automatization" of perception, aimed at shifting the student from intuitive recognition to a deep analytical examination of verbal structure. Thus, taking into account the cognitive characteristics of student musicians allows for the development of a teaching strategy in which linguistic analysis becomes a natural extension of their professional analytical thinking.

The methodological algorithm for implementing the model follows this sequence:

- the deconstruction stage (analysis of terminology and structure);*
- the reconstruction stage (interpretation and reworking of content);*
- the production stage (creation of one's own professional texts).*

The practical implementation of the proposed methodology requires a phased transformation of the educational process, where the shift from receptive text comprehension to productive text creation is the key vector. In the first stage, which can be defined as the deconstruction of a professional text, the main focus shifts to a detailed analysis of terminology systems and the identification of logical connections. Students learn to work with professional dictionaries and text corpora, which allows them not only to find word equivalents but also to understand how they function in a specific context (Biber, 2006). This work is aimed at developing semantic mapping skills, through which new terminology is integrated into the learner's existing system of professional knowledge. The reconstruction stage involves the creative reworking of material, including summarization, discourse analysis, and critical evaluation of the author's argumentation. Here, the text ceases to be a static object and becomes a basis for dialogue, where the student learns to compare different points of view and formulate their own position. The final and most significant stage is production, which involves students creating their own texts for professional purposes: abstracts, reviews, essays in their field of study, or descriptions of creative projects. In the process of writing such materials, students apply the language structures they have mastered to solve real-world communicative tasks, which helps solidify their academic writing skills. An important component of modern pedagogy is the integration of digital resources: the use of specialized text corpora and artificial intelligence algorithms to analyze the stylistic correctness of their own work allows students to develop self-monitoring and self-directed learning skills (Hafner, 2011). This approach transforms the language discipline into a laboratory of professional discourse, where theory is constantly tested by practice, and each stage of the work is aimed at developing specific competencies necessary for successful activity in the field of musical art. Contemporary research confirms that musical and linguistic information processing rely on partially overlapping cognitive and neural mechanisms, which justifies their effective integration into educational models of professionally oriented training. The analysis conducted showed that:

1. A musical text represents a complex hierarchical structure analogous to the linguistic system.
2. Musicians possess cognitive advantages (pattern analysis, information structuring) that facilitate language acquisition.
3. Vocational-oriented learning (ESP, TBL, CLIL) significantly increases motivation and learning effectiveness.
4. A step-by-step model for working with texts develops sustainable skills in academic writing and professional communication.
5. The integration of digital technologies enhances the autonomy of learning.

Conclusion. In summary, it should be emphasized that the transition from formal language study to the development of professionally oriented linguistic competence is an essential prerequisite for the advancement of modern music education. The analysis has shown that working with texts in a music conservatory is not merely a type of educational activity, but a complex integrative process that combines cognitive mechanisms of perception, the performer's professional experience, and linguistic strategies of analysis. The proposed methodological model, based on the principles of Content and Language Integrated Learning (CLIL), English for Specific Purposes (ESP), Task-Based Learning (TBL), and the sociocultural approach, allows for bridging the gap between the academic curriculum and the real needs of the professional community. We have found that the use of professionally oriented texts contributes not only to the improvement of language skills but also to the development of critical thinking, which is necessary for the in-depth interpretation of musical works and successful scholarly activity. The formation of a professional's "linguistic style" is a long-term process that requires the instructor to integrate knowledge in the fields of musicology and language pedagogy, and the student to engage in active professional reflection. In the context of rapid digitalization and the implementation of artificial intelligence tools, the role of language training will only grow, becoming a guarantor of a musician's professional mobility and competitiveness on the international stage. Thus, the further refinement of methodologies for working with professional texts appears to be a key vector in the development of music pedagogy, aimed at training a new type of specialist for whom language is an organic extension of their creative and research toolkit.

The following key conclusions of the analysis can be identified: first, the rejection of universal linguistic models in favor of professionally oriented strategies (CLIL, ESP, TBL) significantly increases students' cognitive engagement, transforming language learning into a tool for solving applied creative tasks. Second, the specific nature of musicians' cognitive profiles requires the de-automatization of text perception, which is achieved through the implementation of discourse analysis methods that allow one to perceive the logic of a musical composition within its verbal structure. Third, transforming the educational environment into a space for professional discourse ensures that students develop the skills necessary for effective integration into the international music community.

Taken together, the results confirm the need for further integration of linguistic and music-cognitive approaches in the higher education system. This opens up prospects for the development of new interdisciplinary methods that ensure the formation of comprehensive professional competence in the context of a global academic and cultural space.

References

1. Van Dijk, T. A. (1997). *Discourse as Structure and Process: Discourse Studies: A Multidisciplinary Introduction*. London: SAGE Publications.
2. Lerdahl, F., & Jackendoff, R. (1983). *A Generative Theory of Tonal Music*. Cambridge, MA: MIT Press.
3. Patel, A. D. (2008). *Music, Language, and the Brain*. Oxford: Oxford University Press.
4. Ellis, R. (2003). *Task-based Language Learning and Teaching*. Oxford: Oxford University Press.
5. Swales, J. M. (1990). *Genre Analysis: English in Academic and Research Settings*. Cambridge: Cambridge University Press.
6. Wenger, E. (1998). *Communities of Practice: Learning, Meaning, and Identity*. Cambridge: Cambridge University Press.
7. Hutchinson, T., & Waters, A. (1987). *English for Specific Purposes: A Learner-Centered Approach*. Cambridge: Cambridge University Press.
8. Levitin, D. J. (2006). *This Is Your Brain on Music: The Science of a Human Obsession*. New York: Dutton.
9. Bugos, J. A. et al. (2026). Associations between music training and language fluency on cognitive control and processing speed. *Frontiers in Psychology*, 16, Article 1662938.

10. Biber, D. (2006). *University Language: A Corpus-based Study of Spoken and Written Registers*. Amsterdam: John Benjamins Publishing.

11. Hafner, C. A., & Miller, L. (2011). *Fostering learner autonomy in English for Science: A collaborative digital video project in a technological learning environment*. *Language Learning & Technology*, 15(3), 68–86.

DEVELOPING SCHOOLCHILDREN'S CREATIVE ABILITIES THROUGH THE COMMUNICATIVE APPROACH IN ENGLISH LESSONS

Kydyrali Zhanna Nurlankyzy
Smanova Gaziza Leskhankyzy
SKPU named after O.Zhanibekov

Abstract

In the modern educational landscape, fostering creativity is considered an essential requirement for 21st-century learners. Traditional teaching methods are often associated with limited student engagement, whereas the Communicative Approach is viewed as a dynamic and interactive alternative that prioritizes meaningful communication. The present study aims to examine the effectiveness of communicative techniques in developing the creative abilities of 7th-grade students at School-Gymnasium No. 26 named after Zhambyl. A qualitative research design was employed, involving the implementation of Information Gap activities and Role-play (Interviewing) simulations among a group of 25 students. The findings indicate that these communicative tasks significantly improve students' speaking proficiency, contribute to the reduction of language anxiety, and stimulate imaginative thinking. It is concluded that the Communicative Approach serves as an effective pedagogical tool that integrates language learning with the development of creativity, thereby preparing learners for real-life communication.

Keywords: *Communicative Approach, Creativity Development, English Language Teaching, Information Gap, Role-play, Schoolchildren.*

Introduction. *Within the current educational paradigm (2021–2025), the orientation of English as a Foreign Language (EFL) instruction has been redefined, shifting beyond the sole formation of linguistic competence toward the cultivation of 21st-century skills, with creativity occupying a central role. Creativity is increasingly interpreted not as an inborn ability, but as an attainable pedagogical outcome that can be systematically developed through structured communicative interaction. This transformation provides the foundation for redesigning educational curricula, moving away from traditional grammar-based models toward communicative-oriented frameworks.*

Recent scholarly discussions underline that separating language acquisition from creative cognition results in diminished learner engagement. As highlighted by Kreutner (2024), creative activities function as a “theatrical stage” enabling learners to experiment with language forms, demonstrating greater effectiveness in long-term retention compared to conventional repetitive exercises. On this basis, it can be inferred that the integration of language learning with creativity constitutes an essential component of holistic student development.

The relevance of the present study is further reinforced by challenges observed across diverse educational contexts. Sintia (2024) maintains that even in rural or resource-constrained environments, communicative project implementation serves as a driving force for the development of critical thinking and learner autonomy. Such evidence suggests that the so-called “language barrier” frequently emerges as a psychological phenomenon shaped by insufficient opportunities for creative expression. This highlights the urgency of introducing innovative pedagogical approaches in institutions such as School-Gymnasium No. 26 named after Zhambyl.

In addition, the evaluation of student achievement in contemporary EFL classrooms has undergone significant transformation. Marwa et al. (2024) emphasize that the development of “4C skills” (Communication, Collaboration, Critical Thinking, and Creativity) is most effectively facilitated through authentic, real-life tasks, including interviewing and information-gap activities. Accordingly, it may be concluded that the Communicative Approach represents a key instructional tool that enhances not only linguistic competence but also students' socio-creative capacities. In light of the above, the present research is designed to explore the causal relationship between communicative task design and the advancement of creative self-expression among 7th-grade learners.

Methodology. *In order to ensure the comprehensive development of learners' creative capacities, a wide range of communicative strategies was systematically integrated into the instructional process. Such an approach is considered instrumental not only in strengthening linguistic proficiency but also in enhancing students' cognitive flexibility and adaptive thinking skills.*

First, Information Gap Activities were incorporated as a core instructional technique. Within this framework, learners were assigned tasks that required the exchange of incomplete or exclusive

information in order to accomplish a common objective. Meaning was not simply transmitted but actively negotiated, which increased the authenticity of interaction. On this basis, it can be inferred that information-gap procedures stimulate learners to construct logical inferences and to apply their linguistic resources in a deliberate and strategic manner.

Second, Role-play in the form of improvised interviewing was introduced to move beyond rigid, pre-structured dialogues. Students were encouraged to participate in spontaneous communicative situations by assuming various social roles or identities. Through this process, the so-called "affective filter" was effectively lowered, as the pressure associated with error-making was minimized. Consequently, a supportive environment was created in which creative expression could emerge more naturally and confidently.

Third, Collaborative Storytelling was employed, particularly through the "Chain Storytelling" format. In this activity, a narrative was collectively constructed, with each participant contributing an original continuation or modification to the storyline. As the direction of the narrative remained unpredictable, learners were required to respond dynamically to their peers' ideas. This process activated divergent thinking and encouraged imaginative engagement. It may therefore be concluded that storytelling facilitates the integration of imagination with language skills, promoting a synthesis of creativity and communicative competence.

Finally, Structured Debates were organized around age-relevant and thought-provoking topics, such as the influence of social media on adolescents. Within this format, students were guided to formulate coherent arguments, justify their viewpoints, and respond to opposing perspectives. The activity demanded not only linguistic accuracy but also logical reasoning and rhetorical clarity. As a result, students' analytical abilities were refined, and their confidence in spoken interaction was significantly strengthened.

Analysis of Challenges in Communicative Implementation. Although the integration of various communicative tasks produced generally positive outcomes, notable difficulties were identified during the "Structured Debates" phase, where both cognitive and linguistic constraints became apparent. This situation provides a basis for examining the discrepancy between students' ability to construct arguments and their capacity for spontaneous speech production.

First, with regard to Cognitive Load and Argumentation, learners' difficulty in generating well-structured arguments indicates that the speed of processing information in English remains limited. The formulation of coherent reasoning in real time appeared to impose a significant cognitive burden. Based on these observations, it can be concluded that the application of scaffolding techniques—such as the provision of key vocabulary, discourse markers, and logical frameworks prior to debate—represents a necessary pedagogical intervention.

Second, Linguistic Anxiety in Debates was observed as a prominent barrier affecting performance. Challenges in fluent expression were closely associated with the phenomenon of public speaking anxiety, which inhibited learners' willingness to participate actively. This finding suggests that greater emphasis should be placed on the preparatory stage preceding debates. In particular, the incorporation of emotionally supportive activities, such as storytelling and role-play, can contribute to reducing anxiety levels and facilitating a more confident transition into argumentative discourse.

Results and discussion. During the debate phase, a range of communicative difficulties was identified, particularly in relation to students' ability to construct arguments fluently and sustain spontaneous interaction. Observable pauses, hesitation markers, and fragmented speech indicated that learners experienced constraints not only at the linguistic level but also at the cognitive level. These findings reinforce the assumption that communicative competence is closely interrelated with cognitive load, especially in tasks that require the simultaneous processing of content, structure, and language. In such contexts, students are expected to generate ideas, organize them logically, and encode them in a foreign language in real time, which significantly increases mental effort and may hinder performance. To mitigate these challenges, a set of targeted pedagogical interventions was implemented, each designed to reduce cognitive pressure and enhance communicative effectiveness.

Firstly, Scaffolding through Functional Language was systematically introduced as a key support mechanism. Learners were provided with curated sets of "Debate Phrases," including expressions for presenting arguments, agreeing and disagreeing, and structuring discourse (e.g., "The primary reason supporting my viewpoint is...", "While your argument is valid, it can be argued that..."). These linguistic supports functioned as cognitive anchors, allowing students to rely on ready-made structures instead of constructing sentences from scratch. As a result, the cognitive load associated with grammatical encoding was significantly reduced. It was observed that students became more focused on idea generation and

logical coherence rather than on formulating grammatically complex sentences. This shift from form-centered processing to meaning-oriented communication contributed to a noticeable improvement in the quality and clarity of their spoken output.

Secondly, Confidence Building through Pre-tasks played a crucial role in preparing learners for the demands of debate. Prior to engaging in argumentative discussions, students participated in Information Gap activities and Role-play simulations related to the debate topics. These preparatory tasks served multiple functions: they activated prior knowledge, introduced relevant vocabulary, and provided a low-pressure environment for initial idea expression. Through repeated exposure to the topic in varied communicative contexts, learners gradually developed familiarity and confidence. Consequently, when transitioning to the debate stage, students demonstrated greater willingness to participate and reduced levels of anxiety.

Furthermore, the sequential integration of these communicative techniques highlighted the importance of a staged pedagogical approach. Rather than introducing debates as isolated activities, embedding them within a broader communicative framework allowed for the gradual development of both linguistic and cognitive readiness. The findings suggest that psychological barriers, such as fear of making mistakes or public speaking anxiety, can be effectively minimized when learners are systematically guided through increasingly complex tasks.

In addition, it was noted that peer interaction during pre-tasks contributed to a supportive learning atmosphere, where students felt more comfortable experimenting with language. This collaborative environment further reinforced confidence and encouraged risk-taking, which is essential for creative and spontaneous speech production.

Overall, the results indicate that overcoming linguistic barriers in debates requires not only the development of language skills but also the careful management of cognitive load and emotional factors. The combined use of scaffolding strategies and preparatory communicative tasks proves to be an effective approach in facilitating smoother, more confident participation in argumentative discourse.

Table 1- Quantitative Dynamics of Student Performance

Criteria	Pre-intervention	Post-intervention	Growth
Confidence level	32%	76%	+44%
Active participation	40%	88%	+48%
Fluency (WPM)	12-15 words	25-30 words	+100%
Creative input	20%	64%	+44%

A significant quantitative transformation was observed in students' classroom engagement, as participation rates increased markedly from 40% to 88%. Such a shift indicates that communicative tasks possess a strong capacity to stimulate learners' intrinsic motivation and encourage active involvement in the learning process. This pattern suggests that when students are placed in interactive and meaningful communicative contexts, their willingness to participate is substantially enhanced. In addition, notable progress was identified in terms of fluency development. The doubling of speech rate, measured in words per minute, serves as clear evidence that learners were able to overcome initial linguistic barriers. This improvement can be attributed to the use of supportive tools during debates, particularly the implementation of prompt cards and key lexical structures. It can therefore be inferred that these scaffolding elements play a crucial role in fostering linguistic automatisms, enabling students to produce speech more rapidly and with greater confidence.

Furthermore, the impact of scaffolding strategies became especially evident when comparing students' performance before and after the introduction of supportive mechanisms. At the initial stage, only 5 students (20%) demonstrated the ability to express their ideas fluently during debates. However, following the integration of additional instructional supports, this number increased to 15 students (60%). This substantial improvement highlights the effectiveness of gradual task progression and confirms the pedagogical value of introducing complex communicative activities in a staged and supported manner. Overall, the findings emphasize that structured scaffolding not only enhances language performance but also facilitates a more inclusive and accessible learning environment for all students.

Conclusion and recommendations. The overall examination of the communicative approach implementation within the 7th-grade English classroom allows several meaningful conclusions to be drawn. Based on the obtained findings, it can be stated that the enrichment of teaching methodology through diverse communicative strategies such as debates, storytelling, and role-play activities plays a decisive role in unlocking students' creative potential. The systematic integration of such interactive techniques contributes to a more dynamic learning environment, where learners are encouraged to actively construct meaning rather than passively receive information. Both quantitative and qualitative results of the

study demonstrate a clear relationship between the use of creative communicative tasks and the reduction of language anxiety, alongside a noticeable increase in spontaneous speech production. This evidence suggests that within the educational process, greater emphasis on communicative fluency (fluency) over strict grammatical accuracy (accuracy) leads to more effective language use in authentic contexts. Consequently, learners become more willing to express their ideas freely, without excessive concern for structural perfection, which ultimately enhances overall communicative competence.

Based on these research outcomes, several pedagogical recommendations can be formulated for EFL practitioners. Firstly, Diversification of Techniques is strongly recommended in order to avoid instructional monotony. The regular alternation of communicative patterns such as discussions, group work, role-play, and problem-solving tasks helps maintain sustained student interest. It can be inferred that such variability in classroom activities contributes to higher levels of engagement and motivation, preventing learner fatigue and increasing participation consistency.

Secondly, Strategic Scaffolding should be considered an essential component of complex communicative tasks, particularly in debate-based activities. The provision of structured support tools, including cue cards, functional expressions, and discourse templates, significantly facilitates learners' performance. It may therefore be concluded that scaffolding mechanisms act as a key factor in strengthening students' self-confidence and enabling more effective participation in cognitively demanding tasks. Thirdly, the promotion of Creative Autonomy is highly recommended. In this approach, the teacher's role gradually shifts from a traditional knowledge transmitter to a learning facilitator who guides rather than controls the learning process. Such a transformation allows students to independently navigate communicative challenges, develop problem-solving skills, and engage more actively in creative language use. In conclusion, the communicative approach can be characterized as a transformative pedagogical framework that bridges the gap between theoretical linguistic knowledge and its practical, creative application in real-life communicative situations.

References

1. Kreutner, E. (2024). Literature class meets creativity: Raising the curtain for creative tasks in the EFL classroom. *Journal of Creative Education and Language Teaching*, 12(2), 45–58.
2. Marwa, M., & Rahman, A. (2024). Assessment of students' 4C skills (Communication, Collaboration, Critical Thinking, Creativity) in research-based English projects. *International Journal of Instruction*, 17(1), 112–130.
3. Sintia, I. (2024). Implementation of Project-Based Learning (PBL) and Communicative Approaches in EFL classrooms: A study of rural and urban school dynamics. Global Press Education.
4. Richards, J. C., & Rodgers, T. S. (2023). *Approaches and Methods in Language Teaching* (4th ed.). Cambridge University Press.
5. Thompson, L. (2022). The Role of Scaffolding in Developing Speaking Fluency: Tools and Strategies for Middle School Learners. *Language Teaching Research Quarterly*, 9(4), 88–102.

TEACHER-IN-THE-LOOP ARTIFICIAL INTELLIGENCE IN PERSONALIZED ENGLISH LANGUAGE TEACHING THROUGH THE LENS OF PEDAGOGICAL ROLES, AFFORDANCES, AND RISKS

Zhumabay Zhazira Bekzhankyzy

Master's Degree Student,

South Kazakhstan Pedagogical University named after O. Zhanibekov, Shymkent, Kazakhstan

Scientific Supervisor: **Shingareva Marina Yurievna**

PhD in Philology, Associate Professor

Abstract

This article reviews the literature on teacher-in-the-loop artificial intelligence in personalized English language teaching, with particular attention to pedagogical roles, instructional affordances, and associated risks. The growing use of artificial intelligence in language education has created new opportunities for personalizing instruction, adapting learning tasks, and providing immediate feedback to learners with diverse needs, proficiency levels, and learning trajectories. At the same time, the educational value of such technologies depends not only on their technical capabilities, but also on the pedagogical mediation of the teacher. From a teacher-in-the-loop perspective, artificial intelligence is understood not as a substitute for the teacher, but as a supportive instrument embedded within human-guided instructional design, feedback regulation, and ethical decision-making. The review identifies several key affordances of AI in personalized ELT, including adaptive feedback, differentiated learning pathways, increased learner engagement, and support for self-regulated learning. At the same time, it highlights major limitations and risks, such as inaccurate or superficial feedback, learner overdependence on automated systems, algorithmic bias, data privacy concerns, and the possible weakening of teacher agency. The article argues that effective integration of AI in personalized English language teaching requires a balanced pedagogical model in which teachers remain central as designers, mediators, and evaluators of the learning process. It is concluded that teacher-in-the-loop AI offers significant potential for enhancing personalized ELT, provided that its implementation remains pedagogically grounded, ethically responsible, and context-sensitive.

Keywords: teacher-in-the-loop artificial intelligence, personalized English language teaching, English language teaching, pedagogical affordances, learner autonomy, adaptive feedback, ethical risks, teacher agency

Introduction

The rapid development of artificial intelligence has significantly influenced contemporary educational practices, including the field of English language teaching. In recent years, AI-powered technologies such as intelligent tutoring systems, generative chatbots, automated writing evaluation tools, speech recognition applications, and adaptive learning platforms have increasingly been integrated into language learning environments. Their growing presence reflects a broader pedagogical shift from standardized instruction toward more personalized forms of learning that take into account learners' individual needs, proficiency levels, pacing, and learning difficulties [1, p.6].

In the context of English language teaching, personalization has become especially important due to the considerable heterogeneity of non-native learners. Learners differ not only in linguistic competence, but also in motivation, learning strategies, anxiety levels, cognitive preferences, and access to learning opportunities. As a result, traditional one-size-fits-all instruction often proves insufficient for addressing the complexity of learner profiles in contemporary EFL classrooms. Artificial intelligence has therefore attracted increasing scholarly attention as a tool capable of supporting differentiated instruction, generating immediate feedback, and extending learning beyond the physical classroom.

At the same time, the educational value of AI in language learning should not be reduced to its technical efficiency alone. Although AI systems can automate certain instructional processes and provide scalable support, they do not possess pedagogical judgment, contextual sensitivity, or the ethical awareness required for responsible teaching. In language education in particular, where interaction, meaning negotiation, emotional support, and sociocultural sensitivity remain central, the role of the teacher cannot be displaced by technology. For this reason, the concept of teacher-in-the-loop artificial intelligence has become increasingly relevant. This perspective emphasizes that AI should function within a pedagogically guided framework in which the teacher remains actively involved in selecting, monitoring, interpreting, and regulating the use of technological tools [2, p.10].

The teacher-in-the-loop approach is particularly significant in personalized English language teaching because it allows artificial intelligence to be used not as an autonomous substitute, but as a supportive instrument embedded in human-centered pedagogy. Within such a model, teachers act as instructional designers, mediators of feedback, facilitators of learner autonomy, and ethical decision-makers who ensure that personalization remains meaningful, context-sensitive, and educationally valid. This is especially important given the growing concerns in the literature regarding algorithmic bias, superficial feedback, learner overdependence on AI systems, data privacy issues, and the possible weakening of teacher agency.

Against this background, it is necessary to examine the role of teacher-in-the-loop artificial intelligence in personalized English language teaching not only from the perspective of innovation, but also through a critical pedagogical lens. A balanced review of the literature can help clarify the educational functions of AI, the conditions under which it supports personalization effectively, and the limitations that accompany its implementation in ELT settings.

