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Arts

THE APPLICATION OF THE PRINCIPLE OF HISTORICAL AWARENESS IN FORTEPIANO PERFORMANCE LESSONS

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PIYANO PERFORMANSI DERSLERINDE TARIHSEL BILINÇLILIK ILKESININ UYGULANMASI

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Abstract

The present article is dedicated to investigating the application of the principle of historical awareness in piano performance instruction. The principle of historical awareness is a fundamental approach that forms the basis of piano performance education. This methodology involves studying and performing a work not merely as a notated text, but within its historical context, taking into account the period's instrumental possibilities, performance traditions, and aesthetic ideals. The application of this principle in the lesson requires, firstly, consulting original sources; secondly, working directly with historical pianos or their reproductions; and thirdly, mastering specific performance techniques based on historical practices. Through this approach, the student gains not only technical skill but also a deep insight into the essence of the musical work, developing critical thinking and independent research abilities. Consequently, the performer learns to create an informed and emotionally artistic interpretation that more accurately conveys the composer's intent and is in harmony with the spirit of the era. Thus, the application of the principle of historical informedness in piano performance instruction contributes to the formation of the student's artistic awareness, deep penetration into the musical work, and the development of independent critical thinking. This principle enables the student to be educated not only as a piano performer but also as a musicologist-researcher.

Özet

Sunulan makale, piyano performansı derslerinde tarihsel bilinçlilik ilkesinin uygulanması gibi konuların incelenmesine adanmıştır. Tarihsel bilinçlilik ilkesi, piyano performansı eğitiminin temelini oluşturan temel bir yaklaşımdır. Bu metodoloji, eseri yalnızca nota metni olarak değil, aynı zamanda ortaya çıktığı tarihsel bağlam, dönemin enstrüman olanakları, icra gelenekleri ve estetik idealler göz önünde bulundurularak öğrenmeyi ve icra etmeyi amaçlar. İlkenin uygulanması için derste, birincisi orijinal kaynaklara başvuru, ikincisi tarihi piyano enstrümanları ile doğrudan veya reprodüksiyon şeklinde çalışma, üçüncüsü ise spesifik icra tekniklerinin tarihi kurallar temelinde öğrenilmesi gerekmektedir. Bu şekilde öğrenci sadece teknik beceri değil, aynı zamanda müzik eserinin özüne derinlemesine nüfuz etme, eleştirel düşünme ve bağımsız araştırma becerisi kazanır. Sonuç olarak, icracı bestecinin niyetini daha doğru ileten, dönemin ruhuna uygun, bilinçli ve duygusal sanatsal yorum oluşturmayı öğrenir. Böylece, piyano performansı derslerinde tarihsel bilinçlilik ilkesinin uygulanması, öğrencinin sanatçılık bilincinin oluşmasına, müzik eserine derinlemesine nüfuz etmesine ve bağımsız eleştirel düşüncesinin gelişmesine yardımcı olur. Bu ilke, öğrenciyi sadece bir piyano icracısı olarak değil, aynı zamanda bir müzikolog-araştırmacı olarak yetiştirmeye imkan tanır.

Keywords: *fortepiano, historical information, composer, principle, performance, thought, methodological aspect, aesthetics, concept.*

Anahtar Kelimeler: *piyano, tarihsel bilgiler, besteci, ilke, performans, düşünce, metodolojik yön, estetik, kavram.*

Introduction: *Fortepiano performance is an artistic field fundamentally different from modern piano performance, not only technically but also from a historical-philosophical perspective. Since the late 20th century, the principle of "historical awareness/informed performance" has increasingly gained wider acceptance in music pedagogy. This principle involves the reconstruction of a musical work based on in-depth knowledge of the performance traditions, instrumental possibilities, and musical-aesthetic*

concepts of the composer's era. The aim of the article is to analyze the methods, methodological aspects, and practical examples of applying the principle of historical awareness in fortepiano performance lessons.

The roots of the historically informed performance movement trace back to the late 19th century, but its systematic development began in the 1970s. Two fundamental concepts underpin this principle:

1. Restoration of Historical Context: Every musical work is created in a specific historical period, within a particular socio-cultural environment, and within the framework of the period's instrumental possibilities and performance traditions. Understanding the sonic ideal intended by the composer for the work is impossible without considering this context.

2. Reference to Sources: The historically informed performance tradition is primarily based on period sources – printed editions, performers' own notes, contemporary music dictionaries, artists' works, and surviving instruments.

Main text: This principle holds particular significance in fortepiano performance, as the fortepiano was an instrument undergoing rapid development from the 18th century to the early 19th century, changing in both construction and sound. Badura-Skoda writes: "There was a significant difference between W.A. Mozart's fortepiano works and L.V. Beethoven's late works. The goal of applying the principle of historical awareness in the pedagogical process is to teach the student not only to read the notes correctly but also to comprehend each work within its historical environment" [Badura-Skoda, E. 1993]

To apply the principle of historical awareness, it is advisable to incorporate the following elements into the lesson structure:

1. Providing brief information about the composer of the piece to be performed, the period of its creation, and its stylistic characteristics, while also displaying pictures or videos of fortepianos from the composer's era;

2. Comparing the modern critical edition with the historical first edition. Discussing the alterations in the musical text and their reasons;

3. Encouraging the student to perform on a fortepiano. If possible, direct familiarization with the instrument;

4. After the performance, discussing with the student the conformity of the interpretation with historical sources, which decisions were made and why.

During the lesson, it is important to show the student how historical information relates to practical performance. For example, knowing the sound range of the fortepiano available during the composer's period helps understand why the octave passages or the bass part in the piece were written that way.

The teacher can use a range of historical materials in the lesson: Numerous digitized musical materials are available in online archives (such as IMSLP, Gallica, Beethoven-Haus Bonn, etc.). For instance, comparing the first edition of Beethoven's "Moonlight" Sonata with modern editions is very beneficial from a pedagogical perspective. Examples of performance treatises written in the 18th-19th centuries include C.P.E.Bach's "Versuch über die wahre Art das Clavier zu spielen" (Essay on the True Art of Playing Keyboard Instruments), D.G.Türk's "School of Clavier Playing" (1789), M.Clementi's "Gradu s ad Parnassum" (1817-1826), and others.

Concert reviews published in period newspapers and magazines, instrument descriptions, iconographic materials, works of art, caricatures, and images related to fortepiano manufacturing allow the performer to see the posture, the placement of the instrument, and the general cultural context. Ideally, fortepiano performance lessons should be conducted on historical instruments themselves or on their high-quality reproductions. However, since this is not always possible, the following alternatives exist:

Fortepianos built by modern makers based on historical models. Such instruments are available in many conservatories and music schools.

High-quality sample-based digital fortepianos can reproduce the historical sound with sufficient accuracy and allow anyone to have access to the fortepiano sound.

İmitating the fortepiano on a modern piano: This is the most challenging path but can be effective to a certain degree. The teacher can instruct the student on how to imitate fortepiano technique on a modern piano: lower sound volume, limited use of pedals, clarity of articulation, etc.

Experience shows that once a student has performed on a historical instrument at least a few times, their understanding of technique and style changes fundamentally. In fortepiano music, ornamentation (ornaments) and articulation (the connecting or separating of notes) are among the most

important elements of performance. In fortepiano music, ornaments (trill, turn, mordent) were often not provided along with the musical text; the rules for their execution were known based on generally accepted traditions. In fortepiano performance, types of articulation such as legato, non-legato, and staccato differed from those on the modern piano. Legato was used less, while non-legato was used more frequently. In the teaching process, it is important not only to explain the historical rules of ornamentation and articulation but also to test them in practice.

İn early fortepianos, the dynamic range was limited, but fortepiano performers worked with subtle execution and sudden contrasts in sound (terraced dynamics). In Beethoven's fortepiano music, however, the gradual increase (crescendo) and decrease (diminuendo) of sound played a more important role. There was no metronome in that period; composers indicated tempos with general terms (Allegro, Adagio) or sometimes with emotional expressions (Allegro con brio, Largo e mesto). The characteristics of the text itself, its style, and meter played a fundamental role in tempo choice. The use of rubato (changing the tempo depending on tension) was quite limited and applied only in specific places.

İn addition to explaining the historical concept of tempo, the teacher should demonstrate the attitudes of different composers of the period (for example, Mozart and Beethoven) towards tempo markings. The use of fortepiano pedal mechanisms differs from that on the modern piano.

"The una corda pedal (left pedal) – on a modern piano, this pedal softens the sound, whereas on the fortepiano, it changes the timbre of the sound, making it thinner, more "flute-like" [Bilson, M. 1979]

The sustain pedal (right pedal) – In early fortepianos, this pedal was short and had little effect on sustaining the sound. Its main purpose was to increase the resonance of chords or bass notes. Long, "blurred" pedal use was unacceptable.

İn the lesson, it is important to explain the historical rules of pedal use and also to show the differences in pedal systems across various fortepiano models.

Respect for the musical text is a fundamental principle in the historically informed performance tradition. However, this does not mean executing every mark literally. The musical text is a "text" written in the language of its period, and to read it correctly, one must know the rules of that language.

For example, the "sf" (sforzando) marking, frequently found in Beethoven's works, is understood in modern performance as a strong accent, but on the period's fortepianos, it signified more of an "emphasis." The performer did not arbitrarily strengthen that note but rather highlighted it melodically. The teacher must explain the historical meaning of such markings in the lesson and suggest various performance possibilities for them.

Knowing the historical context allows for a better understanding of the work's content and the composer's intent, presenting the performer with various performance options from which they can choose the one most suitable for them. The student establishes a connection between music history, music theory, and performance practice.

The following difficulties may arise when applying the principle of historical awareness:

Historical information about the works of some composers may be limited. In this case, the teacher can suggest analyzing the available sources and discussing probable performance variants.

Students may be accustomed to the modern romantic performance tradition. The teacher should compare these two approaches and explain the logic behind the historical approach.

When access to a fortepiano is not possible, the teacher can compensate by describing the sound and technique, using digital instruments, or having students listen to documented historical performance examples.

To overcome these difficulties, the teacher should use creative approaches and involve the student in the research process.

Conclusion: *Thus, the application of the principle of historical awareness in fortepiano performance lessons aids in the formation of the student's artistic consciousness, deep penetration into the musical work, and the development of independent critical thinking. This principle allows for the education of the student not only as a fortepiano performer but also as a musicologist-researcher. The further development of this direction is expected in the future. The progress of digital technologies creates new possibilities: virtual fortepiano models, familiarity with historical instruments through augmented reality, and easy access to online archives. All of these will make fortepiano performance lessons even more interesting and effective. The principle of historical awareness represents a new stage in music pedagogy – it is the education of future performers based on a dialogue with the past, respect for musical heritage, and a profound understanding of art.*

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INTERPRETIVE ISSUES IN SULEYMAN ALASGAROV'S CONCERTO NO. 1 FOR TAR AND FOLK INSTRUMENTS ORCHESTRA

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SÜLEYMAN ELESGEROV'UN TAR VE HALK ÇALGI ALETLERI ORKESTRASI IÇIN 1 NUMARALI KONÇERTOSUNDA YORUM SORUNLARI

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Abstract

Suleyman Alasgarov's Concerto No. 1 for tar and folk instruments orchestra is one of the works that played a significant role in the formation of the Azerbaijani tar performance school. The work successfully synthesizes the improvisational characteristics of Mugham with classical forms such as sonata-allegro. At the heart of the concerto lies the intricate dialogue established between the solo tar and the folk instruments orchestra. This dialogue is shaped not only through question-and-answer forms but also through contrapuntal technique, timbral contrast, and dynamic interaction. The virtuosic technique, lyrical cantilenas, and national ornamentation of the tar are fully revealed against the rich timbral background of the accompaniment.

Özet

Süleyman Elesgerov'un tar ve halk çalgı aletleri orkestrası için 1 numaralı konçertosu, Azerbaycan tar icracılık ekolünün oluşumunda önemli rol oynayan eserlerden biridir. Eserde, muğamın doğaçlama özellikleri ile sonata-allegro gibi klasik formanın başarılı sentezi gerçekleştirilmiştir. Konçertonun merkezinde, solist tar ile halk çalgı aletleri orkestrası arasında kurulan karmaşık diyalog yer alır. Bu diyalog yalnızca soru-cevap biçimlerinde değil, aynı zamanda kontrapuntal teknik, tını karşılaştırması ve dinamik etkileşim yoluyla şekillenir. Tarın virtüöz tekniği, lirik kantilenaları ve milli ornamentik unsurları, eşlik partisinin zengin tını fonunda tam anlamıyla ortaya çıkar.

Keywords: *concerto genre, tar, complex form, main theme, Suleyman Alasgarov, cadenza, dialogue, composer.*

Anahtar kelimeler*: konçerto türü, tar, karmaşık form, ana tema, Süleyman Elesgerov, kadans, diyalog, besteci.*

GİRİŞ: *Seçkin besteci, özverili bir eğitimci, Üzeyir Hacıbeyov adına Cumhuriyet Devlet Ödülü sahibi, Halk Sanatçısı ve profesör Süleyman Elesgerov, Azerbaycan müzik kültürünün gelişimine benzersiz katkılarda bulunmuştur. Bestecinin yaratıcılığı çok yönlü olup, müziğin birçok türünde birbirinden değerli eserler ortaya koymuştur. Süleyman Elesgerov'un tar ve halk çalgıları orkestrası için 1 numaralı konçertosu, Azerbaycan bestecilik ekolünün en parlak örneklerinden biri olmakla birlikte, milli müzik geleneklerinin karmaşık formda işlenmesi bakımından özel bir önem taşır. Eser, tarın virtüöz icra imkanları ile halk çalgıları orkestrasının zengin tını paletini başarıyla birleştirerek, klasik konçerto türünün milli müzik diline uyarlanmasına güzel bir örnektir.*

ESAS METİN: *Süleyman Elesgerov'un tar ve halk çalgıları orkestrası için 1 numaralı konçertosu 1973 yılında bestelenmiş ve ilk defa seçkin tar sanatçısı Ehsen Dadaşov tarafından icra edilmiştir. [Kasımova S., Bağırov N., 1984.]*

Besteci Elesgerov'un tar ve halk çalgıları orkestrası için 1 numaralı konçertosunda, muğam entonasyonları, türkü ve dans gibi milli unsurlar kendine yer bulmuştur. Yorum sürecinde icracı, tarın kendine has teknik imkanlarını yaratıcı bir şekilde uygulayarak, eseri tınısal açıdan zenginleştirmeyi başarmalıdır. 1 numaralı konçerto üç bölümden oluşur ve hem eğitim sürecinde hem de icra pratiğinde önemli bir rol oynar. Konçertonun ilk bölümü sonat allegro formunda, "Allegro con fuoco" temposuyla yorumlanır. İlk bölüm, iki ölçülük bir giriş temasıyla başlar; burada kullanılan akorlar, tar ve orkestra arasında diyalojik bir karşılıklı ilişki kurarak ana temanın sunumu için bir hazırlık aşaması işlevi görür. Ana tema "sol diyez minör" tonundaki "Şur" makamında seslendirilerek neşeli ve şen bir karakterle yorumlanmaya başlasa da, zamanla duygusal bir karakter kazanır.

Solistin icrasında duyulan melodi, kontrapuntal ritimlerle eşlik edilir. Dönemin ikinci kısmında solist ve piyano kanonik üslupla birbirini taklit ederek soru-cevap diyaloğunu oluşturur. Birinci bölümün yardımcı teması polifonik bir doku temelinde kurulur ve tamamlayıcı temanın unsurları üzerinde geliştirilir.

Ekspozisyonun işlenme (geliştirme) bölümünde eserin genel karakteri daha dramatik bir tarzda yorumlanır ve tar icracısının yorumlamasıyla başlar; bu bölüm esere duygusal açıdan bir gerilim getirir. Solo tar partisinde "Pezante" temposunda yardımcı tema yeniden sunulsa da, bu sunum ekspozisyondakinden farklıdır. Yardımcı tema akorlarla eşlik edilerek daha görkemli ve anıtsal bir karakter kazanır.

Eserin sonraki gelişiminde icracı doruk noktasına ulaşır ve bu doruk noktasından sonra solo tar tarafından yorumlanan lirik karakterde yeni bir tema sunulur. Bu bölüm, işlenme (geliştirme) kısmındaki gerginlikten sonra, bölümün tamamlayıcı cümlesi için bir geçiş işlevi görür.

"Meno mosso" bölümüyle başlayarak eserin kadansı duyulur; burada icracı, tarın virtüözlüğünü sergileyerek muğamların doğaçlama özelliklerini ustalıkla ve yaratıcı bir şekilde yorumlar. Birinci bölümün reprise (tekrar) kısmında, klasik form geleneğine uygun olarak her iki tema birlikte yorumlanır. Reprise bölümünde temaların dinamik gelişimi daha da yoğunlaşmış, ana temanın yukarı ve aşağı yönlü hareketi belirginleşmiştir. Yüksek heyecan ve dramatik karakter taşıyan kodada bu dinamizm, tar icracısının yorumunda daha net hissedilir. Koda, virtüöz karakterli beşli-altılı akorlar ve gamvari pasajlarla yorumlanır.

Konçertonun ikinci bölümü "Andante" temposunda yazılmış olup lirik bir tarzda yorumlanır. Dört ölçülük giriş teması üç sesli akorlarla eşlik edilerek birinci temanın sunumu için bir fon oluşturur. Solist, duygusal bir karakterle bölümün özünü kendi yorumunda ifade ederek, lirik düşüncelerin sanatsal ifadesini pekiştirir. Lirik bir türkü türünü hatırlatan birinci tema, iki cümleden oluşur. Sekiz ölçülük birinci cümle iki kez tekrarlanırken, on iki ölçülük ikinci cümle ise ilk dört ölçünün daha pes bir sese sekanslanmasıyla başlar. Cümlenin tekrarında varyasyonlu icra yöntemi kullanılır. Solistin temasının ikinci cümlesi üç sesli akorlarla forte (f) nüansında yorumlanır ve burada halk melodilerine özgü üslup özellikleri gözlemlenir. Tema, solist tarafından bir oktav tizden tekrar edilirken, piyano basit akorlarla bir fon eşliği oluşturur.

"Piu mosso" temposundaki orta bölüm, belirli bir heyecan ruhunda kurulmuş olup "Çahargah" muğamının mücadeleci karakterini yansıtır. Aşık müziğinin entonasyon özellikleri burada kendini gösterir ve dörtlü-beşli akor yapısından kaynaklanan harmonik dönüşümlerden yararlanılır. Bölümün yorumu, dinleyicide aşıkların deyişme sahnesini canlandırır. Bu deyişme motifi, solist ile piyano arasında diyalog formunda işlenir; piyano ise akor eşliğiyle zenginleşir. İcracı, tar enstrümanını saz gibi yorumlayarak aşık havalarının karakteristik özelliğini canlandırır.

Son olarak, Tempo I bölümünün üçüncü kısmı başlar ve burada birinci bölümün teması artık piyano tarafından icra edilir.

Konçertonun sonuncu, üçüncü bölümü "Allegro moderato" temposunda, rondo formunda, neşeli ve dans ruhunda bestelenmiştir. Müzik, dinleyicide büyük bir halk şenliği ve halk dansı olan "yallı"nın canlı bir tasvirini yaratır. Nakarat teması şen bir ruh halinde, "Şur" makamı temel alınarak kurulmuştur. Solist, enerjik yorumuyla rondo formuna özgü oynak ve şuh karakterleri ortaya çıkarmaya çalışır.

[58] numaralı ölçüden itibaren nakarat teması, piyanonun icrasıyla paralel olarak solist-tar sanatçısı tarafından yorumlanır. Bölümün başlangıç müzik cümleleri, bir nevi "Karabağ şikestesi"ni hatırlatan entonasyonlar taşır. Temanın sonraki gelişimi, solist ve piyano arasında kurulan diyalojik karşılıklı ilişki temelinde şekillenir. Soru-cevap prensibiyle düzenlenmiş bu diyaloglar, sekans (ardışık) ilerleyişlerle eşlik edilir. Buradaki sekanslar "Segah" makamının dereceleri üzerine kurulmuştur ki, bu da onları makam-tonal sekans örneği olarak sınıflandırmaya olanak verir. Melodi, üç sesli akorlarla eşlik edilerek, "Segah" makamının toniği olan "la diyez" sesi üzerinde org noktası (pedal ton) sürdürülür.

"B" bölümünün sonunda, bir oktav yukarı yönlü hareket "la minör" üç seslisine ulaştırır. Üç sesli akorlar senkop ritimlerle sunulur ve hemen ardından solistin icrasında nakarat yorumlanır. Nakarat teması tar partisinde verilir ve "B" bölümünde olduğu gibi, "C" bölümüne ("Piu mosso") geçiş için yükselen gamvari pasajlardan yararlanılır.

"Şüştər" makamının entonasyonları temel alınarak kurulan "C" teması önce eşlikte, ardından solist tarafından yorumlanır. Temanın ikinci tekrarı, piyano hariç tutularak, solistin yorumunda gerçekleştirilir.

[69] numaralı ölçüde tema, "mi Şüştər" makamının dereceleriyle inerek "la Şüştər" makamına modülasyon yapar ve tema solist tarafından ters (üçlü) aralığıyla yorumlanır. Dikkat çekicidir ki, temanın bu ikinci icrasında piyano enstrümanı tonik sekst ve kuart-sekst akorlarıyla eşlik eder.

"Piu mosso" bölümünden sonra tonalite değişir ve tema "mi Şüştər" makamında piyano ve solist tarafından yorumlanır.

"Tempo I" temposunun yeniden kurulmasıyla nakarat teması, solist partisinde tekrar yorumlanır ve aynı zamanda eşlik partisinde birinci bölümün ana teması geliştirilmiş biçimde yer alır. Burada icracı, ana müzik karakterini yeniden canlandırarak iki ana tema arasında başarılı bir birleşme ve sentez yaratır. Üçüncü bölümün şen karakterli nakarat teması ile birinci bölümün ağır ve dramatik temasının birleşmesi, güçlü bir kontrapuntal yapının ortaya çıkmasına yol açar. Bu yöntemle besteci karmaşık bir polifonik doku elde etmiştir.

Belirtmek gerekir ki, birinci bölümün ana teması piyano eşliğinde oktavlarla seslendirilirken, solist tarafından staccato çalım tekniği ile desteklenir.

Kodada yukarı doğru ilerleyen gamvari pasajlarla solist ve orkestra arasında yoğun bir diyalojik ilişki oluşur. Kodada ana tema görkemli bir karakter taşır ve melodi derece derece üst ses bölgesine doğru gelişir. Konçertonun üçüncü bölümü senkoplaşmış ritimlerle başlayan ve "sol diyez minör" tonalitesinde çözümlenen bir finalle tamamlanır. Bu tür bir yapısal özellik konçerto türü için karakteristiktir ve besteci bu özellikleri eserinde yüksek ustalıkla uygulamıştır.

Kodanın doğasına uygun olarak solist, bu bölümü yorumlarken ruhsal coşku ve duygusal yoğunlukla sunmalı, ayrıca görkemli karakteri eserin sonuna kadar koruyup sürdürebilmelidir. Final akordu ise fortissimo (ff) dinamik nüansı ile icra edilmelidir.

***SONUÇ**. Böylece Süleyman Elesgerov'un 1 numaralı konçertosu, Azerbaycan müziğinde milli geleneklerin karmaşık formda başarıyla temsil edildiği bir örnek olarak dikkat çeker. Besteci bu eser aracılığıyla tarın icra imkanlarını genişleterek, onun virtüöz bir solist enstrümanı olarak potansiyelini tam anlamıyla ortaya koymuştur. Konçertonun müziğinde muğamın doğaçlama ruhu ile konçerto formunun katı mantığı başarıyla sentezlenir; bu da kendi içinde Azerbaycan bestecilik ekolünün oluşumuna önemli bir katkı sunar. Sonuç olarak bu konçerto, yalnızca bestecinin yaratıcılığında değil, aynı zamanda Azerbaycan profesyonel müziğinin eğitim ve icra repertuvarında sağlam bir yer tutar ve milli müzik mirasının geliştirilmesi yönünde sürekli bir teşvik kaynağı olarak işlev görür.*

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PERFORMANCE ISSUES IN FRÉDÉRIC CHOPIN'S ÉTUDES FOR PIANO AND THEIR SOLUTIONS

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FREDERIC CHOPIN'IN PIYANO IÇIN ETÜTLERINDE İCRA SORUNLARININ ÇÖZÜMÜ

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Abstract

This article is devoted to examining the resolution of technical issues in the piano études of the distinguished composer Frédéric Chopin. Chopin's études for piano stand out as works in which technique and musical expression are in perfect unity within the art of performance. These études demand from the performer not only speed and precision, but also an understanding of the deep emotional content and polyphonic structure of the sounds. Chopin's études are not merely a path for the performer to achieve technical perfection; they also provide a unique opportunity to explore the poetic and expressive possibilities of piano performance. His Op. 10 and Op. 25 series address crucial issues in performance practice. As a foundation of Romantic piano performance, Chopin's études remain a constant source of challenge and inspiration for every generation of performers, maintaining relevance both technically and musically.