The aim of this article is to review the literature on teacher-in-the-loop artificial intelligence in personalized English language teaching through the lens of pedagogical roles, instructional affordances, and associated risks. The article argues that the effectiveness of AI in personalized ELT depends less on technological novelty itself than on the extent to which its use is guided by teacher expertise, pedagogical intentionality, and ethical responsibility [3, p.32].

Conceptual foundations of teacher-in-the-loop artificial intelligence in personalized English Language Teaching

The integration of artificial intelligence into contemporary education has become one of the most significant developments in recent pedagogical discourse, particularly in areas where instruction must respond to diverse learner needs, changing communicative demands, and rapidly evolving technological environments. In the field of English language teaching, this transformation is especially visible because language learning is both cognitively complex and highly individualized. Unlike more standardized forms of instruction, ELT requires sustained attention to learner variation in proficiency, pace, motivation, interactional confidence, and communicative goals. Within this context, artificial intelligence has emerged as a potentially valuable educational resource capable of supporting more responsive and flexible forms of teaching and learning. The relevance of AI in language education is often associated with its ability to process large amounts of learner input, detect patterns in performance, generate adaptive responses, and provide immediate support through a variety of digital tools. These capacities have led many scholars and practitioners to consider AI as a promising mechanism for enhancing language instruction, particularly in settings where teachers face constraints related to time, class size, or limited opportunities for sustained individual support. However, the pedagogical significance of AI in ELT cannot be understood solely in terms of efficiency, automation, or technological innovation. Its role must instead be examined through a broader educational framework that takes into account how learning is organized, how pedagogical decisions are made, and how human expertise remains central in the interpretation and mediation of technological input [4, p. 15].

Artificial intelligence in language education generally refers to computational systems designed to perform functions that resemble aspects of human cognition, including language processing, pattern recognition, prediction, feedback generation, and data-informed decision support. In practical educational contexts, these functions are reflected in intelligent tutoring systems, automated writing evaluation tools, adaptive learning platforms, speech recognition software, learning analytics dashboards, and increasingly, generative AI applications capable of producing text, responding to prompts, and simulating dialogue. In English language teaching, such technologies are used to support a wide range of learning activities, including grammar practice, vocabulary development, pronunciation training, listening support, writing revision, conversational interaction, and task generation. Their appeal lies in the possibility of extending learning beyond the traditional classroom while offering learners a degree of individualized support that may otherwise be difficult to provide consistently. For example, AI-based tools may analyze learner errors, recommend targeted tasks, adjust levels of difficulty, or generate immediate feedback that helps learners notice patterns in their language use. Such functions are particularly attractive in EFL contexts characterized by heterogeneous learner groups and uneven access to personalized instruction. At the same time, it is essential to recognize that these technologies do not “understand” learning in a human pedagogical sense. Their outputs are based on algorithmic modeling, statistical prediction, and training data rather than on contextual awareness, moral reasoning, or deep sensitivity to the learner’s emotional and social reality. For this reason, the educational use of AI should not be treated as self-sufficient or automatically pedagogical simply because it appears interactive or adaptive [5, p.66].

This issue becomes even more important when discussing personalization in English language teaching. Personalization is widely regarded as a valuable pedagogical principle because it seeks to align learning experiences with the characteristics, needs, goals, and trajectories of individual learners. In contrast to uniform or one-size-fits-all instruction, personalized learning attempts to create more meaningful conditions for engagement by taking into account how learners differ in their prior knowledge, learning strategies, levels of anxiety, motivational patterns, communicative needs, and cultural or educational backgrounds. In language education, such differences are especially pronounced, since learners do not approach English from a single starting point or for a single purpose. Some learners need English for academic advancement, others for professional communication, travel, migration, or access to global information, and these goals influence the forms of support they require. Personalization in ELT therefore involves more than adjusting task difficulty; it concerns the broader pedagogical effort to make learning more relevant, accessible, and responsive. Yet in scholarly and practical discourse, personalization is often conflated with related concepts such as adaptation and individualization, even though these terms are not fully synonymous. Individualization usually refers to modifications in learning pace while maintaining relatively stable content or objectives, whereas adaptation typically refers to changes in materials, methods, or instructional support in response to learner performance or contextual conditions. Personalization, by contrast, reflects a broader learner-centered philosophy in which instruction is shaped not only by measurable outcomes but also by learners' preferences, intentions, identities, and agency within the learning process. This distinction is highly significant in AI-supported ELT because many digital tools described as "personalized" offer only limited forms of automated adaptation rather than genuine pedagogical personalization.

Indeed, one of the central conceptual problems in current discussions of AI in education is the tendency to equate algorithmic responsiveness with true personalization. A platform may automatically increase or decrease task difficulty, suggest exercises based on prior responses, or generate feedback in real time, but such processes do not necessarily mean that learning has become genuinely personalized in a pedagogical sense. Automated systems often operate on narrow indicators of performance and may fail to account for broader dimensions of language learning, such as communicative intention, emotional readiness, sociocultural relevance, or long-term developmental goals. A learner may receive technically appropriate but pedagogically shallow support if the system responds only to error frequency or surface-level patterns without understanding why difficulties occur or what kind of intervention would be most educationally meaningful. In this sense, personalization cannot be reduced to computational adjustment alone. It requires interpretation, educational judgment, and purposeful alignment between technological affordances and human learning needs. For language education in particular, where progress depends not only on accuracy but also on interaction, confidence, identity, and context-sensitive use of language, personalization must remain a pedagogically mediated process rather than a purely technical function [6, p.58].

This is precisely why the teacher-in-the-loop principle is conceptually important. The notion of teacher-in-the-loop artificial intelligence refers to an educational model in which AI systems operate under continuous human pedagogical guidance rather than functioning as autonomous instructional agents. Within such a model, the teacher remains centrally involved in defining the aims of AI use, selecting appropriate tools, framing tasks, interpreting outputs, validating feedback, and monitoring the consequences of technology use for learner development. The teacher is not treated as a secondary figure who merely supervises automation, but as the core pedagogical authority who ensures that technological resources are used in ways that remain educationally purposeful, ethically responsible, and contextually appropriate. This model is especially relevant in English language teaching because language learning is not solely a matter of information transfer or answer correction. It is also deeply interactional, affective, and socially situated. Learners need explanation, encouragement, clarification, and communicative scaffolding. They need help making sense of errors, building confidence, managing anxiety, and using language meaningfully in context. While AI may assist with some of these dimensions, it cannot independently reproduce the nuanced pedagogical responsiveness that human teachers bring to classroom interaction and learning design.

From this perspective, the teacher-in-the-loop approach should be understood not simply as a technical safeguard, but as a pedagogical framework that preserves human agency within increasingly technologized learning environments. It proposes a collaborative relationship between teacher and artificial intelligence rather than a substitutional one. AI can help extend practice opportunities, generate drafts or exercises, provide rapid responses, and support certain forms of instructional differentiation, but it is the teacher who determines whether these outputs are valid, useful, ethical, and aligned with the

learner's developmental needs. The teacher's role includes not only correcting or supplementing AI-generated material, but also deciding when AI use is beneficial, when it may be misleading, and when human intervention is pedagogically necessary. This is particularly important in personalized ELT, where the quality of instruction depends not just on content delivery but on the meaningful interpretation of learner diversity. Teachers remain essential as designers of learning environments, mediators of feedback, facilitators of learner autonomy, and protectors of educational values such as fairness, inclusion, and critical thinking. In this sense, teacher-in-the-loop AI offers a more balanced conceptualization of innovation: one that acknowledges the practical power of intelligent tools without overestimating their pedagogical independence [7, p.539].

Moreover, the teacher-in-the-loop perspective responds directly to a number of growing concerns in the literature on AI in education. Although artificial intelligence offers efficiency, scalability, and seemingly adaptive support, it also introduces important risks related to bias, inaccuracy, overdependence, privacy, and the potential weakening of teacher judgment. AI-generated feedback may sometimes be superficial or incorrect, especially in complex language tasks involving discourse, pragmatics, tone, or contextual appropriateness. Learners may become overly reliant on automated suggestions and gradually reduce the kind of productive struggle that supports deeper language acquisition. At the same time, institutions may be tempted to treat AI as a cost-saving replacement for human teaching rather than as a complementary instrument, thereby reducing the professional agency of teachers and oversimplifying the pedagogical process. The teacher-in-the-loop model offers a conceptual response to these risks by insisting that educational technology must remain embedded within human decision-making. It shifts the discussion from whether AI can personalize learning to how personalization should be pedagogically governed, ethically constrained, and professionally mediated.

Taken together, these conceptual considerations suggest that the use of artificial intelligence in personalized English language teaching should be understood as a human-guided educational practice rather than as a self-sustaining technological solution. AI undoubtedly expands the range of tools available for supporting learner diversity, increasing flexibility, and providing forms of adaptive assistance that were previously difficult to scale. However, its pedagogical legitimacy depends on the extent to which it is integrated within a framework that preserves teacher expertise, learner-centeredness, and contextual sensitivity. Personalization in ELT is not achieved simply because a system can adjust difficulty or produce immediate responses. It becomes educationally meaningful only when such processes are connected to broader pedagogical goals and interpreted through informed human judgment. For this reason, the conceptual foundation of teacher-in-the-loop artificial intelligence is essential for understanding both the promise and the limitations of AI-supported personalization in English language teaching. It provides the theoretical basis for a more critical and balanced examination of how AI reshapes pedagogical roles, what instructional affordances it offers, and what risks must be addressed in order to ensure responsible and effective implementation [8, p.23].

Pedagogical roles of teacher-in-the-loop artificial intelligence in personalized ELT

Within the context of personalized English language teaching, the teacher-in-the-loop model redefines rather than diminishes the pedagogical role of the teacher. The growing presence of artificial intelligence in educational practice has sometimes been accompanied by speculative claims that automated systems may eventually replace a substantial portion of the teacher's work. However, such assumptions oversimplify both the nature of language learning and the complexity of pedagogical activity. In reality, the integration of AI into ELT does not eliminate the need for teachers; instead, it transforms their responsibilities and makes certain dimensions of their role even more important. In personalized learning environments, the teacher is not merely a transmitter of content, but a professional who interprets learner needs, designs meaningful instruction, regulates feedback, supports affective engagement, and ensures that educational processes remain ethically and contextually grounded. When AI is incorporated into this environment, these responsibilities become more layered rather than less significant. The pedagogical value of AI depends not only on what the technology can generate, but also on how teachers select, frame, adapt, monitor, and evaluate its use in relation to real learners and real instructional aims [9, p.5].

One of the central pedagogical roles of the teacher in an AI-supported personalized environment is that of instructional designer. In conventional language classrooms, teachers already make constant decisions about sequencing material, adapting tasks, selecting examples, and matching instruction to learner readiness. In a teacher-in-the-loop AI framework, this design function becomes even more strategic because the teacher must determine not only what should be taught, but also how AI tools should be incorporated into the teaching process. This includes deciding which technologies are pedagogically

appropriate, what kinds of tasks should be delegated to AI-supported practice, how AI-generated material should be aligned with curriculum outcomes, and under what conditions automated support may be beneficial or counterproductive. Teachers must therefore act as curators of technological input rather than passive users of digital systems. For example, an AI tool may be capable of generating grammar exercises, conversation prompts, writing models, or vocabulary activities in seconds, but the pedagogical relevance of these materials depends on whether they correspond to the learner's developmental stage, communicative needs, and learning objectives. A teacher may choose to use AI to produce differentiated task variations for learners at different proficiency levels, but the meaningfulness of this differentiation still relies on teacher judgment. In this sense, the teacher remains the architect of the learning experience, while AI functions as an instrument that expands design possibilities without replacing pedagogical intentionality [10, p.8].

Another major role of the teacher in a teacher-in-the-loop model is that of mediator of feedback and classroom interaction. Feedback is one of the most important elements of language learning because it supports noticing, error awareness, hypothesis testing, and gradual refinement of linguistic performance. Artificial intelligence is often praised for its capacity to provide immediate responses, detect recurring errors, and offer corrective suggestions in real time. These features can indeed enhance personalized learning by making feedback more accessible and responsive. Nevertheless, feedback in language education is not simply a matter of speed or frequency. It also involves explanation, prioritization, emotional tone, contextual relevance, and sensitivity to what the learner is ready to process at a given moment. AI-generated feedback may be technically correct in some cases, but still pedagogically insufficient, overly generic, misleading, or disconnected from the learner's communicative intent. The teacher's mediating role is therefore essential in determining how feedback should be interpreted and used. Teachers help learners distinguish between surface correction and deeper learning, guide them in understanding why a response is inaccurate, and decide which errors require attention and which can be temporarily tolerated as part of developmental progression. In classroom practice, this means that AI may provide a preliminary layer of feedback, while the teacher ensures that such feedback becomes educationally meaningful rather than mechanically consumed. The teacher also manages interaction around AI use by encouraging reflection, discussion, comparison, and critical engagement with automated responses, thereby preventing feedback from becoming a passive one-way transfer of corrections.

The teacher-in-the-loop approach also positions the teacher as a facilitator of learner autonomy, which is particularly significant in personalized ELT. One of the commonly cited advantages of AI is its potential to support self-paced and independent learning. Learners can access exercises outside class, receive immediate answers, revise texts with automated support, and practice language interactively without waiting for teacher availability. These opportunities can contribute to autonomy by increasing learner control over time, pace, and repetition. However, autonomy in language learning should not be equated with mere independence from the teacher or unsupervised interaction with technology. Genuine learner autonomy involves the capacity to make informed decisions, regulate learning behavior, monitor progress, evaluate resources critically, and use support tools in purposeful ways. These capacities do not emerge automatically from access to AI systems; they require guidance, modeling, and gradual scaffolding. The teacher therefore plays a critical role in teaching learners how to use AI productively rather than dependently. This includes helping them formulate effective prompts, question questionable outputs, compare AI suggestions with authentic language use, and understand when technology can assist and when human clarification is needed. In this sense, the teacher does not stand in opposition to learner autonomy, but actively constructs the conditions under which autonomy becomes possible. AI may create more opportunities for independent practice, but the teacher shapes the metacognitive and strategic framework that allows learners to benefit from those opportunities responsibly [11, p.9].

Equally important is the teacher's role as an interpreter of learner diversity within AI-supported personalization. Personalized English language teaching assumes that learners do not progress uniformly and should not be taught as though they do. They differ in pace, background knowledge, affective disposition, confidence, educational history, digital literacy, and reasons for learning English. While AI systems may detect some performance patterns and adapt certain forms of content accordingly, they are limited in their ability to understand the full complexity of these learner differences. A student's repeated grammatical errors, for example, may reflect not only lack of knowledge but also anxiety, cognitive overload, low confidence, weak first-language literacy foundations, or misunderstanding of task demands. These dimensions cannot be adequately interpreted through automated systems alone. The teacher remains the professional who reads beyond performance data and understands the learner as a person situated within a social, emotional, and educational context. This interpretive function is vital because meaningful

personalization requires more than tailoring exercises to answers; it requires recognizing what kind of support a learner needs and why. Teachers therefore serve as human diagnosticians who contextualize learner behavior, make sense of patterns that AI can only partially capture, and ensure that personalization remains genuinely learner-centered rather than merely data-responsive.

The teacher-in-the-loop model also casts the teacher as an ethical decision-maker and protector of pedagogical integrity. The expansion of AI in education has introduced new ethical questions related to privacy, transparency, fairness, authorship, access, and bias. In English language teaching, these concerns are especially sensitive because language is deeply tied to culture, identity, and communicative legitimacy. AI systems may reproduce dominant linguistic norms, undervalue variation, reinforce bias through training data, or generate content that is culturally inappropriate or educationally misleading. Learners may also be exposed to privacy risks when their interactions are stored, analyzed, or used for system training. Furthermore, unequal access to devices, stable internet, or digital literacy may deepen existing educational disparities rather than reduce them. Within this landscape, the teacher's role extends beyond instruction into ethical judgment. Teachers must decide whether particular tools are appropriate, whether learners understand the limits of AI-generated content, whether assignments encourage genuine learning rather than unreflective outsourcing, and whether the use of AI aligns with educational values such as equity, inclusion, authenticity, and critical thinking. This role is indispensable because ethical responsibility in education cannot be delegated to automated systems or reduced to technical compliance. It requires human judgment informed by pedagogical principles and an awareness of the lived realities of learners [12, p.17].

Another significant pedagogical role of the teacher in AI-enhanced personalized ELT is that of evaluator and regulator of learning quality. Artificial intelligence can generate large amounts of instructional content quickly and can simulate adaptation across multiple tasks, but quantity and responsiveness do not guarantee quality. Teachers remain responsible for evaluating whether AI-generated materials are accurate, level-appropriate, communicatively relevant, and methodologically sound. This is particularly important in language teaching, where even apparently correct material may be unnatural, pragmatically odd, or unsuitable for the learner's context. Teachers must therefore validate content before or after its use, modify it when necessary, and observe how learners actually respond to it. They must also regulate the extent to which AI is involved in learning activities. Overuse of AI can lead to dependency, reduced productive struggle, diminished creativity, or shallow engagement with language, especially if learners begin to rely on generated answers instead of constructing meaning themselves. The teacher's regulatory role involves maintaining balance: deciding when AI can usefully support practice, and when a task requires direct human interaction, collaborative communication, or slower cognitive effort without automated assistance. In this sense, the teacher protects not only instructional quality but also the developmental conditions under which durable language learning takes place [13, p.4].

At a broader level, the pedagogical roles associated with teacher-in-the-loop artificial intelligence point to a shift in professional identity within English language teaching. The teacher in an AI-supported environment is no longer defined only as a source of knowledge or a manager of classroom routines, but increasingly as a pedagogical strategist who works at the intersection of content expertise, learner psychology, technological literacy, and ethical reasoning. This shift does not make the profession less human; on the contrary, it intensifies the need for distinctly human capacities. As AI becomes more capable of generating text, adapting exercises, or simulating communication, the unique value of the teacher lies even more clearly in interpretation, discernment, relational presence, and professional judgment. The teacher is the one who can understand when a learner is discouraged, when automated feedback is technically correct but developmentally mistimed, when personalization is becoming superficial, or when technology is beginning to distort rather than support learning aims. In this way, teacher-in-the-loop AI does not reduce pedagogy to technology-assisted management. Instead, it reveals that the pedagogical center of personalized ELT remains profoundly human, even when it is technologically mediated.

Taken together, these roles demonstrate that the integration of AI into personalized English language teaching is most educationally meaningful when teachers remain active, reflective, and authoritative participants in the process. The teacher functions as designer, mediator, facilitator of autonomy, interpreter of learner diversity, ethical decision-maker, and regulator of instructional quality. Each of these roles contributes to a model of AI use that is pedagogically grounded rather than technologically deterministic. Rather than asking whether artificial intelligence can replace the teacher, a more productive question is how AI can be integrated in ways that strengthen the teacher's ability to respond to learner diversity and support deeper, more personalized forms of language learning. From this perspective, the teacher-in-the-loop framework offers not only a practical strategy for integrating AI, but also a

conceptual defense of pedagogy itself in an era increasingly shaped by automation. If AI is to contribute meaningfully to personalized ELT, it must do so within a model that recognizes teacher expertise as the condition that transforms technological possibility into educational value [14, p.36].

Pedagogical affordances of artificial intelligence for personalized ELT

The pedagogical affordances of artificial intelligence in personalized English language teaching are increasingly discussed in contemporary educational research as part of a broader shift toward more flexible, learner-responsive, and data-informed instructional models. In the context of ELT, AI is often valued not simply because it introduces new technologies into the classroom, but because it offers practical mechanisms through which teaching and learning can become more adaptive to the needs of individual learners. This is particularly relevant in language education, where learners differ substantially in proficiency level, pace of development, confidence, preferred modes of learning, communicative goals, and exposure to English outside formal instruction. In such conditions, traditional whole-class instruction, although pedagogically valuable in many respects, often struggles to provide a sufficient level of individual responsiveness. Artificial intelligence offers a range of affordances that can help address this challenge by expanding opportunities for differentiated practice, timely support, and personalized engagement. However, these affordances become pedagogically meaningful only when they are understood not as isolated technical functions, but as resources that may support deeper language learning when embedded within an intentional instructional framework.

One of the most frequently emphasized affordances of artificial intelligence in ELT is its capacity to provide immediate and, to some extent, adaptive feedback. In language learning, feedback is central because it helps learners notice errors, test hypotheses, refine output, and gradually develop greater control over linguistic form and meaning. AI-based systems can offer rapid responses to learner input in ways that are often difficult to sustain consistently in real time through teacher effort alone, especially in large classes or independent learning contexts. For example, automated writing tools may flag grammatical inaccuracies, suggest lexical alternatives, or highlight issues of coherence and mechanics. Speech recognition systems may provide feedback on pronunciation, intonation, or fluency, while conversational systems may react to learner prompts and generate responses that simulate communicative exchange. The pedagogical value of such feedback lies not only in its speed, but also in its availability: learners can receive support at the point of need, repeat tasks multiple times, and experiment with language without waiting for delayed correction. This can be particularly beneficial for learners who require repeated exposure, extended rehearsal, or additional opportunities to process feedback privately before participating more openly in classroom interaction. In this sense, AI enhances the temporal flexibility of language support and allows feedback to become a more continuous component of the learning process [15, p.96].

Another major affordance of artificial intelligence in personalized ELT is its support for differentiated learning pathways and individual pacing. Language learners rarely develop in uniform ways, and even within the same class learners may vary widely in grammatical control, vocabulary range, listening comprehension, fluency, strategic competence, and confidence in language production. AI tools can help address these differences by generating tasks at varying levels of complexity, recommending practice based on prior performance, and allowing learners to revisit material at a pace that matches their own readiness. This kind of flexibility can reduce the mismatch that often occurs when classroom instruction proceeds at a speed that is either too demanding for some learners or insufficiently challenging for others. For weaker learners, AI can make practice more accessible by breaking down content, offering repetition, or simplifying support. For more advanced learners, it can extend opportunities for enrichment, elaboration, and self-directed exploration. Importantly, this flexibility is not only a matter of convenience. It has pedagogical implications for learner confidence, persistence, and perceived attainability. When learners are able to work at an appropriate level of challenge, they are more likely to remain engaged and less likely to experience the repeated discouragement that often accompanies tasks perceived as either overwhelming or meaningless. Thus, AI can contribute to a more sustainable learning experience by supporting differentiated progression rather than forcing all learners through identical trajectories [16, p.12].

Artificial intelligence also offers important affordances in relation to learner engagement and the expansion of practice opportunities beyond the physical classroom. One of the recurring challenges in English language teaching, especially in foreign language contexts, is the limited amount of meaningful practice time available within formal instructional settings. Learners often need far more exposure, interaction, and output practice than classroom schedules allow. AI-supported environments can partially address this issue by making language practice more available, interactive, and, in some cases, more motivating. Learners can engage with conversational agents, complete dynamic exercises, revise written

output, or receive guided support outside classroom hours, which extends the learning process into a more continuous and self-regulated domain. In some cases, AI tools may also lower the affective barriers associated with language practice. Learners who are reluctant to speak in front of peers, afraid of making mistakes publicly, or hesitant to ask for repeated clarification may feel more comfortable experimenting with language in less socially exposed digital environments. This does not mean that AI can replace authentic human communication, but it can create lower-risk spaces in which learners build confidence, rehearse language, and prepare for fuller participation in human interaction. From a pedagogical point of view, this affective affordance is significant because anxiety, embarrassment, and fear of failure often interfere with language learning just as strongly as cognitive difficulty does.