Özet

Sunulan makale, seçkin besteci Frederic Chopin'in piyano için etütlerinde teknik meselelerin çözümünün açıklanmasına adanmıştır. Frederic Chopin'in piyano için etütleri, icra sanatında tekniğin müzikal ifade ile tam bir bütünlük oluşturduğu eserler olarak öne çıkar. Bu etütler, icracıdan yalnızca hız ve kesinlik değil, aynı zamanda seslerin derin duygusal içeriğini ve polifonik yapısını anlamasını da gerektirir. Chopin'in etütleri, icracı için yalnızca teknik mükemmelliğe ulaşma yolu değil, aynı zamanda piyano icrasının şiirsel ve ifade edici olanaklarını derinlemesine incelemek için benzersiz bir fırsattır. Onun Op. 10 ve Op. 25 serileri, icra pratiğinde önemli sorunları çözmektedir. Chopin'in etütleri, romantik piyano icrasının temelini oluşturur ve her nesil icracı için hem teknik hem de müzikal açıdan sürekli güncelliğini koruyan bir sınav ve ilham kaynağı olmaya devam etmektedir.

Keywords: *Chopin, étude, technical issues, piano, Romantic, Poland, revolution, homeland, classical.*

Anahtar kelimeler: *Chopin, etüt, teknik meseleler, piyano, romantik, Polonya, devrim, vatan, klasik.*

GİRİŞ: *Ünlü Polonyalı besteci ve piyanist F.Chopin, hayatının büyük bölümünü Fransa'da yaşayıp üreterek dünya klasik müziğinin gelişimine büyük etki göstermiştir. Chopin'in "piyanonun kalbi" olarak adlandırılması boşuna değildir. Çünkü Chopin, yaratıcılığı boyunca tüm eserlerini yalnız piyanoya adamış tek bestecidir. Babası-Nicolas Chopin, Fransız Kontu Skarbek'in Jelyazova Wola'daki çocuklarının eğitmeniydi. İşte onun sarayında F.Chopin dünyaya gözlerini açmıştır. Daha çocukluk yıllarından itibaren Chopin, duyduğu tüm müzikleri piyanoda kolayca çalmaya başlayarak, on iki yaşındayken en iyi Polonyalı piyanistlerle rekabet eder hale gelir. Berlin konserleri, onun müziğe olan ilgisini daha da artırır.*

Frederic Chopin'in yaratıcılığı, fikirlerinin netliği ve formlarının uyumuyla dikkat çeker. Chopin'in yaratıcılık faaliyeti, Polonya halkının özgürlüğü için mücadelesi dönemine denk gelir. Yüksek vatanseverlik, halkına ve vatanına sevgi, o dönemde yaratıcılıkla uğraşan sanatçıların karakteristik özelliğiydi. Frederic Chopin'in piyano için eserleri, onun yaratıcılığının önemli bir bölümünü oluşturur. Besteci tüm yaratıcılığı boyunca bu türde çeşitli eserler yazmıştır. F. Chopin, 58 mazurka, 16 polonez, 21 noktürn, 19 vals, piyano için 3 sonat, 25 prelüd, 4 impromptu, 27 etüt, 4 scherzo, 4 ballad ve diğer eserlerin bestecisidir. Chopin'in piyano yaratıcılığının ana teması vatan teması olup, vatanın tarihi geçmişi, doğası, insanlarıyla ilgili olaylar bestecinin faaliyetinin sanatsal motifini oluşturur ve bestelediği tüm eserlerde bu tema kendini parlak bir şekilde yansıtır.

ESAS METN: *F.Chopin, temkinliliği ve içe dönüklüğü ile ayrılır, onun müziğini sevenler Chopin'i daha iyi tanırlardı. Kendi döneminin birçok sanatçısı: besteciler Franz Liszt, Robert Schumann, Felix Mendelssohn, Giacomo Meyerbeer, Ignaz Moscheles, Hector Berlioz, şarkıcı Adolphe Nourrit, şairler*

Heinrich Heine, Adam Mickiewicz, ressam Eugène Delacroix Chopin'in yeteneği karşısında saygıyla eğilirlerdi.

Robert Schumann, Chopin'i "en güzel Chopin" olarak adlandırarak yazıyordu: "Chopin'in müziği benzersiz ve derin anlamlıdır." [Vahrányov Yu., Sladkovskaya G., 1996.] Schumann, "Novelletten"ini Chopin'e adamış ve onun müziğindeki "Polonya ruhunu" hissettiğini belirtmiştir.

Bahsettiğimiz gibi Chopin çok sayıda piyano etüdünün bestecisi olup, bu etütler teknik egzersizlerin yanı sıra, yüksek sanatsal değere sahip, duygusal ve lirik tonlarla zengin, piyano için bestelenmiş eserlerdir. Bu etütler temel olarak iki büyük seri (Op. 10 ve Op. 25) halinde sunulur ki, bunlar bestecinin virtüözlüğünü ve duyguların derinliğini yansıtır. Chopin etütleri, basit teknik egzersizlerden çok daha fazlasıdır; onları ince ve içten müzik eserlerine dönüştürmüş, kalplere yol bulmuştur. Çılgın tutkulardan derin düşüncelere kadar geniş bir duygu paletini kapsarlar. Her bir etüt belirli bir teknik zorluğa (örneğin, hız, arpejler, süslemeler) sahip olup, bu zorluklar müziğin estetiği ile uyum içindedir. En ünlü seriler Opus 10 (12 etüt) ve Opus 25 (12 etüt) olarak sınıflandırılır. Ayrıca, opus numarası olmayan 3 ek etüt de mevcuttur. Op. 10, No. 3 (Tristesse) Hüzünlü ve lirik melodisiyle ünlüdür, Op. 10, No. 12 (Devrimci) Polonya'nın özgürlüğü için mücadele ruhunu yansıtan dramatik bir etüttür. Op. 25, No. 11 (Kış Rüzgarı) vahşi bir rüzgar gibi şiddetli ve virtüöz bir eserdir. F.Chopin'in etütleri piyano müziği temel repertuvarının bir parçası olup, piyanonun ifade olanaklarını son derece genişletir.

Do minör (c-moll) etüdü "Allegro con brio" temposunda, sağ ve sol elin parmak numaralandırmasında on altılık notaların yukarı-aşağı hareketi icracı için zorluklar yaratır. Bunun üstesinden gelmek için parmak numaralandırması üzerinde özel çalışma sürecinin yürütülmesi tavsiye edilir. Parmak numaralandırması (applikatür) piyano pedagojisinin karmaşık sorunlarından biri olup, müziğin gelişimi ile bağlantılı olarak bu alanda da uygun değişiklikler olmuştur. İcra bakımından yetişmiş her müzisyen parmak numaralandırmasının özünü gerektiği gibi kavrar. Parmak numaralandırmasının doğru seçilmesi, eserin sanatsal içeriği ile ilgili sorunların çözülmesine, icra sırasında ortaya çıkan zorlukları gidermeye yardımcı olur. Chopin'in etütlerinde doku karmaşık olduğu için onları icra eden piyanist parmak numaralandırması bakımından da belirli zorluklarla karşılaşır. Bu nedenle de c-moll etüdünün yorumlanmasında parmak numaralandırması sorunları üzerinde genişçe durmayı kendimize amaç edindik.

Etüdü icra ederken parmak numaralandırmasının temel ilkeleri olan sağ ve sol el parmaklarının birbirine uygun şekilde olmasına dikkat etmek gerekir. Bu ilke, hızlı temp ile icra sırasında parmak numaralandırması zorluklarını savuşturmaya yardımcı olacaktır. Parmak numaralandırması ile ilgili icracının önünde duran önemli sorunlardan biri de seslerin eller arasında doğru bölünmesidir. Birçok yetenekli piyanist bu soruna dikkatle yaklaşmasa da, el hareketlerinin doğru uygulanmasında bu mesele gerekli sayılır.

Anton Rubinstein yazmıştı: "Chopin piyanonun kalbiydi ve piyano için yazdığı eserlerin ruhunu ifade etmiştir. Onun elastik ve narin elleri akorları, arpejleri çok kolaylıkla çalardı. Chopin'in yüksek seviyeli profesyonel icrası oldukça dakik, doğru, hafif ve net olup, enstrümandan çıkardığı sesler zengin renklere, çeşitliliğe sahipti. Chopin'in icracılığının temel göstergelerinden biri de tüm eserlerinde, etütlerinde de çok net görülen legato tekniğiydi." [Milşteyn, 1987]

Analiz ettiğimiz c-moll etüdünde de legato çizgileri dikkati çeker. Chopin beşinci ve birinci parmağı siyahı tuşlarda kullanır, başparmak üzerinden üçüncü ve dördüncü parmakları rahatlıkla geçirirdi. Bu tür bir parmak numaralandırması (applikatür) parmakların gelişimi için gerekli koşulları yaratırdı. Chopin'in etütlerini icra ederken bestecinin yorumlamasına dayanmak, onu dinleyerek icra tarzına dikkat etmek en doğru yol olabilir.

F.Chopin'in "f-moll" tonalitesindeki etüdü "Allegro, molto agitato" temposunda ve karmaşık 6/8 ölçüsünde bestelenerek eserin ritmik özelliği, tonalitesi ve dokusu sonuna kadar değişmeden kalır. Genel olarak, Chopin dokusunun melodik hale getirilmesi için legatonun uygulanması, hem parmak hem de pedalın doğru kullanılması özellikle karakteristiktir. Geniş nefesli cümleler Chopin melodisinin temelini oluşturmalıdır. Etüdün icrasında elin bilek hareketi teknik bir araç olarak mevcut sorunda yardımcı olabilir. Ses gürlüğü meselelerinde ise Chopin müziğinin dinamiklerine pastel tonlar özgü olup, ana renk ses rengidir. Geleneksel anlamda ne açık ses, ne forte-fortissimo (fff), ne de fortissimo (ff) mevcut değildir. Genel olarak Chopin müziğinin dinamik planının açığa çıkarılmasında tüm mümkün renklerin zenginliğine ve çeşitliliğine dikkat etmek daha amaca uygundur. Etüdün icrasında dinamik çizginin yapılandırılmasında ani dinamik karşıtlıklara değil, akıcı geçişlere öncelik verilir. "f-moll" tonalitesindeki etütte sol elin onaltılıklarla eşlik temasına karşı sağ elde sekizlik notlarla ana temanın yorumlanmasını gözlemleriz. Ana icra zorluklarının sol el parmak numaralandırması üzerine düştüğünü göz önünde bulundurarak, sol el üzerinde ayrıca çalışma sürecinin yürütülmesi gereklidir. "Allegro, molto agitato"

temposunda sol elde onaltılık notalara tam zamanında basma becerisi de piyanistten özel bir çalışma süreci talep eder. Sol elin dalga benzeri hareketine karşı sağ el yumuşak bir tarzda karşılık vermelidir. Eserde birçok dinamik renge rastlarız: crescendo, con forza, sotto voce, sempre legatissimo, sempre più, stretto, accelerando, leggierissimo, piano-pianissimo, pianissimo, fortissimo, piano ve benzeri.

Chopin'in etütlerinin yorumlanmasında önemli yönlerden biri de süsleme (melizm) meseleleri olup, neredeyse tüm etütlerinde çeşitli süslemelere rastlanır. Piyanist bu süslemeleri icra ederken ana seslerin bulunduğu vuruş geleneğinin taraftarıydı.

Şimdi ise sunulan etütte parmak numaralandırması meseleleri üzerinde duralım: İlk ölçülerde sol el temasında parmak sıralamasına dikkat edersek görürüz ki, "fa-do-la bemol-do-si bemol-do" notalarında gösterilen parmak sıralaması icra açısından pek elverişli değildir. Zira büyük oktavın "fa" notasının beşinci parmakla ve ondan sonra gelen "do" notasının dördüncü parmakla icrası piyanisti belirli zorluklarla karşı karşıya bırakabilir. Burada iyi olur ki, "fa" notasının ardından gelen "do" notası üçüncü parmakla ve ondan sonra gelen "la bemol" notası birinci parmakla icra edilsin. Bu sıralamayı diğer ölçülerde de uygulamak amaca uygundur.

Dördüncü ölçüde sağ el partisinde birinci oktavın "do" notasına sf (sforzando) nüansının konulduğunu gözlemleriz. Dikkate alırsak ki besteci eseri piano nüansında başlatmıştır, bu durumda söz konusu notu o kadar da keskin icra etmek olmaz.

Chopin'in etütleri piyanist tekniğinin gelişimine dair belirli meseleleri önüne koyar. Lakin bestecinin yaratıcılığında onun ballad, scherzo ve diğer eserleriyle aynı sırada duran etütleri derin anlam taşıyan birer konser parçasına dönüştü. Chopin'in etütleri arasında 12 No'lu Do minör etüdü özel bir yer tutar. İlk 12 etüt Macar bestecisi Franz Liszt'e ithaf edilmiş, tam da onun tarafından bu etüt "devrimci" olarak adlandırılmıştır. Bu kahramanca etüt, 1830 yılında Polonyalıların Rus mutlakiyetine karşı ayaklanmasının trajik kaderini parlak bir şekilde yansıtır. 30 yıl önce Ludwig van Beethoven müzikte devrimci mücadelenin ruhunu yansıtarak "Patenik Sonat"ını yazmıştır. Birinci bölümün girişinde sonraları Chopin'de de rastladığımız o motif seslenir. Her iki eser de do minör tonalitesinde yazılmıştır. Coşkulu, çok hızlı geçişlerin arka planında bir çağrı, yukarı yönelen iradeli bir melodi duyulur. Aynı zamanda, mücadeleye çağrı, özgürlük uğrunda mücadele eden savaşçıların cesaretinin ve kararlılığının ifadesi de işitilir.

Chopin'in 3 No'lu Mi Majör Etüdü – bir tür "sözsüz şarkıdır". Chopin'in müziği derinliği, zarif ve samimi okunurluğu ile ayrılır. 3 numaralı etüdün keman, viyolonsel ve diğer "şarkı söyleyen" enstrümanlar için uyarlamaları da mevcuttur. Majör tonda olmasına rağmen, müzikte bir hüzün hissi vardır.

***SONUÇ:** Frederic Chopin'in piyano için etütleri, yalnızca teknik meseleler değil, aynı zamanda sanatsal ifadenin yüksek seviyede birleşimini temsil eden sanat eserleridir. Onun Op. 10 ve Op. 25 serileri icra pratiğinde önemli sorunları çözer.*

Chopin'in etütleri piyano icrasının gelişiminde bir dönüm noktası yaratarak, teknik egzersizleri tam değerli müzik eserlerine dönüştürmüştür. Onların öğrenilmesi icracıya yalnızca teknik beceri değil, aynı zamanda müzikal ifadenin inceliklerini anlama imkanı verir. Bu eserlerin incelenmesi ve icrası, piyano icracılığının hem teknik hem de sanatsal yönlerinin uyumlu bir şekilde geliştirilmesi için gerekli bir aşama sayılır.

Böylece, Chopin'in etütleri romantik piyano icrasının temel taşlarından biri olarak kalmakta ve her nesil icracı için hem teknik hem de müzikal açıdan sürekli güncelliğini koruyan bir sınav ve ilham kaynağı olmaya devam etmektedir.

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Economic sciences

THE ROLE OF ARTIFICIAL INTELLIGENCE IN THE QUALITATIVE DEVELOPMENT OF CULTURAL ORGANIZATIONS: A COMPARATIVE ANALYTICAL STUDY BASED ON INTERNATIONAL AND KAZAKHSTANI CASES

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Introduction

In the context of the digital transformation of the economy, businesses are required to reconsider their traditional business models, management practices, and interactions with customers. The cultural sector, comprising museums, theatres, creative clusters, leisure and cultural centres, and digital cultural platforms, is expanding as an integral part of the digital landscape.

Artificial intelligence (AI) and virtual reality (VR) technologies are becoming critical factors in the growth of cultural organisations, leading not only to the modernisation of technology but also to the emergence of novel modes of cultural creation, distribution, and consumption. This study is significant due to the importance of integrating AI into the cultural sector, moving beyond the automation of individual processes and becoming a systemic mechanism for the dynamic development of organisational, intellectual, and creative potential within enterprises.

Machine learning algorithms, intelligent recommendation systems, big data analysis, and immersive virtual solutions enable organizations to tailor content to meet the diverse needs of cultural audiences. These technologies also allow for the adaptation of management decisions, enhancement of economic sustainability, and strengthening of socio-cultural impact.

Despite this, the academic literature has yet to adequately explore the role of artificial intelligence in the qualitative growth of cultural enterprises during periods of industrial crisis and digital transformation. Furthermore, it has not addressed the ways in which these technologies can facilitate the adaptation of cultural policies and strategies to foster industry growth.

The aim of this research is to examine the application of artificial intelligence and digital technologies, including virtual reality, in the cultural sector, with a view to understanding their contribution to the growth and development of cultural organizations, as well as their impact on management strategies and cultural policy within the context of digital transformation.

In order to achieve this objective, the study seeks to identify and analyze the systemic relationships between technological innovations, organizational changes, and strategic goals for the advancement of the cultural industry. To achieve this, it is necessary to:

1. To conceptualize the role of artificial intelligence in the qualitative development of cultural organizations within the context of digital transformation, and to clarify its function beyond a purely technological tool.The uniqueness of this research lies in its holistic approach to AI as a systemic component contributing to the overall advancement of the cultural sector, rather than just a technological tool.

2. To analyze how artificial intelligence influences organizational structures, management practices, and the development of creative and intellectual capacities in different types of cultural organizations.

3. To conduct a comparative analysis of international and Kazakhstani cases in order to identify common patterns and context-specific differences in the application of artificial intelligence in the cultural sector.

4. To derive strategic and policy-related implications regarding the adaptive integration of artificial intelligence into cultural organizations to support sustainable and high-quality development.

The uniqueness of this research lies in its holistic approach to AI as a systemic component contributing to the overall advancement of the cultural sector, rather than just a technological tool.

In contrast to previous research that has focused on conventional digital solutions, this study proposes a novel, integrated approach to explore the mechanisms for optimizing the potential of cultural institutions by combining artificial intelligence, virtual reality, and innovative management practices.

The findings of this study contribute to a better understanding of the digital transformation in the cultural sector, providing a scientific basis for the formulation of a flexible cultural strategy that promotes sustainable development and enhances the competitive advantage of cultural organizations in the digital marketplace.

Literature review

In recent years, there has been significant progress in research on the role of artificial intelligence in the field of culture and the digital transformation of cultural institutions. Chinese researcher Xingwang Zhan's work focuses on practical aspects of AI applications, including content creation, cultural heritage preservation, personalized recommendation systems, and market analysis.

The author notes that AI plays a significant role in improving the quality and efficiency of cultural services, but it faces various technological, legal, and ethical challenges. To address these challenges, it is necessary to introduce technological innovations, strengthen copyright protection principles, and develop human resources for digital transformation.

Based on these considerations, the author concludes that AI is an essential component of the modern cultural landscape, but strategic solutions are needed to overcome barriers to its development.

Kazakh researcher Meruert Zhanguzhinova has been exploring the potential applications of artificial intelligence in the educational and artistic environments. This is particularly relevant in the context of industrial culture, which serves as a platform for creative expression and learning.

In her work, Zhanguzhinova addresses the current challenges posed by traditional art teaching methodologies in light of AI integration. She argues for a reevaluation of pedagogical approaches, enhancement of digital literacy, and adaptation of curriculum to accommodate AI-driven learning.

The researcher emphasizes that AI facilitates personalized educational experiences and stimulates creativity. She highlights the need for systematic theoretical frameworks and terminological clarification in art education in order to foster a deeper understanding of the subject.

Within the framework of international research, Manuele Veggi is examining modern artificial intelligence tools for the design of interactive media in digital heritage. In this review, he is examining the existing "cultural style" and identifying the shortcomings of traditional approaches to interaction design.

Special attention is being paid to the fact that many studies conducted over the past nine years on AI either do not consider the specific characteristics of cultural sites or focus on individual tools without a systematic approach to using them in professional museums and cultural spaces.

As a result, Manuele Veggi proposes structuring the design process with the help of AI assistance, which will enable developers, curators, and specialists in national heritage fields to create more adaptable and attractive digital projects.

Another foreign author, I. Suichmez, and co-authors consider the impact of artificial intelligence on museum practices in their research.

In their research, the authors explore the potential of utilizing artificial intelligence to accelerate the digital transformation of museum spaces. They aim to enhance interactivity and personalization of the visitor experience through the use of technologies such as virtual reality and augmented reality.

The study analyzes how the combination of VR/AR with AI makes museum exhibits more engaging and attractive, stimulating the curiosity of visitors and encouraging them to explore cultural content more deeply. The authors argue that AI-driven solutions have the potential to enhance the emotional impact of museum collections, deepening understanding and expanding the educational potential of cultural institutions.

The study also acknowledges the need for further experimentation and exploration in order to fully realize the benefits of these solutions. The authors suggest that additional research is required to identify new motivational strategies and enhance the overall experience for visitors.

A study published in Electronics by M. Kioureksidau and his colleagues examines the impact of AI development on museum attendance.The study employs empirical methods of data analysis based on data from 19 museums. Through experimentation, it has been determined that there is no clear indication of an increase in visitor attendance following the implementation of AI. Nevertheless, correlation analysis reveals a moderate positive correlation between the use of AI and the overall quality of the visitor experience.The researchers interpret this as indicating that AI contributes to enhancing the quality of interaction between visitors and cultural content through personalized recommendations,

interactive exhibits, and visible guides. This suggests that AI serves as a tool for enhancing the quality of cultural offerings, rather than simply increasing the number of visitors.

A review of current literature suggests that artificial intelligence is a crucial component of the transformation of the cultural sector within the digital economy, playing a pivotal role in shaping the future of the cultural landscape.

Authors from China, Kazakhstan and other countries have agreed that AI and related technologies, such as virtual reality, contribute to the improvement of the management of cultural organizations, the personalization of cultural content and the creation of a more interactive and immersive experience for audiences.

Research has shown, however, that the main impact of AI is not in quantitative terms, such as increased attendance or scale, but rather in the qualitative development of the creative,intellectual, and organizational potential of cultural institutions.

Research methodology

This study uses two complementary approaches that provide a comprehensive analysis of the role of artificial intelligence in the qualitative development of cultural enterprises and the formation of adaptive cultural policy.

1. Qualitative analytical and theoretical approach.

This approach involves a systematic analysis of scientific publications, industry reports, strategic documents and regulatory materials related to the introduction of artificial intelligence in the cultural sphere. In the process of applying the approach, the following actions are performed:

- *Collection and classification of sources by subject areas;*
- *Identification of key mechanisms of digital transformation of cultural organizations;*
- *Analysis of the impact of technology on the creative and organizational potential of enterprises;*
- *Generalization of existing methodological approaches to the formation of adaptive cultural policy.*

The application of this method allows us to theoretically substantiate the role of artificial intelligence as a system-forming factor determining the strategic and operational capabilities of organizations in the field of culture.

2. Comparative and analytical method.

This method is aimed at studying the practical application of artificial intelligence in the activities of cultural organizations such as museums, theaters, digital platforms and creative industries. It includes:

- *Comparison of different technology implementation strategies;*
- *Analysis of the impact of digital tools on content management and audience interaction;*
- *Evaluating the effectiveness of innovative approaches to organizational and management processes;*
- *Identification of optimal models of cultural policy adaptation in the context of digital transformation.*

The use of the comparative analytical method makes it possible to identify specific practices and successful models of artificial intelligence integration, as well as to identify the most effective ways to improve the quality and sustainability of cultural enterprises.

Results and discussion

The research is based on a qualitative, analytical, and theoretical methodology aimed at identifying systemic patterns of digital transformation within the cultural industry. This methodology is predicated on the assumption that artificial intelligence and virtual reality technologies are not isolated entities, but rather represent a new paradigm for the development of cultural organizations that impact the processes of production, distribution, and consumption of cultural content.

Table 1 - The method was implemented in practice (in stages)

Stage of analysis	*Description of the stage*	*Objects of analysis*	*Result*
1. Case selection	*Selection of international and national cases driven by the digitalization of culture*	*Museums, cultural platforms, and exhibition spaces applying AI and VR technologies*	*A representative database of cases was formed*
2.Systematization of practices	*Classification of approaches to the application of AI and VR*	*Content creation, curatorial practices, audience interaction, and management processes*	*Recurrent models of AI application were identified*
3. Analytical comparison	*Comparison of objectives and outcomes of digital technology implementation*	*Tasks solved by AI in different countries and cultural institutions*	*Common functional mechanisms were identified*
4. Theoretical generalization	*Interpretation of empirical findings*	*The relationship between digital technologies and the development potential of organizations*	*The key development mechanism was formulated*

Source – compiled by the author

Table 2 – The cases on which the method has settled

Case	*Technological solution*	*Analytical significance*
The British Museum (United Kingdom)	*AI-based curatorial decision support, interactive exhibitions*	*Demonstrated the role of AI in the intellectualization of cultural content management*
The Metropolitan Museum of Art (USA)	*VR tours and AI-driven recommendation systems*	*Illustrated the personalization of the cultural experience*
Shanghai Museum (China)	*AI and VR for digital preservation of cultural heritage*	*Confirmed the strategic role of AI in cultural policy development*
European museums (EU)	*Immersive digital exhibitions*	*Revealed the impact of AI on audience engagement*
Digital cultural platforms	*User behavior analysis algorithms*	*Demonstrated the transition from mass culture to adaptive and personalized cultural models*

Source – The source was compiled based on the data [6-9]

The analysis of the data presented in Tables 1 and 2 demonstrates a systematic and practice-oriented result of the introduction of artificial intelligence (AI) and virtual reality (VR) technologies into the activities of cultural organizations.The step-by-step research methodology allowed us to form a representative sample of cases, including museums, theaters, digital platforms and exhibition spaces, identify general trends in the use of technology and compare their goals and results in different countries.Table 1 illustrates a systematic approach to research: from case selection and practice systematization to analytical comparison and theoretical generalization, which made it possible to identify key mechanisms of digital transformation and develop innovative strategies for the development of cultural organizations.Table 2 describes in detail the practical application of the method, as well as demonstrates the innovative effect achieved with the help of artificial intelligence (AI) and virtual reality (VR).

At the British Museum, AI-based curatorial decision support systems have contributed to the intellectualization of cultural content management, shifting the decision-making process from an intuitive to an analytical level. At the Metropolitan Museum of Art, virtual tours and referral systems have provided a personalized cultural experience, increasing audience engagement.

The Shanghai Museum demonstrated the strategic importance of technology for the preservation of cultural heritage and the integration of AI into national cultural initiatives. Immersive digital exhibitions at European museums have enhanced emotional and interactive engagement with visitors, and digital cultural platforms illustrate the shift from mass culture to adaptive and personalized data-driven models.

The analysis of the results of both stages of the study allowed us to draw the following conclusions.

Artificial intelligence and virtual reality are key factors influencing the organizational, managerial and strategic development of cultural organizations. Digital technologies contribute to the innovative adaptation of cultural policy, the formation of new models of interaction with the audience, the preservation of cultural heritage and content management.

Despite the differences in contexts, there is a common functional effect: increased effectiveness, engagement, and quality of cultural experience.

A step-by-step analytical approach has made it possible to identify recurring mechanisms and patterns of technology implementation, which opens up opportunities for scaling successful practices and developing sustainable digital transformation strategies in the cultural sector.

The method of comparative analysis was used to compare the approaches to the implementation of artificial intelligence and digital technologies in various cultural institutions in Kazakhstan. The study covered museums, theaters, digital cultural platforms, and creative industries, revealing differences in digital transformation strategies, technological progress, and creative potential development (table 3).

Table 3 – A comparison of the types of cultural organizations in Kazakhstan.

Type of cultural enterprise	*Examples (Kazakhstan)*	*Forms of AI and digital technology application*	*Main effect*
Museums	*National Museum of the Republic of Kazakhstan; museums in Almaty and Astana*	*Digital catalogs, virtual tours, interactive exhibitions, elements of recommendation systems*	*Increased accessibility of cultural heritage and improved quality of perception*
Theaters	*State theaters in Almaty, and Astana, regional theaters*	*Online platforms, digital promotion, audience analytics, multimedia performances*	*Expansion of audience reach and renewal of artistic forms*
Digital cultural platforms	*Online museums, educational cultural portals*	*Content personalization algorithms, user behavior analysis*	*Formation of an adaptive digital culture*
Creative industries	*Media studios, design and art start-ups*	*Generative AI tools, content automation, VR projects*	*Growth of innovative activity and creative flexibility*

Source – The source was compiled based on the data [10-13]

The comparative examination of cultural institutions in Kazakhstan demonstrates a wide range of approaches to the implementation of artificial intelligence (AI) and digital technologies across various sectors. This analysis highlights both the functional and strategic differences in the use of AI and digital tools.

Museums, such as the National Museum of the Republic of Kazakhstan and regional teatral institutions in Almaty and Astana, primarily utilize AI and digital technologies to enhance the accessibility and interpretation of cultural heritage.

Digital catalogs, virtual tours, interactive exhibitions, and recommendation systems are employed to transform static collections into more engaging and audience-focused experiences. This allows museums to expand their reach while maintaining the integrity of their cultural content.

Cultural institutions, including national and regional theaters, are embracing digital technologies, online promotion, audience analytics, and multimedia performances to broaden their reach and reinvigorate artistic expression. In this context, AI serves primarily as a tool for comprehending audience preferences and enhancing programming and marketing strategies, reflecting a service-oriented approach focused on engagement and interactive participation.

Digital cultural platforms, such as online museums and educational websites, showcase a higher level of integration, where AI-driven content personalization and user behavior analysis form the foundation of their operations. These platforms exemplify adaptive cultural ecosystems, where data-driven insights enable cultural content to dynamically respond to user needs, creating a more personalized and interactive cultural experience.

The creative industries, encompassing media production, design, and art-based ventures, employ generative AI, automated content creation, and virtual reality technologies to fuel innovative output. In this realm, AI is not a mere enabler but a pivotal force behind creative output, encouraging exploration, adaptability, and the emergence of novel artistic approaches.

In all sectors, a common trend is emerging: AI and digital technologies are driving qualitative advancements rather than just quantitative growth. However, the extent of integration and strategic use varies. Museums and theaters tend to use AI as a supplementary tool to enhance their existing structures, while digital platforms and creative industries incorporate AI deeply into their operations and creative processes. These differences reflect the goals of each organization, their level of digital maturity, and the unique cultural functions they serve. This shows that the impact of AI is context-specific but consistently focused on expanding creative potential, engaging audiences, and enhancing adaptability in the cultural sector(table 4).

Table 4 - Analysis of differences in approaches to the implementation of artificial intelligence

Comparison criterion	*Museums*	*Theaters*	*Digital platforms*	*Creative industries*
Goal of digitalization	*Preservation and promotion of cultural heritage*	*Attracting new audiences*	*Personalization of cultural consumption*	*Creation of new creative products*
Role of AI	*Support for interpretation and visitor navigation*	*Analysis of audience preferences*	*Core operational mechanism*	*Tool for creativity and production*
Level of automation	*Medium*	*High*	*High*	*Medium–high*
Impact on management	*Optimization of exhibition policy*	*Improvement of marketing activities*	*Full integration into management processes*	*Flexible project-based management models*

Source – compiled by the author

The analysis of AI implementation strategies in different types of cultural organizations reveals that regional theaters hold a particularly dynamic position in the digital transformation of the cultural

industry. Unlike museums, which primarily utilize AI for interpretation and navigation support, theaters – especially regional ones – actively employ AI-powered digital tools to engage and retain audiences through social media platforms.

Using AI-enabled video editing, generative visual content, and algorithm-driven optimization of content distribution, regional theaters produce short, atmospheric promotional videos, trailers, and backstage narratives that capture the emotional depth and artistic value of their performances. These materials are disseminated widely through platforms such as Instagram, TikTok, YouTube, and Facebook, enabling performances to reach an audience beyond the physical confines of the theater building[14].

This practice significantly transforms the traditional communication model between theaters and audiences. AI-powered analytics allow theaters to analyze audience behavior, preferences, and engagement, which then informs their repertoire planning and marketing strategies. Therefore, digitalization in theaters goes beyond mere technical modernization and becomes a strategic tool to enhance cultural participation.

This approach also increases the visibility of regional cultural institutions among tourists, who are increasingly relying on digital content and social media to select cultural experiences during their travels. AI-generated promotional materials help position regional theaters as attractive cultural destinations and integrate them into broader tourism and creative economy ecosystems.

Digital platforms represent the highest level of AI integration. Personalization algorithms form the core operational mechanism in these platforms, while the creative industries utilize AI as a direct tool for artistic production. However, theaters demonstrate a hybrid approach, where AI is primarily applied to marketing, audience analysis, and content management, rather than the artistic process itself.

This confirms that the impact of AI on cultural organizations is strongly dependent on the context. In all sectors, AI contributes to the quality development of cultural institutions by enhancing audience engagement, increasing adaptability, and aligning cultural content with contemporary digital consumer trends.

The findings from the applied research indicate that artificial intelligence acts as a crucial enabler for the qualitative advancement of cultural organizations by enhancing their adaptability, creativity, and audience focus. The analysis based on the methods employed demonstrates that AI-powered tools, such as audience analytics, personalized content, and automated digital production, allow cultural institutions to transition from static, institution-centric models to dynamic, data-driven management and communication approaches.

The comparative analysis of cultural organizations reveals that museums and theatres primarily utilize AI to improve accessibility and engagement for their audiences, while digital platforms and the creative industries incorporate AI more deeply into their core operations and creative processes. These findings confirm that the success of AI is not solely determined by the level of technical sophistication, but rather by its strategic fit with organizational objectives, regional context, and user behavior. This leads to sustainable cultural growth and the systematic enhancement of creative and management capabilities.

Combining the results of both research methods revealed several key patterns.

The impact of artificial intelligence on the development of cultural organizations depends on the type of institution, the level of digital maturity and strategic goals.

In all sectors, artificial intelligence contributes to improving the quality of cultural content, audience engagement, and organizational adaptability, not just quantitative indicators.

The integration of technologies has a multi-level nature. Museums and theaters use artificial intelligence primarily to support existing functions, while digital platforms and creative industries incorporate it into the foundation of their operations and creative processes.

Digitalization is gaining strategic importance, acting as a tool for managing, personalizing and expanding the audience, as well as contributing to the integration of cultural sites into broader tourism and creative ecosystems.

Conclusion

This study demonstrates that the use of artificial intelligence (AI) and related digital technologies has become a significant factor in the qualitative development of cultural organizations. This development is transforming not only the operational processes of these organizations, but also their strategic approaches to management and policy.

The integration of AI allows cultural organizations to move away from traditional, resource-based models and towards more flexible, data-driven systems that are able to adapt to their audiences. These

systems are capable of continuous learning and improvement, enabling cultural organizations to better meet the needs and expectations of their audiences.

Across various types of cultural organizations, including museums, theaters, digital platforms, and the creative industries, AI supports the dynamic growth of creative, organizational, and communication potential. This growth is achieved through enhanced accessibility, improved audience engagement, and expanded cultural experiences.

The findings indicate that AI is not a one-size-fits-all solution. Rather, its impact depends heavily on the context, being shaped by institutional objectives, regional characteristics, and the level of digital maturity.

Museums primarily utilize AI for interpretation, preservation, and the digital mediation of cultural heritage. Theaters, especially those in regional areas, employ AI-assisted social media strategies and content analytics to enhance their reach, attract visitors, and foster emotional connections with their audiences.

Digital cultural platforms exhibit the highest degree of AI integration. Personalization algorithms and user data analysis constitute the core operational mechanisms. Creative industries utilize AI as a primary driver of innovation and the creation of new artistic forms.

The study confirms that artificial intelligence (AI) contributes to sustainable cultural development by augmenting rather than replacing human creativity. This enables cultural organizations to proactively respond to changes in audience behavior, technological developments, and policy requirements.

The qualitative benefits of AI, such as enhanced adaptability, strategic coherence, and creative diversity, indicate that its thoughtful implementation is essential for creating resilient cultural ecosystems within the context of digital transformation.

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THEORETICAL ASPECTS OF ORGANISING THE FINANCING OF INVESTMENT PROJECTS IN CONTEMPORARY CONDITIONS

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ТЕОРЕТИЧЕСКИЕ АСПЕКТЫ ОРГАНИЗАЦИ ФИНАНСИРОВАНИЯ ИНВЕСТИЦИОННЫХ ПРОЕКТОВ В СОВРЕМЕННЫХ УСЛОВИЯХ

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Abstract

The article discusses the theoretical and methodological foundations of organising the financing of investment construction projects in the context of modern economic development. It shows that the effectiveness of construction projects depends on the quality of financial mechanisms, the level of institutional support, and the state's ability to create a favourable investment environment. It concludes that there's a need to improve project financing models, expand public-private partnership mechanisms, and introduce innovative tools for raising capital.

Аннотация

В статье рассматриваются теоретико – методологические основны организации финансирования инвестиционных строительных проектов в условиях современного экономического развияти. Показано, что эффективность реализации строительных проектов определяется качеством финансовых механизмов, уровнем институционального обеспечения и способностью государства формировать благоприятную инвестиционную среду. Делается вывод о необходимости соверошенствования моделей проектного финансирования, расширения механизмов государственно – частного партнёрства и внедрения инновационных инструментов привлечения капитала.

Keywords: *investment project, construction financing, project financing, capital investments, housing construction, financial mechanisms, investment activities in construction, crowdfunding.*

Ключевые слова: *инвестиционный проект, финансирование строительства, проектное финансирование, капитальные вложения, жилищное строительства, финансовые механизмы, инвестиционная деятельность строительства краудфандинг.*

Строительная отрасль, являясь одним из ключевых драйверов экономического роста нуждается в устойчивых и эффективных механизмах финансирования, обеспечивающих воспроизводство капитала и создание обьектов социально – экономической инфраструктуры. В этих условиях организация финансирования инвестиционных проектов становится стратегически значимой задачей, определяющей возможность модернизации строительного комплеска, повышения его конкурентоспособности и удовлетворения потребностей населения в жилье и общественных пространствах

Финансовая составляющая инвестиционных строительных проектов играет ведущую роль в системе последовательных процессов способствующих реализации готовой строительной продукции. Само понятие отражает неразрывную связь строительной и инвестиционной деятельности. Процесс создания строительной продукции взаимосвязан с генерированием финансовых потоков проекта, а конечным результатом деятельности является получение прибыли. Острасль жилищного строительства играет одну из ключевых ролей в экономике страны, а ее стабильность напрямую завист от эффективности применяемых моделей финансирования.

Очевидно, что любая деятельност предприятий тесно связана с вложением инвестиций. Для того чтобы реализовать цели инвестирования, предполагается создание инвестиционного

проекта, который позволит всем участникам проекта получить необходимую информацию, влияющую на принятие решения о целесообразности вложения средств.

Понятие «инвестиционный проект» имеет множество трактовок, и не всегда данный термин понимается однозначно. Согласно {2} проект приставляет собой комплексный системный процесс, направленный на изменения всех областей жизни людей.

Другие авторы инвестиционным проектом считают «Совокупность инвестиций и генерируемых ими доходов». На наш взгляд данное определение также не отражает всей сути понятия «проект», как совокупности целей и обоснования его целесообразности.

Согласно {3} под инвестиционным проектом понимается обоснование экономической целесообразности, объема и сроков осуществления капитальных вложений, в том числе необходимая проектная документация, разработанная в соответствии с законадательством, а также описание практических действий по осуществлению инвестиций (бизнес-план).

Более подробно суть проекта показывает Закон Республики Таджикистан «Об инвестициях», согласно котораму под инвестиционным проектом понимается стратегически важный коммерческий проект, предусматривающий привлечение инвестиций для развития определенной сферы экономики Республики Таджикистан и повышения уровня жизни населения Республики Таджикистан.

Каждый строительный проект проходит определенные стадии разработки: предынвестиционную стадию, инвестиционную стадию и заключительную стадию. Предынвестиционный этап включает в себя разработку и согласование концепции проектирования, сравнение различных вариантов, создание и утверждение проектных предложений, подготовку к строительству, проведение технико – экономических обоснований, рассмотрение и утверждение плана проекта, получение разрешений на строительство и составление плана развития бизнеса для проекта.

Инвестиционный этап характеризуется высокий стоимостью проекта. сумма инвестиций. На данном этапе большая часть работы по реализации проекта осуществляется: организацией закупок и поставок (закупка проектных и измерительных работ, поставка оборудования, закупочные работы и заключение контрактов), строительно – монтажными работами. На заключительном этапе выполняются пусконаладочные работы, и сдается готовое здание, установка используется, т.е. достигается конечная цель проекта и обобщаются результаты.

Традиционно долгосрочные проекты, такие как производство энергии, добыча полезных ископаемых, строительство газопроводов, строительство автомобильных или железных дорог, считаются рискованными проектами из-за того, что эти проекты требуют крупных инвестиций в акционерный капитал. Однако, принимая во внимание важность этих секторов для экономики каждой страны, в случае успеха проекта, размер прибыли спонсоров проекта от реализации проекта также будет огромен.

Эффективность инвестиционных процессов в строительстве определяется не только наличием капитала, но и качеством механизмов управления им, структурой финансовых потоков и способностью государства и бизнеса формировать институциональную среду, благоприятную для притока инвестиций

Проектному финансированию присущи следующие характеристики:

1. Традиционно метод проектного финансирования используется для долгосрочных, высоко рискованных и капиталоемких проектов.

2. При проектом финансировании спонсорам обычно предоставляется кредит для реализации проекта на условиях безвозмездного финансирования или финансирования с ограниченными ресурсами, что является ключом к привлечению спонсоров для осуществление долгосрочных, капиталоемких проектов. Однако денежных потоков и октивов отдельного юридического лица в рамках Проекта обычно недостаточно для обеспечения кредита. Таких образом, кредиторам требуется кредитная поддержка наряду с денежными потоками и активами проекта, гарантиями, рекомендательными письмами, контрактные обязательства всех учасников, таких как спонсоры, поставщики, подрядчики, третьи стороны, правительство и т.д., чтобы иметь возможность нести кредитные риски, но не риски акционерного капитала.

3. Проектное финансирование позволяет распределить все риски, возникшие в рамка проекта и между участниками проекта. Спонсоры стремятся избежать проектных рисков, в то время как кредиторы также не осуществляют финансирование без достаточной кредитной поддержки; следовательно, участники, объединят свои интересы, вынуждены искать решения,

например, распределят риски между собой таким образом, чтобы каждый участник мог разумно нести их в течение периода реализации проекта. Как правило, в период проектирования и строительства риски проекта выше, пока проект не приносит прибыль, в то время как после этапа запуска в эксплуатацию долг может быть погашенза счет денежных потоков от реализации проекта. После идентификации спонсоры могут управлять рисками путем удержания, нейтрализации или передачи другим участникам.

В ходе подготовка технико – экономического обоснования проекта риски выявляются и анализируются с помощью нескольких конкретных сценариев. Существует несколько инструментов хеджирования {3}, с помощью которых конкретные риски могут быть распределены между участниками. Например, риски, связанные с перерасходе средств, подрядчик может покрыть строительные дефекты или задержки, заключив контракты под ключ, по которым подрядчик обязан взять на себя обязательства (в виде заранее определенных убытков, штрафных санкций, компенсаций или других гарантий, таких как гарантии исполнения обязательств, право проектной компании удерживать оплату за некачественное или несвоевременное выполнение работ и т.д.).

Риски, связанные с поставкой товаров, услуг или оборудования, необходимых для реализации проекта, могут быть снижены путем заключения с поставщиками долгосрочных соглашений о поставках. Другие возможные риски, может быть снижены с помощью хорошо подготовленного технико – экономического обоснования.

4. Проектное финансирование позволяет спонсорам не учитывать финансовые и проектные обязательства на балансе. Основной целью внебалансового финансирования является сокращение задолженности компаний – спонсоров для поддержания минимального соотношения долга к собственному капиталу, так называемых долговых обязательств, поэтому, если копания нарушит свои долговые обязательства, кредиторы будут считать, что компания не является финансово устойчивой.

5. Одним из перспективных инструментов, призванных помочь в решении проблемы финансового обеспечения инновационных идей, является краудфандинг, который на публичных платформах организует площадки для совместного финансирования потенциально интересных новшеств.

Под краудфандингом понимается оди н из способов совместного вложения денежных средств в проект, для коллективного финансирования реализации на практике идеи других людей. Краудфандинг предоставляет возможность вплотную изучитьи расширать целевую аудиторию, на которую направлено нововведение, узнать ее потребности и протестировать идею. Он дает потенциальным инвестором уникальную возможность принять участие во вложении свободных денежных средств в развитие новшеств и заработать на этом. А автором он помогает найти необходимое финансирование в достаточно короткие сроки и реализовать идеи, которые вызывают интерес в сообществе заинтересованных пользователе интернет – площадок.

Краудфандинг – одна из самых быстрорастущих форм инвестирования в жилую и коммерческую недвижимость. Согласно прогнозу Всемирного банка, к 2025 году объем индустрии краудфандинга может вырасти до 96 миллиардов долларов. Основной целью краудфандинга является привлечение инвесторов через краудфандинговые платформы для реализации конкретного проекта, который может осуществляться отдельными лицами, группами физических лиц, физическими или юридическими лицами.

Выводы. Проектное финансирование – это финансовый инструмент, который структурирован под конкретный, высокорискованный, затратный и реализации проекта, и активов проектной компании. Риски должны нести участники проекта, но не сам проект. Проектная компания, не устанавливает долговых обязательств перед спонсором.

Хорошо структурированный проект с тщательным анализом всех рисков гарантирует успешную реализацию проекта. В Таджикистане правительство автивно поддерживает большинство инвестиционных проектов, поскольку основные инвестиционные проекты являются стратегически важными для экономики, такие как строительство заводов, дорог, гидроэлектростанции, разработка новых технологий и т.д.

Таким образом, инвестиционные строительные проекты представляют собой сложные организационно – экономические системы, эффективность которых определяется качеством модели финансирования, уровнем институциональной поддержки и степенью управления рисками. В современных условиях возрастающей неопределенности особое значение

приобретают проектное финансирование, механизмы государственно – частного партнёрства и инновационные инструменты привлечения инвестиций. Формирование устойчивой финансовой архитектуры позволяет не только повысить результативность строительной отрасли, но и способствует социально – экономическому развитию страны в целом.

Также, следует внедрит инновационные формы привлечения финансов для реализации проектов, такие как краудфандинг представляющий собой инновационный инструмент для цифровой трансформации мировой финансово – инвестиционной системы. Возрастающая популярность краудфандинга объясняется простотой, быстротой и доступностью сбора средств по сравнению с государственным инвестированием и сложными процедурами банковского кредитования.

DIGITAL TRANSFORMATION IN ACCOUNTING AND AUDITING

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Abstract

Digital transformation has become one of the most significant drivers of change in contemporary accounting and auditing practices. The rapid development of information technologies, data analytics, automation tools, and artificial intelligence has fundamentally reshaped traditional accounting systems and audit methodologies. This article aims to examine the essence, directions, and implications of digital transformation in accounting and auditing, with particular attention to its impact on transparency, efficiency, and decision-making quality in enterprises. The study is based exclusively on recent academic research and professional publications focusing on digitalization, continuous auditing, digital twin technologies, and advanced data-driven approaches in accounting and audit systems.

The research highlights that digital transformation in accounting is not limited to the automation of routine operations but represents a comprehensive restructuring of accounting processes, information flows, and control mechanisms. Modern accounting systems increasingly rely on integrated digital platforms, enterprise resource planning systems, and real-time data processing, which enable higher accuracy, timeliness, and reliability of financial information. In parallel, auditing practices are undergoing profound changes through the adoption of continuous auditing models, audit analytics, and big data technologies, allowing auditors to move from periodic inspections to ongoing risk-based assurance.

Special attention is paid to the role of advanced technologies, including big data analytics and digital twin concepts, in enhancing audit effectiveness and strengthening internal control systems. The article also analyzes sector-specific features of digital transformation, particularly in telecommunication enterprises, where complex operations and large data volumes require innovative accounting and auditing solutions. The experience of both developing and developed economies demonstrates that digitalization contributes to improved resource management, increased transparency, and stronger accountability.

At the same time, the study identifies key challenges associated with digital transformation, such as technological complexity, data security risks, regulatory adaptation, and the need for professional competencies. The findings confirm that successful digital transformation in accounting and auditing requires a balanced integration of technology, organizational change, and professional judgment. The results of the study contribute to the academic discussion on digital accounting and auditing and provide practical insights for enterprises and regulators seeking to enhance the effectiveness of financial management in the digital economy.

Keywords. *financial information systems; audit analytics; continuous auditing; accounting automation; digital twin; enterprise transparency; data-driven decision-making*

Introduction

Digital transformation has emerged as a strategic priority for organizations operating in increasingly complex and data-intensive environments. In recent years, accounting and auditing functions have experienced substantial changes driven by the rapid diffusion of digital technologies, including automation, data analytics, and integrated information systems. Traditional accounting models, which relied heavily on manual processing and periodic reporting, are progressively being replaced by digital platforms capable of real-time data collection, processing, and analysis.

The relevance of digital transformation in accounting and auditing is particularly evident in sectors characterized by high transaction volumes and technological intensity, such as telecommunication enterprises. In such environments, conventional accounting and audit approaches are often insufficient to ensure transparency, accuracy, and effective control. As noted by Pashayeva (2024), the digitalization of accounting and auditing in communication enterprises enables the integration of operational and financial data, thereby enhancing the reliability of financial reporting and managerial decision-making.

The transformation of auditing practices is closely linked to advancements in digital accounting systems. Continuous auditing models, supported by automated controls and real-time data access, allow auditors to move beyond traditional ex post verification toward proactive risk assessment and

monitoring. Pashayeva (2025) emphasizes that the integration of continuous auditing with digital twin technologies provides a comprehensive framework for evaluating enterprise processes and identifying deviations in a timely manner.

From a broader perspective, digital transformation in accounting and auditing contributes to improved efficiency, transparency, and accountability within organizations. International research highlights that the adoption of advanced digital tools supports more effective resource management and enhances the strategic role of accounting and auditing functions (Yerdavletova & Bimendiyeva, 2024). However, the transition to digital models also presents significant challenges, including technological complexity, regulatory adaptation, and the need for new professional competencies.

The aim of this article is to analyze the key dimensions of digital transformation in accounting and auditing, identify its practical implications, and assess its impact on organizational performance. The study synthesizes recent academic findings and professional insights to provide a structured understanding of how digital technologies reshape accounting and auditing practices. The article is organized as follows: the next section discusses the theoretical foundations of digital transformation, followed by an analysis of digitalization in accounting systems, changes in auditing practices, sector-specific applications, and the challenges and future directions of digital accounting and auditing.