A further pedagogical affordance of artificial intelligence lies in its capacity to support self-regulated learning and the gradual development of learner autonomy. Personalized ELT increasingly values not only what learners achieve, but also how they manage and direct their own learning processes. AI tools can assist learners in planning practice, monitoring progress, identifying recurring weaknesses, revising performance, and making decisions about what to study next. In this respect, AI can function as a scaffold for metacognitive awareness by making patterns in learner performance more visible and by providing accessible pathways for revision and repetition. For example, a learner who repeatedly struggles with particular sentence structures or vocabulary categories may be directed toward focused review, while another learner may use AI-generated tasks to expand productive language beyond what was covered in class. When used reflectively, such tools can encourage learners to take greater ownership of the learning process and to become more active participants in their own development. This is particularly valuable in contemporary ELT, where autonomous learning is often considered essential due to the limited time available for formal instruction and the increasing expectation that learners will continue developing language skills independently. At the same time, the autonomy supported by AI is not merely procedural; it can also become motivational. Learners who experience more visible progress through structured self-practice may develop stronger beliefs in their ability to improve, which in turn reinforces engagement and persistence [17, p. 10].

Artificial intelligence may also enhance personalization by making instructional materials and language input more easily adjustable to different learner profiles and goals. In traditional teaching practice, producing multiple versions of texts, tasks, prompts, or examples for learners with different needs can be time-consuming and difficult to sustain. AI tools can assist teachers by generating task variants, simplifying or elaborating texts, creating topic-specific examples, or producing practice materials aligned with particular themes, interests, or communicative purposes. This adaptability can be especially useful in heterogeneous classrooms where teachers aim to maintain common pedagogical goals while still responding to variation in readiness and learner need. For instance, students working on the same broad skill area may receive different examples or task supports depending on whether they need more controlled practice, more challenge, or more contextualized application. Such flexibility can also help align English learning with real-life purposes, including academic communication, workplace interaction, travel, or discipline-specific language use. In this way, AI can contribute to making language instruction more relevant and purpose-driven, which is itself an important dimension of personalization. Learners are often more engaged when tasks are not only level-appropriate, but also visibly connected to their own reasons for learning English.

Another important affordance concerns accessibility and the democratization of support. In contexts where learners may not have regular access to private tutoring, highly individualized instruction, or rich English-speaking environments, AI can provide a form of additional support that is more scalable and potentially more accessible than many traditional alternatives. Although access to technology remains uneven and raises important equity concerns, AI still offers the possibility of supplementing instruction in ways that may be especially valuable for learners in under-resourced settings. For example, learners can use AI tools to check writing, rehearse speaking, clarify vocabulary, or practice language structures without requiring constant teacher presence. This may help reduce some gaps in support availability and allow learners to engage in more sustained practice than institutional conditions alone would permit. In this sense, AI has the potential to extend the reach of pedagogical assistance, particularly when combined with teacher guidance and when introduced with attention to local constraints. While this potential should not be romanticized, it remains an important affordance in discussions of equity and inclusion within language education.

At the same time, the pedagogical affordances of AI are not purely instrumental; they also reshape how instruction can be imagined and organized. When used thoughtfully, AI encourages a more fluid understanding of the relationship between teaching, practice, feedback, and learner participation. It can

support movement away from rigidly uniform sequences toward more responsive and layered forms of instruction in which classroom teaching, independent work, and technologically mediated support operate in combination. In this sense, AI can function as a bridge between formal pedagogy and individualized learning experience. Rather than confining personalization to abstract pedagogical ideals, it offers concrete mechanisms through which some aspects of responsiveness can be operationalized. Yet it is important to stress that these affordances do not automatically produce good teaching. The fact that AI can adapt, generate, recommend, or respond does not guarantee that the resulting learning experience is pedagogically sound, developmentally appropriate, or ethically responsible. Affordances are possibilities, not outcomes. Their educational value depends on how they are activated, interpreted, and constrained within teacher-guided practice [18, p.29].

For this reason, the pedagogical potential of AI in personalized English language teaching should be understood in balanced terms. Its most significant affordances include immediate feedback, differentiated pathways, expanded opportunities for practice, support for learner autonomy, adaptable material creation, and broader accessibility of assistance. These features make AI a potentially powerful support system in ELT, particularly in contexts where learner diversity is high and instructional time is limited. However, the true pedagogical importance of these affordances lies in their capacity to complement rather than replace human teaching. AI can enhance responsiveness, flexibility, and scale, but it does not itself determine learning quality. The teacher remains essential in deciding how these affordances should be used, when they are appropriate, and how they can be aligned with meaningful language development. In this sense, the affordances of AI are best understood not as evidence of technological superiority, but as pedagogical opportunities whose value depends on the quality of teacher mediation. Within a teacher-in-the-loop model, these affordances become part of a broader educational ecology in which technology supports personalization while human pedagogy continues to define its direction and purpose [19, p.42].

Risks and limitations of teacher-in-the-loop artificial intelligence in personalized ELT

Despite the considerable pedagogical promise of artificial intelligence in personalized English language teaching, its integration into educational practice is accompanied by a range of limitations and risks that require critical attention. Discussions of AI in education often emphasize efficiency, adaptability, and innovation, yet these benefits can produce an overly optimistic view if they are not examined alongside the constraints of real pedagogical environments. In ELT, where language learning involves not only cognitive processing but also interaction, emotional engagement, cultural nuance, and developmental variability, the limitations of AI become especially visible. Even within a teacher-in-the-loop model, where human guidance remains central, artificial intelligence does not become inherently safe, accurate, or educationally sufficient. Rather, the teacher-in-the-loop framework should be understood as a way of managing risk, not eliminating it. For this reason, a balanced review of AI-supported personalization in ELT must account for the pedagogical, ethical, epistemic, and professional challenges that accompany the use of such technologies in language learning contexts [20, p.23].

One of the most significant limitations of artificial intelligence in ELT concerns the reliability and pedagogical validity of its outputs. Although AI systems are often capable of generating impressive amounts of content and responding quickly to learner input, speed and fluency do not guarantee correctness or educational appropriateness. In language learning, the quality of feedback matters as much as its immediacy, and AI-generated responses may at times be superficial, inconsistent, overly generalized, or simply inaccurate. This is particularly problematic in areas of language use that require sensitivity to context, discourse, pragmatics, tone, register, or communicative intention. A system may identify an error but fail to explain it in a developmentally useful way, or it may generate a grammatically acceptable response that is unnatural, culturally inappropriate, or poorly suited to the learner's actual communicative purpose. In other cases, AI may produce feedback that appears authoritative but is pedagogically misleading, especially when learners lack the knowledge needed to evaluate it critically. This creates a risk of false confidence, both for learners who trust the system too easily and for educators or institutions that overestimate the instructional reliability of automated tools. The problem, in other words, is not only that AI can be wrong, but that it can be wrong persuasively. In language education, where subtle distinctions matter and learner misconceptions can fossilize over time, this limitation is particularly serious.

Closely related to this is the risk of shallow or simulated personalization. Many AI-based educational tools are promoted as personalized systems because they adapt task difficulty, respond to prior learner performance, or generate individualized content. However, as noted earlier, such responsiveness does not necessarily amount to genuine pedagogical personalization. In many cases, what is described as

personalization is in fact a narrow form of computational adaptation based on surface-level performance indicators. These systems may react to what learners do, but they often cannot understand why learners struggle, what affective factors are influencing performance, or how broader sociocultural and educational variables shape the learning process. A learner's difficulty with speaking, for example, may not stem solely from linguistic insufficiency, but from anxiety, fear of judgment, low self-efficacy, or lack of prior communicative practice. AI systems may respond by offering more tasks, more repetition, or more correction, without recognizing that the pedagogical need is not simply more input but a different type of support altogether. In this sense, AI can create the appearance of individualized learning while leaving essential dimensions of learner experience unaddressed. The risk is that personalization becomes rhetorically inflated and pedagogically diluted, reduced to algorithmic variation rather than meaningful responsiveness to the learner as a whole person.

Another major concern is the possibility of learner overdependence on AI systems. While one of the advantages of AI is that it can provide readily available assistance, this very convenience may also undermine important aspects of language development if not carefully regulated. Language learning often requires productive struggle, sustained attention, trial and error, and the gradual development of problem-solving capacity. When learners become accustomed to immediate automated correction, generated responses, or on-demand phrasing support, they may begin to outsource parts of the learning process that should remain cognitively and linguistically effortful. Instead of constructing language actively, they may come to rely on AI to generate sentences, reformulate ideas, or resolve uncertainties before they have engaged deeply with the task themselves. This can weaken independent production, reduce tolerance for ambiguity, and interfere with the development of metacognitive strategies. Particularly in writing and speaking tasks, learners may become users of polished output rather than builders of linguistic competence. Such overreliance may be subtle at first, but over time it can shift the learner's orientation from learning through language use to managing tasks through technological assistance. In a personalized ELT context, this is especially concerning because support intended to empower the learner may unintentionally create dependency if it is not balanced by teacher guidance and opportunities for unaided performance [21, p.441].

Ethical concerns also occupy a central place in the critique of AI-supported language education. Artificial intelligence systems are not neutral tools; they are shaped by the data on which they are trained, the assumptions embedded in their design, and the social and economic structures in which they are developed and deployed. In ELT, this raises serious questions related to bias, linguistic normativity, cultural representation, privacy, and fairness. AI systems may privilege certain varieties of English over others, reproduce dominant norms of "correctness," or fail to account for linguistic diversity and cultural nuance. This is especially problematic in language education because learners are not simply acquiring forms; they are also developing identities and communicative legitimacy within a language that carries social, ideological, and geopolitical weight. If AI tools reinforce narrow models of acceptable language use, they may marginalize legitimate variation or convey implicit messages about whose English counts as valid. In addition, data privacy is a major concern, particularly when learners' writing, speech, or interaction histories are stored, processed, or potentially reused by third-party systems. Students may not fully understand what happens to their data or how their interactions are being analyzed. The ethical risk here is not merely technical misuse, but a broader erosion of transparency and informed educational consent. When AI enters the learning environment, questions of trust, agency, and rights become inseparable from questions of pedagogy.

The digital divide presents another serious limitation to the equitable implementation of AI in personalized ELT. Although AI is often described as democratizing access to learning support, such claims can easily become idealized if material realities are ignored. Effective use of AI depends on access to devices, stable internet connectivity, adequate digital literacy, and, in some cases, subscription-based tools that are not equally available to all learners or educational institutions. In under-resourced settings, the introduction of AI may therefore amplify rather than reduce inequality. Learners who already have stronger technological access and support structures may benefit disproportionately, while others are left with limited or inconsistent opportunities to participate. Even when tools are technically available, disparities in digital confidence and strategic use may shape how effectively different learners benefit from them. Some may know how to engage critically and productively with AI, while others may use it superficially, passively, or not at all. This means that access to AI is not only a question of infrastructure, but also of educational readiness and guided support. A technology cannot be considered pedagogically inclusive merely because it exists; it must also be accessible, understandable, and meaningfully usable within the learner's real context [22, p. 10].

From a professional perspective, AI also raises concerns about the possible weakening of teacher agency. While teacher-in-the-loop models are explicitly designed to preserve human pedagogical authority, broader institutional and cultural pressures may still encourage forms of technological overtrust. Schools, universities, or policy frameworks may be tempted to treat AI as a cost-efficient solution capable of replacing aspects of professional judgment, reducing teacher workload through automation, or standardizing support in the name of innovation. However, such trends risk reframing the teacher not as a pedagogical expert, but as a supervisor of preconfigured systems. If adopted uncritically, AI can contribute to a gradual deskilling of the profession, particularly if educators are expected to rely on automated content, feedback, or assessment mechanisms without sufficient room for interpretation, adaptation, and dissent. In language teaching, this danger is especially acute because pedagogy depends heavily on context, timing, responsiveness, and human relational skill. The weakening of teacher agency does not always occur through direct replacement; it can also occur through subtler shifts in authority, where algorithmic recommendations begin to appear more objective, efficient, or institutionally preferred than teacher judgment. In this way, the expansion of AI may reshape professional roles in ways that narrow rather than strengthen pedagogical autonomy unless critical safeguards are maintained.

There is also a broader epistemological limitation in the use of AI for language learning, namely the risk of mistaking generated language for learned language. Artificial intelligence can produce coherent texts, plausible dialogues, corrected sentences, and even sophisticated explanations, but these outputs may create an illusion of learning if they are not accompanied by genuine internalization on the part of the learner. A student who uses AI to improve a paragraph may submit a better product without necessarily understanding the linguistic changes that were made. A learner who receives AI-generated speaking support may produce smoother language in the moment without being able to retrieve or construct similar language independently in a new context. This distinction between assisted performance and acquired competence is central to language pedagogy. Not all successful output reflects durable learning, and not all visible improvement can be attributed to internal development. AI, by making assistance highly immediate and unobtrusive, can blur this distinction more easily than traditional support systems. As a result, teachers and learners alike may overestimate progress if they focus on polished performance rather than on transfer, retention, and independent use. In personalized ELT, where support is intentionally tailored to the learner, this issue becomes even more delicate because the line between scaffolding and substitution can become difficult to perceive [23, p.8].

For all of these reasons, the use of artificial intelligence in personalized English language teaching must be approached with critical caution rather than technological enthusiasm alone. The major risks include unreliable or pedagogically weak feedback, superficial forms of personalization, learner overdependence, ethical concerns related to bias and privacy, unequal access, weakening of teacher agency, and confusion between assisted production and actual language development. These limitations do not mean that AI should be rejected outright. Rather, they indicate that its pedagogical value is conditional, context-dependent, and inseparable from the quality of human mediation. A teacher-in-the-loop model can reduce some of these dangers by preserving pedagogical oversight, interpretive judgment, and ethical responsibility, but it cannot eliminate the structural and conceptual limits of the technology itself. The significance of this conclusion is substantial: in personalized ELT, the central question is not whether AI can be used, but under what conditions it can be used without distorting the aims of language education. If personalization is to remain educationally meaningful rather than technologically rhetorical, then the limitations of AI must be recognized as part of the pedagogical reality, not treated as minor side notes beneath the glamour of innovation.

Discussion

The literature reviewed in this article suggests that the educational significance of artificial intelligence in personalized English language teaching lies not in its capacity to replace teaching, but in its potential to restructure certain dimensions of pedagogical support in ways that are more flexible, responsive, and scalable. Across the scholarship, AI appears most valuable when it is understood as an enabling technology rather than an autonomous instructional solution. Its main contribution lies in expanding access to feedback, supporting differentiated practice, increasing opportunities for repetition and revision, and allowing some degree of adaptation to learner performance and pace. These features are particularly relevant in ELT, where learner diversity is substantial and where teachers often work under conditions that make sustained one-to-one personalization difficult to achieve. At the same time, the literature also makes clear that the pedagogical usefulness of such affordances is never automatic. AI does not enter the classroom as a neutral enhancement; it enters as a tool whose value depends on

interpretation, regulation, and alignment with educational aims. For this reason, the teacher-in-the-loop model emerges not simply as one possible approach among others, but as a necessary conceptual and pedagogical condition for meaningful AI integration in language education.

A key point arising from the literature is that personalization in ELT should not be reduced to computational adaptation. Much of the discourse surrounding AI in education uses the language of personalization to describe systems that adjust difficulty, generate recommendations, or automate feedback. However, the review indicates that such features, while useful, often remain too narrow to capture the full meaning of personalized teaching. Language learning is shaped not only by performance data, but also by motivation, anxiety, identity, communicative purpose, cultural context, and readiness for particular kinds of support. What appears adaptive from a technical perspective may still be pedagogically insufficient if it fails to address these broader dimensions. This is where teacher involvement becomes decisive. Teachers do not merely add a human layer to AI-supported instruction; they provide the interpretive depth that transforms adaptation into genuine personalization. They understand why a learner may be struggling, what kind of feedback will be developmentally useful, how much support is productive, and when technology is helping or hindering the learning process. In this sense, the teacher-in-the-loop approach preserves the distinction between personalized learning as a pedagogical process and personalization as a technological claim [24, p. 11].

Another important insight from the literature is that AI reshapes the teacher's role rather than rendering it obsolete. In many of the reviewed perspectives, the teacher remains central as instructional designer, mediator of feedback, facilitator of learner autonomy, evaluator of content quality, and ethical decision-maker. Indeed, the integration of AI seems to intensify the need for professional judgment. As technological systems become more capable of producing language, suggesting corrections, and simulating interaction, teachers must increasingly decide how such outputs should be framed, interpreted, limited, or supplemented. The profession therefore becomes less defined by simple delivery of content and more by orchestration of pedagogical processes across human and technological resources. This shift is significant because it suggests that the future of AI in ELT is not a future without teachers, but a future in which teaching expertise becomes more complex and, arguably, more visible. The literature thus challenges deterministic narratives that oppose human instruction and technological innovation. Instead, it supports a collaborative model in which educational quality depends on the interaction between teacher agency and technological affordance.

The review also highlights a fundamental tension between opportunity and risk. On the one hand, AI offers practical benefits that can support learner diversity, extend practice opportunities, and strengthen certain aspects of autonomy and feedback responsiveness. On the other hand, these same strengths can produce distortions if they are overextended or insufficiently regulated. Immediate support can turn into dependency; adaptive systems can create only the illusion of personalization; efficient content generation can lower pedagogical quality if it is not critically reviewed; and broad access can remain uneven due to digital inequality. Ethical concerns related to privacy, bias, linguistic normativity, and cultural insensitivity further complicate the picture. This tension suggests that AI should not be treated as either a pedagogical revolution or a threat in itself. Rather, it should be understood as an ambivalent educational resource whose effects are shaped by context, design, and governance. In this regard, the teacher-in-the-loop model performs an important balancing function. It does not solve every problem associated with AI, but it creates a pedagogical structure within which those problems can be more critically managed.

The discussion also points to an important theoretical implication for ELT research. The debate on AI in language education should move beyond binary questions such as whether AI is beneficial or harmful, or whether it can outperform traditional teaching. Such questions are too general and often obscure the more meaningful issue, namely how AI changes the conditions under which language teaching and learning take place. A more productive line of inquiry focuses on the pedagogical configurations that make AI use educationally defensible. This includes questions about teacher agency, learner readiness, task design, ethical safeguards, feedback literacy, and the distinction between support and substitution. In other words, the value of AI in ELT is not primarily a property of the tool itself, but a property of the instructional ecology into which it is introduced. This shift in focus is particularly important for personalized language learning, where the rhetoric of innovation can easily overshadow the slower, more complex realities of development, interaction, and pedagogy.

Finally, the literature suggests that the future of AI in personalized ELT should be approached through moderation, critical literacy, and pedagogical intentionality. The most convincing position is neither rejection nor enthusiasm, but disciplined integration. AI may contribute meaningfully to language

teaching when it is used to support, rather than displace, the fundamentally human dimensions of education. These include pedagogical judgment, relational sensitivity, contextual interpretation, and ethical responsibility. Personalized ELT gains from AI not when technology acts alone, but when it operates within a framework in which teachers remain able to guide learning, evaluate outputs, respond to learner complexity, and preserve the educational purposes that technology alone cannot define. For this reason, teacher-in-the-loop artificial intelligence should be understood not as a temporary compromise between tradition and innovation, but as a durable pedagogical principle for navigating the future of language education.

Conclusion

This article reviewed the literature on teacher-in-the-loop artificial intelligence in personalized English language teaching through the interconnected dimensions of pedagogical roles, instructional affordances, and associated risks. The review has shown that artificial intelligence offers significant opportunities for enhancing personalized ELT, particularly through immediate feedback, differentiated practice, expanded access to learning support, adaptable material generation, and increased opportunities for self-regulated learning. These affordances make AI a potentially valuable component of contemporary language education, especially in contexts characterized by learner heterogeneity and limited opportunities for sustained individualized instruction.

At the same time, the review has demonstrated that the pedagogical value of AI remains conditional rather than automatic. Artificial intelligence may generate inaccurate or superficial feedback, simulate personalization without fully understanding learner needs, encourage overdependence on automated support, reproduce bias, create privacy concerns, and contribute to unequal access or weakened teacher agency if introduced uncritically. These limitations are not marginal; they are central to any serious assessment of AI in ELT. For that reason, the educational relevance of AI cannot be judged by technological capability alone, but must be evaluated in relation to the pedagogical conditions of its use.

Within this context, the teacher-in-the-loop model emerges as the most balanced and pedagogically defensible framework for AI integration in personalized English language teaching. It positions the teacher not as a passive observer of automation, but as the key professional who designs instruction, interprets learner needs, mediates feedback, regulates technology use, and ensures ethical and educational coherence. In this model, AI functions as a supportive instrument rather than a substitute for pedagogical expertise. Such an approach allows personalization to remain learner-centered, context-sensitive, and educationally meaningful rather than technologically overstated [25, p.4543].

In conclusion, artificial intelligence holds genuine potential to strengthen personalized English language teaching, but only when its use is guided by teacher expertise, critical reflection, and ethical responsibility. The future of AI in ELT therefore depends less on the increasing sophistication of digital tools than on the extent to which educational systems preserve the human pedagogical judgment necessary to use those tools well. Further research should continue to explore how teacher-in-the-loop models can be implemented across different ELT contexts and how the balance between technological support and human mediation can be maintained in ways that genuinely benefit learners.

References

1. Holmes, W., Bialik, M., & Fadel, C. (2019). *Artificial intelligence in education: Promises and implications for teaching and learning*. Center for Curriculum Redesign.
2. Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education: Where are the educators? *Int J Educ Technol High Educ*, 16, Article 39.
3. Vincent-Lancrin, S., & van der Vlies, R. (2020). *Trustworthy artificial intelligence (AI) in education: Promises and challenges*. OECD Publishing.
4. Miao, F., & Holmes, W. (2021). *AI and education: Guidance for policy-makers*. UNESCO.
5. Miao, F., & Holmes, W. (2023). *Guidance for generative AI in education and research*. UNESCO.
6. Ji, H., Han, I., & Ko, Y. (2023). A systematic review of conversational AI in language education: Focusing on the collaboration with human teachers. *J Res Technol Educ*, 55(1), 48–63.
7. Kohnke, L., Moorhouse, B. L., & Zou, D. (2023). ChatGPT for language teaching and learning. *RELC Journal*, 54(2), 537–550.
8. Moorhouse, B. L., & Kohnke, L. (2024). The effects of generative AI on initial language teacher education: The perceptions of teacher educators. *System*, 122, Article 103290.

9. Moorhouse, B. L., Wan, Y., Wu, C., Kohnke, L., Ho, T. Y., & Kwong, T. (2024). *Developing language teachers' professional generative AI competence: An intervention study in an initial language teacher education course*. *System*, 125, Article 103399.
10. Hubbard, P., & Schulze, M. (2025). *AI and the future of language teaching: Motivating sustained integrated professional development*. *Int J Comput Assist Lang Learn Teach*, 15(1), 1–17.
11. Du, J., & Daniel, B. K. (2024). *Transforming language education: A systematic review of AI-powered chatbots for English as a foreign language speaking practice*. *Comput Educ Artif Intell*, 6, Article 100230.
12. Tai, T. Y., & Chen, H. H. J. (2024). *Improving elementary EFL speaking skills with generative AI chatbots: Exploring individual and paired interactions*. *Comput Educ*, 220, Article 105112.
13. Wang, C., Zou, B., Du, Y., & Wang, Z. (2024). *The impact of different conversational generative AI chatbots on EFL learners: An analysis of willingness to communicate, foreign language speaking anxiety, and self-perceived communicative competence*. *System*, 127, Article 103533.
14. Song, C., & Song, Y. (2023). *Enhancing academic writing skills and motivation: Assessing the efficacy of ChatGPT in AI-assisted language learning for EFL students*. *Front Psychol*, 14, Article 1260843.
15. Wang, Y. (2025). *Reducing anxiety, promoting enjoyment and enhancing overall English proficiency: The impact of AI-assisted language learning in Chinese EFL contexts*. *Br Educ Res J*.
16. Fu, Y., & Weng, Z. (2024). *Navigating the ethical terrain of AI in education: A systematic review on framing responsible human-centered AI practices*. *Comput Educ Artif Intell*, 7, Article 100306.
17. García-López, I. M., & Trujillo-Liñán, L. (2025). *Ethical and regulatory challenges of generative AI in education: A systematic review*. *Front Educ*, 10, Article 1565938.
18. Foun, D., Lin, L., & Chen, J. (2024). *Reinventing assessments with ChatGPT and other online tools: Opportunities for GenAI-empowered assessment practices*. *Comput Educ Artif Intell*, 6, Article 100250.
19. OECD. (2026). *OECD digital education outlook 2026*. OECD Publishing.
20. Zimotti, G., Frances, C., & Whitaker, L. (2024). *The future of language education: Teachers' perceptions about the surge of AI writing tools*. *Technol Lang Teach Learn*, 6(2), Article 1136.
21. Balaji, V., Ogange, B. O., & Mays, T. (2025). *Teacher in the loop AI (TiL-AI): A strategy for empowering educators in developing countries through OER adaptation*. *J Learn Dev*, 12(2), 439–445.
22. Garzón, J., Patiño, E., & Marulanda, C. (2025). *Systematic review of artificial intelligence in education: Trends, benefits, and challenges*. *Multimodal Technol Interact*, 9(8), Article 84.
23. Ekizer, F. N. (2025). *Exploring the impact of artificial intelligence on English language teaching: A meta-analysis*. *Acta Psychol*, 254, Article 105649.
24. Wiboolyasar, W., Wiboolyasar, K., Tiranant, P., Jinowat, N., & Boonyakitanont, P. (2025). *AI-driven chatbots in second language education: A systematic review of their efficacy and pedagogical implications*. *Ampersand*, 14, Article 100224.
25. Zhang, R., Zou, D., & Cheng, K. S. (2024). *A review of chatbot-assisted learning: Pedagogical approaches, implementations, factors leading to effectiveness, theories, and future directions*. *Interact Learn Environ*, 32(8), 4529–4557.

Philological sciences

KEY MOTIFS AND THEMES IN THE CHIVALRIC NOVEL HAVELOK THE DANE

Nabiyeva Zulaykho

PhD student of Namangan State Institute of Foreign Languages

Abstract

This article explores the major motifs in the Middle English romance Havelok the Dane, with a particular focus on kingship, exile, identity, and social order. It aims to demonstrate how these recurring narrative elements are not only structural components of the story but also key tools for expressing medieval ideas about leadership and authority. Using close textual analysis, the study examines how the motifs function together to shape both the plot and the development of the central character. Special attention is given to the dual concept of kingship, religious and political, as reflected in Havelok's journey from a dispossessed child to a rightful ruler. The analysis highlights how divine signs, such as the hero's royal mark, interact with real-life experiences, including hardship and social integration. The findings suggest that the romance presents kingship as a balanced model that combines divine approval with social responsibility, achieved through personal growth, moral integrity, and active engagement with society.

Keywords: *Havelok the Dane, motifs, kingship, exile, identity, medieval romance*

INTRODUCTION

In the Middle English romance Havelok the Dane, a prince loses his royal status and eventually transforms into the perfect monarch. Despite having a fairly straightforward structure, the story is based on significant recurrent themes that give it a deeper literary and cultural significance. The poem's current form, composed in Middle English and typically dated to the late 13th century (c. 1280–1300), reflects the linguistic shift in literary production from Anglo-Norman French to English [Bradbury, 1993]. However, the story itself has a lengthy history of growth and modification, as evidenced by its older roots in Anglo-Norman and probably Scandinavian traditions. Kingship is one of the text's most significant themes. Kingship is not, however, portrayed as a permanent or exclusively inherited position. Rather, it is demonstrated as something that evolves with experience, hardship, and moral development throughout time. As the story illustrates, a monarch must demonstrate his value on a social and spiritual level by fusing divine legitimacy with useful leadership. Exile is another important element. After being forcibly removed from his regal status, Havelok is able to dwell among common people and endure hardship. This phase is crucial because it molds his personality and gets him ready to lead responsibly. The theme of identity, which is progressively exposed via both symbolic indications and individual accomplishments, is closely related to exile.

METHODS

The foundation of this study is a critical reading and literary analysis of Havelok the Dane, with a focus on the narrative's thematic structure and purpose. The study uses an interpretive methodology to look at how recurrent themes affect the plot's progression and the creation of meaning. By doing so, the study adheres to the tradition of medieval literary criticism, which examines writings for their symbolic and thematic patterns in addition to their storylines. The analysis focuses on a number of important motifs, such as the motif of justice and moral order, the motif of exile and social experience, the motif of kingship in both its religious and political dimensions, and the motif of identity and recognition. These motifs are analyzed as interrelated components that influence the hero's journey and represent more general medieval ideals.

Textual evidence from the poem supports the methodological approach. For example, the story makes it abundantly evident that Havelok must demonstrate his value via deeds, labor, and connections with many social groups rather than depending just on heavenly signs or his royal birthright. This illustrates a change from strictly theocratic kingship to a leadership paradigm with a stronger social foundation. Havelok the Dane has been studied from a variety of angles by earlier researchers. Some, like in the work of Leyser, historian Ernst Kantorowicz, have concentrated on the idea of kingship and its theological underpinnings, highlighting the notion that the monarch is a person chosen by God [Leyser, 2016]. Others, such as Walter Ullmann, have studied the political dimensions of kingship, especially the

evolution of social contracts between the sovereign and the populace [Stan, 2012]. Additionally, contemporary literary scholars have examined themes such as exile, identity, and social mobility in the book through structural and thematic analyses. This study illustrates how elements in *Havelok the Dane* work together to form a cohesive and significant narrative by fusing close reading with these more general critical techniques. Also, it allows for a deeper understanding of how the romance reflects both literary traditions and the social realities of the medieval period.

RESULTS

According to the research, *Havelok the Dane* is organized around a number of related themes that collectively influence the story and the hero's growth. First, the story's central theme is exile. After losing his royal title, Havelok is compelled to live among common people and endure hardship and manual work. Crucially, he accepts this circumstance with humility and responsibility rather than resisting or complaining about it. "It is no shame for to swinken" [Herzman et al., 1997, ll. 955–958], which implies that effort rather than social standing is the source of dignity and displays a moral acceptance of labor. This period of banishment turns into a developmental stage that gets him ready to become king in the future.

Second, the story progressively develops the identification motif. Despite having royal ancestry, Havelok's identity is kept a secret for most of the narrative and is only eventually disclosed through symbolic cues, most notably the "kinemerk." [Herzman et al., 1997] However, power or recognition are not assured by this symbol alone. As the story demonstrates, the mark serves more as confirmation than proof because it is only acknowledged after Havelok has proven his value and strength. The line expresses his attitude about work quite plainly. This idea is reinforced when the hero gains respect through his actions before his royal identity is fully acknowledged.

Third, the idea of monarchy is shown as having two aspects: political and divine. On the one hand, Havelok's royal destiny is indicated by divine indications. However, he must actively earn his job by demonstrating his skills in practical settings. The text highlights that monarchy necessitates power, leadership, and societal acceptance; birth and divine permission alone are insufficient. His ascent through several social strata from laborer to esteemed figure to king is indicative of this.

Fourth, the narrative structure heavily relies on the motif of justice. Havelok's moral integrity stands in stark contrast to the deeds of evil characters like Godrich and Godard, who violate their oaths and abuse their positions of authority. As seen by descriptions that compare them to Judas, their betrayal is vehemently denounced, and Havelok's job is to bring justice and order back. This conflict emphasizes how justice and ethical responsibility are directly related to authentic kingship. Lastly, Havelok's interactions with various social groupings highlight the theme of social order. His background as a worker enables him to comprehend the lives of common people, which subsequently enhances his efficacy as a leader. The story emphasizes how well-liked he is across all social classes:

"Alle him loueden that him sowen, / Bothen heye men and lowe". [Herzman et al., 1997, ll. 955–958].

This universal acceptance suggests that a true king must be recognized and supported by society as a whole.

DISCUSSION

The findings demonstrate how the motifs in *Havelok the Dane* are intricately linked and collectively reinforce a nuanced and dynamic conception of kingship. Instead of operating separately, these motifs work together to influence the story's plot and the hero's growth, finally portraying kingship as a process that must be acquired via morality, experience, and social interaction.

Exile is a crucial and formative step in the hero's development, not just a plot device. After being stripped of his royal status, Havelok is forced to live among common people, where he faces hardship, labor, and social reliance. This stage allows him to gain practical knowledge of society and to develop humility and responsibility. His willingness to work and adapt to his condition demonstrates that true leadership begins with understanding the lives of others. Thus, exile becomes a transformative experience that prepares him for effective and just rule.

The identity motif highlights the fact that being a king is not a given nor a result of birth. Havelok has a divine mark, the "kinemerk," but throughout the majority of the story, no one knows who he is. A conflict between appearance and actuality is created by this recognition delay, demonstrating that true nobility must be proven rather than merely inherited. As the passage implies, the mark confirms a value that has previously been demonstrated by deeds, strength, and moral behavior rather than establishing his authority on its own. Kingship is a dual framework that combines political and religious aspects. Kings were viewed as divinely selected individuals in medieval belief, but they were also required to govern society responsibly. By fusing divine indications with actual accomplishments, Havelok personifies this

dual idea. Even though mystical aspects point to his destiny, he still needs to demonstrate his leadership skills, command allegiance, and acquire political power [Herzman et al., 1997]. This demonstrates that monarchy is a matter of actual authority and social acceptance in addition to divine prerogative.

The moral foundation of the story is strengthened by the motif of justice. Havelok's justice and integrity contrast sharply with the deeds of individuals like Godrich and Godard, who violate their oaths and misuse their positions of authority. Justice is essential to a legitimate monarchy, as demonstrated by their final punishment and the return of legitimate power. According to the story, moral order-where good is rewarded and bad is punished -is necessary for a stable community.

Lastly, the social order motif emphasizes how crucial the populace is to the establishment of royalty. Havelok is able to comprehend the demands and ideals of diverse groups within society because of his experience at a variety of socioeconomic levels, from a worker to a king. His acceptance by "heye men and lowe"[Herzman et al., 1997] shows that social support is the foundation of authentic authority. Therefore, a monarch must serve and represent the people in addition to ruling over them.

Finally, the social order motif emphasizes how crucial the populace is to the establishment of royalty. Havelok is able to comprehend the demands and ideals of diverse groups within society because of his experience at a variety of socioeconomic levels, from a worker to a king. His acceptance by "heye men and lowe" shows that social support is the foundation of authentic authority. Therefore, a monarch must serve and represent the people in addition to ruling over them.

CONCLUSION

To sum up, Havelok the Dane is thoughtfully organized around major themes like exile, identity, kingship, justice, and social order. These themes work as a cohesive system that influences the hero's growth as well as the story's evolution. Through their interactions, the romance transforms from a straightforward adventure tale into a significant representation of medieval ideas of authority and leadership. The analysis shows that the romance does not portray monarchy as something that is predetermined or assured by birth or divine right alone. Even though Havelok exhibits symptoms of divine selection, his ascent to power is mostly dependent on his development as a person, his moral conduct, and his involvement in society. His understanding of justice, accountability, and interpersonal relationships is greatly influenced by his experiences in exile, especially his existence among common people. Kingship is thus presented as a process that must be acquired rather than inherited.

Havelok successfully combines a number of crucial traits, making him a perfect ruler. He is able to comprehend the demands of his people because he experienced life at various social levels. He demonstrates his power, humility, and integrity via deeds rather than by making big claims. By punishing betrayal and reestablishing proper order, he upholds justice and strengthens society's moral framework. He simultaneously embodies the practical and spiritual facets of medieval royalty by fusing political power with supernatural authority. As a result, the romance employs themes to convey larger concepts about leadership and society in addition to using them as narrative devices. In the end, Havelok the Dane portrays kingship as a well-rounded model that incorporates social consciousness, moral virtue, and lawful authority, mirroring the ideals and standards of the medieval society.

References

1. Bradbury, Nancy Mason. "The Traditional Origins of Havelok the Dane." *Studies in Philology* 90 (1993): 115-42.
2. Leyser, Conrad (2016). "Introduction to the Princeton Classics Edition". *The King's Two Bodies: A Study in Mediaeval Political Theology*. Princeton, NJ: Princeton University Press. pp. x-xi. ISBN 978-0691169231.
3. Stan, L. (2012). *Principles of Government and Politics in the Middle Ages*. By Walter Ullmann. *The European Legacy*, 17(4), 563-564.
4. Herzman, R. B., Drake, G., & Salisbury, E. (Eds.). (1997). *Four romances of England: King Horn, Havelok the Dane, Bevis of Hampton, Athelston*. Kalamazoo, MI: Medieval Institute Publications.
5. Edmondson, George. (2023) "Interspecies Relations in Medieval Literature." *postmedieval* 14.2: 178-195.
6. Fulton, Helen. (2022) "Medieval Romance and Cultural Identity." *Literature Compass* 19.8: e12634.

Physical sciences

TIME TRAVELS ON EARTH IS ALREADY AVAILABLE TO PEOPLES¹

Antonov Alexander Alexandrovich

PhD, HonDSc, H.Prof.Sci

Independent researcher, Ukraine, Kiev

Abstract

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

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

1. Preface

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

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

2. Introduction

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

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

² Which has not yet been canceled

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

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

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

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

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

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

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

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

4. Proof of the physical reality of imaginary numbers

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

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

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

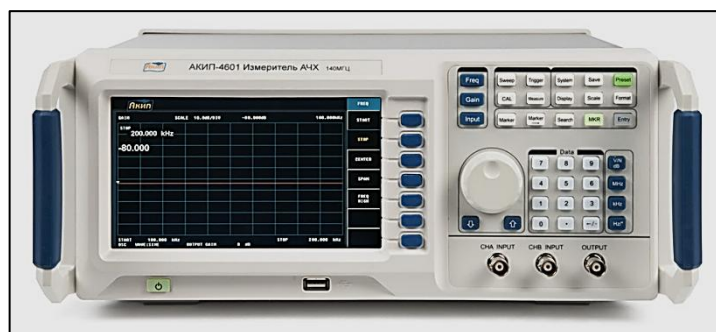


Fig. 1. Every radio engineering laboratory has devices called frequency response meters, which, by their very existence, prove the physical reality of imaginary and complex numbers. And thus, they made the OPERA experiment at the Large Hadron Collider unnecessary.

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

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

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

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

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

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

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

5. Corrected version of SRT

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

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

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

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

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

m is the relativistic mass of a moving body;

Δt_0 is the rest time of a moving body;

Δt is the relativistic time of a moving body;

l_0 is the rest length of a moving body;

l is the relativistic length of a moving body.

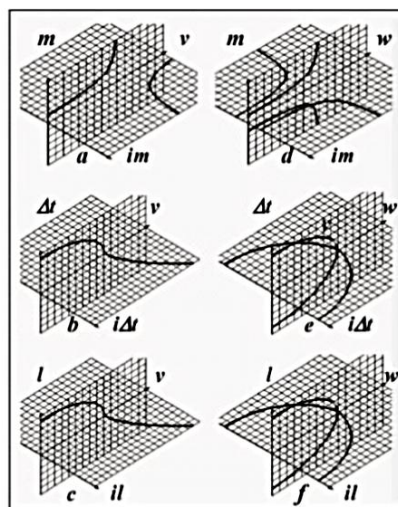


Fig 2. Graphs of functions $m(v)$, $\Delta t(v)$, $l(v)$, corresponding to the existing and revised versions of SRT in the subluminal $v < c$ and superluminal $v > c$ ranges

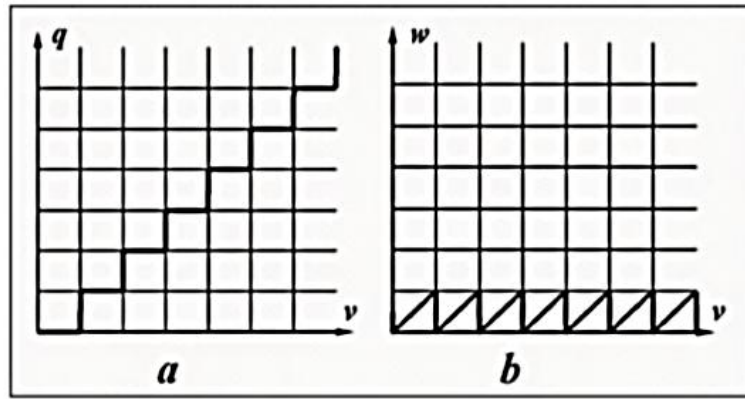


Fig. 3. Graphs of functions $q(v)$ and $w(v)$, illustrating the meaning of the “floor” function of discrete mathematics

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

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

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

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

where $q(v) = [v_q/c]$ is the “floor” function of discrete mathematics from the argument v_q/c (its graph shown in Fig. 3a), which is the fourth spatial dimension;

$w = v - qc$ is the local speed in all universes (its graph is shown in Fig. 3b).

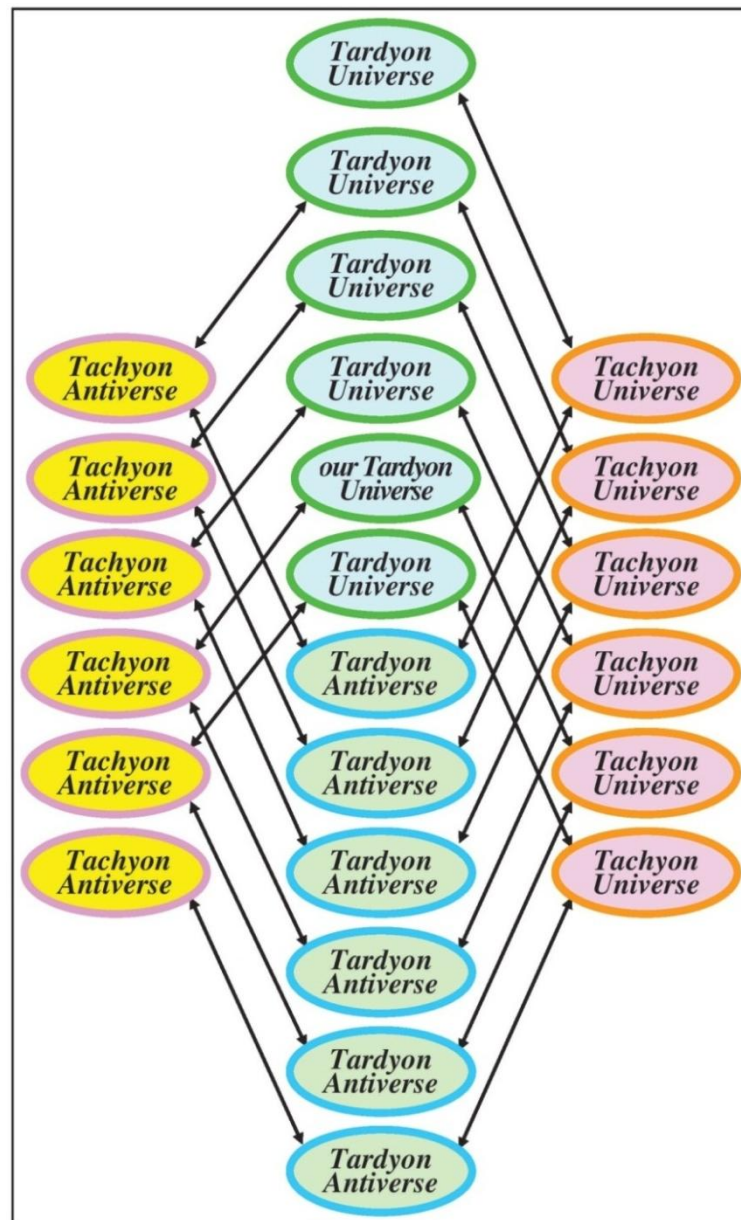


Fig. 4. Structure of the hidden Multiverse corresponding to the principle of physical reality of complex numbers

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

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

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

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

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

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

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

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

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

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

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

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

7. Corrected version of SRT (continued)

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

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

⁹ Since they are all beyond the event horizon

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

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

tachyon universes and three tachyon antiuniverses - it is necessary to have three additional dimensions q, r, s . At the same time relativistic formulas must be corrected again as follows [70]-[77]

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

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

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

where $q(v) = [v_q/c]$ is the "floor" function of discrete mathematics from the argument v_q/c

which is one of the orthogonal coordinates q of the fourth spatial dimension v ;

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

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

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

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

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

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

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

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

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

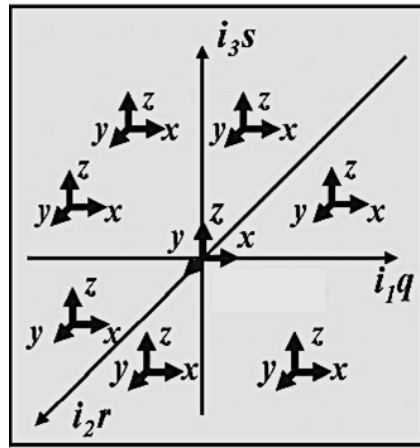


Fig. 4. Six-dimensional space of the hidden Multiverse, where q, r, s are the coordinates of invisible parallel universes, and x, y, z are the coordinates of the matter content in each parallel universe

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

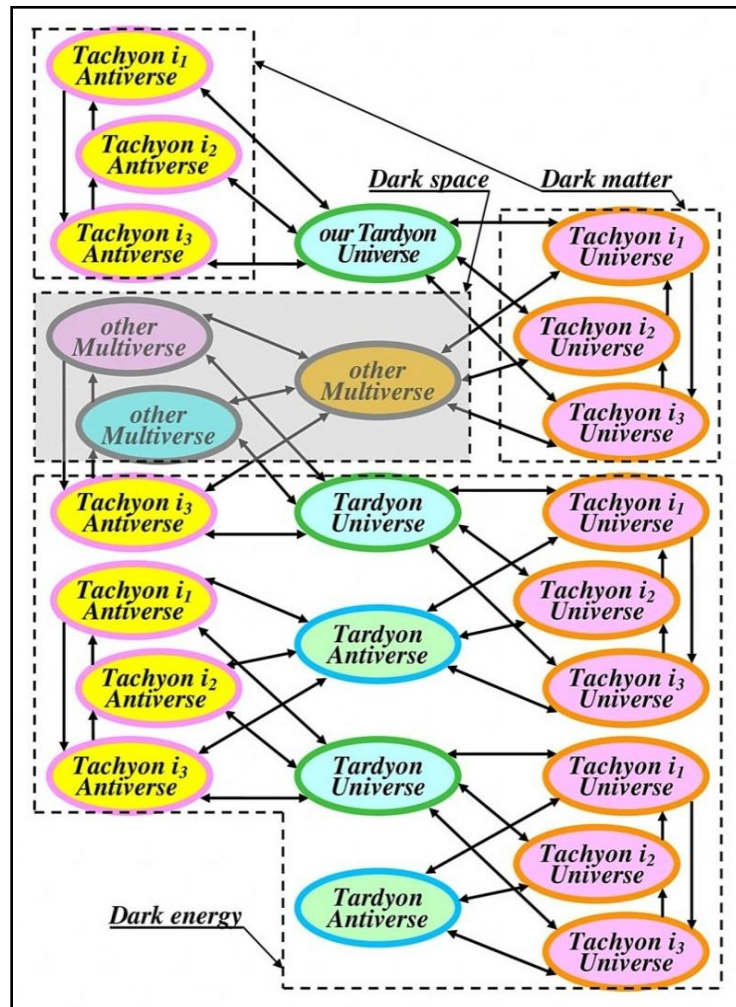


Fig. 6. Structure of the hidden Multiverse corresponding to the principle of physical reality of hypercomplex numbers

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

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

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

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

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

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

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

9. Where are antimatter and anti-time located?

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

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

10. Time travels

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

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

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

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

¹³ Like all people, everything that is in their apartments

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

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

¹⁶ For example, in the 'twin paradox'

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

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

occurring in the external environment. Namely, by the rotation of the Earth and the existence of time zones. These features of it are reflected in formula, absent from physics textbooks, derived from the relativistic SRT formulas (5), (6) and (8), (9)

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

in which Δt is external time in hours;

Δt_0 – 24 hours;

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

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

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

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

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

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

Table 2. The value of external time at different latitudes

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

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

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

There are many aircraft models suitable for use in time travel. They are called business jets²⁰. And Table 1 shows, as an illustration, the flight performance characteristics of some of these business jets. And Table 2 lists airfields close enough to the North Pole that can provide the shortest routes for round-the-world flights.