Theoretical foundations of digital transformation

Digital transformation is commonly understood as a multidimensional process that involves the integration of digital technologies into all areas of organizational activity, fundamentally altering how value is created and delivered. In the context of accounting and auditing, digital transformation extends beyond the adoption of new software solutions and encompasses changes in processes, structures, and professional roles.

Reis et al. (2018) conceptualize digital transformation as a strategic phenomenon driven by technological innovation, organizational change, and external environmental factors. Their framework emphasizes that successful digital transformation requires alignment between technological capabilities and organizational objectives. Applied to accounting and auditing, this perspective suggests that digital tools must be embedded within coherent governance and control systems to generate sustainable benefits.

Recent studies highlight that digital transformation in accounting is closely associated with the increasing use of integrated information systems, automation technologies, and data analytics. Sampaio and Silva (2025) argue that automation and artificial intelligence enhance the efficiency and accuracy of accounting processes while enabling accountants to focus on analytical and advisory functions. This shift reflects a broader transformation of the accounting profession from transaction-oriented activities to value-added services.

Auditing theory has similarly evolved in response to digitalization. The availability of large volumes of structured and unstructured data has given rise to new audit methodologies based on continuous monitoring and advanced analytics. Vasarhelyi et al. (2015) underline that big data technologies expand the scope of audit evidence and support more comprehensive risk assessments. As a result, auditing is increasingly characterized by ongoing assurance rather than periodic evaluations.

The theoretical foundations of digital transformation in accounting and auditing thus rest on the interaction between technological innovation, organizational adaptation, and professional judgment. Understanding these foundations is essential for analyzing how digitalization reshapes accounting systems and audit practices, as well as for addressing the challenges associated with the implementation of digital solutions in diverse organizational contexts.

Digitalization of accounting systems

The digitalization of accounting systems represents one of the core components of digital transformation in financial management. Traditional accounting systems, which were primarily based on manual data entry and periodic reporting, are increasingly being replaced by automated and integrated digital platforms. These systems enable real-time data processing, reduce human error, and improve the consistency and reliability of accounting information.

One of the most significant outcomes of accounting digitalization is the automation of routine accounting operations. According to Sampaio and Silva (2025), automation technologies significantly reduce the time required for data processing and reconciliation, while simultaneously increasing the accuracy of financial records. Automated accounting systems allow enterprises to standardize accounting procedures and ensure compliance with internal and external reporting requirements.

The implementation of enterprise resource planning (ERP) systems has further accelerated the digital transformation of accounting. ERP-based accounting systems integrate financial data with

operational, logistical, and managerial information, creating a unified information environment. Ionescu and Barna (2021) emphasize that ERP systems enhance transparency and traceability by linking accounting entries directly to underlying business processes. This integration supports more effective internal control and facilitates timely managerial decision-making.

Digital accounting systems also play a critical role in improving the quality of financial information. Real-time data availability enables organizations to generate up-to-date financial reports and performance indicators, which are essential in dynamic and competitive environments. Pashayeva (2024) notes that in telecommunication enterprises, digital accounting systems support the processing of large transaction volumes and complex revenue streams, thereby strengthening the accuracy and reliability of financial reporting.

From a broader perspective, accounting digitalization contributes to enhanced organizational efficiency and accountability. Yerdavletova and Bimendiyeva (2024) argue that digital accounting systems improve resource management by providing comprehensive and timely information for planning and control. However, the successful implementation of digital accounting solutions requires substantial investments in technology, data governance, and professional training. Without adequate organizational readiness, digitalization initiatives may fail to deliver their expected benefits.

Overall, the digitalization of accounting systems constitutes a fundamental shift in the way financial information is generated, processed, and utilized. This transformation lays the foundation for advanced auditing practices and supports the transition toward more transparent and data-driven organizational models.

Transformation of auditing practices

The transformation of auditing practices is closely linked to the digitalization of accounting systems and the increasing availability of data. Traditional audit approaches, which relied on sample-based testing and periodic inspections, are gradually being replaced by technology-enabled models that emphasize continuous monitoring and comprehensive data analysis.

One of the most notable developments in this area is the emergence of continuous auditing. Continuous auditing refers to the use of automated procedures and real-time data access to provide ongoing assurance on financial and operational information. Pashayeva (2025) highlights that continuous auditing enhances audit effectiveness by enabling timely identification of risks, errors, and irregularities. This approach allows auditors to move from retrospective verification to proactive risk management.

The application of big data technologies has further transformed audit methodologies. Vasarhelyi et al. (2015) emphasize that big data analytics expands the scope of audit evidence by incorporating large volumes of structured and unstructured data. Advanced analytical tools enable auditors to detect patterns, anomalies, and trends that may not be observable through traditional audit techniques. As a result, audit quality and reliability are significantly improved.

Digitalization also affects the role and competencies of auditors. As auditing becomes more technology-driven, auditors are required to develop new skills in data analytics, information systems, and digital risk assessment. Quraishi et al. (2025) argue that the impact of digitalization on auditing is particularly significant in developing economies, where digital tools can enhance audit coverage and strengthen institutional accountability.

Sector-specific studies demonstrate that digital auditing practices are especially relevant in industries characterized by complex processes and high data intensity. Pashayeva (2025) shows that in telecommunication enterprises, the integration of digital auditing tools supports more effective control over revenue assurance, operational efficiency, and regulatory compliance. These findings confirm that digital transformation fundamentally reshapes the objectives, methods, and outcomes of auditing.

Despite its advantages, the digital transformation of auditing also presents challenges, including data security risks, regulatory uncertainty, and resistance to change. Addressing these challenges requires coordinated efforts by enterprises, auditors, and regulators to ensure that digital auditing practices are both effective and trustworthy.

Digital Twin and advanced technologies in accounting and auditing

Advanced digital technologies have become integral to the transformation of accounting and auditing systems, enabling organizations to move toward more predictive, transparent, and adaptive models of financial control. Among these technologies, the concept of the digital twin has gained increasing attention as an innovative tool for enhancing both accounting and auditing practices.

A digital twin can be defined as a virtual representation of physical assets, processes, or systems that is continuously updated using real-time data. In the context of accounting and auditing, digital twin

technology allows organizations to model financial and operational processes, simulate alternative scenarios, and monitor performance dynamically. Pashayeva (2025) emphasizes that the integration of digital twin models with continuous auditing frameworks enables auditors to assess enterprise activities in real time and identify deviations from expected patterns more effectively.

The application of digital twin technology extends the traditional boundaries of accounting information systems. By linking financial data with operational indicators, digital twins provide a holistic view of enterprise performance. This integration enhances the relevance of accounting information for managerial decision-making and strategic planning. Pashayeva (2024) argues that in communication enterprises, where service delivery processes are complex and highly automated, digital twin-based accounting systems support more accurate cost allocation and revenue recognition.

In auditing, digital twin technology complements big data analytics and continuous auditing approaches. As noted by Vasarhelyi et al. (2015), advanced analytical tools improve the auditor's ability to process large datasets and identify anomalies. When combined with digital twins, these tools enable auditors to compare actual performance with simulated benchmarks, thereby strengthening risk assessment and audit planning. This approach reduces reliance on historical data and supports forward-looking assurance.

Artificial intelligence and automation further enhance the effectiveness of digital accounting and auditing systems. Sampaio and Silva (2025) highlight that AI-driven tools support automated classification, anomaly detection, and predictive analysis, contributing to higher audit quality and efficiency. However, the adoption of such technologies also raises concerns related to data governance, model transparency, and professional judgment. Effective implementation therefore requires clear regulatory frameworks and robust internal controls.

Overall, the integration of digital twin technology and advanced digital tools represents a significant advancement in accounting and auditing practices. These technologies enable organizations to move toward more proactive, data-driven, and resilient financial management models, while also posing new challenges that must be carefully addressed.

Digital transformation in telecommunication enterprises

Telecommunication enterprises represent a particularly relevant context for analyzing digital transformation in accounting and auditing due to their high level of technological complexity, extensive infrastructure, and large volumes of transactional data. The rapid growth of digital services and customer interactions in this sector necessitates advanced accounting and auditing solutions capable of ensuring transparency, efficiency, and regulatory compliance.

Digital transformation in telecommunication accounting is primarily driven by the need to process and analyze large-scale data generated by diverse service offerings. Pashayeva (2024) demonstrates that the digitalization of accounting systems in mobile communication services enables more accurate revenue recognition, improved cost control, and enhanced financial reporting. Integrated digital platforms allow telecommunication enterprises to consolidate financial and operational data, thereby improving the consistency and reliability of accounting information.

Auditing practices in telecommunication enterprises have also undergone significant transformation. Traditional audit approaches are often insufficient to address the complexity and speed of operations in this sector. Pashayeva (2025) highlights that the adoption of continuous auditing and digital twin technologies enhances audit coverage and supports real-time monitoring of key risk areas. This approach is particularly effective in addressing issues related to revenue assurance, fraud prevention, and compliance with regulatory requirements.

International experience further confirms the importance of digitalization in enhancing the effectiveness of accounting and auditing in telecommunication enterprises. Pashayeva (2024) and Yerdavletova and Bimendiyeva (2024) note that digital accounting and auditing systems contribute to improved resource management and operational efficiency by providing timely and comprehensive information for decision-making. These findings are consistent with broader international research on the impact of digital transformation on organizational performance.

Despite its benefits, digital transformation in telecommunication enterprises also presents specific challenges. These include the integration of legacy systems, data security risks, and the need for specialized professional competencies. Quraishi et al. (2025) argue that addressing these challenges requires a coordinated approach involving technological investment, regulatory support, and continuous professional development.

In summary, telecommunication enterprises illustrate the transformative potential of digital accounting and auditing systems. The sector's experience demonstrates how advanced digital

technologies can enhance transparency, efficiency, and accountability, while also highlighting the importance of strategic planning and effective governance in managing digital transformation.

Impact of digitalization on efficiency and transparency

Digitalization has a transformative impact on the efficiency and transparency of accounting and auditing systems by reshaping how financial information is generated, processed, and communicated. The integration of digital technologies enables organizations to move away from fragmented, manual procedures toward automated, real-time, and data-driven financial management models. This transformation significantly enhances the operational effectiveness of accounting functions and strengthens the transparency of financial reporting and assurance processes.

Table 1.

Impact of digitalization on efficiency and transparency in accounting and auditing

Digital Tool / Approach	Impact on Efficiency	Impact on Transparency	Accounting Implications	Auditing Implications
Accounting automation	High reduction in processing time and operational costs	Medium improvement through standardized procedures	Faster transaction processing, reduced human error	Indirect support through reliable data
ERP systems	High efficiency due to system integration	High transparency via unified data environment	Integrated financial and operational reporting	Strong audit trail and data traceability
Continuous auditing	Medium efficiency through automation of controls	Very high transparency due to real-time monitoring	Continuous access to accounting data	Ongoing risk-based assurance
Big data analytics	High efficiency in data analysis and forecasting	High transparency through comprehensive data coverage	Data-driven decision support	Enhanced risk detection and anomaly analysis
Digital twin technology	Medium efficiency via process simulation	High transparency through virtual process modeling	Improved cost allocation and performance analysis	Predictive audit and scenario testing

Source: Compiled by the author based on Pashayeva (2024, 2025), Vasarhelyi et al. (2015), Ionescu and Barna (2021), and Sampaio and Silva (2025).

ANALYSIS AND EVALUATION

The data presented in Table 1 illustrate the differentiated impact of digital technologies on efficiency and transparency in accounting and auditing systems. The findings confirm that digitalization does not affect all dimensions of financial management uniformly; rather, each digital tool contributes to efficiency and transparency in distinct ways.

Accounting automation demonstrates the strongest impact on operational efficiency by significantly reducing processing time and minimizing human error. However, its direct contribution to transparency remains moderate, as transparency improvements largely depend on system integration and data accessibility rather than automation alone (Sampaio & Silva, 2025). This indicates that automation should be viewed as a foundational element rather than a comprehensive solution for transparency enhancement.

ERP systems exhibit a balanced and substantial impact on both efficiency and transparency. By integrating financial data with operational processes, ERP platforms create a unified information environment that supports real-time reporting and consistent data flows. As emphasized by Ionescu and Barna (2021), such integration strengthens audit trails and improves data traceability, making ERP systems particularly valuable for both accounting control and audit assurance.

Continuous auditing shows a comparatively moderate effect on efficiency but delivers the highest level of transparency. Real-time monitoring and automated control mechanisms allow auditors to identify risks and irregularities promptly, thereby improving the relevance and timeliness of audit findings. Pashayeva (2025) highlights that this approach represents a fundamental shift from retrospective verification to proactive assurance, especially in complex and data-intensive sectors.

Big data analytics significantly enhance both efficiency and transparency by enabling the analysis of large and diverse datasets. These technologies support advanced forecasting, anomaly detection, and risk assessment, which are essential for modern auditing practices (Vasarhelyi et al., 2015). Nevertheless, their effectiveness is highly dependent on data quality and analytical expertise.

Digital twin technology, while still emerging, contributes notably to transparency through virtual modeling and simulation of business processes. Its efficiency impact is moderate, as implementation requires substantial technological investment. However, its value lies in predictive analysis and scenario testing, which strengthen both accounting accuracy and audit planning, particularly in telecommunication enterprises (Pashayeva, 2025).

Overall, the evaluation confirms that the greatest improvements in efficiency and transparency are achieved through the combined application of multiple digital tools rather than the isolated use of individual technologies. An integrated digital transformation strategy, supported by appropriate governance and professional competencies, is therefore essential for maximizing the benefits of digitalization in accounting and auditing.

One of the most notable efficiency gains resulting from digitalization is the automation of routine accounting tasks. Automated accounting systems reduce the need for repetitive manual data entry, accelerate transaction processing, and minimize the risk of human error. According to Sampaio and Silva (2025), automation allows accounting professionals to redirect their efforts from time-consuming operational tasks toward analytical and strategic activities, thereby increasing the overall productivity of the accounting function. As a result, accounting departments become more agile and capable of responding to rapidly changing business conditions.

Digitalization also improves efficiency through the integration of accounting systems with other organizational processes. ERP-based platforms link financial data with operational, logistical, and managerial information, creating a unified information environment. Ionescu and Barna (2021) emphasize that such integration enhances process coordination and eliminates data inconsistencies, which are common in decentralized accounting systems. By providing a single source of reliable data, digital accounting systems support faster decision-making and more effective internal control.

Transparency represents another critical dimension of the impact of digitalization on accounting and auditing. Digital systems enhance transparency by increasing the traceability and accessibility of financial information. Each accounting transaction can be directly linked to underlying business processes, enabling managers, auditors, and regulators to verify data origins and assess compliance more effectively. This increased traceability strengthens accountability and reduces information asymmetry between internal and external stakeholders.

In the auditing context, digitalization significantly enhances transparency through continuous auditing and advanced analytical tools. Continuous auditing models enable auditors to monitor financial and operational activities in real time, rather than relying solely on periodic reviews. Pashayeva (2025) demonstrates that real-time access to accounting data improves the relevance and timeliness of audit findings, allowing organizations to identify and address risks at an early stage. This shift from retrospective to proactive assurance represents a fundamental improvement in audit transparency.

The impact of digitalization on efficiency and transparency is particularly pronounced in data-intensive industries, such as telecommunication enterprises. These organizations process vast volumes of transactions and generate complex revenue streams, which pose significant challenges for traditional accounting and auditing systems. Pashayeva (2024) notes that digital accounting and auditing tools enable telecommunication enterprises to improve revenue assurance, cost control, and financial discipline by providing comprehensive and timely information. Enhanced transparency in this sector also supports regulatory compliance and strengthens stakeholder confidence.

At a broader level, digitalization contributes to improved efficiency and transparency in resource management beyond individual organizations. Yerdavletova and Bimendiyeva (2024) argue that digital accounting and auditing systems enhance the quality of information available for public-sector decision-making and national resource management. Reliable and timely financial data support more effective policy formulation, monitoring, and evaluation, thereby increasing the overall transparency of economic governance.

Despite these advantages, the efficiency and transparency gains associated with digitalization are not automatic. They depend on the quality of system implementation, data governance practices, and professional competencies. Without adequate controls and oversight, digital systems may introduce new risks related to data integrity and misuse. Therefore, achieving sustainable improvements in efficiency and transparency requires a balanced approach that combines technological innovation with strong governance frameworks and continuous professional development.

In summary, digitalization substantially enhances the efficiency and transparency of accounting and auditing systems by enabling automation, integration, and real-time analysis. These improvements strengthen the strategic role of accounting and auditing in organizational governance and contribute to more informed decision-making at both the organizational and macroeconomic levels.

Challenges and risks of digital transformation

Despite its significant benefits, digital transformation in accounting and auditing is accompanied by a range of challenges and risks that must be carefully managed. These challenges arise from

technological, organizational, regulatory, and professional factors, and they can undermine the effectiveness of digitalization initiatives if not adequately addressed.

Technological complexity represents one of the most prominent challenges. The implementation of advanced digital systems, such as ERP platforms, big data analytics, and digital twin technologies, requires substantial financial investment and technical expertise. Pashayeva (2024) highlights that in communication enterprises, the integration of new digital solutions with existing legacy systems often poses significant difficulties, leading to implementation delays and increased costs.

Data security and privacy risks are also critical concerns in digital accounting and auditing environments. The increasing reliance on digital platforms and real-time data exchange exposes organizations to cybersecurity threats and unauthorized data access. Vasarhelyi et al. (2015) emphasize that the use of large datasets in auditing requires robust data governance frameworks to ensure data integrity, confidentiality, and reliability. Failure to address these risks may compromise the credibility of financial information and audit outcomes.

Organizational resistance to change constitutes another major barrier to digital transformation. The adoption of digital accounting and auditing systems often necessitates changes in workflows, responsibilities, and professional roles. Quraishi et al. (2025) note that in developing country contexts, limited digital literacy and resistance from personnel can slow the pace of digitalization and reduce its effectiveness. Addressing this challenge requires targeted training programs and strong leadership support.

Regulatory and standard-setting issues further complicate the digital transformation of accounting and auditing. Existing accounting and auditing standards may not fully accommodate digital processes, continuous auditing models, or advanced analytical techniques. Sampaio and Silva (2025) argue that regulatory frameworks must evolve to provide clear guidance on the use of digital technologies while preserving the principles of professional judgment and accountability.

In summary, while digital transformation offers substantial opportunities for improving accounting and auditing practices, it also introduces complex challenges and risks. Effective management of these issues requires a holistic approach that combines technological innovation, organizational change, regulatory adaptation, and continuous professional development.

Discussion

The analysis presented in this study demonstrates that digital transformation fundamentally reshapes accounting and auditing practices by redefining processes, professional roles, and control mechanisms. The reviewed literature consistently highlights that digitalization is not merely a technological upgrade but a comprehensive organizational transformation that affects information flows, decision-making structures, and assurance models.

One of the central findings of this discussion is the convergence between accounting digitalization and the transformation of auditing methodologies. As accounting systems become increasingly automated and data-driven, auditing practices evolve toward continuous and analytical models. The integration of real-time accounting data into audit processes enhances audit relevance and timeliness, as emphasized by Pashayeva (2025). This convergence supports a more proactive approach to risk identification and internal control evaluation.

Another important aspect concerns the growing role of advanced technologies, such as big data analytics and digital twin models. The literature indicates that these technologies significantly expand the analytical capacity of both accounting and auditing systems. Vasarhelyi et al. (2015) and Sampaio and Silva (2025) underline that data-intensive technologies enable auditors and accountants to move beyond descriptive reporting toward predictive and prescriptive analysis. However, this shift also increases dependence on data quality, system reliability, and professional judgment.

Sector-specific evidence, particularly from telecommunication enterprises, further enriches the discussion. Studies by Pashayeva (2024, 2025) show that digital transformation is especially critical in sectors characterized by complex operations and high transaction volumes. In such environments, digital accounting and auditing systems support effective revenue assurance, transparency, and regulatory compliance. These findings are consistent with international research on digitalization in accounting and auditing within both developed and developing economies (Quraishi et al., 2025; Yerdavletova & Bimendiyeva, 2024).

At the same time, the discussion highlights persistent challenges related to digital transformation. Technological complexity, cybersecurity risks, regulatory gaps, and skill shortages remain significant barriers to effective implementation. The literature suggests that addressing these challenges requires

coordinated efforts at the organizational, professional, and regulatory levels. Digital transformation, therefore, should be viewed as an ongoing and adaptive process rather than a one-time initiative.

Overall, the discussion confirms that digital transformation enhances the strategic importance of accounting and auditing while simultaneously raising new questions regarding governance, ethics, and professional responsibility. These issues warrant continued academic attention and practical experimentation.

Conclusion

This article has examined the key dimensions of digital transformation in accounting and auditing, focusing on its theoretical foundations, practical applications, and organizational implications. Based exclusively on recent academic literature, the study demonstrates that digital transformation represents a fundamental shift in the way accounting and auditing functions operate within modern enterprises.

The findings indicate that digitalization significantly improves the efficiency, accuracy, and transparency of accounting systems by enabling automation, real-time data processing, and integrated information environments. In auditing, the adoption of continuous auditing models, big data analytics, and digital twin technologies enhances audit quality and supports proactive risk management. These developments strengthen the role of accounting and auditing as strategic tools for organizational governance and decision-making.

At the same time, the study highlights that the benefits of digital transformation are contingent upon effective implementation and governance. Technological investments must be accompanied by organizational change, regulatory adaptation, and the development of professional competencies. Without these complementary measures, digitalization initiatives may fail to deliver sustainable improvements.

The analysis of telecommunication enterprises illustrates both the transformative potential and the practical challenges of digital accounting and auditing. The sector's experience confirms that advanced digital tools can enhance transparency and accountability in complex operational environments. These insights are particularly relevant for developing economies seeking to modernize their financial management systems.

In conclusion, digital transformation in accounting and auditing is an inevitable and multifaceted process that reshapes professional practices and organizational structures. Future research should further explore the long-term implications of digitalization, including its impact on professional ethics, regulatory frameworks, and the evolving role of accountants and auditors in the digital economy.

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DIGITALISATION OF THE CONSTRUCTION INDUSTRY AS A FACTOR IN THE TRANSFORMATION OF COST ESTIMATES

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ЦИФРОВИЗАЦИЯ СТРОИТЕЛЬНОЙ ОТРАСЛИ КАК ФАКТОР ТРАНСФОРМАЦИИ СТОИМОСТНЫХ РАСЧЁТОВ

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Abstract

The article discusses the impact of digitalisation processes in the construction industry on the transformation of the cost calculation system. Determining the cost of construction is a key element of the investment and construction process, as it serves as the basis for planning capital investments, financing and economic justification of design solutions. With the introduction of digital technologies, traditional methods of cost estimation and pricing are undergoing significant changes. Particular attention is paid to the use of BIM technologies, automated estimation systems and digital regulatory databases as tools for improving the accuracy and transparency of cost calculations. The need to transition to digital models for determining construction costs, taking into account modern technological and economic conditions, is justified.

Аннотация

В статье рассматривается влияние процессов цифровизации строительной отрасли на трансформацию системы стоимостных расчётов. Определение стоимости строительства является ключевым элементом инвестиционно-строительного процесса, так как служит основой для планирования капитальных вложений, финансирования и экономического обоснования проектных решений. В условиях внедрения цифровых технологий традиционные методы сметного нормирования и ценообразования претерпевают существенные изменения. Особое внимание уделено применению BIM-технологий, автоматизированных сметных комплексов и цифровых нормативных баз как инструментов повышения точности и прозрачности стоимостных расчётов. Обоснована необходимость перехода к цифровым моделям формирования стоимости строительства с учётом современных технологических и экономических условий.

Keywords: *digitalisation of construction; cost calculations; estimated cost; BIM technologies; construction economics; pricing.*

Ключевые слова: *цифровизация строительства; стоимостные расчёты; сметная стоимость; BIM-технологии; экономика строительства; ценообразование.*

Цифровизация строительной отрасли — это внедрение информационных технологий в проектирование, строительство и управление объектами недвижимости. Главной ее целью является повышение эффективности строительного процесса: снижение ошибок в проектировании и издержек, улучшение контроля за выполнением строительных работ, повышение безопасности труда, автоматизация документооборота.

Цифровизация строительства в мире началась в последней четверти прошлого века, когда компьютеры начали все больше и больше использовать для создания чертежей и моделей домов жилищного комплекса, мостов, зданий производственных предприятий и других объектов недвижимости.

Концепция BIM существует с 1970-х годов. Первые программные инструменты для моделирования зданий появились в конце 1970-х и начале 1980-х годов и включали продукты для

рабочих станций, такие как система описания зданий Чарльза Истмана, GLIDE, RUCAPS, Sonata, Reflex и серия 4D Gable. Ранние приложения и оборудование, необходимое для их работы, были дорогими, что серьезно ограничивало их распространение.

С помощью этой технологии создаются информационные модели строительных сооружений, ведется разработка проекта, контролируется их строительство, а также их дальнейшая эксплуатация и демонтаж. Главные преимущества информационного моделирования — максимальная наглядность и практически моментальная доступность для всех участников проекта. Это упрощает переработку и систематизацию информации об объекте, уменьшает сроки поиска рациональных решений и время внесения необходимых изменений.