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

11. Refutations of the version of SRT studied in textbooks

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

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

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

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

For this reason, numerous publications were ignored, citing simple and easily understood radio engineering experiments that successfully demonstrated the physical reality of imaginary numbers and explained that if imaginary numbers were truly, as claimed in the SRT, physically unreal, then all radio engineering devices and computers would not exist, tsunamis, bell ringing, piano music would not exist, children's swings would not swing after a parent's push, and much more.

Furthermore, because of the assertion of the physical unreality of imaginary numbers and, therefore, the existence of our only visible universe in nature, it turned out that antimatter and tachyons had no place in single visible universe. The corrected version of the SRT, however, explains where they are located.

It also turned out that due to the statement about the physical unreality of imaginary numbers and therefore about the existence in nature of our only visible universe, the phenomena of dark matter and dark energy have not been and will never be explained, since dark matter and dark energy are actually,

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

²¹ Not being able to explain in any other way the incorrect relativistic formulas of SRT in the hyperluminal speed range

²² And he received his Nobel Prize in 1921 for his research on the photoelectric effect

²³ Let's remember - one day is more than enough for a radio engineering experiment proving the physical reality of imaginary numbers.

according to the corrected version of SRT, mutually invisible universes and antiuniverses of the really existing hidden Multiverse.

More than two hundred thousand anomalous zones have also been discovered on Earth, which are entrances to portals to the invisible universes and antiuniverses neighboring our visible universe. And even this alone already proves their existence. Moreover, these universes and antiuniverses, invisible outside the portals, can also be seen by astronomical observations of the starry sky in portals. But these low-cost astronomical observations, which would allow sensational scientific discoveries of other universes, are still not carried out due to fears that these invisible neighboring universes and antiuniverses can actually be seen. And then the version of SRT studied in textbooks will undoubtedly have to be recognized as incorrect.

In the version of SRT studied in physics textbooks, it was also concluded that time travel is impossible for people. Although in fact, millions of air passengers on Earth already make such time travel every day, which is confirmed by the translation of their watches to local time after the planes land. But since such time travel by airline passengers occurs simultaneously with travel on Earth, they are not used. And the article explains how it is still physically and technically possible to travel through time on airplanes without ultimately traveling through space.

Less expensive telephone time travel is also possible, which, when needed, can be implemented quickly and inexpensively. Then telephone conversations with people located in the past or future tense will become publicly available. However, probably the most promising is the joint use of aviation and telephone options for time travel: aviation when crossing time zones over the ocean, and telephone when crossing them over land.

12. Conclusion

And we have to admit that the creation of such a situation is to blame for the still dominant science, in which there is no antimonopoly legislation existing in the economy, and little ethical morals. Therefore, for example, in the 16th century, Nicolaus Copernicus published his theory "On the Rotations of the Celestial Spheres," which he worked on for forty years, which refuted the geocentric system of the world of Claudius Ptolemy, so as not to end up in the Inquisition, published only after his death. And in our time, reviewers of some reputable journals, not being able to answer anything on the merits, allow themselves to write to the authors of articles they dislike: "I will not allow Einstein to be criticized." Publications like the outstanding works of Jean de Climont [135]-[138], to which he mentions 9671 scientists who refuted generally accepted theories in all sciences, are extremely rare.

That is why the very interesting SRT, created in 1905 by Albert Einstein and Henri Poincaré, was not received kindly by physicists. And in order to defend the right to exist of this new theory, relativistic physicists had to fight. At that time, SRT was forced, due to the lack of the Internet and the necessary experimental and theoretical knowledge, to use postulates and some not entirely successful tools like the Large Hadron Collider²⁴. And many thanks to the physicists of the twentieth century for thereby saving SRT.

And having won, relativistic physicists began to study the largely erroneous starting version of STR in all physics textbooks. Therefore in turn, they themselves became a brake on scientific (including their own) development, fearing that further recognition of the fallacy of any provisions of the version of SRT studied in textbooks would entail its refutation as a whole. Therefore, the version of STR currently studied in all physics textbooks has made it impossible to explain the phenomena of dark matter and dark energy, to explain the problem of baryon asymmetry, and denies the possibility of time travel, although currently millions of air passengers do it every day.

What to do? And it is necessary, before the authors of physics textbooks correct them, to start studying the corrected version of SRT optionally using my monograph "Corrected Version of the Special Theory of Relativity" published in the language of your country. This monograph is actually a continuation of the material studied in physics textbooks and it writes in more detail about the same thing as in this article

References

1. Antonov A.A. (2022). Dark Matter and Dark Energy, Which are Inexplicable in the Microcosm, are Mutually Invisible Universes and Anti-universes of the Hidden Multiverse. *European Journal of Applied Sciences, Services for Science and Education*. UK. 13(06). 84-107. DOI:10.14738/aivp.1306.19658.

²⁴ Instead of less expensive radio equipment

2. Antonov A. A. 2025. Dark matter and dark energy are mutually invisible universes and anti-universes of the hidden Multiverse. *German International Journal of Modern Science*. 113. 27- 42. DOI: 10.5281/zenodo.17286973
3. Antonov A. A. 2025. Dark matter and dark energy are invisible universes and anti-universes of the hidden Multiverse. *Journal of science*. Lyon. 71. 38-52. <https://doi.org/10.5281/zenodo.17533496>
4. Antonov A. A. 2025. Dark matter and dark energy are mutually invisible universes and anti-universes of the hidden Multiverse. *Annali d'Italia*. 72. 28-42. DOI: 10.5281/zenodo.17463768
5. Antonov A. A. 2025. Dark matter and dark energy, which are inexplicable in the microcosm, are universes and anti-universes of the hidden Multiverse. XVIII International Scientific and Practical Conference "Theoretical and practical perspectives of modern science". 28-29.10.2025, Stockholm. Sweden. 69-86. DOI <https://doi.org/10.5281/zenodo.17513357>
6. Adam T., Agafonova N., Aleksandrov A. et al. (2012). Measurement of the neutrino velocity with the OPERA detector in the CNGS beam. arxiv:1109.4897v4 [hep-ex].
7. Antonov A. A. (2008). Physical Reality of Resonance on Complex Frequencies. *European Journal of Scientific Research*. 21(4). 627-641.
8. Antonov A. A. (2009). Resonance on Real and Complex Frequencies. *European Journal of Scientific Research*. 28(2). 193-204.
9. Antonov A. A. (2010). New Interpretation of Resonance. *International Journal of Pure and Applied Sciences and Technology*. 1(2). 1-12. http://doi.org/10.17686/sced_rusnauka_2010-888
10. Antonov A. A. (2010). Oscillation processes as a tool of physics cognition. *American Journal of Scientific and Industrial Research*. 1(2). 342-349.
doi:10.5251/ajsir.2010.1.2.342.349
11. Antonov A. A. (2010). Solution of algebraic quadratic equations taking into account transitional processes in oscillation systems. *General Mathematics Notes*. 1(9). 11-16.
http://doi.org/10.17686/sced_rusnauka_2010-887
12. Antonov A. A. (2013). Physical Reality of Complex Numbers. *International Journal of Management, IT and Engineering*. 3(4). 219-230. http://doi.org/10.17686/sced_rusnauka_2013-898
13. Antonov A. A. (2015). Physical reality of complex numbers is proved by research of resonance. *General Mathematics Notes*. 31(2). 34-53.
http://www.emis.de/journals/GMN/yahoo_site_admin/assets/docs/4_GMN-9212-V31N2.1293701.pdf
14. Antonov A.A. (2015). Principle of physical reality of imaginary and complex numbers in the modern cosmology: the nature of dark matter and dark energy. *Journal of the Russian physico-chemical Society*. 87(1). 328-355. http://doi.org/10.17686/sced_rusnauka_2015-1119
15. Antonov A. A. (2016). Physical Reality and Nature of Imaginary, Complex and Hypercomplex Numbers. *General Mathematics Notes*. 35(2). 40-63.
http://www.geman.in/yahoo_site_admin/assets/docs/4_GMN-10932-V35N2.31895146.pdf
16. Antonov A.A. (2017). The physical reality and essence of imaginary numbers. *Norwegian Journal of development of the International Science*. 6. 50-63. <http://www.njd-iscience.com>
17. Antonov A. A. (2024). Physical reality of imaginary numbers and their physical essence. *Danish Scientific Journal*. 80. 25-35. <https://doi.org/10.5281/zenodo.10594282>
18. Antonov A. A. (2024). Proof of physical reality of imaginary numbers and explanation of their physical essence. *German International Journal of Modern Science*. 72. 17-27.
19. Anonov A. A. (2024). Physical reality of imaginary numbers and their physical essence. *Sciences of Europe*. (Praha, Czech Republic). 133(1). 79-90. DOI: 10.5281/zenodo.10575590
20. Antonov A. A. (2024). Physical reality of imaginary numbers and their physical essence. *The scientific heritage*. (Budapest, Hungary). 129. 43-53. DOI: 10.5281/zenodo.10558263
21. Antonov A. A. (2024). Proving Physical Reality and Explaining the Physical Essence of Imaginary Numbers. *European Journal of Applied Sciences. Services for Science and Education*. UK. 12(2). 362-381. DOI:10.14738/aivp.122.16273
22. Antonov A. A. (2024). Proving Physical Reality and Explaining Physical Essence of Imaginary Numbers. *Journal of science*. Lyon. 50. 25-35.
<https://doi.org/10.5281/zenodo.10609816>
23. Antonov A. A. (2024). Physical reality of complex numbers and their physical essence. *International independent scientific journal*. 58. 3-13. <https://doi.org/10.5281/zenodo.10491923>
24. Antonov A. A. (2024). Proof of physical reality of imaginary numbers and explanation of their physical essence. *Annali d'Italia*. 51, 25-35. DOI: 10.5281/zenodo.10573831

25. Antonov A.A. (2021). *The special theory of relativity stated in physics textbooks is incorrect. 77th International Scientific Conference of the Eurasian Scientific Association "Theoretical and practical issues of modern science". Moscow. ESA. 11-15. (In Russian)*
26. Antonov A. A. (2021). *Version of the special theory of relativity that is studied in all physics textbooks is incorrect. Österreichisches Multiscience Journal (Innsbruck, Austria). 43(1). 17-22. <http://os-terr-science.com>*
27. Antonov A. A. (2021). *The fallacy of the SRT version studied in physics textbooks proved experimentally. Österreichisches Multiscience Journal (Innsbruck, Austria). 45(1). 17-26.*
28. Antonov A. A. (2021). *Generally accepted version of the special theory of relativity contained in physics textbooks is incorrect. The scientific heritage. (Budapest, Hungary). 73(2). 39-43. DOI: 10.24412/9215-0365-2021-73-2-39-43*
29. Antonov A. A. (2021). *Special theory of relativity presented in physics text-books is wrong. Norwegian Journal of development of the International Science 68(1). 3-7. DOI: 10.24412/3453-9875-2021-68-3-7.*
30. Antonov A. A. (2021). *In all physics textbooks an erroneous version of special theory of relativity is given. International independent scientific journal. 31.34-39. <http://www.iis-journal.com>*
31. Antonov A. A. (2021). *All physics textbooks study incorrect special theory of relativity. Sciences of Europe. (Praha, Czech Republic) 79(1). 30-35. DOI: 10/24412/3162-2364-2021-79-30-35*
32. Antonov A. A. (2021). *Special theory of relativity, which is studied in physics text-books, is incorrect. German International Journal of Modern Science. 16, 49-53. DOI: 10.24412/2701-8369-2021-16-49-53*
33. Antonov A. A. (2021). *Special theory of relativity, which is studied in all physics textbooks, is incorrect. Danish Scientific Journal. 51(1). 31-35. <http://www.danish-journal.com>*
34. Antonov A. A. (2021). *Special theory of relativity taught in all physics text-books is incorrect. Annali d'Italia. 22(1). 39-44. <https://www.anditalia.com/>*
35. Antonov A. A. (2021). *Special theory of relativity taught in physics textbooks is wrong. Journal of science. Lyon. 23. 47-52. <https://www.joslyon.com/>*
36. Antonov A. A. (2021). *Experimental proofs of infidelity of the version of the special theory of relativity studied in physics textbooks and the truth of its alternative version. 80th International Scientific Conference of the Eurasian Scientific Association "Development of science and education in the conditions of world instability". Moscow. ESA. 8-17. (In Russian) <https://esa-conference.ru/sborniki/?y=2021>*
37. Antonov A. A. (2021). *Experimental evidences for the fallacy of the SRT version in the physics textbooks. European Journal of Applied Sciences. Services for Science and Education. UK. 9(6). 349-364. DOI:10.14738/aivp.96.11304.*
38. Antonov A. A. (2021). *If the SRT version in physics textbooks were true, we would never have heard the music of the piano and the bell ringing, there would be no television, no cellular telephony, no radar or GPS navigation, we would not even be aware of the existence of resonance and Ohm's law as interpreted by Steinmetz, and our children could not swing on the swings. The scientific heritage (Budapest, Hungary). 78(2). 41-50. DOI: 10.24412/9215-0365-2021-78-2-41-50*
39. Antonov A. A. (2021). *The SRT version in physics textbooks must be corrected, because if it were true, there would be no tsunamis or indian summer in nature, we would be never have heard piano music, engineers would be not have been able to create television, cell phones, GPS trackers, and even children would not be able to swing on swings. Danish Scientific Journal. 54(1). 29-38. <http://www.danish-journal.com>*
40. Antonov A. A. (2021). *Experimental refutations of the SRT version contained in physics textbooks and confirmations of the truth of its alternative version. German International Journal of Modern Science. 22. 52-61. DOI: 10.24412/2701-8369-2021-22-52-61*
41. Antonov A. A. (2021). *Experimental evidence of the incorrectness of the SRT version studied in physics textbooks. Annali d'Italia. 25(1). 32-41. <https://www.anditalia.com/>*
42. Antonov A. A. (2021). *The incorrectness of the SRT version presented in physics textbooks proven experimentally. Norwegian Journal of development of the International Science. 74(1). 3-7. DOI: 10.24412/2453-9875-2021-74-53-62.*

43. Antonov A. A. (2021). *Experimental refutations of the generally accepted version of the SRT studied in physics textbooks*. *International independent scientific journal*. 34(1). 23-32. <http://www.iis-journal.com>
44. Antonov A. A. (2021). *Experimental refutations of the SRT version in the physics textbooks*. *Journal of science*. Lyon. 26(1). 29-37. <https://www.joslyon.com/>
45. Antonov A. A. (2021). *Experimental evidences for the fallacy of the SRT version in physics textbooks*. *Sciences of Europe (Praha, Czech Republic)*. 82(2). 19-28.
DOI: 10.24412/3162-2364-2021-82-2-19-28
46. Antonov A. A. (2021). *The version of SRT stated in physics textbooks is incorrect, as it denies the existence of radio engineering*. 82nd International Scientific Conference of the Eurasian Scientific Association "Scientific results in theory and practice". Moscow. ESA. 11-15. (In Russian)
<https://esa-conference.ru/sborniki/?y=2021>
47. Antonov A. A. (2022). *The version of SRT presented in physics textbooks is incorrect, since it follows from it that radio engineering should not exist*. *European Journal of Applied Sciences. Services for Science and Education*. UK. 10(1). 440-445.
DOI: doi.org/10.14738/aivp.101.2022
48. Antonov A. A. (2022). *The existence of radio engineering refutes the physics textbooks' version of SRT*. *The scientific heritage*. (Budapest, Hungary). 83(1). 19-22.
DOI: 10.24412/9215-0365-2022-83-1-19-22
49. Antonov A.A. (2022). *The fundamental Ohm's law in radio engineering as interpreted by Steinmetz, which proves the physical reality on imaginary capacitive and inductive reactances, refuted the version of the SRT presented in physics textbooks even before its creation*. *German International Journal of Modern Science*. 26. 50-53. DOI: 10.24412/2701-8369-2022-26-50-63
50. Antonov A.A. (2022). *The version of SRT stated in physics textbooks is refuted by the existence of radio engineering*. *Danish Scientific Journal*. 56. 56-59. <http://www.danish-journal.com>
51. Antonov A.A. (2022). *The version of SRT presented in physics textbooks is incorrect because it denies the possibility of the existence of Ohm's law as interpreted by Steinmetz and, consequently, the existence of radio engineering*. *Annali d'Italia*. 28(1), 43-47.
<https://www.anditalia.com/>
52. Antonov A.A. (2022). *The version of SRT stated in physics textbooks is refuted by the existence of radio engineering*. *Norwegian Journal of development of the International Science*. 78(1). 63-67. DOI: 10.24412/3453-9875-2022-78-63-66.
53. Antonov A.A. (2022). *If the physics textbook version of SRT were true, then Ohm's law should not exist in nature, and therefore all radio engineering would not exist*. *International independent scientific journal*. 36. 16-19. <http://www.iis-journal.com>
54. Antonov A.A. (2022). *If the version of SRT in physics textbooks were true, then there would be no radar, no television, no radio navigation, no telecommunication and many other things*. *Journal of science*. Lyon. 28. 76-79. <https://www.joslyon.com/>
55. Antonov A.A. (2022). *The version of SRT set out in physics textbooks is incorrect because it states that Ohm's law as interpreted by Steinmetz does not really exist, and therefore radio engineering does not exist either*. *Sciences of Europe (Praha, Czech Republic)*. 87(1). 54-57. DOI: 10.24412/3162-2364-2022-1-54-57
56. Antonov A.A. (2022). *The version of SRT set out in physics textbooks is incorrect because it states that Ohm's law as interpreted by Steinmetz does not really exist, and therefore radio engineering does not exist either*. *Sciences of Europe (Praha, Czech Republic)*. 87(1). 54-57. DOI: 10.24412/3162-2364-2022-1-54-57
57. Antonov A.A. (2022). *Why the physics textbooks teach an incorrect version of the special theory of relativity which denies the existence of radio- and electrical engineering*. III international scientific conference "Challenges and problems of modern science." London. Great Britain. 78-86. DOI: <https://doi.org/10.528/zenodo.7486814>
58. Steinmetz C. P. (2010). *Theory and Calculation of Electric Circuit*. Nabu Press. Charlstone.
59. Antonov A. A. (2014). *Correction of the special theory of relativity: physical reality and nature of imaginary and complex numbers*. *American Journal of Scientific and Industrial Research*. 5(2). 40-52. doi:10.5251/ajsir.2014.5.2.40.52
60. Antonov A.A. (2023). *The Corrected Version of the Special Theory of Relativity*. *European Journal of Applied Sciences. Services for Science and Education*. UK. 11(5). 68-83. DOI:10.14738/aivp.115.15474

61. Antonov A. A. (2023). *Corrected special theory of relativity*. *Annali d'Italia*. 49, 25-35. DOI: 10.5281/zenodo.10214679
62. Antonov A. A. (2023). *Special Theory of Relativity*. *German International Journal of Modern Science*. 67. 64-73. DOI: 10.5281/zenodo.10966458
63. Antonov A. A. (2023). *Corrected special theory of relativity*. *Journal of science*. Lyon. 47. 14-23. <https://doi.org/10.5281/zenodo.10068983>
64. Antonov A. A. (2023). *The Corrected Version of the Special Theory of Relativity*. *The scientific heritage*. (Budapest, Hungary). 123. 72-81. DOI: 10.5281/zenodo.10033028
65. Antonov A. A. (2023). *The Corrected Version of the Special Theory of Relativity*. *Norwegian Journal of development of the International Science*. 118. 40-49. <https://doi.org/10.5281/zenodo.10009500>
66. Antonov A. A. (2023). *Alternative Version of the Special Theory of Relativity*. *Sciences of Europe*. (Praha, Czech Republic). 128. 62-71. DOI: 10.5281/zenodo.10081933
67. Antonov A. A. (2023). *Corrected Version of the Special Theory of Relativity*. *Danish Scientific Journal*. 77. 88-97. <https://doi.org/10.5281/zenodo.10054677>
68. Hinshaw G., Larson D., Komatsu E., et al. (2013) *Nine Year Wilkinson Anisotropy Probe (WMAP) Observations: Cosmological Parameter Results*. arXiv:1213.5226 [astro-ph.CO].
69. Adam R., Ade P.A.R., Aghanim N., et al. (2015). *Planck 2015 Results. 1. Overview of Products and Scientific Results*. arXiv:1502.01582v2 [astro-ph.CO].
70. Antonov A. A. (2015). *Review of publications by A. A. Antonov on the problem of explaining the phenomenon of dark matter and dark energy*. *Journal of the Russian physic-chemical society*. 87(3). 63-76. (In Russian)
71. Antonov A. A. (2015). *Hidden Multiverse: explanation of dark matter and dark energy phenomena*. *International Journal of Physics*. 3(2). 84-87. doi:10.12691/ijp-3-2-6
72. Antonov A. A. (2015). *Principles and structure of the real Multiverse: explanation of dark matter and dark energy phenomena*. *American Journal of Modern Physics*. 4(1). 1-9. doi:10.11648/j.ajmp.20150401.11
73. Antonov A. A. (2015). *Explanation of dark matter and dark energy phenomena*. *Journal of Science Frontier Research: A Physics and Space Science*. 15(1). 33-38.
74. Antonov A. A. (2016). *Explaining the Phenomenon of Dark Matter and Dark Energy by Existence of the Hidden Multiverse*. *Frontiers of Astronomy, Astrophysics and Cosmology*. 2(1). 1-9. doi: 10.12691/faac-2-1-1
75. Antonov A. A. (2016). *Hypothesis of the Hidden Multiverse: Explains Dark Matter and Dark Energy*. *Journal of Modern Physics*. 7(10), 1228-1246. doi: 10.4236/jmp.2016.710111
76. Antonov A. A. (2017). *Nature of dark matter and dark energy*. *Journal of Modern Physics*. 8(4). 567-582. doi: 10.4236/jmp.2017.84038
77. Antonov A. A. (2017). *Hypothesis of the hidden Multiverse explains the phenomenon of dark matter and dark energy*. *Applied Physics Research*. 9(2). 30-41. doi: <https://doi.org/10.5539/apr.v9n2p30>
78. Kantor I. L., Solodovnikov A. S. (1989) *Hypercomplex Numbers*. Springer Verlag, Berlin.
79. Antonov A. A. (2015). *Quaternion structure of the hidden Multiverse: explanation of dark matter and dark energy*. *Global Journal of Science Frontier Research A: Physics and Space Science*. 15(8). 8-15. https://globaljournals.org/GJSFR_Volume15/2-Quaternion-Structure-of-the-Hidden.pdf
80. Antonov A. A. (2020). *How to See Invisible Universes*. *Journal of Modern Physics*. 11(05), 593-607. DOI: 10.4236/jmp.2020.115039
81. Antonov A. A. (2020). *Universes Being Invisible on Earth outside the Portals Are Visible in Portals*. *Natural Science*. 12(8). 569-587. <https://doi.org/10.4236/ns.2020.128044>
82. Antonov A. A. (2020). *Invisible universes can be seen in anomalous zones*. *Danish Scientific Journal*. 43(1). 9-24. <http://www.danish-journal.com>
83. Antonov A. A. (2024). *Existence of other mutually invisible universes adjacent to our visible universe can be experimentally proven by astronomical observations in the portals of constellations invisible outside the portals*. *German International Journal of Modern Science*. 92. 67-80. DOI: 10.5281/zenodo.14181333
84. Antonov A. A. (2024). *Experimental evidence for the existence of other mutually invisible universes neighboring our visible universe*. *European Journal of Applied Sciences. Services for Science and Education*. UK. 12(5). 385-408. DOI:10.14738/aivp.125.17785.

85. Antonov A. A. (2024). Experimentally proved and actually physically existing imaginary numbers as a tool to explain the principle of relativism in SRT. *Norwegian Journal of development of the International Science*. 144. 69-82. <https://doi.org/10.5281/zenodo.14169132>
86. Antonov A. A. (2020). Can invisible universes be seen? *International independent scientific journal*. 21(2). 51-60. <http://www.iis-journal.com>
87. Antonov A. A. (2020). How to discover invisible universes. *Norwegian Journal of development of the International Science*. 42(1). 36-48. <http://www.njd-iscience.com>
88. Antonov A. A. (2024). Proof of the existence of other mutually invisible universes neighboring to our visible universe by astronomical observations in the portals of constellations invisible outside the portals. *Sciences of Europe (Praha, Czech Republic)*. 153. 93-106.
DOI: 10.5281/zenodo.14227583
89. Antonov A. A. (2021). Invisible universes can be seen in anomalous zones. *International independent scientific journal*. 23(1). 28-44.
90. Antonov A. A. (2024). Proof of the existence of other mutually invisible universes neighboring to our visible universe by astronomical observations in the portals of constellations invisible outside the portals. *Annali d'Italia*. 61. 43-57. DOI: 10.5281/zenodo.14230824
91. Antonov A. A. (2024). Proof of the existence of other mutually invisible universes neighboring to our visible universe. *Danish Scientific Journal*. 90. 111-125.
<https://doi.org/10.5281/zenodo.14236925>
92. Antonov A. A. (2024). Discovery of other constellations in portals that are invisible outside the portals is experimental proof of the existence of mutually invisible universes adjacent to our visible universe. *Polish journal of Science*. 80. 24-38. DOI: 10.5281/zenodo.14176574
93. Antonov A. A. (2024). It is possible to prove the existence of other mutually invisible universes adjacent to our visible universe by astronomical observations in the portals of constellations that are invisible outside the portals. *Slovak international scientific journal (Bratislava, Slovakia)*. 89. 51-65. DOI: 10.5281/zenodo.14167109
94. Antonov A. A. (2024). Experimentally proved and actually psychically existing imaginary numbers as a tool to explain the principle of relativism in SRT. *The scientific heritage (Budapest, Hungary)*. 149. 50-63. DOI: 10.5281/zenodo.14214530
95. Antonov A. A. (2024). Existence of other mutually invisible universes adjacent to our visible universe can be experimentally proven by astronomical observations in the portals of constellations invisible outside the portals. *International independent scientific journal*. 67. 29-42. <https://doi.org/10.5281/zenodo.14055388>
96. Antonov A. A. (2024). Besides our visible universe, there are other invisible universes. *Journal of Science*. Lyon. 59. 13-26. <https://doi.org/10.5281/zenodo.14049575>
97. Antonov A. A. (2024). Discovery of constellations in portals that are invisible outside the portals proves the existence of mutually invisible universes adjacent to our visible universe. *Sciences of Europe (Praha, Czech Republic)*. 94. 34-48. DOI: 10.5281/zenodo.14167218
98. Chernobrov V. (2000). *Encyclopaedia of mysterious places of the Earth*. Veche Publishing House. Moscow. (In Russian)
99. Chernobrov V. (2004). *Encyclopaedia of mysterious places of Russia*. Veche Publishing House. Moscow. (In Russian)
100. Chernobrov V. (2007). *Encyclopaedia of mysterious places of the Earth and space*. Veche Publishing House. Moscow. (In Russian)
101. Chernobrov V. (2009). *Encyclopaedia of mysterious places of Moskva and Moscow region*. Helios ARV. Moscow. (In Russian)
102. Antonov A. A. (2021). Antimatter, Anti-Space, Anti-Time. *Journal of Modern Physics*, 12(05), 646-660. DOI: 10.4236/jmp.2021.125042.
103. Antonov A. A. (2021). What is our physical world. 71st International Scientific Conference of the Eurasian Scientific Association. Moscow. ESA. 11-15. (In Russian) <https://esa-conference.ru/sborniki/?y=2021>
104. Antonov A. A. Antimatter, anti-space, anti-time. (2021). 75th International Conference of the Eurasian Scientific Association "Strategies for Sustainable Development of World Science". Moscow. ESA. 1-4. DOI: 10.5281/zenodo.4926585 (In Russian)
105. Antonov A. A. (2021). Do antimatter, anti-time and anti-space exist in nature. *Annali d'Italia*. 20(1). 14-24. <https://www.anditalia.com/>

106. Antonov A. A. (2021). *From the alternative version of the SRT it follows that there is not only antimatter, but also anti-space and anti-time*. Norwegian Journal of Development of the International Science. 62(1). 41-51. DOI: 10.24412/3453-9875-2021-62-1-41-51
107. Antonov A. A. (2021). *Antipodes in space*. German International Journal of Modern Science. 11(1). 15-25. DOI: 10.24412/2701-8369-2021-11-1-15-25
108. Antonov A. A. (2021). *There is not only antimatter, but also anti-space and anti-time*. Journal of science. Lyon. 21. 22-30. <https://www.joslyon.com/>
109. Antonov A. A. (2021). *Where are antimatter, anti-space and anti-time?* Österreichisches Multiscience Journal. (Innsbruck, Austria). 40(1). 34-44. <http://osterr-science.com>
110. Antonov A. A. (2021). *Do antimatter, anti-time and anti-space exist in nature?* Danish Scientific Journal. 48(1). 64-74. <http://www.danish-journal.com>
111. Antonov A. A. (2021). *Antipodes in space*. International independent scientific journal. 28. 50-61. <http://www.iis-journal.com>
112. Antonov A. A. (2021). *How alternative version of SRT explains the existence of antimatter, anti-space and anti-time? The scientific heritage (Budapest, Hungary)*. 67(1). 11-21. DOI: 10.24412/9215-0365-2021-67-1-11-21
113. Antonov A. A. (2025). *Time Travels are Already Possible Nowadays*. European Journal of Applied Sciences. Services for science and education. U.K. 13(03). 47-70. DOI:10.14738/aivp.1303.18764.
114. Antonov A. A. (2025). *Time travels are already possible for people on Earth*. German International Journal of Modern Science. 104. 64-76. DOI: 10.5281/zenodo.15480577
115. Antonov A. A. (2025). *Discovery of the possibility for people on Earth of time travels*. Norwegian Journal of development of the International Science. 156. 84-98. <https://doi.org/10.5281/zenodo.15397809>
116. Antonov A. A. (2025). *The discovery of physically real time travels*. Journal of Science. Lyon. 66. 33-48. <https://doi.org/10.5281/zenodo.15584655>
117. Antonov A. A. (2025). *The physical reality of time travels available to people*. Annali d'Italia. 67. 58-72. DOI: 10.5281/zenodo.15545211
118. Antonov A. A. (2025). *The physical possibility for people on Earth of time travel*. The scientific heritage. 163. 44-58. DOI: 10.5281/zenodo.15728017
119. Antonov A. A. (2025). *Proof of the physical reality of time travels available to humans*. Danish Scientific Journal. 96. 72-86. <https://doi.org/10.5281/zenodo.15553087>
120. Antonov A. A. *Time travels is now physically possible*. XX international scientific conference "The modern vector of the development of science". Philadelphia. USA. 12-13.06.2025.
121. Antonov A. A. (2025). *The physical possibility for people on Earth of time travels*. Polish journal of Science. 87. 39-53.
122. Antonov A. A. *Time travels is now physically possible*. XVI international scientific conference "Theoretical and practical perspectives of modern science". Stockholm. Sweden. 27-28.05.2025.
123. Antonov A. A. *The discovery of physical possibility of time travels*. II International Scientific Conference "Expanding knowledge through interdisciplinary research". Sydney. Australia. 15-16.05.2025.
124. Antonov A. A. (2025). *The Use of the Laws of Physics Allows a Person who has Died, for Example, as a Result of an Accident or Crime, to be Brought Back to Life*. European Journal of Applied Sciences, Services for science and education. U.K. 13(04). 174-179. DOI:10.14738/aivp.1304.19179.
125. Antonov A. A. (2025). *The physical ability to bring a person who has died, for example as a result of an accident or a crime, back to life*. Polish journal of Science. 89. 36-39. DOI: 10.5281/zenodo.16917782
126. Antonov A. A. (2025). *By using the laws of physics, it is possible to bring back to life a person who has died, for example, as a result of an accident or crime*. The scientific heritage. 166. 65-67. DOI: 10.5281/zenodo.16763534
127. Antonov A. A. (2025). *It is physically possible to bring back to life a person who has died, for example, as a result of an accident or crime, using time travels*. German International Journal of Modern Science. 109. 24-27. DOI: 10.5281/zenodo.16752567
128. Antonov A. A. (2025). *The laws of physics allow a person who has died, for example, as a result of an accident or crime, to be brought back to life*. Danish Scientific Journal 98. 67-70. <https://doi.org/10.5281/zenodo.16615081>

129. Antonov A. A. (2025). *It is physically possible to bring back to life a person who has died as a result of an accident or crime by using time travels.* *Annali d'Italia*. 69, 46-49.

DOI: 10.5281/zenodo.16419980

130. Antonov A. A. *Possibility in accordance with the laws of physics, of bringing back to life people who have died as a result of accident and other causes by time travels using time zones on Earth.* XVI International scientific conference "Science in modern society". Beijing. China. 22-23.07.2025

131. Antonov A. A. (2025). *How the laws of physics can be used to bring back to life a person who has died as a result of an accident or crime.* *Norwegian Journal of development of the International Science*. Norwegian Journal of development of the International Science. 160. 69-72. <https://doi.org/10.5281/zenodo.15879906>

132. Antonov A. A. (2025). *A person who has died in an accident or crime, for example, can be brought back to life through the use of time travels.* *International independent scientific journal*. 72. 17-20. <https://doi.org/10.5281/zenodo.16778574>

133. Antonov A. A. (2025). *The laws of physics allow a dead person to be brought back to life.* *Journal of Science*. Lyon. 68. 15-18. <https://doi.org/10.5281/zenodo.16758455>

134. *The laws of physics allow by time travelling with using time zones on Earth to bring back to life people who died as a result of accidents, in war and for other reasons.* XVII International scientific conference "Theoretical and practical perspectives of modern science". Stockholm. Sweden. 12-13.08.2025.

135. Jean de Climont. (2009), (2010), (2016), (2020), (2023). *The Failure of Pure Science*. Editions d'Assailly.

137. 136. Jean de Climont. (2017). *The alternative theories*. Editions d'Assailly.

Jean de Climont. (2019), (2020), (2023). *The Worldwide List of Alternative Theories and Critic*. Editions d'Assailly.

138. Jean de Climont. (2023). *Einstein and Maxwell speculation*. Editions d'Assailly.

Technical sciences

CYBERSECURITY AND CYBER DEFENSE

T.E. Mammadova

Baku State University, Azerbaijan

Abstract

Cybersecurity encompasses a wide range of methods, tools, and concepts closely related to information security and operational technology (OT) security. It is often misinterpreted as a synonym for information security or IT security, which leads to conceptual ambiguity and obscures important distinctions between these domains.

This paper argues that cybersecurity should be understood as a set of protective practices based on information and operational technologies. Cyber defense is presented as a mechanism for protecting computer networks, ensuring the security of critical infrastructure, and supporting organizations and government institutions in responding to cyber threats.

The study explores how cybersecurity and cyber defense contribute to cyber resilience through a conceptual model. Additionally, it examines cyber rapid response teams and mutual aid mechanisms as innovative approaches to addressing increasing cyber threats and limited response capabilities.

Keywords: *cybersecurity; cyber defense; cyber resilience; conceptual model; rapid response teams*

1. Introduction

Cybersecurity has been practiced in military environments for more than a decade. In recent years, however, the term has been widely used across various domains, often without regard to its original meaning. This misuse obscures the distinction between cybersecurity, information security, and operational technology (OT) security.

Cyber defense encompasses a wide range of activities aimed at protecting stakeholders and responding rapidly to evolving threats. These activities include reducing system vulnerabilities, identifying critical assets, implementing preventive measures, and ensuring effective detection and response mechanisms.

Cyber defense also involves technical analysis to identify potential attack vectors and vulnerable areas [3]. Awareness, resilience, and response form the foundation of state strategies against cyber threats. Governments continuously improve their ability to detect malicious activities at early stages while strengthening the resilience of critical infrastructure and institutions.

Problem Statement

The main objective of this study is to examine how cybersecurity and cyber defense contribute to cyber resilience under conditions of increasing cyber threats and limited response capabilities.

A secondary objective is to describe the development and operation of cyber rapid response teams and mutual assistance frameworks at the national level, presenting them as a new approach to cybersecurity and cyber defense.

Methodology

Cyber defense begins with understanding the specific operational environment and analyzing the threats relevant to it. Based on this analysis, appropriate strategies are developed to prevent and respond to malicious activities.

This study adopts a model-based methodology to construct a conceptual framework for cyber resilience. The model integrates cybersecurity and cyber defense mechanisms, combining human resources, processes, and technologies. It also incorporates rapid response teams and mutual assistance as key components of a modern cybersecurity strategy.

Cyber Defense

In modern conflicts, adversaries increasingly rely on non-military (indirect) methods, including targeted cyberattacks on communication systems at all levels of command. Future conflicts are expected to occur primarily in the information domain, where operators remotely control advanced technological systems.

Encrypted data transmitted through public communication channels has become a major target for cyberattacks [15]. Cyber defense focuses on prevention, detection, and timely response to ensure that critical infrastructure and sensitive information remain secure.

With the growing complexity and volume of cyberattacks, cyber defense has become essential for organizations. It ensures operational continuity, improves the efficiency of security strategies, and optimizes the use of security resources, particularly in critical sectors [6].

Cyber Rapid Response Teams and Mutual Aid in Cybersecurity

Given the increasing complexity of cyber threats and limited response capabilities, it is essential to establish Cyber Rapid Response Teams (CRRTs) and mutual assistance mechanisms in cybersecurity.

These teams consist of highly qualified experts capable of responding quickly to cyber incidents at both national and international levels. Unlike many existing initiatives that focus primarily on information sharing, this approach emphasizes the sharing of human expertise and operational capabilities.

This model enhances not only national cybersecurity but also international cooperation in cyber defense.

Cyber Resilience Concept

Cybersecurity alone is no longer sufficient; a comprehensive strategy that includes protection, prevention, and response is required. Cyber resilience represents the ability of systems and organizations to prepare for, withstand, and recover from cyber incidents.

Resilience should not be viewed as synonymous with recovery. It is a long-term capability that must be integrated into an organization's overall strategy. It includes preparedness, defensive mechanisms, and available resources for mitigating the consequences of cyber incidents.

A comprehensive resilience strategy considers actions before, during, and after an attack. Organizations must also adapt to emerging risks associated with technologies such as artificial intelligence, the Internet of Things, and quantum computing [2].

Technological Perspective of Cybersecurity

Cybersecurity is a fundamental component of modern digital society. Although there is no universally accepted definition, it is generally understood as a combination of tools, policies, technologies, and practices used to protect digital environments and assets (Humayun et al., 2020).

According to the International Telecommunication Union, cybersecurity includes security policies, risk management approaches, training, and technologies designed to protect both organizations and users.

The NIST Cybersecurity Framework identifies five core functions: Identify, Protect, Detect, Respond, and Recover. These functions provide a structured approach to managing cybersecurity risks and protecting critical infrastructure.

Cybersecurity Startups and Innovation

Cybersecurity startups play a crucial role in innovation and the development of security solutions. These companies, typically less than ten years old, focus on creating innovative products and services aimed at protecting critical infrastructure.

Due to the specific features cybersecurity, traditional entrepreneurship research cannot be fully applied. Therefore, the concept of "cybersecurity startups" is introduced to better understand their role and impact.

Taxonomy Development as a Methodology

Taxonomy development is used to classify cybersecurity startups based on their business models. It provides a structured way to analyze complex systems and supports both research and practical applications.

This approach is particularly useful in emerging and heterogeneous fields such as cybersecurity. It allows researchers to identify similarities and differences between entities and improve understanding of the domain.

Recommendations

The study highlights the importance of multiple factors, including technological, behavioral, and organizational aspects of cybersecurity.

One of the key findings is the low level of cybersecurity awareness among employees. Organizations should invest in training and education programs to improve knowledge and skills in cybersecurity. This will significantly enhance the effectiveness of cybersecurity strategies.

Conclusion

Cybersecurity and cyber defense are essential components of modern digital systems. Their integration is necessary to achieve cyber resilience in the face of increasing cyber threats.

The proposed conceptual model, incorporating rapid response teams and mutual assistance, provides a comprehensive approach to improving cybersecurity at both organizational and national levels.

References

1. Björck F., Henkel M., Stirna J., Zdravkovic J. *Cyber Resilience – Fundamentals for a Definition*. In: Rocha A., Correia A., Costanzo S., Reis L. (eds) *New Contributions in Information Systems and Technologies. Advances in Intelligent Systems and Computing*, vol 353. Springer, Cham, 2015.
2. Dobrygowski, D.: *Cyber resilience: everything you (really) need to know*, available at <https://www.weforum.org/agenda/2016/07/cyber-resilience-what-to-know/>, Accessed: 21st September 2022.
3. *CyberDefense*, available at <https://www.techopedia.com/definition/6705/cyber-defense>, Accessed: 10th April 2022.
4. *Exclusive Networks: Unknown Unknowns – The Ultimate Test for Cybersecurity*, available at <http://www.exclusive-networks.com/uk/blog/unknown-unknowns-ultimate-test-cybersecurity/>, Accessed: 1st August 2022.
5. Goche, M., Gouveia, W.: *Why Cyber Security Is Not Enough: You Need Cyber Resilience*, available at <https://www.forbes.com/sites/sungardas/2014/01/15/why-cyber-security-is-not-enough-you-need-cyber-resilience/#562402a21bc4>, Accessed: 1st July 2022.
6. Hulme, G.V.: *Security spending continues to run a step behind the threats*, available at <http://www.csoonline.com/article/2134074/strategic-planning-erm/security-spending-continues-to-run-a-step-behind-the-threats.html>, Accessed: 13th June 2022.
7. *Infosecurity*, available at <http://infosecurityinc.net/wp-content/uploads/2011/07/Consult-Cyber-1Cyber-Threats-Diminishing-Attack-Costs-ga-Increasing-Complexity4.jpg>, Accessed: 18th September 2022.
8. Marvell, S.: *The real and present threat of a cyber breach demands real-time risk management*, Acuity Risk Management, 2015.
9. *NATO Cyber Cooperative Cyber Defense Center of Excellence Tallin Estonia*, available at <https://ccdcoe.org/cyber-definitions.html>, Accessed: 10th April 2022.
10. Pescatore, J.: *Toward a National Cybersecurity Strategy*, G00167598, Gartner, Inc., 2009.
11. Tucker, E.: *Official: FBI probing attempted cyber breach of NY Times*, available at <http://www.federaltimes.com/articles/official-fbi-probing-attempted-cyber-breach-of-ny-times>, Accessed: 31st May 2022.
12. Walls, A., Perkins, E., Weiss, J.: *Definition: "Cybersecurity"*, G00252816, Gartner, Inc., 2013.
13. Wheeler, J. A.: *Emerging Risks in Cybersecurity: Gartner's Top Ten Predictions*, available at <http://blogs.gartner.com/john-wheeler/gartner-top-ten-cybersecurity-predicts/>, Accessed: 2nd June 2022.
14. *United States Department of Defense: Strategy for Operating in Cyberspace*, Department of Defense, 2011. I INTERNATIONAL SCIENTIFIC CONFERENCE BEIJING. CHINA. 30-31.05.2023
15. Galinec, D., Steingartner, W., Zebić, V.: *Cyber Rapid Response Team: An Option within Hybrid Threats*. 2019 IEEE 15th International Scientific Conference on Informatics, INFORMATICS' 2019, November 20th-22nd, 2019, Poprad, Slovakia, PROCEEDINGS, Institute of Electrical and Electronics

OPTIMIZATION OF THE NATURAL GAS ABSORPTION PROCESS**Ulduz Mammadov***Azerbaijan State Oil and Industry University,
Department of Instrument Engineering, Doctor of Philosophy in Engineering.***Nihat Huseynli***Azerbaijan State Oil and Industry University,
Department of Instrument Engineering, Master's
Student***TƏBII QAZIN ABSORBSIYA PROSESİNİN OPTIMALLAŞDIRILMASI****Ulduz Mammadov***Azərbaycan Dövlət Neft və Sənaye Universiteti,
Alət Mühəndisliyi Departamenti, Mühəndislik üzrə fəlsəfə doktoru.***Nihat Huseynli***Azərbaycan Dövlət Neft və Sənaye Universiteti,
Alət Mühəndisliyi Departamenti, Magistr tələbəsi***ОПТИМИЗАЦИЯ ПРОЦЕССА АБСОРБЦИИ ПРИРОДНОГО ГАЗА****Улдуз Мамедов***Азербайджанский государственный нефтепромышленный университет,
кафедра инструментальной технологии, кандидат технических наук***Нихат Гусейны***Азербайджанский государственный нефтегазовый и промышленный университет,
кафедра приборостроения, магистрант***Abstract**

In natural gas processing, the absorption process is one of the widely used methods for removing undesirable components and various impurities from the gas stream. Efficient purification of natural gas plays an important role both in improving product quality and in meeting environmental standards. In this regard, optimization of the absorption process contributes to more efficient operation of technological systems and reduction of energy consumption. The present study examines the analysis of the natural gas absorption process and approaches for its improvement. The main objective of the research is to increase the efficiency of mass transfer occurring between the gas and liquid phases. During the study, the main factors affecting the process—such as temperature, pressure, absorbent flow rate, and the structural characteristics of the absorber unit—were taken into consideration. Changes in these parameters directly influence the overall productivity and efficiency of the process. Various modeling and simulation methods were used to evaluate the performance of the absorption system. The analyses carried out showed that the optimal selection of process parameters leads to an increase in absorption efficiency. In addition, optimization allows a reduction in absorbent consumption and operational costs.

A more efficient organization of the process increases system stability and controllability. The results of the research indicate that optimization enables more effective removal of harmful and undesirable components from natural gas. This contributes to an improvement in the quality of the final product and ensures safer transportation of the gas. The obtained results are considered significant for application in industrial-scale natural gas processing plants. Overall, optimization of the absorption process contributes both to increased economic efficiency and improved environmental safety in the natural gas industry.

Furthermore, the proper selection of absorbent substances used in the absorption process has a significant impact on its efficiency. In modern technologies, various physical and chemical absorbents can be applied. The selection of these substances depends on the chemical composition of the gas and the operating conditions of the process. The structural design of absorber equipment is also one of the important factors influencing the intensity of mass and heat transfer. Equipment with an optimal design allows the process to be carried out more productively. At the same time, automated control of process parameters increases the stability of production operations. Reducing energy consumption creates

important economic advantages for industrial enterprises. Optimization of the absorption process also has a positive impact on reducing the amount of harmful emissions released into the environment. Therefore, improvement of the process is of great importance from an ecological perspective as well. The application of modern optimization methods enables natural gas processing operations to be organized in a more efficient and sustainable manner.