Их использование тоже можно отнести к технологиям цифровизации. Благодаря дронам значительно упростился визуальный осмотр строительных сооружений и инспекция труднодоступных мест: нахождение с помощью камер высокого разрешения на летательных аппаратах трещин, деформаций, невидимых на первый взгляд мест повреждений от воды. Установленная на дронах соответствующая аппаратура также может легко выявлять места утечек тепла и целый ряд других дефектов. Также, с помощью дронов возможно выполнение ряда рутинных или опасных процессов, например, точечные ремонтные работы в труднодоступных местах, например, сварочные работы.

Она также является перспективной технологией. С помощью 3D-печати можно создавать декоративные элементы зданий, модульные конструкции, отдельные компоненты, макеты и прототипы зданий. Одно из главных преимуществ строительной 3D-печати – возможность создания элементов конструкций очень сложной формы. Важным достоинством строительной 3D-печати является сокращение числа нужных для возведения дома работников. Для управления оборудованием достаточно всего нескольких операторов. Плюсом технологии также является сокращение отходов и мусора. Все элементы изготавливаются точно в таком объеме, в котором это необходимо для конкретного проекта. Неиспользованные компоненты легко перерабатываются в новый филамент.

Технология взаимодействующих между собой различных приборов и устройств: камер, электронных браслетов, датчиков. Система может использоваться как при самом строительстве, так и при эксплуатации уже построенного здания, в том числе в структуре ЖКХ. Видеонаблюдение позволяет вести контроль за строительными работами и обеспечивает безопасность объекта. С помощью специальных браслетов можно отслеживать состояние здоровья строителей, предотвращать несчастные случаи. Вмонтированные в здание датчики выявляют повреждения, трещины и другие дефекты на самых ранних стадиях их возникновения.

Технология сбора, анализа и использования больших объемов информации позволяет принимать более обоснованные решения при оценке связанных с различными аспектами строительства объекта рисков: климатическими факторами, экологическими факторами, состоянием грунта. При прогнозировании затрат на строительство Big Data дают возможность спрогнозировать ситуацию на рынке недвижимости, предугадать увеличение или уменьшение трат при изменении логистики транспортных потоков. Очень большую роль аналитика данных играет и для контроля качества на этапе строительства, начиная от выбора участка для него и заканчивая вводом сооружения в эксплуатацию.

Применение искусственного интеллекта также, безусловно, один их самых актуальных трендов в строительной индустрии. По сути, его применение переплетается с большинством обозначенных трендов. Наибольшую эффективность применение ИИ может обеспечивать в прогнозировании. Например, внедрив алгоритмы машинного обучения в инструменты работы с BIM-данными, можно научить программу подбирать оптимальные варианты прохождения коммуникаций без образования коллизий. Или осуществлять подбор альтернативных вариантов при их наличии. Быстро прогнозировать расходы и их превышение от изначальных планов по объекту, на базе уже имеющейся big data по выполненным объектам в сопоставлении с ключевыми характеристиками нового здания (этажность, материалы, геопозиция и т.д.). Анализировать данные с камер видеонаблюдения и мониторинговых приборов для выявления потенциально опасных процессов — в целях повышения безопасности объекта. Предсказывать техническое обслуживание и энергоэффективность, на базе анализа о состоянии оборудования и значимой инфраструктуры.

Эффективное функционирование строительной отрасли в значительной степени определяется достоверностью стоимостных расчётов, поскольку именно они формируют основу для принятия инвестиционных решений, заключения подрядных договоров и контроля эффективности использования финансовых ресурсов. В современных условиях развитие строительного комплекса невозможно без внедрения цифровых технологий, обеспечивающих повышение прозрачности и управляемости инвестиционно-строительных процессов.

Стоимостные расчёты в строительстве представляют собой систему определения затрат на возведение объектов капитального строительства с учётом проектных решений, нормативных требований и рыночных условий. Традиционные подходы к формированию сметной стоимости базируются на нормативных методах, которые, несмотря на их широкое распространение, обладают рядом ограничений. К числу таких ограничений относятся высокая трудоёмкость сметных расчётов, ограниченная актуальность нормативных баз, а также зависимость результатов от субъективных факторов.

В условиях цифровой трансформации экономики строительная отрасль постепенно переходит к использованию современных информационных технологий, позволяющих автоматизировать и интегрировать процессы проектирования, расчёта стоимости и управления строительством. Цифровизация в строительстве представляет собой не только внедрение программных средств, но и изменение методологии формирования и анализа данных, используемых при принятии управленческих решений.

Одним из ключевых направлений цифровизации является внедрение BIM-технологий, которые обеспечивают создание информационной модели объекта строительства, содержащей данные о геометрических, конструктивных, технологических и стоимостных характеристиках. Использование BIM позволяет формировать ведомости объёмов работ в автоматизированном режиме, что значительно снижает вероятность ошибок и повышает точность стоимостных расчётов. При этом любые изменения проектных решений автоматически отражаются в сметной стоимости, что обеспечивает её актуальность на всех стадиях реализации проекта.

Автоматизация сметных расчётов на основе цифровых программных комплексов способствует сокращению сроков подготовки сметной документации и повышению её достоверности. Современные сметные системы интегрируются с цифровыми нормативными базами и рыночными ценами на строительные ресурсы, что позволяет учитывать фактические условия реализации проектов. Это особенно важно в условиях нестабильности цен на материалы, оборудование и трудовые ресурсы.

Цифровые нормативные базы представляют собой развитие традиционной системы сметного нормирования. В отличие от статичных сборников нормативов, цифровые базы данных обеспечивают возможность оперативного обновления информации, анализа статистических данных и адаптации нормативов к современным технологиям строительства. Переход к цифровым нормативам способствует повышению прозрачности формирования сметной стоимости и снижению рисков её искажения.

В последние годы всё большее значение приобретает использование интеллектуальных технологий в системе стоимостных расчётов. Применение методов анализа больших данных и элементов искусственного интеллекта позволяет прогнозировать стоимость строительства на ранних стадиях проектирования, выявлять отклонения фактических затрат от плановых и оценивать экономическую эффективность альтернативных проектных решений. Это формирует предпосылки для перехода от статических смет к динамическим моделям управления стоимостью.

Таким образом, цифровизация строительной отрасли выступает важнейшим фактором трансформации стоимостных расчётов. Внедрение BIM-технологий, автоматизированных сметных систем и цифровых нормативных баз позволяет повысить точность, прозрачность и обоснованность определения стоимости строительства. В современных условиях цифровые технологии становятся неотъемлемым элементом системы управления инвестиционно-строительными проектами и способствуют повышению экономической эффективности строительства в целом.

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MALIGNANT BONE TUMORS: CURRENT STATE OF THE PROBLEM

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Abstract

This scientific and analytical work presents modern world and local-regional data on incidence, mortality, lethality rates and five-year survival of such oncological pathology as malignant bone tumors. The issues of etiology and pathogenesis, features of distribution, modern principles of complex diagnostics, as well as prognosis are covered in detail. The epidemiological characteristics of this pathology in our republic are given in the context of regions of the country.

Keywords: *oncology, malignant bone tumors, bone sarcomas, biomarkers, epidemiology, incidence, mortality, lethality, five-year survival, prognosis.*

Malignant bone tumors (BT) are divided into: osteosarcoma; chondroblastic osteosarcoma; fibroblastic osteosarcoma (osteofibrosarcoma); telangiectatic osteosarcoma; osteosarcoma in Paget's disease of bone; small cell (round cell) osteosarcoma; central osteosarcoma; intraosseous well-differentiated osteosarcoma; parosteal (juxtacortical) osteosarcoma; periosteal osteosarcoma; highly malignant superficial osteosarcoma; intracortical osteosarcoma; aggressive (malignant) osteoblastoma; chondrosarcoma; conventional chondrosarcoma; mesenchymal chondrosarcoma; dedifferentiated chondrosarcoma; malignant giant cell tumor of bone; giant cell tumor (GCT) of bone; Ewing's sarcoma; undifferentiated sarcoma of bone; chordoma; peripheral neuroectodermal tumor; fibrosarcoma [1].

The TNM classification system is applicable to all primary malignant BT except for malignant lymphoma, multiple myeloma, superficial/juxtacortical osteo- and juxtocortical chondrosarcoma. There must be histological confirmation of the diagnosis, allowing to determine the morphological type of the tumor and the degree of malignancy.

The diagnostic criteria are as follows. Complaints about: the presence of a BT, enlargement of peripheral lymph nodes. Anamnesis: the time of tumor onset and/or other symptoms associated with the

tumor, the diagnostic and/or therapeutic measures taken are specified.

Physical examination: palpation of the tumor localization area, determination of size, density, mobility, tenderness, involvement of adjacent anatomical structures and regions; palpation of all accessible groups of lymph nodes (cervical, axillary, inguinal-femoral, etc.).

Laboratory tests: 1) cytological examination (increase in cell size up to giant, change in shape and number of intracellular elements, increase in size of nucleus, its contours, different degrees of maturity of nucleus and other cellular elements, change in number and shape of nucleoli); 2) histological examination (pronounced cellular polymorphism, increase in cell size, pronounced hypochromia, large nuclei contain one or more nucleoli, there are glandular structures of cancer cells in the form of rosettes, many cells in a state of mitosis); 3) immunohistochemical examination of biopsy and surgical material for detailed determination of sarcoma subtype; 4) molecular genetic study of microsatellite instability to determine the possibility of immunotherapy.

Instrumental tests: 1) Ultrasound of abdominal organs and retroperitoneal space (determination of metastatic lesions of abdominal organs and retroperitoneal space); 2) computed tomography (CT) of the chest, abdominal cavity and pelvis (assessment of the pelvic lymph nodes and retroperitoneal space, organic changes in the chest and abdominal organs); 3) magnetic resonance imaging (MRI) of the brain (performed in case of suspected metastatic lesions of the brain); 4) CT of the chest and abdominal cavity (mandatory determination of metastatic lesions of the chest organs); 5) positron emission tomography (PET), PEC/CT of the whole body (performed to diagnose the prevalence of the tumor process or disease progression, or to assess the dynamics of the effectiveness of special treatment); 6) MRI of the brain (if CT is not possible) for alveolar sarcoma, osteosarcoma, Ewing's sarcoma (metastatic lesions of the brain are most often detected).

As noted by Hosseini H. et al. [2], though relatively rare, BT significantly impact patient health and treatment outcomes. This systematic review analyzes the incidence, types, survival rates, and risk factors associated with BT, including both benign and malignant forms. This systematic review was conducted using the keywords "BT," "epidemiology," "benign BT," "malignant BT," "osteosarcoma," "Ewing sarcoma," "chondrosarcoma," "risk factors," and "survival" in electronic databases including PubMed, Scopus, Web of Science, and Google Scholar from 2000 to 2024. The search strategy was based on the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) statement. Finally, 9 articles were selected for inclusion in the study. The systematic review highlights that primary BT can be classified into benign and malignant types, with osteosarcoma being the most prevalent malignant form, particularly among adolescents and young adults. The epidemiology of BT is influenced by factors such as age, gender, geographic location, and genetic predispositions. Recent advancements in imaging techniques have improved the detection of these tumors, contributing to an increasing recognition of their prevalence. Data shows that the limited-duration prevalence of malignant bone tumors has increased significantly. This increase is from 0.00069% in 2000 to 0.00749% in 2018, indicating an increasing recognition and diagnosis of these rare tumors over time. Survival rates vary significantly by tumor type, with approximately 50-60% for osteosarcoma and around 70% for Ewing's sarcoma, though these rates decrease with metastasis. Key risk factors identified include genetic predispositions such as Li-Fraumeni syndrome and TP53 mutations, environmental exposures like radiation, and growth patterns related to height.

The authors emphasize that this systematic review lays the groundwork for further investigations into the epidemiological profile of bone tumors, yet several promising avenues remain for future research. Building on the current findings, future studies could aim to: 1) expand data integration across geographies and populations: the present review focused on studies published in English and derived primarily from databases frequently used in Western countries; future research should seek to incorporate data from non-English literature and diverse geographical regions to enhance the generalizability of results on bone tumor prevalence, risk determinants, and survival patterns; 2) employ prospective and multicenter study designs: moving beyond the retrospective analyses predominating in the current literature, prospective and well-coordinated multicenter studies can help validate and refine the observed associations; these studies would ideally be designed to monitor patients over time, allowing for a more robust assessment of factors such as the impact of genetic predispositions, environmental exposures, and growth patterns on tumor pathogenesis and survival outcomes; 3) leverage advanced methodologies for biomarker discovery: the association between genetic predispositions (e.g., Li-Fraumeni syndrome) and osteosarcoma risk provides a compelling case for further research into specific biomarkers; future perspectives include integrating high-throughput sequencing and other omics technologies to identify genetic and molecular signatures that might predict tumor

behavior or response to treatment; 4) investigate preventive and therapeutic strategies: considering the identified risk factors – including the role of ionizing radiation exposure and rapid growth patterns – targeted prevention strategies should be developed; future research could explore screening protocols for high-risk groups and also evaluate novel therapeutic interventions that modify the underlying biological pathways (e.g., insulin-like growth factor (IGF)-1 signaling) linked to tumorigenesis; 5) incorporate meta-analytic techniques where feasible: although data heterogeneity limited the scope of meta-analysis in the current review, ongoing accumulation of homogeneous and high-quality data may allow for comprehensive meta-analyses in future studies; such efforts could provide more definitive evidence regarding survival rates and the impact of various risk factors on different bone tumor types.

Clinical implications: 1) enhanced early detection and screening: the rising prevalence of malignant bone tumors highlights the need for improved screening protocols; clinicians should consider integrating routine examinations for high-risk populations, particularly those with known genetic predispositions such as Li-Fraumeni syndrome or individuals with a history of significant ionizing radiation exposure; 2) risk stratification and personalized management: given the identified risk factors – including genetic mutations, environmental exposures, and rapid growth patterns – there is a clear rationale for implementing personalized risk assessment strategies; tailoring follow-up, diagnostic testing, and preventive interventions to the individual risk profile could lead to earlier diagnosis and better treatment outcomes; 3) multidisciplinary approach to treatment planning: the variation in survival rates between osteosarcoma and Ewing's sarcoma, and the impact of localized versus metastatic disease, underscore the importance of a coordinated, multidisciplinary approach to patient management; collaboration among oncologists, radiologists, surgeons, and genetic counselors can ensure comprehensive care that addresses the complexities of bone tumor treatment; 4) implementation of genetic counseling and testing: with the significant association between osteosarcoma and genetic conditions such as Li-Fraumeni syndrome, clinicians should consider referring patients with a positive family history or suggestive clinical indicators for genetic counseling and testing; early identification of genetic risks can facilitate timely surveillance and intervention strategies; 5) informed decision-making based on epidemiological insights: the detailed synthesis of prevalence, risk determinants, and survival patterns in this review can aid clinicians in making evidence-based decisions; this includes counseling patients regarding prognosis and potential treatment outcomes, and may also inform the development of local or national guidelines aimed at reducing disease burden; 6) promotion of preventive strategies: the association of environmental factors such as ionizing radiation with an increased risk of developing bone tumors suggests that minimizing unnecessary radiation exposure could be a crucial preventive measure; this calls for the careful consideration of radiation doses in medical imaging and therapeutic procedures, as well as public health initiatives to reduce exposure in high-risk settings.

These clinical implications underscore the importance of integrating epidemiological data into clinical practice, promoting risk-adapted screening and management strategies, and fostering multidisciplinary collaboration to enhance patient outcomes in the field of bone tumor management [2].

At the same time, our colleagues highlight the limitations of this systematic review. They are as follows: 1) language and publication bias: the review exclusively included studies published in English; this language restriction, along with the omission of non-indexed or unpublished studies, may have introduced a publication bias, thereby limiting the comprehensiveness of the evidence base; 2) heterogeneity of study designs and data sources: the included studies varied widely in methodological approaches, sample sizes, and populations studied; this heterogeneity, particularly in data collection and analysis methods, could affect the consistency and comparability of the reported outcomes, potentially reducing the robustness of the synthesized findings; 3) retrospective nature of most studies: a significant proportion of the evidence was derived from retrospective analyses, including database studies and reviews; such designs are subject to inherent limitations (e.g., recall bias, and incomplete data) that may influence the accuracy and reliability of the conclusions related to risk factors and survival patterns; 4) limited assessment of confounding factors: although efforts were made to assess methodological quality using tools like the Joanna Briggs Institute critical appraisal tools, many studies did not thoroughly control for confounding variables, which may have impacted the observed associations between risk determinants and bone tumor outcomes; 5) restricted time frame and data availability: the literature search was confined to publications from 2000 to 2024; this temporal limitation may have excluded earlier but potentially relevant studies and the rapidly evolving nature of cancer diagnosis and treatment may mean that some findings could soon require re-evaluation as new data emerge; 6) reliance on secondary data sources: the review depended heavily on data extracted from established databases [(such as the Surveillance, Epidemiology, and End Results (SEER) database)] and gray literature; while

these sources provide valuable insights, they might also be accompanied by issues related to data completeness, accuracy, and potential reporting biases.

In conclusion, the researchers say that bone tumors represent a critical area within oncology, characterized by their unique epidemiological features and significant impact on affected individuals. This systematic review provides valuable insights into the incidence rates, survival outcomes, and risk factors associated with various types of bone tumors, including both benign and malignant forms. The findings indicate that osteosarcoma remains the most common primary malignant bone tumor, particularly affecting adolescents and young adults. The review highlights the importance of early diagnosis and treatment intervention, as survival rates are significantly better for patients with localized disease compared to those with metastatic conditions. The observed variations in survival rates across different tumor types underscore the need for tailored treatment strategies. Key risk factors identified include genetic predispositions, environmental exposures, and growth patterns, which can inform targeted screening protocols for high-risk populations. The increasing recognition of bone tumors, facilitated by advancements in imaging techniques and heightened awareness among healthcare professionals, suggests a positive trend in early detection. Despite these advancements, there remains a need for ongoing research efforts to improve diagnostic accuracy and treatment strategies further. Enhanced awareness among healthcare providers regarding the epidemiological landscape of bone tumors can lead to timely interventions that ultimately improve patient outcomes. Future studies should focus on novel biomarkers and the application of machine learning techniques to refine diagnosis and treatment approaches for bone tumors [2].

In the study by Vaezi M.A. et al. [3] tried to provide insights into the expression pattern and diagnostic significance of the IGF-1 axis main mediators in three main primary bone tumor types with different degrees of severity. The real-time quantitative reverse transcriptase/polymerase chain reaction [(qRT-PCR) (to analyze IGF-1 receptor (R) gene expression)], the immunohistochemistry (to measure IGF-1R protein), and the ELISA assay (to assess the circulating level of IGF-1, IGF-binding protein (BP)-1, and IGFBP-3) were applied to confirm this hypothesis. A total number of 180 bone tissues (90 tumors and 90 noncancerous adjacent tissues) and 120 blood samples drained from 90 patients with bone tumors and 30 healthy controls were enrolled in the study. The association of IGF-1 axis expression pattern with the patient's clinical pathological characteristics and tumor aggressive features, the diagnostic and predictive values were assessed for all tumor groups. A significantly elevated level of IGF-1R gene and protein was detected in bone tumors compared to the noncancerous bone tissues that were prominent in osteosarcoma and Ewing sarcoma compared to the GCT group. The positive association of the IGF-1R gene and protein level with tumor grade, metastasis, and recurrence was detected in the osteosarcoma and Ewing sarcoma groups. The circulating level of IGF-1, IGFPB-1, and IGFBP-3 were increased in osteosarcoma and Ewing sarcoma and GCT groups that were correlated significantly to the tumor severity. The ability of the IGF-1 axis to discriminate between bone tumors also malignant and benign tumors was considerable. In conclusion, the researchers emphasize that their data indicate that IGF-1R, IGF-1, IGFBP-1, and IGFBP-3 levels are associated with bone tumor malignancy, metastasis, and recurrence, which may serve as biomarkers for osteosarcoma and Ewing sarcoma recurrence.

*In the study on homogeneous and heterogeneous prognostic factors for patients with bone sarcoma [4], the survival of patients with different bone sarcomas and homogeneous and heterogeneous prognostic factors for different types of bone sarcomas were studied. The inclusion criteria were as follows: (i) patients with malignant bone sarcomas, including osteosarcoma, chondrosarcoma, Ewing sarcoma, and chordoma; (ii) patients with clear information on the metastatic sites and surgery treatments; (iii) vital status was recorded and the survival time was provided; (iv) the related variables to be analyzed were complete; and (v) the survival time and related prognostic factors were retrospectively analyzed. The exclusion criteria were as follows: (i) bone sarcomas originated from other sites; and (ii) bone sarcomas diagnosed at autopsy or indicated in death certification. All the data were obtained from the SEER program and organized using the SEER*Stat application (version 8.3.5). The database, named Incidence-SEER 18 Regs Research Data + Hurricane Katrina Impacted Louisiana Cases, Nov 2018 Sub (1975-2016 varying), was released on April 2019. To obtain enough detailed information about metastases, authors collected all patients with malignant bone sarcomas [(adolescents and young adults (AYA) site recode/ World Health Organization (WHO) 2008 = 4 Osseous & Chondromatous Neoplasms)] diagnosed between January 2010 and December 2016. According to the inclusion criteria, the primary site was restricted to "bones and joints" (the ICD-O-3 topographical code: C40.0-C41.9) in the SEER program. A total of 5274 patients who were actively followed up were selected initially. According to "AYA site recode/WHO 2008" in the SEER program, "4.1 Osteosarcoma," "4.2 Chondrosarcoma," and*

"4.3 Ewing tumor," presented osteosarcomas, chondrosarcomas, and Ewing sarcomas, respectively, were selected from these 5274 patients. Because chordoma (defined using the International Classification of Diseases for Oncology, third edition morphological code 9370/3) took up a large proportion of the section "4.4 Other specified and unspecified bone tumors," patients with chordoma were also included in final cohort.

The primary outcome of the survival analysis was the overall survival (OS), which was defined as the time from the diagnosis of bone sarcomas to death by all causes. For subjects who had been lost to follow up prior to death, the last follow-up time is usually calculated as time of death. The OS was used to reveal the survival condition of patients. The survival curve, which is a Kaplan-Meier curve, is the curve describing the survival condition of patient on time. It is important in the survival analysis and can be used to compare the survival difference of various cohorts. Prognostic factors are factors related to the survival of patients and can be used to predict the prognosis of patients. They are determined using Cox proportional hazard regression analysis. They can be used in the prediction of survival outcome and for clinical management. A total of 4732 patients were included with a follow up of 25 (0-83) months. The mean age of patients was 39.7±24.1 years. The 1-year, 3-year, and 5-year OS rate for the entire cohort was 86.2% (95% confidence interval [CI]: 85.2%-87.2%), 70.5% (95% CI: 68.9%-72.1%), and 63.0% (95% CI: 61.2%-64.8%), respectively. Factors including age older than 40 years, higher grade, regional and distant stage, tumor in the extremities, T2 stage, bone and lung metastases, and non-surgery were significantly associated with the poor survival of the entire cohort. The mean OS duration of patients with chordoma, chondrosarcoma, Ewing sarcoma, and osteosarcoma was 66.86 (95% CI: 64.06-69.66), 63.53 (95% CI: 61.81-65.25), 58.06 (95% CI: 55.49-60.62) and 54.91 (95% CI: 53.14-56.69) months, respectively. Compared with chordoma, the hazard ratio and 95% CI for patients with chondrosarcoma, Ewing sarcoma, and osteosarcoma were 1.30 (95% CI: 1.04-1.62; P = 0.023), 1.69 (95% CI: 1.33-2.14; P < 0.001), and 2.00 (95% CI: 1.61-2.48; P <0.001), respectively. Different bone sarcomas showed homogenous and heterogenous prognostic factors. In conclusion, our colleagues note that the best survival was found in patients with chordoma, followed by chondrosarcoma, Ewing sarcoma, and osteosarcoma. Different bone sarcomas showed homogenous and heterogenous prognostic factors, which can be used to assist sarcoma-specific management [4].

Eghtedari A.R. et al. [5] in their study determined the expression pattern, diagnostic value and association of PD-L1, IFN-γ and TGF-β with bone tumor type, severity and recurrence. 300 human samples from patients with osteosarcoma, Ewing sarcoma, and GCT were enrolled. The PD-L1 gene and protein expression were assessed by qRT-PCR and immunohistochemistry, respectively. Enzyme-linked immunosorbent assay and flow cytometry was used to detect cytokines and CD4/CD8 T cell percentages, respectively. A considerable increase in PD-L1 level was detected in bone tumor tissues at both gene and protein levels that was considerable in osteosarcoma and Ewing sarcoma. A positive correlation was detected regarding the PD-L1 and tumor metastasis and recurrence in osteosarcoma and Ewing sarcoma. The increased IFN-γ level was detected in patients with metastatic, and recurrent osteosarcoma tumors that were in accordance with the level of TGF-β in these samples. The simultaneous elevation of IFN-γ and TGF-β was detected in Ewing sarcoma and GCT, also the CD4 + /CD8 + ratio was decreased significantly in patients with osteosarcoma compared to GCT tumors. The elevated levels of PD-L1, TGF-β, and IFN-γ were associated with bone tumor severity that can provide insights into the possible role of this axis in promoting immune system escape, suppression, and tumor invasion.