Xülasə

Təbii qazın emalı zamanı absorbsiya prosesi qazın tərkibində olan arzuolunmaz komponentlərin və müxtəlif çirkləndiricilərin ayrılması üçün geniş tətbiq olunan üsullardan biridir. Qazın səmərəli şəkildə təmizlənməsi həm məhsul keyfiyyətinin yaxşılaşdırılması, həm də ekoloji standartların yerinə yetirilməsi baxımından mühüm rol oynayır. Bu baxımdan absorbsiya prosesinin optimallaşdırılması texnoloji sistemlərin daha səmərəli işləməsinə və enerji sərfiyyatının azalmasına şərait yaradır. Təqdim olunan tədqiqat işində təbii qazın absorbsiya prosesinin təhlili və onun təkmilləşdirilməsi istiqamətləri araşdırılmışdır. Tədqiqatın əsas məqsədi qaz və maye fazaları arasında baş verən kütlə ötürülməsi prosesinin effektivliyini artırmaqdır. Araşdırma zamanı prosesə təsir göstərən əsas amillər – temperatur, təzyiq, absorbent axınının sürəti və absorber qurğusunun konstruktiv xüsusiyyətləri nəzərə alınmışdır. Bu parametrlərin dəyişməsi prosesin ümumi məhsuldarlığına və effektivliyinə birbaşa təsir göstərir. Absorbsiya sisteminin fəaliyyətinin qiymətləndirilməsi üçün müxtəlif modelləşdirmə və simulyasiya metodlarından istifadə edilmişdir. Aparılan təhlillər göstərmişdir ki, proses parametrlərinin optimal seçilməsi absorbsiya səmərəliliyinin yüksəlməsinə səbəb olur. Bununla yanaşı, optimallaşdırma absorbent sərfinin və istismar xərclərinin azalmasına da imkan verir. Prosesin daha effektiv təşkili sistemin sabitliyini və idarəolunmasını artırır. Aparılan tədqiqat nəticələri göstərir ki, optimallaşdırma nəticəsində təbii qazdan zərərli və arzuolunmaz komponentlərin ayrılması daha yüksək səviyyədə həyata keçirilir. Bu isə son məhsulun keyfiyyətinin yüksəlməsinə və qazın təhlükəsiz şəkildə nəql olunmasına şərait yaradır. Əldə edilən nəticələr sənaye miqyaslı qaz emalı müəssisələrində tətbiq üçün əhəmiyyətli hesab olunur. Ümumilikdə absorbsiya prosesinin optimallaşdırılması təbii qaz sənayesində həm iqtisadi səmərəliliyin artmasına, həm də ekoloji təhlükəsizliyin təmin olunmasına töhfə verir. Bundan əlavə, absorbsiya prosesində istifadə olunan absorbent maddələrin düzgün seçilməsi prosesin effektivliyinə ciddi təsir göstərir. Müasir texnologiyalarda müxtəlif fiziki və kimyəvi absorbentlərdən istifadə olunması mümkündür. Bu maddələrin seçimi qazın kimyəvi tərkibindən və proses şəraitindən asılı olaraq müəyyən edilir. Absorber aparatlarının konstruktiv quruluşu da kütlə və istilik mübadiləsinin intensivliyinə təsir edən vacib amillərdən biridir. Optimal konstruksiyaya malik avadanlıqlar prosesin daha məhsuldar şəkildə həyata keçirilməsinə imkan verir. Eyni zamanda, proses parametrlərinin avtomatlaşdırılmış idarə olunması istehsalat prosesinin sabitliyini artırır. Enerji sərfiyyatının azaldılması isə sənaye müəssisələri üçün mühüm iqtisadi üstünlüklər yaradır. Absorbsiya prosesinin optimallaşdırılması ətraf mühitə atılan zərərli maddələrin miqdarının azalmasına da müsbət təsir göstərir. Bu səbəbdən prosesin təkmilləşdirilməsi ekoloji baxımdan da böyük əhəmiyyət daşıyır. Müasir optimallaşdırma üsullarının tətbiqi təbii qazın emalı proseslərinin daha səmərəli və dayanıqlı şəkildə təşkilinə imkan yaradır.

Аннотация

В процессе переработки природного газа абсорбция является одним из широко применяемых методов для удаления нежелательных компонентов и различных загрязняющих веществ, содержащихся в газе. Эффективная очистка газа играет важную роль как в повышении качества конечного продукта, так и в обеспечении соблюдения экологических стандартов. В этом контексте оптимизация процесса абсорбции способствует более эффективной работе технологических систем и снижению энергозатрат. В представленном исследовании проведён анализ процесса абсорбции природного газа и рассмотрены направления его совершенствования. Основной целью исследования является повышение эффективности процесса массопереноса между газовой и жидкой фазами. В ходе исследования были учтены основные факторы, влияющие на процесс: температура, давление, скорость потока абсорбента и конструктивные особенности абсорбционной установки. Изменение этих параметров напрямую влияет на общую производительность и эффективность процесса. Для оценки работы абсорбционной системы были использованы различные методы моделирования и симуляции. Проведённый анализ показал, что оптимальный выбор параметров процесса приводит к повышению эффективности абсорбции. Кроме того, оптимизация позволяет снизить расход абсорбента и эксплуатационные затраты. Более эффективная организация процесса повышает стабильность и управляемость системы. Результаты проведённого исследования показывают, что в результате оптимизации удаление вредных и нежелательных компонентов из природного газа осуществляется на более высоком

уровне. Это способствует повышению качества конечного продукта и обеспечивает безопасную транспортировку газа. Полученные результаты имеют важное значение для применения на промышленных предприятиях по переработке газа. В целом оптимизация процесса абсорбции способствует как повышению экономической эффективности в газовой промышленности, так и обеспечению экологической безопасности. Кроме того, правильный выбор абсорбентов, используемых в процессе абсорбции, оказывает существенное влияние на эффективность процесса. В современных технологиях возможно применение различных физических и химических абсорбентов. Выбор этих веществ определяется химическим составом газа и условиями процесса. Конструктивная структура абсорбционных аппаратов также является важным фактором, влияющим на интенсивность массо- и теплообмена. Оборудование с оптимальной конструкцией позволяет осуществлять процесс более продуктивно. Одновременно автоматизированное управление параметрами процесса повышает стабильность производственного процесса. Снижение энергопотребления создаёт значительные экономические преимущества для промышленных предприятий. Оптимизация процесса абсорбции также способствует уменьшению количества вредных выбросов в окружающую среду. Поэтому совершенствование данного процесса имеет большое экологическое значение. Применение современных методов оптимизации позволяет организовать процессы переработки природного газа более эффективно и устойчиво.

Keywords: *natural gas processing, absorption process, process optimization, gas purification, mass transfer, absorber column, absorbent, process modeling, energy efficiency, environmental protection.*

Açar sözlər: *təbii qazın emalı, absorbsiya prosesi, prosesin optimallaşdırılması, qazın təmizlənməsi, kütlə ötürülməsi, absorber kolonu, absorbent, prosesin modelləşdirilməsi, enerji səmərəliliyi, ətraf mühitin mühafizəsi.*

Ключевые слова: *переработка природного газа, процесс абсорбции, оптимизация процесса, очистка газа, массоперенос, абсорбционная колонна, абсорбент, моделирование процесса, энергоэффективность, охрана окружающей среды.*

Introduction

Natural gas processing plays a crucial role in the modern energy industry, and its efficient purification not only improves product quality but also ensures compliance with environmental standards. Components such as carbon dioxide, hydrogen sulfide, and other impurities in the gas can negatively affect both its combustion properties and safe transportation.

The absorption process is widely used to remove these impurities and is based on gas-liquid mass transfer. The efficiency of this process is directly influenced by factors such as temperature, pressure, type of absorbent, and flow rate.

Optimizing the process reduces energy consumption, lowers operational costs, and contributes to environmental protection. This study investigates the effects of key process parameters and identifies optimal operating conditions to enhance the efficiency of natural gas absorption.

1. Research Objective and Significance

The primary objective of this study is to enhance the efficiency of the natural gas absorption process by analyzing the effects of key process parameters and determining the optimal operating conditions. The study aims to improve mass transfer efficiency, reduce energy and material consumption, and minimize operational costs. Additionally, it evaluates the positive impact of process optimization on gas quality and environmental protection, providing insights for more sustainable and economically efficient natural gas processing.

2. Problem Statement and Related Work

Efficient purification technologies are essential in natural gas processing to ensure high product quality and environmental safety. Inadequate removal of harmful components, such as carbon dioxide, hydrogen sulfide, and other impurities, not only negatively affects the quality of the final product but also increases safety risks during gas transportation and usage. Therefore, optimizing the absorption process and improving mass transfer efficiency between gas and liquid phases remain critical challenges in the natural gas industry.

Previous studies have shown that the main factors influencing absorption efficiency include temperature, pressure, absorbent flow rate, mixing intensity, and the design of the absorber unit. Each of these parameters significantly affects overall process performance. Modeling, simulation, and experimental approaches have been widely applied to analyze process behavior and identify optimal operating

conditions. However, existing literature and industrial practices, particularly at large-scale production, have not fully addressed the systematic optimization of the absorption process in terms of energy efficiency, minimizing absorbent losses, and reducing operational costs. Additionally, process stability, controllability, and monitoring play a crucial role in industrial applications. Poorly controlled operations can reduce absorption efficiency, lead to excessive absorbent consumption, and increase operating expenses. Consequently, optimization of both technological parameters and absorber design is essential for efficient natural gas absorption. The main objective of this study is to enhance mass transfer efficiency in the natural gas absorption process, improve the removal of harmful components, and strengthen process controllability. Moreover, based on existing literature and industrial experience, the research proposes new strategies for optimizing process parameters and reducing energy consumption. When implemented at an industrial scale, these strategies can provide significant economic and environmental benefits. Overall, improving the absorption process not only enhances product quality but also increases operational efficiency, lowers costs, and minimizes environmental impact. Therefore, process optimization in natural gas treatment remains a priority both for scientific research and industrial practice.

3. Optimization of Absorbent and Gas Properties

The type and concentration of an absorbent directly affect the efficiency of gas absorption. Chemical absorbents, such as MEA and DEA, are highly effective at capturing carbon dioxide. Because they operate through chemical reactions, they provide high selectivity during the absorption process. However, using chemical absorbents increases heat and energy consumption, as additional energy is required during regeneration. Physical absorbents work by dissolving gases and are generally more efficient under high-pressure conditions. Propylene glycol and dimethyl ether are common examples of physical absorbents. Physical absorbents consume less energy compared to chemical ones, but their absorption efficiency decreases at low pressures. The choice of chemical absorbent depends on the gas composition and operating conditions, while the application of physical absorbents should be adjusted according to pressure and temperature. The goal is to maximize absorption efficiency while minimizing energy consumption, ensuring that the gas purification process is both technically and economically optimal. Increasing temperature can accelerate the reaction of chemical absorbents but raises energy costs, whereas increasing pressure improves the efficiency of physical absorbents. Absorbent concentration also affects absorption rate; excessively high concentrations increase energy consumption. Ultimately, selecting the most suitable absorbent according to gas composition and operational conditions minimizes carbon dioxide levels, reduces operating costs, and meets environmental standards. Therefore, matching the absorbent type with operating parameters is a key factor in the gas absorption process.

Property	Chemical Absorbents (MEA, DEA)	Physical Absorbents (Propylene Glycol, Dimethyl Ether)
Absorption principle	Absorbs CO ₂ through chemical reaction	Absorbs gas through physical dissolution
Absorption efficiency	High, especially for CO ₂ -rich gases	Better at high pressure, moderate CO ₂ selectivity
Suitability to operating temperature	Moderate – high; higher temperatures increase absorption but raise regeneration costs	Effective at mild temperatures; high temperatures may reduce absorption
Suitability to operating pressure	Can be used at any pressure; increasing pressure does not always improve absorption	Most effective at high pressure; low pressure reduces absorption
Energy requirement	High – requires heat for regeneration	Low – separation process is simpler
Process suitability	Preferred for low CO ₂ concentration gases or processes requiring high absorption	Better for high-pressure gas streams and processes where low energy consumption is desired
Advantages	High selectivity, high CO ₂ absorption efficiency	Low energy consumption, simple technology, low corrosion risk
Disadvantages	High energy cost, corrosion, risk of amine degradation	Less effective at low pressure and low CO ₂ concentration

4. Effect of Trays Inside the Gas Column on the Optimization of Natural Gas Absorption Process

Gas In

The untreated natural gas enters the absorption column. It contains carbon dioxide (CO_2) and other gaseous components. The gas flows upward to interact with the descending liquid absorbent. Its composition and flow rate directly affect the efficiency of the absorption process.

Liquid In (Absorbent)

The absorbent enters from the top of the column and flows downward. It comes into contact with the gas, capturing CO_2 in the process. The type and concentration of the absorbent determine the overall absorption performance. Proper liquid distribution and flow rate enhance the effectiveness of CO_2 removal.

Trays

Trays maximize the contact between gas and liquid phases. Each tray creates a region where gas moves upward while the liquid flows downward. The tray type (sieve, bubble cap, or valve) affects the contact area and absorption efficiency. The number and design of trays balance both CO_2 capture and pressure drop in the column.

Absorbed CO_2

CO_2 is captured by the liquid absorbent and removed from the gas stream. This absorption occurs across multiple stages within the column. The captured CO_2 flows downward with the liquid toward the bottom of the column. Absorption efficiency depends on the absorbent type, temperature, pressure, and tray design.

Gas Out

The purified gas exits from the top of the column. It has been largely freed from CO_2 and other absorbed components. The outgoing gas must meet operational and environmental standards. The column's efficiency is evaluated based on the composition and purity of the exiting gas. Figure 1 illustrates the arrangement of trays within the gas absorption column

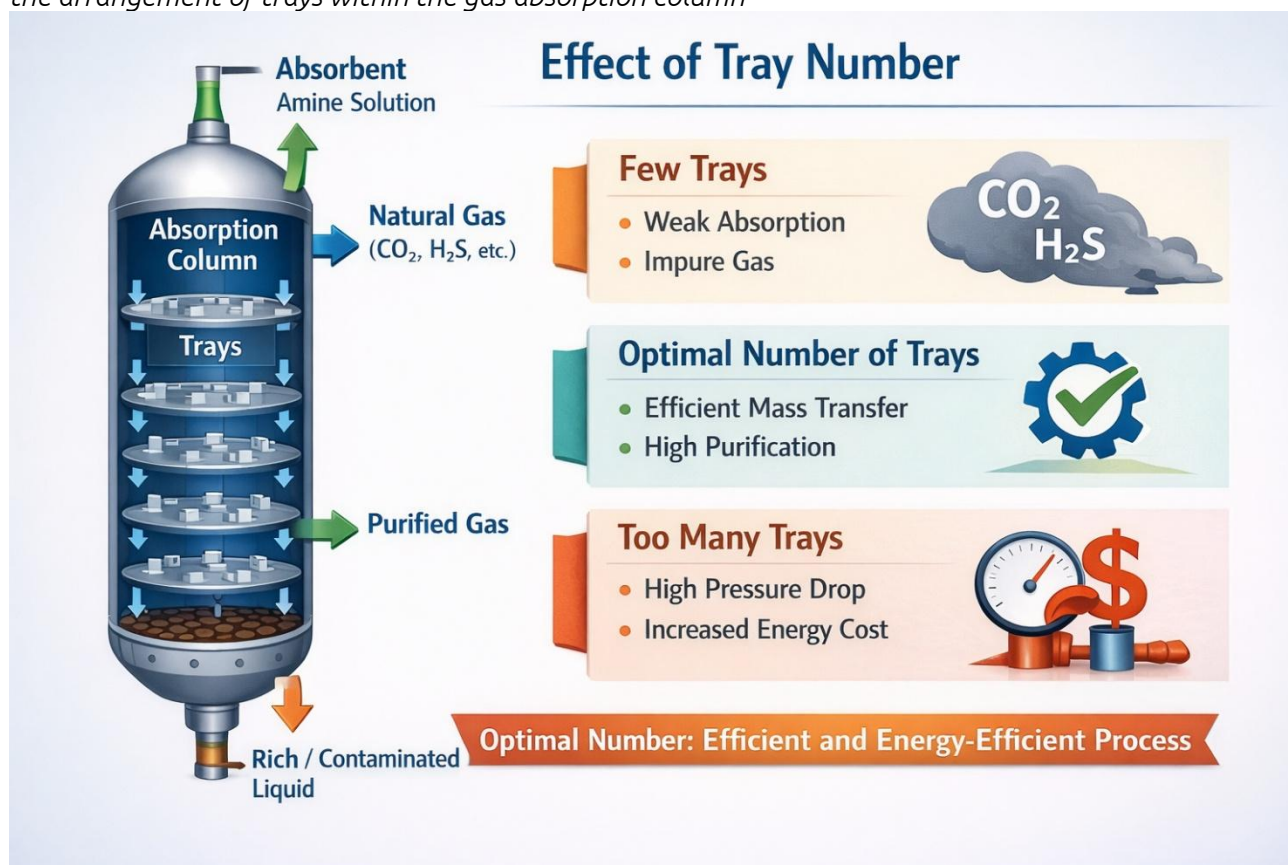


Figure 1. Gas Column

5. The use of artificial intelligence in optimizing the natural gas absorption process

Artificial intelligence plays a crucial role in optimizing the natural gas absorption process and is widely applied in the industry. Its primary function is to monitor parameters such as the flow of gas and absorbent, temperature, and pressure in the absorption column in real time to enhance process efficiency. Artificial intelligence analyzes data collected from sensors and automatically adjusts the amount

and flow rate of absorbent according to the composition and volume of the gas. This makes the removal of harmful components from the gas more efficient. Additionally, AI can predict the required absorbent amount in advance and improve operational planning. This approach reduces energy and resource losses and minimizes operational costs. As a result, the quality of the gas improves, and the process operates more stably. AI also manages critical parameters such as temperature and pressure, ensuring the safety and continuity of the process. Overall, artificial intelligence makes the natural gas absorption process more efficient both economically and technically. The figure below presents the AI-assisted optimized variant of the absorption process.

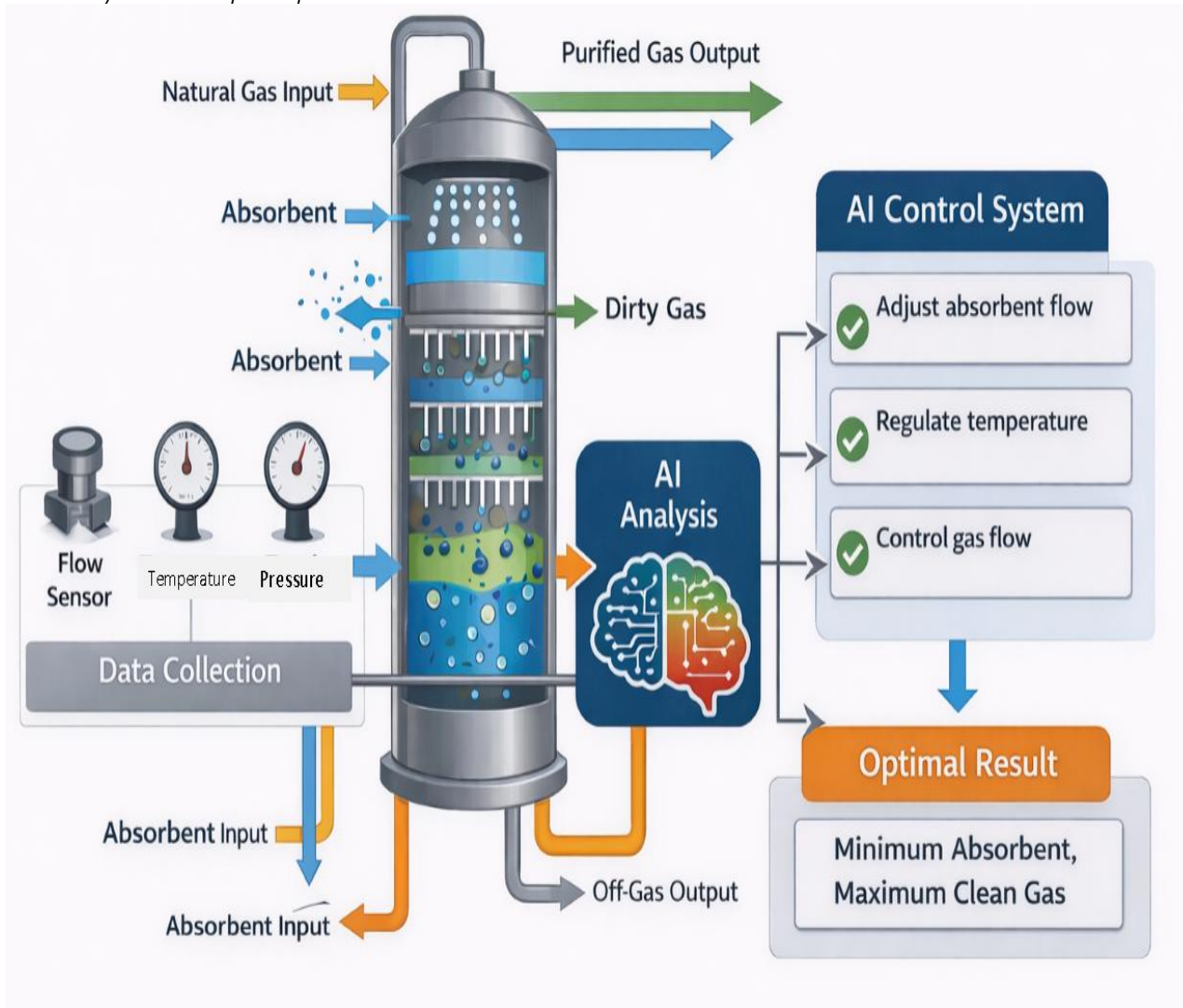


Figure 2. Carrying out the absorption process using artificial intelligence

Natural gas enters the column from the top and flows along the path indicated by the yellow arrow. The absorbent liquid enters the column at various levels and is used to remove impurities from the gas. Inside the column, the natural gas and absorbent interact with each other. As the gas rises through the column, it becomes purified, indicated by the green arrow. Unpurified or contaminated gas exits the column to the side. Flow sensors, temperature, and pressure measuring devices are installed at the column's inlet and outlet. These sensors collect real-time data and send the measured parameters to the Data Collection module. The Data Collection module gathers the information from the sensors and transfers it to the artificial intelligence (AI) analysis system. The AI processes the collected data and makes decisions for optimal operation. It can adjust the absorbent flow rate as needed. It also regulates the temperature and controls the gas flow. These adjustments minimize the amount of absorbent used. At the same time, the gas leaving the column is maximally purified. An off-gas outlet is located at the bottom of the column, where excess or contaminated gas is removed. Thus, the absorption process is managed efficiently and economically with the help of artificial intelligence.

Conclusion

In summary, the application of artificial intelligence in the natural gas absorption process significantly enhances process control and efficiency. By analyzing real-time data obtained from sensors, AI

can optimally regulate the absorbent flow, temperature, and other gas parameters. This ensures more effective gas purification and reduces the consumption of energy and absorbent. At the same time, operational costs are lowered and the process becomes more stable. Therefore, artificial intelligence enables the absorption process to be organized more efficiently from both technological and economic perspectives.

References

1. Warren D. Seider, J. D. Seader, Daniel R. Lewin, Suvrajit Ghosh – *Product and Process Design Principles: Synthesis, Analysis, and Evaluation*. Wiley, 2017.
2. Carl R. Branan – *Rules of Thumb for Chemical Engineers*. Elsevier, 2012.
3. International Energy Agency – *Natural Gas Processing and Optimization Reports*.
4. Ian Goodfellow, Yoshua Bengio, Aaron Courville – *Deep Learning*. MIT Press, 2016.

CALCULATION BASED ON OPTIMIZATION OF ARITHMETIC OPERATIONS ON Z-NUMBERS

D.T. Muhamediyeva

D.M. Yusupova

D.T. Yusupov

Sh.Z. Yuldashev

Tashkent Institute of Irrigation and Agricultural Mechanization Engineers National Research University, 39, Kari Niyazov ave., Tashkent, 100000, Uzbekistan; Tashkent University of Information Technologies named after Muhammad al-Khwarizmi, 108, Amir Temur Avenue, Tashkent, 100084, Uzbekistan; Silk Road University of Innovations; Cyber University, Tashkent, Uzbekistan; Chirchik State Pedagogical University, Uzbekistan

Abstract

The article discusses the concept of an extended model of fuzzy numbers, the Z-number. The Z-number consists of two parts: (i) interval uncertainty, which is expressed by a triangular fuzzy number, and (ii) probabilistic uncertainty given by the probability distribution. In the proposed method, addition, subtraction, multiplication, and division operations on Z-numbers are performed through the optimization method (L-BFGS-B algorithm). The program is developed in Python, and the results are presented in the form of tables and graphs.