Wang Z. et al. [6] in their work they say that aggressive benign, malignant and metastatic bone tumors can greatly decrease the quality of patients' lives and even lead to substantial mortality. Several clinical therapeutic strategies have been developed to treat bone tumors, including preoperative chemotherapy, surgical resection of the tumor tissue, and subsequent systemic chemo- or radiotherapy. However, those strategies are associated with inevitable drawbacks, such as severe side effects, substantial local tumor recurrence, and difficult-to-treat bone defects after tumor resection. To overcome these shortcomings and achieve satisfactory clinical outcomes, advanced bifunctional biomaterials which simultaneously promote bone regeneration and combat bone tumor growth are increasingly advocated. These bifunctional bone substitute materials fill bone defects following bone tumor resection and subsequently exert local anticancer effects. In their study, the authors describe the different types of the most common bone tumors and provide an overview of the common treatment options. Our colleagues also review the current progress in the development of bifunctional bone replacement materials that combine osteogenic and anticancer efficacy. To this end, they classify these biomaterials based on their anticancer mechanism resulting from i) the intrinsic properties of the biomaterial, ii) local release of anticancer agents, and iii) biomaterials inducing oxidative stress and iv)

inducing hyperthermia. Accordingly, this review offers researchers, surgeons, and oncologists an up-to-date overview of our current knowledge about bone tumors, their treatment options, and the development of modern bifunctional biomaterials with great potential for clinical application in oncological orthopedics.

Scuderi S.A. et al. [7] focus on the fact that micro ribonucleic acids (miRNAs) are small endogenous noncoding RNAs molecules that regulate gene expression post-transcriptionally. A single miRNA is able to target hundreds of specific messenger RNA (mRNAs) by binding to the 3'-untranslated regions. miRNAs regulate different biological processes such as cell proliferation, differentiation and apoptosis. Altered miRNA expression is certainly related to the development of the most common human diseases, including tumors. Osteosarcoma, Ewing's sarcoma, and chondrosarcoma are the most common primary bone tumors which affect mainly children and adolescents. A significant dysregulation of miRNA expression, in particular of mir-34, mir-21, mir-106, mir-143, and miR-100, has been revealed in osteosarcoma, Ewing's sarcoma and chondrosarcoma. In this context, miRNAs can act as either tumor suppressor genes or oncogenes, contributing to the initiation and progression of bone tumors. The in-depth study of these small molecules can thus help to better understand their biological functions in bone tumors.

Our colleagues point out that despite countless scientific advances, current therapies and diagnostic procedures for osteosarcoma, Ewing's sarcoma, and chondrosarcoma have not yet proven very satisfactory. Thus, continuous research is needed in order to identify new molecular targets and new therapies for osteosarcoma, Ewing's sarcoma, and chondrosarcoma and to improve outcomes and quality of life for patients. Thanks to their direct involvement in biological processes and in human diseases such as tumors, miRNAs could reveal useful treatments and early diagnosis techniques for bone tumors such as osteosarcoma, Ewing's sarcoma and chondrosarcoma. It is well-demonstrated that miRNAs can be valid biomarkers for cancer diagnosis and prognosis. To date, however, the available evidence on miRNAs as diagnostic and prognostic biomarkers for bone tumors is only in the early stages. The present state of knowledge on miRNAs suggests that they are able to regulate osteoblast differentiation and bone formation and that their dysregulation induces bone degeneration and bone-related diseases, thus conferring relevant value for both medicine and basic research. Therefore, further studies are needed in order to better understand their role and function in bone tumors in a way that could be useful for the development of new biomarkers for the treatment and early diagnosis of osteosarcoma, Ewing's sarcoma, and chondrosarcoma. In the field of oncology research, miRNAs represent very interesting molecules to study for the development of new therapeutic approaches to counteract bone tumor progression. Advances in molecular techniques have contributed to better understanding of the molecular mechanisms involved in bone tumors. Thanks to their multiple properties, miRNAs could represent alternatives therapeutic treatment vectors for the management of bone tumors such as osteosarcoma, Ewing's sarcoma, and chondrosarcoma, either alone or in association with common chemotherapy drugs, thereby improving patients' quality of life [7].

Now, as for this pathology in our country at the republican level. The incidence of BT in the Republic of Kazakhstan in 2023 was 0.87 per 100 thousand population (0.93 in 2022), amounting to 174 people in absolute numbers (181 cases a year earlier). The proportion of cases with a diagnosis established for the first time in life, recorded by oncology organizations, was 0.5%, as in 2022. At the same time, 99 men fell ill (proportion - 0.6%), women - 75 (proportion - 0.4%) [8].

Above the average republican level of BT (0.9 per 100 thousand population) was established in 7 regions of the country: Zhetysu - 1.3 (maximum indicator); Turkestan and Almaty - 1.2; Aktobe and the city of Almaty - 1.1; Zhambyl and Atyrau - 1.0. Two regions - North Kazakhstan and Pavlodar - are on par with the national average. This indicator is lower than the national average in 11 regions: West Kazakhstan - 0.4 (the lowest level); Ulytau, Karaganda and Abay - 0.5; Akmola, Kyzylorda, Mangistau regions, as well as in the cities of Astana and Shymkent - 0.6; East Kazakhstan - 0.7; Kostanay - 0.8 regions per 100 thousand people.

Mortality from this pathology was 0.3 per 100 thousand people (0.4 - a year earlier). The regions with the BT mortality rate above the national average (0.3 per 100,000 population) include: North Kazakhstan and East Kazakhstan - 0.8 (maximum level); Akmola, Turkestan and Ulytau - 0.5; Almaty, Kostanay regions and the city of Almaty - 0.4. Zhambyl, West Kazakhstan, Karaganda regions, as well as the cities of Astana and Shymkent are on par with the national average. The lowest rates were noted in Atyrau and Mangistau - 0.0; Aktobe, Zhetysu, Kyzylorda and Pavlodar - 0.1; Abay - 0.2 regions per 100,000 population [8].

The one-year lethality rate was a high 20.8% (19.7% in 2022). At the same time, the ratio between one-year lethality and neglect (stage IV) was 1.8. At the same time, we recall that the farthest from "1"

is the worst ratio between one-year lethality and neglect.

Now, regarding preventive examinations. It should be noted that during large-scale preventive examinations of the population in 2023, significantly more patients with malignant neoplasms were actively identified than in 2022. This is 25,193 patients versus 23,623 patients identified in 2022, i.e. +6.6%. This is due to the further abatement of the epidemiological troubles due to coronavirus and the increased availability of preventive care for the population. The proportion of patients identified during preventive examinations increased from 62.0% to 62.4% of the total number of patients identified per year.

Of course, when analyzing the epidemiological situation, early diagnosis indicators are very important issues.

In general, in terms of the total number of detected cancer cases of all localizations, in 2023 the proportion of forms detected at early stages (0, I-II stages) increased from 66.3% to 67.9%.

As for BT, during preventive examinations the early detection of this pathology increased from 52.6% to 54.4%. The absolute number of BT patients detected during preventive examinations was 92 people (91 - a year earlier).

At the same time, it should be noted that the proportion of BT patients detected at early stages has significantly decreased from 73.6% to 64.1%. In absolute numbers, this is 59 people in 2023 and 67 in 2022, detected at stages I-II of the disease. The regions where the proportion of patients with early stage I of the pathology under consideration is higher than the national average (14.8% and a low 16th rank place) include the following: Kyzylorda - 60.0% (the best indicator); North Kazakhstan - 40.0%; West Kazakhstan - 33.3%; Atyrau and Kostanay - 28.6%; Akmola and Zhetysu - 25.0%; Aktobe - 22.2%; East Kazakhstan - 20.0% and the city of Almaty - 16.0%. The lowest indicators of early diagnosis were recorded in: Abay, Almaty, Zhambyl, Karaganda, Mangistau, Pavlodar and Ulytau regions (the worst indicator is not a single patient detected at stage I of the disease - 0.0%). Next come: the city of Astana - 11.1%; Turkestan region - 12.5% and the city of Shymkent - 14.3% [8].

BT among all nosological forms of malignant tumors by early diagnosis (stages I-II) took 12th place, amounting to 62.1%.

The regions where the proportion of patients with BT, identified at stages I-II is above the national average include the following regions. The undisputed leaders (indicator - 100.0%) include five regions, including Abay, West Kazakhstan, Kyzylorda, North Kazakhstan and Ulytau. Then come: Atyrau and Pavlodar - 85.7%; the city of Astana - 77.8%; Akmola and Zhetysu - 75.0%; Kostanay - 71.4%; Aktobe - 66.7% of the region of the republic. Low rates of early diagnosis were recorded in the following regions. The anti-leader in this indicator and the worst result in the country is the Karaganda region, where not a single patient with this pathology was identified in the early stages of the disease - 0.0%. Mangistau and East Kazakhstan - 40.0%; Zhambyl - 41.7%; the city of Shymkent - 42.9%; Turkestan - 50.0%; Almaty - 58.8% of the region and the city of Almaty - 60.0% [8].

As is clearly seen from the above data, there is a very large spread in the early diagnostics rates across the country, from very good to disappointing. Of course, it is necessary to take into account migration processes and other factors that affect the early diagnostics rates, but nevertheless, the results obtained give reason not to stop there, both for oncologists and traumatologists, radiologists - visual diagnostics doctors, sports medicine doctors, and, of course, for general practitioners, since improving the early diagnostics rates of malignant tumors, as one of the main postulates and one of the main tasks of medicine as a whole, continues to be relevant today.

The proportion of stage IV BT among all nosological forms of malignant neoplasms was 11.2%, and this is the 16th ranking place. In general, in 2023, the share of malignant neoplasms of stage IV in the republic for the sum of all nosologies decreased from 12.58 to 11.7% (from 4790 to 4735 patients). As for the average republican indicator of the share of stage IV (11.2%), the following regions stand out against this background: Abay, Almaty, Atyrau, Zhetysu, West Kazakhstan, Kyzylorda, Kostanay, Pavlodar, North Kazakhstan, Ulytau regions and the city of Astana - 0.0%. Then come: the city of Almaty - 8.0% and the Zhambyl region - 8.3%. In the Karaganda region, every second patient with BT was detected in the terminal stage of the disease - 50.0%. Next come: the city of Shymkent - 42.9%; Mangistau and East Kazakhstan 40.0%; Akmola 25.0%; Aktobe - 22.2% and Turkestan - 12.5% regions.

The morphological verification rate of the disease in the country was 84.6%. In 12 regions out of 20, this is a 100% figure (Abay, Akmola, Aktobe, Atyrau, East Kazakhstan, Zhambyl, West Kazakhstan, Mangistau, Pavlodar, North Kazakhstan, Ulytau regions, as well as the city of Astana). The lowest figure is in the city of Almaty - 44.0%. Further down the list: Zhetysu - 50.0%, Kyzylorda - 60.0%; Kostanay - 71.4%; Karaganda - 83.3%; the city of Shymkent - 85.7%; Almaty - 94.1% and Turkestan 95.8% regions

[8].

The total number of patients with malignant neoplasms registered with specialized oncology organizations of the republic continued to grow and by the end of 2023 amounted to 218,186 people, with an increase of 6.0% compared to the level of the previous year (2022 - 205,822, +5.8%). The overall incidence rate of malignant neoplasms increased by 3.9%, from 1055.3 to 1096.4 per 100 thousand population. The growth of this indicator is due to both the increase in the incidence and detection of pathology, and the increase in the survival rate of cancer patients.

In addition, statistical data on patients diagnosed with malignant neoplasms, who have been under observation for 5 years or more and continue to be observed in 2023, showed that the number of patients under observation by oncological organizations in Kazakhstan for over five years continued to grow and at the end of the reporting year amounted to 117,616 people, with an increase of 6.2% (2022 - 110,790 people, +6.6%) (form No. 7).

One cannot ignore such an important clinical aspect as the coverage in the Republic of Kazakhstan of special treatment for patients diagnosed with BT for the first time in their lives. In 2023, the number of hospitalizations for all nosological forms of malignant tumors in oncological organizations of the country amounted to 108,252 cases (2022 - 101,095), with an increase of 7.1% compared to the previous year, which is associated with a constant increase in the number of cancer patients, improvement of the standardization of oncological care, and the development of palliative and restorative services.

At the end of 2023, the absolute number of BT patients who completed specialized treatment was 83 people, continuing treatment - 64 patients. In percentage terms, the following results were obtained by methods and types of treatment. The overwhelming majority of patients received complex treatment - 53.0%, only surgical - 26.5%, only drug - 9.6%, combined - 2.4%, only radiation - 1.2%, chemoradiation - 1.2%.

Further, regarding the five-year survival of patients. As for BT, at the end of 2023, 1,661 people were registered with the dispensary, or 8.3 per 100 thousand of the population (at the end of 2022 - 1,637 patients, or 8.4 per 100 thousand of the population, respectively).

At the same time, the mortality rate of the observed contingents in 2023 was 3.9%, 4.8% - a year earlier.

The five-year survival rate of patients with BT slightly decreased from 74.0% in 2022 to 73.1% - in 2023 [8].

Summarizing the above, we can conclude that BT, despite not having the highest place in terms of incidence among all existing malignant tumors of other localizations, a priori leads to high disability of this contingent of patients. At the same time, despite the small percentage of patients detected at stage IV, given a number of factors, low rates of early diagnosis do not allow oncologists to "sleep peacefully", since the locally advanced stage III, which significantly prevails over all stages, in addition to the prevalence itself, leads, as indicated above, to aggressive treatment methods and, as a consequence, to disability of these patients, despite the recent development and implementation of various technologies for prosthetics of bone defects. The veiled and variable symptoms, and in some cases their complete absence, the similarity of clinical manifestations with various non-core processes, leads to the neglect of the disease. All this requires both oncologists and, first of all, primary health care workers and, of course, traumatologists, radiologists - visual diagnostic doctors, sports medicine doctors to increase the level of cancer alertness, inform the population about early symptoms that may indicate this pathology or the onset of proliferative changes and conduct high-tech diagnostic measures and, as a result, timely treatment. People from the risk group are recommended to visit specialized specialists annually and, if necessary, undergo an examination.

An epidemiological assessment of the situation with BT in our country suggests that there are sometimes significant differences in the regions not only in incidence rates, but also in the parameters of early diagnosis and mortality from this pathology. In connection with the above, this pathology continues to be a serious problem in modern clinical oncology.

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ACTUAL CLINICAL AND DIAGNOSTIC ASPECTS OF PROSTATE CANCER

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Abstract

This scientific and analytical work presents modern global and local-regional epidemiological data and algorithms for complex diagnostics of such a common oncological pathology as prostate cancer. The issues of etiology and pathogenesis, features of distribution, as well as three basic principles of diagnosis are covered in detail: the role of prostate biomarkers, methods of visualization and histological verification. The epidemiological characteristics of this pathology in our republic are presented in the context of regions of the country.

Keywords: *oncology, prostate cancer, biomarkers, epidemiology, incidence, diagnostics, mortality, lethality, five-year survival rate.*

Prostate cancer (PC) is a malignant neoplasm that arises from the epithelium of the alveolar cell elements of the prostate gland. Histological classification: 1) adenocarcinoma (small acinar, ductal, large acinar, cribriform, solid or trabecular and others); 2) transitional cell carcinoma; 3) squamous cell carcinoma; 4) sarcomotoid; 5) undifferentiated cancer. The morphological classification according to the Gleason scale is applicable only for adenocarcinomas. According to the Gleason classification, the degree of tumor differentiation is assessed on a 5-point scale, where 1 point is the most highly differentiated tumor, 5 points is the least differentiated tumor. The Gleason index is the sum of the degree of differentiation of the glands of the main tumor component and the degree of differentiation of the glands of the second most common tumor component (from 2 to 10 points). The Gleason classification has particular prognostic significance for assessing the results of treatment of PC [1,2].

The criteria for primary diagnostics and subsequent staging of PC are based on anamnesis, physical examination, results of instrumental and laboratory research methods, and pathomorphological conclusion. Complaints and medical history: in the initial stages – asymptomatic; with a tumor within the prostate gland - weakening and intermittency of the urine stream, a feeling of incomplete emptying of the bladder, increased frequency of urination, imperative urge to urinate, stress urinary incontinence;

with local tumor progression - hemospermia, hematuria, urinary incontinence, erectile dysfunction, pain in the suprapubic region and perineum; when metastases appear - pain in the bones, lower back (with ureteral obstruction), swelling of the lower extremities (lymphostasis), paraplegia (compression of the spinal cord), weight loss, anemia, uremia, cachexia. The history of patients with PC should identify hereditary and etiological risk factors. Physical examination includes transrectal digital examination, which can detect: one or more localized nodules; asymmetry of the gland with unclear outlines; almost always mobile rectal mucosa; "bull's horns" symptom: strands of infiltrate spreading from the upper edge of the prostate gland towards the seminal vesicles; in advanced cases - rocky density, blocking the lumen of the rectum, the upper border of which is inaccessible to the finger. Laboratory tests are as follows: 1) general blood test - there are no changes in the initial stages; in later stages, the presence of anemia, of varying severity, is most typical; leukocytosis, increased erythrocyte sedimentation rate; 2) general urine analysis - macro- or microhematuria; slight increase in protein, leukocyturia, bacteriuria. There may be no change in the analysis; 3) biochemical blood test (total protein, urea, creatinine, bilirubin, glucose) - can identify complications in the form of the development of signs of renal failure and concomitant pathology; 4) coagulogram - there may be blood clotting disorders; 5) determination of the level of prostate-specific antigen (PSA) in the blood serum - an increase above 4 ng/ml is noted; 6) molecular genetic study for the presence of mutations in homologous DNA recombination genes (BRCA1, BRCA2, ATM). Indicated for patients with a family history (breast, ovarian, pancreatic and prostate cancer in close relatives) or when PC is diagnosed in a patient aged ≤ 55 years; 7) testing for germline mutations in the MLH1, MSH2, MSH6, PMS2 genes - if Lynch syndrome is suspected or if this syndrome is present in blood relatives. Instrumental studies include radiation and pathological diagnostics [1].

Radiation diagnostics of PC includes [1]:

1. Transrectal ultrasound (TRUS) - recommended for all patients with suspected PC in order to identify pathological areas in the prostate gland and improve the accuracy of transrectal prostate biopsy; a typical echographic picture is hypoechoic focal zones in the peripheral parts of the prostate gland; with an increase in the size of tumor foci, hypo- and hyperechoic areas are possible; in every third case, prostate tumors diagnosed by biopsy are represented by isoechoic areas on TRUS; the routine use of additional techniques to TRUS, such as sonoelastography, ultrasound with contrast, and histoscanning of the prostate gland is not recommended due to the insufficient evidence base; it is not recommended for all patients with an established diagnosis of PC to perform TRUS to determine the extent of the primary tumor.

2. Magnetic resonance imaging (MRI) and computed tomography (CT) - recommended to assess the extent of the primary tumor and, in doubtful cases, based on the results of bone scintigraphy; the use of dynamic magnetic resonance prostatovesiculography with contrast enhancement and an endorectal magnetic coil increases the accuracy of staging; It is not recommended to perform a CT scan of the prostate gland for staging the process; patients with metastases in the pelvic lymph nodes are shown CT/MRI of the abdominal cavity and retroperitoneal space with contrast and chest radiography; if radiographic changes in the lung tissue are detected, a CT scan of the chest organs is indicated; if enlargement of the intrathoracic lymph nodes is suspected, a CT scan of the chest cavity organs with contrast is indicated.

3. Bone scintigraphy is recommended in the presence of unfavorable risk factors (PSA 20 ng/m and Gleason 4 or 5 tumors) and clinical signs of bone metastasis to identify bone metastases; patients with increased accumulation of radiopharmaceuticals undergo radiography or CT or MRI of bones.

4. Positron emission tomography (PET)/CT: 11C-choline PET/CT is not recommended for routine use in primary staging to determine the presence of lymph node metastases due to comparable sensitivity to multiparametric MRI; recommended in doubtful cases based on the results of bone scintigraphy; prostate specific membrane antigen PET/CT has significantly greater specificity and sensitivity compared to traditional diagnostic methods in high-risk patients; place for routine use in clinical practice has not been determined.

Targeted prostate biopsy includes the following aspects [1]: 1) the final diagnosis is based on the results of puncture biopsy of the prostate gland and histological examination; 2) TRUS is the main method of visual control of puncture biopsy for targeted collection of tissue samples from suspected tumor foci; 3) it is possible to perform a prostate biopsy under MRI guidance; for sufficient information content, the biopsy is multifocal in nature, that is, it consists of obtaining several (12 or more) pieces of tissue, each of which has the shape of a column with a diameter of 1-2 mm and a length of 17-20 mm; 4) for prostate adenocarcinoma, for each column indicate the level of differentiation on the Gleason scale, the percentage of the affected area to the total area of the sections, and note signs of perineural invasion

and invasion into the gland capsule; 5) for prostatic intraepithelial neoplasia (PIN), indicate the depth of morphological changes, distinguishing high and low grade PIN; 6) if necessary, prostate biopsy can be performed again after 3-6 months; 7) patients with a biopsy diagnosis should be examined to determine the clinical stage of the disease in accordance with the TNM classification.

As for world data, they are as follows. PC is the third most common cancer and the second most common cancer affecting men worldwide

In a study by Ferlay J. et al. [3] briefly reviews the data sources and methods used to compile the International Agency for Research on Cancer GLOBOCAN cancer statistics for 2020 and summarizes the main findings. National estimates were calculated using the best available data on cancer incidence from population-based cancer registries and mortality from the World Health Organization (WHO) mortality database. Cancer incidence and mortality rates for 2020 by sex and age group were estimated for 38 cancer centers and 185 countries or territories worldwide. There were an estimated 19.3 million (95% uncertainty interval [UI]: 19.0-19.6 million) new cancer cases (18.1 million excluding nonmelanoma skin cancer) and nearly 10.0 million (95% UI: 9.7-10.2 million) cancer deaths (9.9 million excluding non-melanoma skin cancer) worldwide in 2020. The most commonly diagnosed cancers worldwide were breast cancer in women (2.26 million cases), lung cancer (2.21) and PC (1.41) – ranked 3rd; the most common causes of cancer death were lung (1.79 million deaths), liver (830,000) and stomach (769,000).

As noted in their fundamental work by Rafikova G. et al. [4], epidemiological data highlight that PC is an important global health problem, with high incidence and a significant impact on the quality of life of patients. The prevalence of this disease is associated with various factors, including age, heredity and race. Recent research into the genetics of PC has identified several genetic variants that may be associated with an increased risk of developing this disease. However, despite the significance of these results, genetic markers of PC are not currently used in clinical practice as reliable indicators of the disease. Apart from genetics, epigenetic changes also play a crucial role in the development of PC. Aberrant DNA methylation, changes in chromatin structure, and microRNA (miRNA) expression are major epigenetic events influencing tumorigenesis. Current markers of PC, such as PSA, have limitations in terms of sensitivity and specificity. The cost of testing, follow-up procedures, and treatment of false-positive results and overdiagnosis increases overall healthcare costs. Increasing the efficiency of diagnosis and prognosis of PC requires either narrowing the risk group by identifying new genetic factors or increasing the sensitivity and specificity of existing markers. Immunological biomarkers (both circulating and intratumoral), including markers of immune response and immune dysfunction, represent a potentially useful area of research to improve the diagnostics and prognosis of PC. Our review highlights the need to develop new immunological biomarkers to improve the diagnostics, prognosis and treatment of PC. The authors describe the most recent advances in the identification of biomarkers provided by circulating monocytes and tumor-associated macrophages. Colleagues emphasize that biomarkers derived from monocytes and tumor-associated macrophages may provide missing links between genetic predisposition, hormonal metabolism and immune responses in PC.

The WHO estimates that cancer caused 10 million deaths in 2020, accounting for nearly one in six deaths. According to the Global Cancer Observatory (gco.iarc.fr, accessed 10 March 2023), 1,414,259 new cases of PC and 375,304 deaths from this type of cancer were reported worldwide in 2020. Epidemiological studies conducted worldwide have reported the highest incidence of PC among persons aged 75-79 years. In 2022, incidence rates are recorded at 155 cases per 100,000 in ages 55-59 years, 510 cases per 100,000 in ages 65-69 years, and 751 cases per 100,000 in ages 75-79 years [4].

As indicated by Chen S.L. et al. [5], the relationship between the mortality-to-incidence ratio of cancer and differences in cancer treatment between countries is an interesting issue that has rarely been studied. The rankings and total health expenditures of various countries were obtained from the WHO. The authors analyzed the relationship between the variables using linear regression analysis. In their study, they assessed the role of the mortality-to-incidence ratio in 35 countries where the incidence of PC exceeded 5000 cases per year. As expected, high incidence and mortality rates from PC were observed in more developed regions such as Europe and America. However, in less developed regions this ratio was 2.5 times higher. Regarding the relationship between mortality-to-incidence ratio and cancer treatment inequalities, countries with a good WHO ranking and high total health expenditure/gross domestic product had a significant correlation with low mortality-to-incidence ratio. Variations in the mortality-to-incidence ratio of cancer correlate with differences in cancer care between countries, further supporting the role of differences in cancer care in clinical outcomes.

Rebbeck T.R. shows [6] that the incidence of PC varies significantly depending on race, ethnicity and geographic location. These differences may be explained by differences in access to screening and

treatment, differences in exposure to risk factors for PC, and differences in the biology underlying prostate carcinogenesis (including the genomic propensity of some groups to develop biologically aggressive disease). Clearly, access to screening and treatment is critical to the incidence of cancer, but even among geographically diverse populations with similar access to health care (eg, low- and middle-income countries), men of African descent have a higher incidence of PC and worse prognosis. To date, the proportion of PC cases that can be explained by environmental exposures is small, and the impact of these factors on different racial, ethnic, or geographic populations is poorly understood. In contrast, PC has one of the highest heritability rates of all major cancers. Numerous markers of genetic susceptibility have been identified through family studies, candidate gene association studies, and genome-wide association studies. Several PC loci, including risk loci found on chromosome 8q24, have consistent effects across all groups studied to date. However, replication of many susceptibility loci across race, ethnicity, and geographic location remains limited, and as the authors note, more research is needed in specific populations (especially men of African descent) to better understand the underlying genetic basis of PC.

Jacklin C. et al. [7] in their work ""More men die with prostate cancer than because of it" - an old adage that still holds true in the 21st century" demonstrate that the incidence of PC has increased due to PSA testing, making it the most common malignant disease in men. Although curative treatment has increased, mortality from PC has changed little. There is an increasing incidence of over-detection of clinically insignificant PC and active surveillance. Colleagues compared 21st century studies with earlier reports demonstrating how often PC is incidentally discovered at autopsy. A literature review of PubMed and Scopus was conducted using the search terms "prostate cancer or carcinoma," "latent," or "autopsy" as of January 2019. Citations and references from all publications found in this search were manually screened to identify additional articles. As a result, 63 publications were identified between 1898 and 2017, reporting more than 29,000 autopsies on subjects aged 20 to 90 years or older. The prevalence of PC was 21% among all ages; however, the researchers found no significant differences in 21st century studies compared to earlier studies. Incident cases of PC found at autopsy were usually small (~0.5 cc), predominantly low grade, and only rarely (10%) outside the prostate. The prevalence of PC increased with age and was detected in >50% of men aged ≥90 years. The incidence of high-grade PC almost doubled with each age category. In conclusion, the authors note that most cases of PC detected at autopsy remain clinically insignificant. The prevalence of autopsy-detected PC was 30 times higher than the mortality rate from this pathology in each ten-year age category. Therefore, this should be considered when counseling older men about PSA testing, especially in the context of competing comorbidities.

As for our region, i.e. countries of Asia, then Kimura T., Egawa S. In their work [8] they emphasize that the growing trend in the incidence of PC is increasing even in Asian countries, where the incidence has traditionally been low. One possible explanation is changes in lifestyle due to a more Westernized diet. Declines in mortality rates in Australia, New Zealand and Japan since the 1990s may be due to improved treatment and/or early detection efforts. However, the rate is rising in most other Asian countries. In addition, the prevalence of latent and incidental PC in modern Japan and Korea is similar to that in Western countries, suggesting the influence of lifestyle changes on carcinogenesis. Many studies have reported the presence of both congenital and acquired risk factors for PC carcinogenesis. Recent changes in acquired risk factors may be associated with the increasing incidence of PC in Asian countries. This trend may continue, especially in developing countries in Asia.

Wong M.C. et al. [9] analyzed patterns for 36 countries using data obtained from cancer incidence on five continents. Correlations between incidence or mortality rates and socio-economic indicators such as the Human Development Index (HDI) and gross domestic product (GDP) were assessed. Our colleagues found that the highest incidence rates were observed in Micronesia/Polynesia, the USA and European countries. The mortality rate was consistent with the incidence rate, except in Africa, where the mortality rate from PC was the highest. Countries with higher HDI (r=0.58) and GDP per capita (r=0.62) reported higher incidence rates. According to the most recent 10-year data available, most countries have seen an increase in incidence, with sharp increases in incidence rates observed in Asia and northern and western Europe. Significant reductions in mortality rates were reported in most countries, with the exception of some countries in Asia and Eastern Europe, where mortality rates increased. Drawing conclusions, the authors note that in most countries the incidence of PC has increased, and mortality from PC has decreased. However, the reported incidence was higher in countries with higher socio-economic development.

Turkish researchers Ahmed Amar S.A. et al. [10] examined the activity of antioxidant enzymes such as SOD, GSH and CAT and the level of malondialdehyde (MDA), which is an end product of lipid

peroxidation, in serum samples collected from patients diagnosed with PC. It was found that the activity of the antioxidant enzymes SOD, GSH and CAT in groups of patients with PC was significantly lower than in the healthy control group (p<0.05). MDA levels increased in patients suffering from PC. The authors concluded that SOD, GSH, CAT and MDA parameters may play an important role in the etiopathogenesis of PC.

We cannot ignore the issue of PC in transgender women. Deebel N.A. et al. [11] in their work set the goal of critically analyzing the available data regarding the incidence, etiopathogenesis and treatment of PC in this category of patients. An electronic non-systematic literature search was conducted to identify relevant studies. The following search terms were used in the PubMed search engine: "prostate cancer," "male-to-female transsexual," "transgender patient," "androgen + prostate cancer," "estrogen therapy + prostate cancer," and "health care barrier." In addition, a clinical case study conducted at the authors' institution was reviewed and critically discussed. The results are as follows: including our own clinical case, only 10 cases of PC in transgender women were reported. In addition, new literature questions the role of androgens in the development of PC and suggests that estrogen therapy may not be as protective as originally thought. Thus, available evidence suggests that transgender women should be screened for PC in the same manner as non-transgender men. Barriers to care for transgender women include access to resources, deficits in medical knowledge, ethics of transition-related care, diagnosis or pathologization of transgender patients, patient financial constraints, and health care system determinants. The researchers conclude that, although rare, cases of PC in transgender women have been reported. Both the mechanism and the effect of bilateral orchiectomy on the development of the disease are unclear. Future research is needed to examine these factors and further inform treatment and screening regimens for these patients.

Next, let's move on to the issue of diagnosing PC. Sedláčková H. et al. [12] in their work "Prostate Cancer Diagnostic Algorithm as a "Road Map" from the First Stratification of the Patient to the Final Treatment Decision" note that the diagnosis of PC is currently based on three main principles: a panel of prostate biomarkers, imaging methods and histological verification. This work, as the authors point out, presents a diagnostic algorithm that can serve as a "road map": from the initial stratification of patients to the final treatment decision. The algorithm is based on a review of current literature combined with our own experience. Colleagues note that diagnostic algorithms are a feature of the modern healthcare system, in which all stages are consciously coordinated and optimized to ensure proper individualization of the treatment process. A diagnostic algorithm for PC was created using PSA and, in particular, the prostate health index (PHI) in the first line of patient stratification. He then continued the diagnostic path through imaging, biopsy, or active surveillance before moving on to the treatment decision itself. In conclusion, the algorithm for diagnosing PC presented by colleagues is a functional tool for initial patient stratification, comprehensive staging and assessment of aggressiveness. First of all, the emphasis is on the use of PHI in the first stratification of patients as a predictor of aggressiveness and clinical stage of PC. The inclusion of PHI in the algorithm significantly increases the accuracy and speed of the diagnostic procedure and allows you to choose the optimal path from the very beginning. The use of advanced diagnostic methods allows us to move to a more advanced level of cancer treatment. This diagnostic algorithm has become the standard of care in the hospital of the algorithm's developers, which, as the authors note, is constantly tested and modified based on the results obtained.

Nordström T. et al. [13] note in their work that PC screening using PSA alone leads to unnecessary biopsy and overdiagnosis. PSA density is easily accessible, but early evidence on its use for biopsy decisions was conflicting and use of PSA density is not commonly recommended in guidelines. The authors analyzed biopsy outcomes in 5291 men in the population-based STHLM3 study with PSA ≥ 3 ng/ml and ultrasound-guided prostate volume measurements by using percentages and regression models. PSA density was calculated as total PSA (ng/ml) divided by prostate volume (ml). Main endpoint was clinically significant cancer (csPCa) defined as Gleason Score ≥ 7. The following results were obtained: The median PSA-density was 0.10 ng/ml2 (IQR 0.075-0.14). PSA-density was associated with the risk of finding csPCa both with and without adjusting for the additional clinical information age, family history, previous biopsies, total PSA and free/total PSA (OR 1.06; 95% CI:1.05-1.07 and OR 1.07, 95% CI 1.06-1.08). Discrimination for csPCa was better when PSA density was added to a model with additional clinical information (AUC 0.75 vs. 0.73, p<0.05). The proportion of men with Gleason Score 6 (ISUP 1) was similar across stratas of PSA-density. Omitting prostate biopsy for men with PSA-density ≤0.07 ng/ml2 would save 19.7% of biopsy procedures, while missing 6.9% of csPCa. PSA-density cutoffs of 0.10 ng/ml2 and 0.15 ng/ml2 resulted in detection of 77% (729/947) and 49% (461/947) of Gleason Score ≥7 tumors. In connection with the results obtained, our colleagues concluded that PSA-density might inform biopsy

decisions, and spare some men from the morbidity associated with a prostate biopsy and diagnosis of low-grade PC.

A year earlier, Nordström T. and his colleagues [14] conducted a similar study in order to optimize the diagnostic algorithm, where the determination of the biological activity of the tumor, on the one hand, and the prostate biopsy, on the other, are on the "tip the scales". In their work, the authors evaluated the effects of raising the PSA threshold for performing additional biomarker tests before prostate biopsy. As the researchers emphasize, multi-step testing might enhance the performance of the PC diagnostic pipeline. Using PSA >1 ng/ml for first-line risk stratification and the Stockholm 3 Model (S3M) blood-test >10% risk of Gleason Score > 7 PC to inform biopsy decisions has been suggested. We aimed to determine the effects of changing the PSA cutoff to perform reflex testing with S3M and the subsequent S3M cutoff to recommend prostate biopsy while maintaining the sensitivity to detect Gleason Score ≥ 7 PC. The authors used data from the prospective, population-based, paired, diagnostic Stockholm 3 (STHLM3) study with participants invited by date of birth from the Swedish Population Register during 2012-2014. All participants underwent testing with PSA and S3M (a combination of plasma protein biomarkers [PSA, free PSA, intact PSA, hK2, MSMB, MIC1], genetic polymorphisms, and clinical variables [age, family, history, previous prostate biopsy, prostate exam]). Of 47,688 men in the STHLM3 main study, researchers used data from 3133 men with S3M >10% and prostate biopsy data. Logistic regression models were used to calculate PC detection rates and proportion saved biopsies. 44.2%, 62.5% and 67.9% of the participants had PSA <1, <1.5 and <1.7 ng/ml, respectively. Increasing the PSA cut-off for additional work-up from 1 ng/ml to 1.5 ng/ml would thus save 18.3% of the performed tests, 4.9% of the biopsies and 1.3% (10/765) of Gleason Grade ≥ 7 cancers would be un-detected. By lowering the S3M cutoff to recommend biopsy, sensitivity to high-grade PC can be restored, to the cost of increasing the number of performed biopsies modestly. In conclusion, the authors emphasize that sensitivity to detect PC can be maintained when using different PSA cutoffs to perform additional testing. Biomarker cut-offs have implications on number of tests and prostate biopsies performed. A PSA cutoff of 1.5 ng/ml to perform additional testing such as the S3M test might be considered.

And, of course, we need to dwell on the aspects of diagnosing PC using radiological diagnostic methods and, in particular, MRI. At the same time, the created Prostate Imaging Reporting and Data System (PI-RADS) classification allows you to optimize the process of diagnosing this pathology.

As emphasized by Padhani A.R. et al. [15], high-quality evidence shows that MRI in biopsy-naive men can reduce the number of men who need prostate biopsy and can reduce the number of diagnoses of clinically insignificant cancers that are unlikely to cause harm. In men with prior negative biopsy results who remain under persistent suspicion, MRI improves the detection and localization of life-threatening PC with greater clinical utility than the current standard of care, systematic transrectal US-guided biopsy. Systematic analyses show that MRI-directed biopsy increases the effectiveness of the PC diagnosis pathway. The incorporation of MRI-directed pathways into clinical care guidelines in PC detection has begun. The widespread adoption of the PI-RADS for multiparametric MRI data acquisition, interpretation, and reporting has promoted these changes in practice. The PI-RADS MRI-directed biopsy pathway enables the delivery of key diagnostic benefits to men suspected of having cancer based on clinical suspicion.

Beyer T. et al. [16] emphasize that multiparametric MRI of the prostate plays a central role in the diagnosis of patients with suspected PC. The increasing distribution and application of the guideline for the standardization of image acquisition, evaluation, and reporting PI-RADS, which was updated in 2019 to version 2.1, contributes to the success of the technique. PI-RADS version 2.1 published in 2019 addresses a number of changes to the previous version, including both the examination technique and image interpretation. Prospective clinical studies have yet to prove the extent to which the goals of reducing interreader variability and increasing the detection rate in the transition zone will be achieved.

As noted by Dutruel S.P. et al. [17], the PI-RADS has revolutionized the use of MRI for the management of PC. The most recent version 2.1, PI-RADS v2.1, provides specific refinements in the performance, relaxing some recommendations which were not found to be helpful, while reinforcing and clarifying others. The interpretation of T2-weighted imaging (T2WI) in the transition zone (TZ), and the overall assessment of TZ nodules, now allows for a clearer distinction between those which are clearly benign and those which might warrant tissue sampling. Additional changes also resolve discrepancies in T2WI and diffusion-weighted imaging (DWI) of the peripheral zone (PZ). PI-RADS v2.1 is a simpler, more straightforward, and more reproducible method to better communicate between physicians regarding findings on prostate MRI.

Wen J. et al. [18] in their work evaluated the diagnostic efficacy of the combination of the PI-RADS

v2.1 assessment system with PSA density for the detection of PC. A total of 266 participants with suspicion of PC underwent multiparametric MRI in our hospital, after at least 4 weeks all patients underwent subsequent systematic TRUS-guided biopsy or MRI-TRUS fusion targeted biopsy. All multiparametric MRI images were scored in accordance with the PI-RADS v2.1, and univariate and multivariate logistic regression analyses were performed to determine significant predictors of PC. As a result, 119 patients were diagnosed with PC in the biopsy, of them 101 patients were diagnosed with clinically significant PC. The multivariate analysis revealed that PI-RADS v2.1 and PSA were independent predictors for PC. For PZ, the area under the ROC curve (AUC) for the combination of PI-RADS score and PSA was 0.90 (95% CI 0.83-0.96), which is significantly superior to using PI-RADS score (0.85, 95% CI 0.78-0.93, p=0.031) and PSA alone (0.83, 95% CI 0.75-0.90, p=0.037). For TZ, however, the combination model was not significantly superior to PI-RADS alone, with AUC of 0.94 (95% CI 0.89-0.99) vs. 0.93 (95% CI 0.88-0.97, p=0.186). The authors conclude that the combination of PI-RADS v2.1 with PSA could significantly improve the diagnostic performance of PC in PZ. Nevertheless, no significant improvement was observed regarding PC in TZ.

In addition, the modern direction in the radiological diagnosis of PC is the use of S-PI-RADS and PI-RADS for biparametric MRI in the detection of PC and post-treatment local recurrence. Scialpi M. et al. in their publication [19] demonstrate the application of biparametric MRI [T2WI and DWI/apparent diffusion coefficient (ADC)] using dedicated structured methods, such as Simplified Prostate Imaging Reporting and Data System (S-PI-RADS) for the detection, categorization, and management of PC is reported. Also, PI-RADS for the detection and assessment of the probability of local recurrence after radiotherapy or radical prostatectomy in patients with biochemical recurrence is proposed. Both S-PI-RADS and PI-RADS assign to DWI/ADC a main role for the above purpose. S-PI-RADS identifies four categories and, on the basis of the qualitative and quantitative analysis of the restricted diffusion on ADC map and lesion volume, distinguishes two categories of lesions: category 3 (moderately homogeneous hypointense on ADC map) and category 4 (markedly homogeneous or inhomogeneous hypointense on ADC map). In category 3, two subcategories (3a: volume <0.5 cm3 and 3b: volume ≥0.5 cm3) suggesting clinical management. PI-RADS distinguishes four assessment categories and suggests the stratification of the probability (ranging from very low for category 1 to very high for category 4) of local disease recurrence. As the authors emphasize in clinical practice, S-PI-RADS and PI-RADS, based on biparametric MRI represent a potential valid approach that may facilitates the detection and management of PC and for detecting local recurrence after treatment improving communication with other professionals.

Now, as for this pathology in our country. The incidence of PC in the Republic of Kazakhstan in 2022 was 7.5 per 100 thousand population with a growth rate compared to the previous year of as much as 22.9% (6.1 in 2021), which in absolute numbers amounted to 1465 people (1169 cases – in 2021). In terms of growth rates, PC took 4th place after malignant neoplasms of the thyroid gland (29.3%), leukemia (24.2%), bones and articular cartilage (24.1%). In the structure of the incidence of malignant neoplasms in the population of the Republic of Kazakhstan, PC took 8th place (4.2%), inferior in the structure of cases of malignant neoplasms of both sexes to breast cancer - 14.7%, lung cancer - 11.2%, stomach cancer – 8.3%, malignant tumors of lymphatic and hematopoietic tissues - 5.6%, colon cancer - 5.53%, cervical cancer - 5.51% and rectal cancer - 4.88%.

In the structure of oncological pathology, the share of PC with a first-time diagnosis of a malignant neoplasm among the male population registered by oncological organizations was 9.7% (a year earlier - 8.3%) and this is the 3rd ranking place after lung cancer (19.9 %, 20.0% - in 2021) and stomach cancer (12.5%, 12.1% - in 2021). An analysis of the incidence rates of malignant tumors by gender and location demonstrates that per 100 thousand male population, lung cancer was also more often recorded - 31.7 (2021 - 30.2), stomach - 19.9 (18.2) and PC -15.4 (12.6) [20].

The incidence of PC is higher than the national average (7.5 per 100 thousand population) in 8 regions of the country. At the same time, the East Kazakhstan region stands out sharply for this indicator - 22.1 (maximum value). This is followed by: Pavlodar - 15.2; Kostanay - 14.2; Karaganda - 13.3; North Kazakhstan - 12.2; Almaty city – 10.5; Akmola – 8.7 and Abay – 8.5 regions. The indicator is less than the national average in 11 regions: in Kyzylorda - 2.3 (the lowest level); Turkestan – 2.5; Atyrau – 2.6; Shymkent city – 2.8; Mangystau - 2.9; Aktobe - 4.3; Astana city - 5.2; Almaty and Zhambyl - 5.3; Zhetysu – 6.4; West Kazakhstan - 6.7 regions per 100 thousand population.

The mortality rate from this pathology was 1.7 per 100 thousand population, which in absolute numbers amounted to 325 people. In the structure of causes of mortality for both sexes in 2022, this pathology ranks 12th, as in the previous year, amounting to 2.4% (2.9% in 2021).

In the structure of deaths of men, depending on the localization of the oncological process, PC

occupies 8th position, accounting for 4.7% (5.61% in 2021), inferior to the following localizations: 1) lung cancer - 24.5% (2021 – 23.4%); 2) stomach cancer – 15.1% (15.3%); 3) rectal cancer – 5.7% (5.7%); 4) esophageal cancer – 5.7% (5.2%); 5) pancreatic cancer – 5.5% (5.3%); 6) colon cancer – 5.2% (4.4%); 7) liver cancer – 5.1% (4.75%). The indicators per 100 thousand population are as follows: 1) lung cancer - 17.7 - 1688 cases (2021 - 18.1 - 1682 cases); 2) stomach cancer – 10.9 – 1037 cases (11.8 – 1095 people); 3) rectal cancer – 4.11 – 391 patients (4.4 – 410 cases); 4) esophageal cancer – 4.10 – 390 cases (4.0 – 376 cases); 5) pancreatic cancer – 4.0 – 380 patients (4.1 – 381 cases); 6) colon cancer – 3.8 – 357 cases (3.4 – 318 patients); 7) liver cancer – 3.7 – 352 patients (3.7 – 341 patients); 8) PC – 3.4 – 325 cases (4.3 – 403 patients).

The regions where the mortality rate from PC is higher than the national average (1.7 per 100 thousand population) include: East Kazakhstan – 5.6; (maximum level); Abay - 3.3; Almaty city – 2.7; Akmola – 2.4; Kostanay - 2.3; North Kazakhstan - 2.2; Pavlodar, Karaganda and West Kazakhstan – 1.9. The lowest rates were noted in Kyzylorda and Aktobe - 0.4 (minimum level); Atyrau and Turkestan – 0.6; Mangystau - 0.7; Zhetysu and Astana city – 1.0; Zhambyl - 1.2; Shymkent city – 1.5; Almaty – 1.6 regions per 100 thousand population [20].

The number of deaths from malignant PC that were not registered with oncology organizations and diagnosed posthumously in the Republic of Kazakhstan was 2 people; at the same time, the share was 0.1% and 21st ranking place. In 2021, there were 7 such cases, the share was 0.6%, 18th ranking place.

At the same time, one-year mortality decreased compared to the previous year and amounted to 7.1% (in 2021 – 10.6%). The ratio between one-year mortality and neglect (stage IV) was 0.3 in 2022, and this is the lowest figure among all nosological forms of malignant neoplasms in our country. At the same time, let us recall that the furthest distance from "1" is the worst ratio between the indicators of one-year mortality and neglect. In other words, this is the best indicator, and only three nosological forms of malignant tumors have not yet reached a ratio of "1" - kidney cancer and thyroid cancer (indicator - 0.5) and breast cancer (ratio was 0.7).

It should also be noted that during preventive examinations in 2022, PC can be classified as one of the most actively detected tumors among all cancer locations - 63.1% (909 patients), with a slight increase compared to the level of 2021 (62.3% or 715 people - in 2021). Of these, 62.0% (564 patients) were identified in early stages I-II of the disease (in 2021 - 458 patients, which amounted to 64.1%).

The level of morphological verification of PC in the country was 94.3%. At the same time, in 3 regions 100% verification of the diagnosis was provided (Almaty, Zhambyl and North Kazakhstan regions); high rates were achieved in Karaganda (99.4%), Astana city (97.0%), Shymkent city (96.8%), Abay (96.1%), East Kazakhstan (95.7%); low - in Kyzylorda (72.2% - the worst result in the country), Akmola (74.2%), Aktobe (82.1%), Turkestan (88.7%), Mangistau (90.5%) regions.

The proportion of patients with early stage I of the pathology under consideration was 12.6% and this is the 14th ranking place among all nosological forms of oncological pathology. The regions where the proportion of patients with stage I PC is above the national average include the following regions: Astana city - 38.8%; (maximum indicator); Zhambyl - 23.4%; North Kazakhstan - 22.7%; Kyzylorda - 22.2%; Zhetysu – 21.4%; East Kazakhstan – 20.5%; Almaty city – 14.3%; Kostanay - 12.7% of the regions of the republic.

The lowest rates of early diagnosis were stated: in Mangistau and Turkestan - 0.0% (i.e., not a single patient with PC detected at stage I of the disease); Aktobe - 2.6%; Pavlodar - 2.7%; Shymkent city – 3.2%; Abay - 3.9%; Atyrau – 5.6%; Almaty - 6.4%; Akmola - 10.6%; West Kazakhstan - 11.4%; Karaganda – 11.5% of the country's regions [20].

At the same time, every second patient with PC is detected in the early (I-II) stages of this pathology. The regions where the proportion of patients with PC detected at stages I-II is above the national average (54.2% and only 15th ranking place for this indicator) include the following regions. The uncontested leader is Kostanay region (83.1% - the maximum value in the republic). This is followed by: North Kazakhstan (69.7%); Pavlodar (66.4%); Almaty city (61.3%); Abay (60.8%); Zhetysu (57.1%); Astana city (56.7%); Zhambyl (54.7%) region.

Low rates of early diagnosis of PC have been established: in Shymkent city (12.9% - the worst indicator); Turkestan (24.5%); Akmola (34.8%); Mangistau (38.1%); Kyzylorda; East Kazakhstan (40.4%); Aktobe (46.2%); Almaty (48.7%); West Kazakhstan and Atyrau (50.0%); Karaganda (54.0%) regions of our republic [20].

As is clearly seen from the above data across the country, there is a very wide range in early diagnosis indicators, from very good to depressing. Of course, it is necessary to take into account

migration processes and other factors influencing early diagnosis rates, but nevertheless, the results speak for themselves.

The share of stage IV PC among all nosological forms of malignant neoplasms was 19.9%, in other words, every fifth patient is detected in an advanced stage of the disease, and this is the fifth worst indicator in the republic.

As for the average republican indicator of the share of stage IV, the Kyzylorda region showed itself on the negative side, where this parameter was 50.0%, Akmola - 48.5% and Turkestan - 47.2% of the region. This is followed by the following regions: Aktobe - 38.5%; Zhetysu and Mangistau - 38.1%; Shymkent city – 35.5%; Abay - 27.5%; Astana city – 25.4%; West Kazakhstan - 25.0% and Karaganda - 21.3% regions.

The following showed themselves to be the best in this aspect: East Kazakhstan - 1.2% (optimal result); Kostanay - 7.6%; Pavlodar - 8.0%; Atyrau – 11.1%; Almaty - 11.5%; Zhambyl - 14.1%; North Kazakhstan - 15.2%; Almaty city - 19.4% [20].