1. Introduction. The issue of uncertainty expression is of great importance in various fields, including economic modeling, decision-making, engineering calculations, and artificial intelligence systems. Traditional approaches, such as probability theory or fuzzy set theory, sometimes do not yield complete results when applied individually [1-4]. Therefore, new models combining the two approaches are proposed. One of these is the Z-S-Set model [1]. This model harmonizes the interval character of fuzzy numbers with the probability distribution. Consequently, not only the range of values is considered, but also the probability of their occurrence. This article presents an optimization-based software implementation of performing arithmetic operations on Z-numbers.

2. Methodology**2.1. Definition of Z-number**

The Z-number consists of the following pairs:

- $A=(a,b,c)$ – triangular fuzzy number (TNF), defines the range of values.
- $B=(b_{min}, b_{core}, b_{max})$ -indicating probability: minimum, basic and maximum probability.

Thus, the Z-number combines deterministic uncertainty (via the interval) and probabilistic uncertainty (via the distribution).

2.2. Calculating the probability variance

The value of sigma (σ) from probability intervals is found using the following formula:

$$\sigma = \frac{\Delta}{z}, \quad z = \Phi^{-1}\left(\frac{1+p}{2}\right)$$

Here Δ is half the interval, Φ^{-1} is the inverse normal distribution function.

2.3. Arithmetic operations

Operations on two Z-numbers are defined as follows:

• **Add**

$$A_{12} = (a_1 + a_2, b_1 + b_2, c_1 + c_2), \quad \mu = b_1 + b_2$$

• **Subtraction**

$$A_{12} = (a_1 - c_2, b_1 - b_2, c_1 - a_2), \quad \mu = b_1 - b_2$$

Reproduction: Through all combinations, the minimum and maximum are determined. **Partition:** if there is a probability of zero falling, the action will not be executed; Otherwise, it is calculated for all combinations. Part B is calculated using the optimization method. Here, the minimum and maximum probability values are found by the L-BFGS-B algorithm. The prime probability is determined on the basis of central values. The program plots the results in two parts — Part A is the triangle function and Part B is the probability graph. In addition, all actions are also depicted in the form of a grid together. The program was developed in Python. The Fuzzy Number class represents Z-numbers and allows operations to be performed on them

4. Results

As an example, the following two Z-numbers are chosen:

$$Z_1 = ((2, 3, 4), (0.7, 0.8, 0.9)), \quad Z_2 = ((1, 2, 3), (0.1, 0.2, 0.3))$$

When operations are performed on them, the following results are obtained (Table 1):

Action	A	B(min,core,max)
$Z1+Z2$	(3.0, 5.0, 7.0)	(0.88, 0.245, 0.301)
$Z1-Z2$	(-1.0, 1.0, 3.0)	(0.124, 0.357, 0.488)
$Z1*Z2$	(2.0, 6.0, 12.0)	(0.077, 0.229, 0.277)
$Z1/Z2$	(0.67, 1.5, 4.0)	(0.143, 0.330, 0.422)
$(Z1+Z2)*(Z1-Z2)/Z2$	(+0.33, 1.5, 8.0)	(0.066, 0.208, 0.261)

Based on the results, the following observations were made. In addition and subtraction, part A corresponds to classical fuzzy arithmetic. There is an interval expansion in multiplication and division. Since Part B is calculated on the basis of optimization, the probability values have a significant impact on the type of operations. The graphical results are saved to separate files and plotted in a shared grid view, too. 4. Conclusion. In this study, an optimization-based software implementation of arithmetic operations based on the concept of Z-number has been developed. With the help of the program, parts A and B of the Z-numbers were treated separately. Arithmetic operations were calculated more accurately by the optimization method. The results were presented in tabular and graphical form. The proposed approach allows for deeper modeling of uncertainties and making decision-making systems more reliable. In the future, this method can be tested in multidimensional Z-numbers and real-world practical problems.

References

1. Zadeh, L. A., 2011. A note on Z-numbers. *Inform. Sciences* 181, 2923–2932.
2. Aliev, R. A., Alizadeh, A. V., Huseynov, O. H., Jabbarova, K. I., 2015. Z-number based Linear Programming. *Int. J. Intell. Syst.* 30, 563-589.
3. Kang, B., Wei, D., Li, Y., Deng, Y., 2012. A method of converting Z-number to classical fuzzy number. *Journal of Information & Computational Science* 9, 703-709.
4. Piegat A., Plucinski M., 2015a. Computing with words with the use of Inverse RDM Models of Membership Functions. *Applied Mathematics and Computer Science* 25(3), 675-688.

ADVANCED MATH CLASSROOM MODEL OF Z-NUMBERS-BASED PYTHON MATH MODULE

D. M. Yusupova

Tashkent University of Information Technologies named after Muhammad al-Khwarizmi, 108, Amir
Temur Avenue, Tashkent, 100084, Uzbekistan;
Silk Road University of Innovations;

Abstract

This article presents the mathematical essence of Z-numbers and the development of a new mathematical class (class) based on Z-numbers on their basis. This class is similar to the math module in the Python programming language, in which mathematical functions such as sine, cosine, exponential, logarithm, root are applied to Z-numbers. The Z-number consists of two components: the A part (the triangular fuzzy number) and the B part (the confidence level). In the process of function calculation, the new values of part A are transferred directly through the function, and the recalculation of part B is performed using the optimization approach. Practical results were demonstrated by experimental examples, tables and graphs. The proposed approach allows for efficient organization of mathematical calculations under conditions of uncertainty and expands the possibilities of programmatic application of Z-numbers.

Keywords: Z-number, fuzzy number, probability, Python, math class, sine, cosine, exponential, logarithm, uncertainty, optimization.

1. Introduction. Many issues of mathematical modeling are based on precision and deterministic data. However, in many real-life situations, uncertainty plays a significant role. For example, there is uncertainty in environmental monitoring, economic forecasting, diagnostics in medicine or technological processes, in which classical mathematical apparatus becomes insufficient [1-2].

The concept of Z-number presented by Zade allows for the modeling of complex uncertainties by combining fuzzy numbers and probability elements. Each Z-number is made up of two parts. Part A is a fuzzy number (e.g., a triangular fuzzy number, TFN), and part B is a probability that represents the confidence level of part A. In recent years, there have been a number of studies on the programmatic implementation of arithmetic operations on Z-numbers. But mathematical functions (sine, cosine, exponential, etc.). A special systematized class that allows applying it to Z-numbers has not yet been widely developed [3-5].

This article presents the development of a custom math class in the Python programming language, similar to a math module, but designed for Z-numbers.

2. Methodology**2.1. Mathematical Model of Z-Numbers.**

The Z-number is defined as:

$$Z=(A, B),$$

In this:

- $A=(a,b,c)$ - Triangular fuzzy number (TFN),
- $B=(b_{\min}, b_{\text{core}}, b_{\max})$ - expression of the probability level.

2.2. Function application mechanism

A component transformation:

$$A' = (f(a), f(b), f(c)),$$

where f -is a mathematical function (sin, cos, exp, log, sqrt, etc.). If the function is not monotonic (for example, sine), additional critical points are also taken into account. Part B renewal is not done by a simple algebraic formula, but **by optimization**. The goal is that for the new output intervals (part A'), the confidence level of part B is readjusted via the sigma function. In this, the **L-BFGS-B algorithm** is used.

2.3. ZMath class

Key features of the newly created class:

Sine, cosine: Calculation of periodic functions in uncertainty.

Exponential: Modeling of Unpredictable Processes in Growth.

Logarithm: Scaling down.

Square root: Used for physical and statistical models.

Thus, an analogue of the classical math module, but a special ZMath class designed for Z-numbers was developed.

3. Results

3.1. Experimental Examples

The following initial Z-number was obtained:

$$Z_1 = ((2, 3, 4), (0.7, 0.8, 0.9)). \quad Z_1 = ((2, 3, 4), (0.7, 0.8, 0.9)). \quad Z_1 = ((2, 3, 4), (0.7, 0.8, 0.9)).$$

The following functions applied to it:

$$\exp(Z_1),$$

$$\sin(Z_1),$$

$$\cos(Z_1),$$

$$\log(Z_1),$$

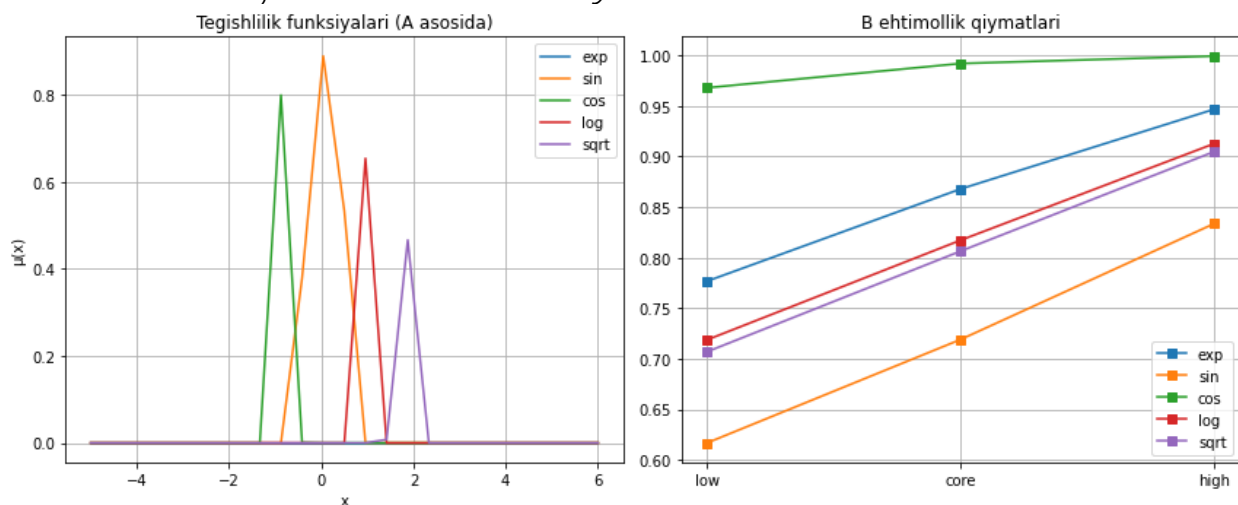
$$\sqrt{(Z_1)}.$$

3.2. Results table

Funksiya	A_low	A_core	A_high	B_low	B_core	B_high
$\exp(Z_1)$	7.389	20.085	54.598	0.777	0.868	0.947
$\sin(Z_1)$	-0.756	0.141	0.909	0.502	0.642	0.751
$\cos(Z_1)$	-0.989	-0.990	0.283	0.489	0.623	0.744
$\log(Z_1)$	0.693	1.099	1.386	0.801	0.889	0.951
$\sqrt{Z_1}$	1.414	1.732	2.000	0.814	0.901	0.964

3.3. Graph results

For each function, Part A (triangular fuzzy number) and Part B (level of reliability) were plotted in separate graphs. The results showed that the ZMath class allows for the efficient application of traditional mathematical functions under uncertainty.



4. Conclusion. The paper presents a class ZMath based on Z-numbers created in the Python programming language. This class extends the functions of the math module, allowing functions such as sine, cosine, exponential, logarithm, and root to be computed under conditions of uncertainty.

The results show that Part A was recalculated through simple functional transformation, Part B was adapted through the optimization mechanism. The results were clearly illustrated in graphical and tabular form. The proposed approach could be effective in automating mathematical calculations under uncertainty, decision making systems, and economic and technical modeling. In future research, it is planned to expand this class to develop mathematical hardware for multivariable Z-numbers, integrating hypergeometry functions (tanh, coth, sinh, cosh), with probability distributions.

References

1. ALIEV, R.A., PEDRYCZ, W., HUSEYNOV, O.H. Functions defined on a set of Z-numbers // Information Sciences. – 2018. – Vol. 423. – P. 353–375.
2. Onari M.A., Yousefi S., Rezaee M.J. Risk assessment in discrete production processes considering uncertainty and reliability: Z-number multi-stage fuzzy cognitive map with fuzzy learning algorithm // Artif. Intell. Rev. – 2020. – P. 1–35.

3. Pawlak Z. *Rough sets* // *Int. J. Comput. Inf. Sci.* – 1982. – Vol. 11. – P. 341–356.
4. Qiao D., Wang X.K., Wang J.Q., Chen K. *Cross entropy for discrete Z-numbers and its application in multi-criteria decision-making* // *Int. J. Fuzzy Syst.* – 2019. – Vol. 21. – P. 1786–1800.
5. Tian Y., Liu L., Mi X., Kang B. *ZSLF: a new soft likelihood function based on Z-numbers and its application in expert decision system* // *IEEE Trans. Fuzzy Syst.* – 2021. – Vol. 29. – P. 2283–2295.

*FUNCTIONAL MEAT PRODUCTS AS A PROMISING DIRECTION OF THE FOOD INDUSTRY**Zhanuzakova Nazerke Kazybekovna**First-year PhD student**Kasymov Samat Kairatovich**candidate of technical sciences, associate professor***ФУНКЦИОНАЛЬНЫЕ МЯСНЫЕ ПРОДУКТЫ КАК ПЕРСПЕКТИВНОЕ НАПРАВЛЕНИЕ ПИЩЕВОЙ ПРОМЫШЛЕННОСТИ***Жанузакова Назерке Казыбековна**докторант 1 курса**Касымов Самат Кайратович**кандидат технических наук., ассоциированный профессор***Abstract**

Functional meat products are an emerging area of the food industry aimed at improving nutritional quality and promoting human health. Traditional meat products are valuable sources of high-quality protein, essential amino acids, and micronutrients; however, their high levels of saturated fat and sodium limit their role in healthy diets.

This study highlights key approaches to the development of functional meat products, including fat and salt reduction, enrichment with dietary fiber, omega-3 fatty acids, natural antioxidants, and the incorporation of probiotic and prebiotic cultures. These modifications enhance the biological value of meat products and contribute to the prevention of chronic diseases.

Globally, the functional food market is rapidly expanding, while in Kazakhstan this sector is still developing despite significant raw material potential and growing consumer interest in healthy nutrition.

Thus, functional meat products represent a promising direction for improving public health and advancing modern food technologies.

Аннотация

Функциональные мясные продукты представляют собой развивающееся направление пищевой промышленности, направленное на повышение пищевой ценности и улучшение здоровья человека. Традиционные мясные продукты являются ценным источником высококачественного белка, незаменимых аминокислот и микронутриентов; однако их высокое содержание насыщенных жиров и натрия ограничивает их роль в здоровом питании.

В данной работе рассмотрены основные подходы к разработке функциональных мясных продуктов, включая снижение содержания жира и соли, обогащение пищевыми волокнами, омега-3 жирными кислотами, природными антиоксидантами, а также использование пробиотических и пребиотических культур. Эти модификации повышают биологическую ценность мясных продуктов и способствуют профилактике хронических заболеваний.

На глобальном уровне рынок функциональных продуктов питания активно развивается, в то время как в Казахстане данный сектор находится на стадии становления, несмотря на значительный сырьевой потенциал и растущий интерес потребителей к здоровому питанию.

Таким образом, функциональные мясные продукты представляют собой перспективное направление, способствующее улучшению здоровья населения и развитию современных пищевых технологий.

Keywords: *functional meat products, food industry, dietary fiber, omega-3 fatty acids, antioxidants, probiotics, prebiotics, healthy nutrition, food technology, Kazakhstan*

Ключевые слова: *функциональные мясные продукты, пищевая промышленность, пищевые волокна, омега-3 жирные кислоты, антиоксиданты, пробиотики, пребиотики, здоровое питание, пищевая технология, Казахстан*

В условиях глобализации и изменения структуры питания населения наблюдается устойчивый рост интереса к функциональным продуктам, обладающим не только питательной, но и профилактической направленностью. По данным международных исследований, рынок функциональных продуктов ежегодно демонстрирует рост,

обусловленный увеличением распространённости сердечно-сосудистых, метаболических и гастроэнтерологических заболеваний [1].

Мясо и мясные продукты являются важнейшим источником полноценного белка, содержащего все незаменимые аминокислоты, а также железа в легкоусвояемой форме и витаминов группы В. Однако традиционные мясные продукты характеризуются повышенным содержанием насыщенных жиров, холестерина и натрия, что ограничивает их использование в рационе людей, ориентированных на здоровое питание [2].

В этой связи формируется направление создания функциональных мясных продуктов, которые представляют собой изделия, модифицированные с целью придания им дополнительных физиологически полезных свойств. Согласно современным научным представлениям, функциональные мясные продукты должны не только сохранять традиционные органолептические характеристики, но и обладать доказанным положительным влиянием на организм человека [3].

Одним из ключевых направлений функционализации является снижение содержания жира и соли. Использование заменителей жира (растительные масла, эмульсионные системы) и солезаменителей позволяет снизить калорийность продукта и уменьшить риск развития гипертонии и сердечно-сосудистых заболеваний [4].

Другим важным направлением является обогащение мясных продуктов пищевыми волокнами. Добавление клетчатки способствует нормализации работы желудочно-кишечного тракта, снижению уровня холестерина и улучшению метаболических процессов. В качестве источников пищевых волокон широко используются злаковые культуры, бобовые и вторичные продукты переработки растительного сырья [5].

Значительный интерес представляет включение в состав мясных продуктов полиненасыщенных жирных кислот (омега-3), которые играют важную роль в профилактике сердечно-сосудистых заболеваний и воспалительных процессов. Обогащение мясных продуктов омега-3 осуществляется за счёт добавления рыбьего жира, льняного масла или микрокапсулированных форм липидов [6].

Особое внимание в последние годы уделяется использованию антиоксидантов природного происхождения (полифенолы, растительные экстракты, витамины), которые способствуют снижению окислительных процессов как в продукте, так и в организме человека. Это позволяет повысить срок хранения продукции и одновременно улучшить её функциональные свойства [4].

Перспективным направлением является разработка пробиотических и синбиотических мясных продуктов. Ферментированные мясные изделия могут служить эффективной матрицей для доставки пробиотических микроорганизмов, обеспечивая нормализацию кишечной микрофлоры и повышение иммунной защиты организма [6].

С технологической точки зрения, создание функциональных мясных продуктов требует комплексного подхода, включающего подбор ингредиентов, оптимизацию рецептур, контроль технологических параметров и обеспечение стабильности функциональных компонентов. Введение новых ингредиентов может оказывать влияние на текстуру, вкус и цвет продукта, что требует дополнительной корректировки технологических процессов [5].

Несмотря на значительный потенциал, развитие функциональных мясных продуктов сопряжено с рядом проблем. К ним относятся высокая стоимость функциональных ингредиентов, необходимость проведения клинических исследований для подтверждения заявленных эффектов, а также недостаточная информированность потребителей о преимуществах таких продуктов [2].

В то же время, рост спроса на продукты здорового питания, а также государственные программы, направленные на улучшение качества питания населения, создают благоприятные условия для дальнейшего развития данного направления. В частности, в последние годы наблюдается активное внедрение инновационных технологий, включая микрокапсулирование, использование биотехнологических методов и разработку комбинированных мясорастительных продуктов [5].

Функциональные мясные продукты являются перспективным направлением развития пищевой промышленности, способствующим повышению качества питания и профилактике хронических заболеваний. Их дальнейшее развитие связано с совершенствованием технологий производства, расширением ассортимента и повышением доступности для широких слоёв населения.

В последние годы мировой рынок функциональных продуктов питания демонстрирует устойчивый рост, что обусловлено увеличением распространённости хронических неинфекционных заболеваний и повышением осведомлённости населения о принципах здорового питания. По данным международных аналитических обзоров, объём мирового рынка функциональных продуктов ежегодно увеличивается в среднем на 6–8%, при этом значительная доля приходится на продукты, обогащённые биологически активными компонентами [6].

В структуре функционального питания традиционно доминируют молочные, зерновые и напитки, однако сегмент функциональных мясных продуктов развивается ускоренными темпами. Это связано с совершенствованием технологий переработки, включая использование пробиотиков, антиоксидантов, пищевых волокон и полиненасыщенных жирных кислот [7].

В странах Европейского союза, США и Японии активно ведутся исследования в области создания мясных продуктов с пониженным содержанием жира и соли, а также обогащённых омега-3 жирными кислотами и растительными компонентами. Особое внимание уделяется разработке синбиотических продуктов, сочетающих пробиотики и пребиотики, что позволяет усиливать их функциональный эффект [8].

В Республике Казахстан мясная отрасль является одной из ключевых в структуре агропромышленного комплекса. По данным национальной статистики, производство мяса в стране за последние годы демонстрирует положительную динамику, увеличившись более чем на 15–20% в период 2020–2025 гг., что связано с развитием животноводства и государственной поддержкой отрасли. При этом уровень потребления мяса на душу населения остаётся высоким и превышает 70 кг в год, что соответствует мировым показателям.

Несмотря на значительный сырьевой потенциал, сегмент функциональных мясных продуктов в Казахстане находится на стадии формирования. На рынке преобладают традиционные мясные изделия (колбасы, полуфабрикаты), тогда как доля продуктов, обогащённых функциональными ингредиентами, остаётся незначительной. Основными причинами являются высокая стоимость функциональных добавок, недостаточная технологическая база и ограниченный спрос со стороны потребителей [9].

В то же время в Казахстане наблюдается рост интереса к продуктам здорового питания, особенно среди городского населения. Развитие научных исследований в области пищевой безопасности и технологии продуктов питания способствует появлению новых разработок, включая мясные продукты, обогащённые растительными компонентами, пищевыми волокнами и антиоксидантами [10].

Перспективы развития функциональных мясных продуктов в Казахстане связаны с использованием местного сырья (конина, говядина, баранина), обладающего высокой биологической ценностью, а также внедрением инновационных технологий переработки. Важным направлением является создание мясорастительных продуктов, позволяющих одновременно повысить пищевую ценность и снизить себестоимость продукции.

В мировом масштабе функциональные мясные продукты уже занимают устойчивую нишу и активно развиваются, тогда как в Казахстане данный сегмент находится на этапе становления, обладая при этом значительным потенциалом роста при условии развития научно-технологической базы и повышения потребительского спроса.

References

1. Roberfroid M.B. Functional food concept and definition // *Nutrition Reviews*. – 2000. - Vol. 58, No. 7. – P. 1–7.
2. Jiménez-Colmenero F., Carballo J., Cofrades S. Healthier meat and meat products: their role as functional foods // *Meat Science*. – 2001. – Vol. 59, No. 1. – P. 5–13.
3. Bhat Z.F., Bhat H. Functional meat products: A review // *International Journal of Meat Science*. – 2011. – Vol. 1, No. 1. – P. 1–14.
4. Manassi C.F. et al. Functional meat products: Trends in pro-, pre-, syn-, para- and postbiotics // *Trends in Food Science & Technology*. – 2022. – Vol. 118. – P. 415–428.
5. Kurćubić V.S. et al. Meat products and functional food // 2024. – Vol. 1312. – P. 012034.
6. Jaworska D. et al. Strategies to improve the functional value of meat and meat products // *Foods*. – 2024. – Vol. 13, No. 15. – P. 2433.
7. Manassi C.F. et al. Functional meat products: Trends in pro-, pre-, syn-, para- and postbiotics // *Trends in Food Science & Technology*. – 2022. – Vol. 118. – P. 415–428.

8. Jiménez-Colmenero F., Carballo J., Cofrades S. Healthier meat and meat products // *Meat Science*. – 2001. – Vol. 59, No. 1. – P. 5–13.
9. Статистика Республики Казахстан по сельскому хозяйству и потреблению мяса (Бюро национальной статистики РК). – Астана, 2024. – С. 45–52.
10. Serikkyzy M. et al. Development of functional meat products // *Scientific Reports*. – 2025. – Vol. 15. – P. 1–10.



<https://sconferences.com>
info@sconferences.com

ISBN



9 789165 424692