Statistical data on patients diagnosed with a malignant neoplasm who have been under observation for 5 years or more, and who continue to be observed in 2022, showed that the number of patients under the supervision of oncological organizations in Kazakhstan for more than five years continued to grow and at the end of the reporting year amounted to 110,790 people, with an increase of 6.6% (2021 – 103,935 people, +4.4%) (form No. 7). The share of this category of patients or five-year survival rate for malignant neoplasms with a growing trend is 55.3% (55.0% in 2021).

We cannot ignore such an important clinical aspect as the coverage in the Republic of Kazakhstan of special treatment for patients diagnosed with PC for the first time in their lives. At the end of 2022, the absolute number of people who completed specialized treatment was 641 people, with almost the same number of patients continuing treatment - 636 patients. The following results were obtained in percentage terms by methods and types of treatment. Only 24.0% of patients received surgical treatment, only radiation – 22.8%, only medication – 10.1%, combined – 15.0%, complex – 8.9% and chemo-radiation – 1.4%.

Further regarding the five-year survival rate of patients. As for PC, at the end of 2022, 6995 people were registered at the dispensary, or 35.9 per 100 thousand population. At the end of 2021 – 6406 patients or 33.5 per 100 thousand population, respectively.

At the same time, the mortality rate of the observed contingents in 2022 decreased compared to the previous year and amounted to 4.6% in 2022 (6.3% in 2021).

The five-year survival rate of patients with PC increased and amounted to 45.1% in 2022 (in 2021 and 41.4%) [20].

Summarizing the above, we can conclude that "Man's Heart" cancer occupies a significant place among all existing malignant tumors of other localizations. The variability and veiling of symptoms, its similarity with various non-core processes, leads to neglect of the disease. All this requires both oncologists and, first of all, primary health care workers and, of course, urologists to increase the level of oncological alertness, inform the population about early symptoms that may indicate this pathology or the onset of proliferative changes and carrying out high-tech diagnostic measures and, as a result, timely treatment. People at risk are recommended to visit a urologist annually and, if necessary, undergo examination.

An epidemiological assessment of the situation with PC in our country suggests that there are sometimes significant differences across regions not only in incidence rates, but also in the parameters of early diagnosis and mortality from this pathology. In connection with the above, this pathology continues to be a serious problem in modern clinical oncology.

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Pedagogical sciences

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TEACHING ENGLISH FOR STUDENTS IN HIGHER EDUCATION: COMPETENCE-BASED, INTERDISCIPLINARY AND INNOVATIVE PERSPECTIVES

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Abstract

The rapid transformation of higher education in the context of globalization, digitalization, and interdisciplinary integration has significantly influenced approaches to teaching English as a Foreign Language (EFL) at universities. This paper explores contemporary theoretical and practical perspectives on teaching English to students of humanities disciplines, including linguistics, history, philosophy, cultural studies, and related fields. The study analyzes modern pedagogical methodologies such as communicative language teaching, task-based learning, content and language integrated learning (CLIL), project-based learning, and artificial intelligence–enhanced instruction. Special attention is paid to learner-centered and competence-based approaches that foster critical thinking, academic literacy, intercultural communicative competence, and soft skills. The paper also presents practical teaching strategies and classroom practices that demonstrate the effectiveness of innovative methods in university-level EFL instruction for humanities students.

Keywords: *English as a Foreign Language, higher education, humanities students, innovative teaching methods, communicative competence, digital pedagogy, artificial intelligence.*

Introduction

In the modern academic environment, English has become not only a means of international communication but also a fundamental tool for professional and academic development. For students specializing in the humanities, English proficiency enables access to global academic discourse, participation in international conferences, publication in indexed journals, and engagement with diverse cultural perspectives. Consequently, teaching English at the university level requires a shift from traditional grammar-translation approaches to innovative, student-centered methodologies aligned with contemporary educational demands.

The growing internationalization of higher education has intensified the need for advanced academic literacy and intercultural communicative competence among humanities students. English increasingly functions as a lingua franca of science, culture, and intellectual exchange, shaping the ways knowledge is produced and disseminated. As a result, university-level English instruction must address not only linguistic accuracy but also critical thinking, academic writing, and disciplinary discourse conventions.

Furthermore, rapid technological development and digital transformation have significantly influenced teaching and learning practices in higher education. Online platforms, digital resources, and artificial intelligence–based tools offer new opportunities for personalized learning, collaborative knowledge construction, and formative assessment. However, their effective integration requires sound methodological frameworks and pedagogical awareness.

The theme of the international conference "Theoretical and Practical Perspectives of Modern Science" highlights the necessity of integrating theory with practice. In this context, English language teaching (ELT) must be grounded in solid pedagogical theory while responding to real classroom challenges and the evolving needs of humanities students. The alignment of theoretical models with practical classroom strategies ensures the relevance and sustainability of innovative ELT practices.

This paper aims to examine modern methodologies for teaching English in higher education and to demonstrate their practical applicability for training future specialists in the humanities. By combining

theoretical analysis with practical examples, the study seeks to contribute to ongoing discussions on the modernization of English language education in university contexts.

Theoretical Foundations of Modern English Language Teaching

Competence-Based and Learner-Centered Approaches

Modern ELT is strongly influenced by the competence-based approach, which emphasizes the development of communicative, academic, intercultural, and digital competencies rather than the accumulation of isolated linguistic knowledge. For humanities students, communicative competence is closely connected with the ability to interpret texts, construct arguments, and express critical opinions in English.

The learner-centered approach positions students as active participants in the learning process. The teacher acts as a facilitator, mentor, and designer of learning experiences. This paradigm supports autonomy, motivation, and reflective learning, which are particularly important for humanities students accustomed to analytical and interpretive thinking.

Constructivism and Social Interaction

Constructivist learning theory underpins many contemporary ELT methodologies. According to this theory, knowledge is constructed through interaction, collaboration, and meaningful engagement with content rather than through passive reception of information. Social interaction, discussion, debate, and collaborative tasks enable humanities students to connect linguistic learning with their disciplinary knowledge and personal experience. Within this framework, language learning is viewed as a socially mediated process in which meaning emerges through dialogue and shared problem-solving.

For humanities students, whose academic training emphasizes interpretation, critical reflection, and argumentation, constructivist approaches provide particularly relevant learning conditions. Classroom practices such as seminars, peer feedback, group research projects, and reflective discussions foster deeper cognitive engagement and promote higher-order thinking skills. These activities encourage students to articulate their ideas in English, negotiate meaning, and develop academic discourse competence.

Moreover, constructivist learning environments support learner autonomy and responsibility for learning outcomes, which are essential components of higher education. The teacher's role in this context shifts from that of a knowledge transmitter to a facilitator who guides, scaffolds, and supports students' intellectual and linguistic development. As a result, constructivist pedagogy enhances motivation, intercultural awareness, and the ability to apply English in authentic academic and professional contexts.

Contemporary Methodologies in Teaching English to Humanities Students

Communicative Language Teaching (CLT)

Communicative Language Teaching remains a core methodology in university-level ELT. Its primary goal is the development of communicative competence through authentic language use. In humanities-oriented classrooms, CLT is particularly effective when combined with discussions of philosophical texts, historical sources, literary excerpts, and socio-cultural issues.

Typical CLT activities include seminars, debates, role-plays, and problem-solving discussions. These tasks encourage students to use English as a tool for meaning-making rather than as an abstract system of rules. Through sustained interaction, learners develop fluency, pragmatic awareness, and discourse competence essential for academic communication. CLT also promotes collaborative learning and peer interaction, which are central to the interpretive nature of humanities education. By engaging in extended spoken and written exchanges, students learn to formulate arguments, justify viewpoints, and respond critically to alternative perspectives. Such practices contribute to the development of intercultural communicative competence and academic confidence. As a result, CLT supports the transition from language learning to meaningful participation in academic and professional discourse communities.

Task-Based Learning (TBL)

Task-Based Learning focuses on completing meaningful tasks that reflect real-life academic and professional situations. For humanities students, tasks may include preparing conference presentations, writing abstracts, conducting interviews, analyzing case studies, or moderating panel discussions.

TBL supports the integration of language skills and promotes fluency, accuracy, and complexity through purposeful communication. It also enhances students' ability to work collaboratively and manage academic projects in English. By prioritizing outcome-oriented tasks, this approach encourages learners to focus on meaning while naturally developing linguistic form. TBL creates opportunities for authentic interaction and negotiation of meaning, which are essential for effective academic communication. In humanities-oriented contexts, task-based activities stimulate critical reflection and

contextualized language use. Moreover, TBL fosters learner autonomy by involving students in planning, decision-making, and self-evaluation. As a result, students become more confident and competent users of English in academic and professional settings.

Content and Language Integrated Learning (CLIL)

CLIL is one of the most relevant methodologies for teaching English to humanities students. It involves teaching subject-related content through a foreign language, allowing students to develop linguistic competence alongside disciplinary knowledge. For example, courses on cultural studies, media discourse, or global history can be partially delivered in English.

CLIL contributes to deeper cognitive engagement and helps students perceive English as a working language for academic inquiry rather than merely a subject of study.

Project-Based Learning (PBL)

Project-Based Learning emphasizes long-term, interdisciplinary projects that result in tangible outcomes such as research papers, digital presentations, podcasts, or academic posters. In humanities education, PBL aligns well with research-oriented learning and critical analysis.

Projects conducted in English encourage students to apply language skills creatively while developing research, collaboration, and presentation skills essential for their future careers.

Digital Technologies and Artificial Intelligence in ELT

Digital Learning Environments

The integration of digital tools has transformed English language teaching in higher education. Learning management systems, online discussion forums, academic databases, and multimedia resources enable flexible and blended learning formats. For humanities students, digital platforms support access to authentic texts, lectures, and global academic communities.

Artificial Intelligence–Enhanced Instruction

Artificial intelligence (AI) offers new opportunities for personalized learning, formative assessment, and academic writing support. AI-based tools can assist students with vocabulary development, grammar feedback, pronunciation practice, and text analysis. When used critically and ethically, AI enhances learner autonomy and reflective practice.

However, educators must also address potential risks, such as over-reliance on automated tools and issues of academic integrity. Therefore, AI should be integrated as a supportive instrument rather than a replacement for pedagogical interaction.

Practical Teaching Strategies and Classroom Applications

In practice, the effective teaching of English to humanities students requires a balanced combination of methodologies. Integrated lessons may include pre-reading discussions, critical analysis of texts, collaborative tasks, reflective writing, and oral presentations. Assessment should be aligned with learning outcomes and include formative feedback, peer assessment, and portfolio-based evaluation.

Authentic academic tasks—such as writing research abstracts, participating in simulated conferences, or conducting intercultural dialogues—enhance students' motivation and prepare them for real academic contexts. In addition, scaffolding techniques, guided practice, and structured peer interactions help students gradually develop higher-order language and cognitive skills. Incorporating multimodal resources, such as video lectures, digital archives, and interactive platforms, allows learners to engage with content in diverse ways and supports different learning styles. Project-based and inquiry-driven tasks encourage independent research and critical thinking while strengthening disciplinary knowledge. Regular reflection and self-assessment activities foster metacognitive awareness and learner autonomy, which are essential for lifelong learning. Ultimately, these strategies ensure that classroom activities are meaningful, contextually relevant, and closely connected to students' future academic and professional endeavors.

Discussion

The analysis of modern ELT methodologies demonstrates that innovative, student-centered approaches are particularly effective for humanities students in higher education. These learners benefit from methodologies that emphasize critical thinking, interpretation, discussion, and intercultural awareness. The integration of digital technologies and AI further expands pedagogical possibilities while requiring thoughtful methodological guidance from educators.

The findings indicate that communicative and task-based frameworks create learning environments in which language is used as a tool for meaning-making rather than as an isolated system of rules. Such environments align closely with the epistemological traditions of the humanities, where dialogue, interpretation, and reflective inquiry play a central role. As a result, students demonstrate increased engagement, motivation, and confidence in using English for academic purposes.

Furthermore, content-integrated and project-based approaches contribute to the development of academic literacy and disciplinary discourse competence. By working with authentic texts and research-oriented tasks, students are able to bridge linguistic skills with subject-specific knowledge. This integration supports deeper cognitive processing and facilitates long-term retention of both language and content.

The use of digital platforms and AI-enhanced tools also enables more personalized learning pathways and continuous formative assessment. However, the results suggest that such technologies are most effective when embedded within pedagogically sound frameworks and accompanied by explicit instruction in ethical and critical use. Teachers play a crucial role in mediating technology use and maintaining academic integrity.

Overall, the discussion highlights the necessity of balancing innovation with methodological rigor, ensuring that emerging technologies and modern pedagogical approaches serve clear educational objectives in humanities-oriented ELT contexts.

Conclusion

Teaching English to humanities students in higher education is a complex and dynamic process that requires alignment with contemporary theoretical and practical perspectives. Modern methodologies such as CLT, TBL, CLIL, and PBL, supported by digital and AI-based tools, create a holistic learning environment that fosters linguistic, academic, and professional development. These approaches promote learner autonomy, interdisciplinary thinking, and meaningful engagement with authentic academic content, which are essential for humanities-oriented education.

The findings of this paper confirm that innovative approaches to ELT contribute to the formation of globally competent, critically minded humanities specialists capable of active participation in international academic and professional communities. Furthermore, the integration of technology-enhanced instruction prepares students to navigate multilingual academic contexts, adapt to rapidly changing professional demands, and engage in lifelong learning.

From a pedagogical perspective, the effective implementation of these methodologies requires systematic teacher training, continuous professional development, and institutional support. In addition, curriculum design should be flexible enough to integrate interdisciplinary content, digital literacy, and ethical use of artificial intelligence in academic learning environments.

Future research may focus on empirical evaluation of AI-enhanced and blended learning models in humanities-oriented EFL classrooms, as well as on students' perceptions of innovative instructional practices. Such investigations would contribute to the further modernization of English language teaching in higher education and strengthen the connection between theory and classroom practice.

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METHODOLOGICAL READINESS OF FUTURE FOREIGN LANGUAGE TEACHERS TO USE DIGITAL AUTHENTIC MATERIALS

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Abstract

Digital authentic materials are increasingly used in foreign language teacher education as a means of connecting instruction with real-life communication and contemporary discourse. However, their pedagogical effectiveness depends not only on authenticity or digital format, but largely on future teachers' methodological readiness to apply them in a pedagogically justified manner. This study examines the methodological readiness of pre-service foreign language teachers to work with digital authentic materials in instructional contexts. Methodological readiness is conceptualized as an integrated professional capacity that includes material selection, pedagogical evaluation, adaptation to learners' proficiency levels, and alignment with instructional objectives. The study adopts a descriptive exploratory design and focuses on pre-service teachers' self-perceived preparedness and methodological awareness related to the use of digital authentic resources. Empirical data were collected through a structured questionnaire combining closed-ended and open-ended items administered to undergraduate students in a foreign language teacher education program. The findings indicate that while participants regularly engage with digital authentic materials and demonstrate adequate conceptual understanding, their methodological readiness remains uneven. Lower confidence levels are reported in material adaptation and task design, which are perceived as the most challenging aspects of classroom implementation. Participants also identify linguistic complexity, implicit cultural meanings, and preparation time as key methodological difficulties. Overall, the study underscores the need for systematic methodological training within competence-based teacher education programs and confirms that methodological readiness is a critical condition for the effective integration of digital authentic materials in foreign language instruction.

Keywords: digital authentic materials; methodological readiness; pre-service foreign language teachers; competence-based teacher education, authentic materials.

Introduction

Modern foreign language education is developing in response to globalization, rapid digital change, and the increasing need for communication in authentic sociocultural and professional settings. These factors have transformed the role of the foreign language teacher, who is now expected to guide learners toward meaningful communicative engagement rather than focus on the reproduction of isolated language forms. Consequently, teacher education programs are required to prepare future teachers to work with materials that represent real language use.

Digital authentic materials are generally understood as texts and media produced for genuine communicative purposes outside the classroom. Their instructional value lies in providing learners with access to natural language, contextualized meanings, and contemporary discourse. At the same time, research shows that authenticity alone does not ensure effective learning. The pedagogical impact of authentic materials depends on teachers' ability to select, adapt, and integrate them appropriately into the learning process. In this context, methodological readiness emerges as a crucial condition for the effective use of digital authentic materials. Although pre-service teachers regularly encounter authentic content in digital environments, such exposure does not automatically lead to methodologically sound classroom application. Authentic resources often involve linguistic density and culturally embedded meanings that require deliberate pedagogical mediation.

Within competence-based teacher education, methodological readiness is viewed as an integrated professional capacity that enables future teachers to critically evaluate materials, adapt them to learner needs, and apply them in line with instructional objectives. However, systematic training in working with digital authentic materials remains insufficient in many teacher education programs, which highlights the need to address methodological readiness as a distinct area of professional preparation.

***The research focuses** on their perceptions of preparedness to select, adapt, and pedagogically apply digital authentic resources, as well as on identifying areas that require targeted methodological development. The study pursues the **following objectives**:*

1. To examine pre-service teachers' understanding of digital authentic materials as instructional resources;

2. To assess their self-evaluated ability to select and adapt digital authentic materials across different learning contexts and proficiency levels;

3. To identify perceived methodological challenges related to classroom use of digital authentic materials;

4. To outline directions for improving materials-oriented training in foreign language teacher education.

Literature Review

Current developments in foreign language teacher education reflect a growing orientation toward preparing future teachers for participation in real communicative practices rather than for the reproduction of pre-selected textbook language models. This shift is closely associated with the recognition of digital authentic materials as a means of bringing instructional activity closer to real-life language use. Nevertheless, recent studies emphasize that the pedagogical value of digital authentic materials is shaped not by their authentic origin alone, but by teachers' capacity to work with them in a methodologically informed manner [1].

Digital authentic materials are typically described as resources emerging from genuine communicative situations, such as mass media discourse, professional interaction, and digitally mediated environments. Over time, scholarly interpretations of authenticity have evolved from an emphasis on the origin of materials toward approaches that highlight pedagogical processing and teacher mediation (see table 1).

Table 1.

Definitions of digital authentic materials in foreign language education

Author	*Definition*
Gilmore (2007)	*Materials created for real communicative purposes and used without pedagogical simplification.*
Orooq & Abdel Razeq (2022)	*Resources derived from real-life language use that require pedagogical mediation.*
Kałuża & Polok (2023)	*Authentic texts and media reflecting contemporary language and cultural contexts.*
K. Jannah, D. Sudana, & F. Hilman (2025)	*Digital authentic materials can be defined as digitally available language resources originating from everyday communication, including but not limited to podcasts, audiovisual media, online texts, and interactive digital environments. Although these materials are initially created for native language users rather than instructional purposes, they are subsequently repurposed and pedagogically contextualized for use in language education.*

Although digital authentic materials allow learners to engage with natural language and sociocultural meaning, they frequently pose methodological difficulties due to linguistic density, implicit cultural references, and mismatches with learners' proficiency levels. Empirical evidence indicates that addressing these issues requires purposeful pedagogical intervention and well-grounded instructional choices.

Within competence-based approaches to teacher education, the ability to respond to such challenges is associated with methodological readiness. This concept is understood as a multidimensional professional capacity that supports teachers in evaluating learning materials, adapting them to instructional conditions, and using them pedagogically in accordance with educational goals and classroom contexts. Methodological readiness may be conceptualized as a holistic professional disposition that enables future foreign language teachers to design, implement, and reflect on instructional practices in alignment with educational goals. This readiness is grounded in the integration of methodological knowledge and pedagogical skills and is expressed through teachers' capacity to make informed instructional decisions, flexibly adapt teaching materials to learning contexts, and sustain continuous professional and methodological growth within a competency-based educational framework (Maiier, 2017). Within pedagogical research traditions, professional readiness is commonly viewed as an outcome of systematic professional training. Scholars emphasize that readiness for professional activity emerges as a holistic construct combining cognitive, operational, and motivational components. It encompasses not only the mastery of knowledge and skills required for effective instructional performance, but also the development of professional motives, needs, and personal dispositions that influence teachers' attitudes toward their work and determine the effectiveness of their pedagogical actions (Leifa et al, 2021).

In pedagogical research grounded in the ideas of V. A. Slastenin, professional competence is interpreted as a combination of functional and personal preparedness that enables teachers to effectively address professional tasks. Functional readiness is viewed as a teacher's internally formed

confidence in their ability to perform professional duties, grounded in an integrated system of knowledge, skills, and practical experience, as well as a willingness to apply them in instructional practice. Personal readiness, in turn, reflects a teacher's internal orientation toward purposeful professional action, including motivation, responsibility, and conscious engagement in pedagogical activity (Nasyrova & Drozdova, 2015).

Despite sustained scholarly interest in digital authentic materials, the methodological readiness of future foreign language teachers has rarely been examined as an independent object of research. Existing studies more often focus on teachers' attitudes toward authenticity or the frequency of authentic material use, while comparatively little attention is paid to perceived preparedness for their methodologically sound implementation. This research gap provides the theoretical and conceptual foundation for the present study.

Methodology

1. Research design

The research is based on a ***descriptive exploratory design*** *intended to examine how future foreign language teachers perceive their methodological readiness to work with digital authentic materials in educational settings. This approach makes it possible to capture participants' self-evaluations, levels of methodological awareness, and perceived instructional difficulties at an initial stage of professional development.* ***A questionnaire*** *survey was chosen as the main research method, as methodological readiness is treated in this study as a reflective construct encompassing awareness, self-confidence, and the perceived ability to make pedagogically justified instructional decisions.*

2. Participants

The sample consisted of 30 undergraduate students in their second year of study enrolled in a foreign language teacher education program at a higher education institution.

3. Research instrument

The empirical data were gathered using a structured questionnaire:

- ***Section A*** *included two closed-format items aimed at collecting background information on participants' academic status and the frequency with which they engage with digital authentic materials.*
- ***Section B*** *contained eight closed-ended statements addressing central components of methodological readiness, such as conceptual understanding of digital authentic materials, confidence in selection and adaptation, task development, perceived methodological difficulties, and overall readiness for classroom implementation.*
- ***Section C*** *consisted of three open-ended questions designed to elicit reflective responses concerning anticipated or experienced challenges, approaches to adapting digital authentic materials.*

4. Data collection procedure

The questionnaire was distributed in an online format to ensure participant anonymity and facilitate access. Data collection took place within a predetermined time period. Participation was voluntary, and respondents were informed about the purpose of the study prior to completion.

5. Data analysis

Responses from Sections A and B were processed using descriptive statistical techniques, primarily frequency counts and percentage distributions. Open-ended responses from Section C were analyzed through thematic coding to identify recurring themes related to methodological challenges, strategies for adapting digital authentic materials, and perceived needs for professional support.

Results

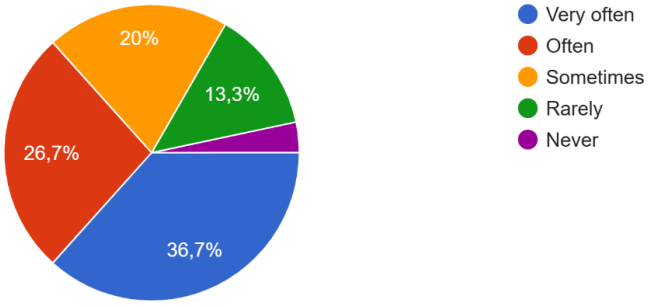
The analysis of questionnaire responses makes it possible to outline the current state of methodological readiness among pre-service foreign language teachers in relation to the use of digital authentic materials.

1. Frequency of working with digital authentic materials

The data indicate that the majority of participants have experience working with ***digital authentic materials*** *during their studies and teaching practice. Very frequent engagement was reported by 36.7% of respondents, while 26.7% indicated frequent use. At the same time, 20% stated that they use digital authentic resources occasionally, and 13.3% reported rare involvement. Only a negligible proportion indicated no prior experience (see Picture 1).*

Picture 1.

Frequency of using digital authentic materials in studies and teaching practice

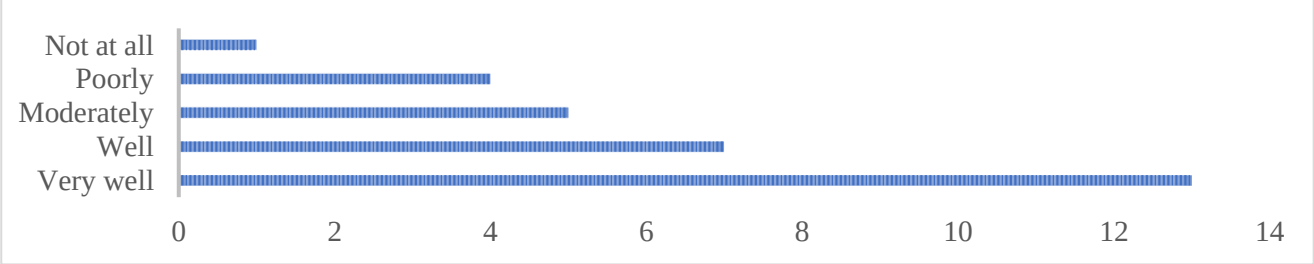


2. Understanding of the concept of digital authentic materials

*A high or very high level of understanding of **digital authentic materials** was reported by 66.6% of respondents, while 16.7% positioned themselves at a moderate level. Limited understanding was indicated by 13.3% of participants, with only isolated responses reflecting minimal familiarity. These findings suggest that the concept of digital authenticity is largely recognized, though not equally consolidated among future teachers (see Picture 2).*

Picture 2.

Level of conceptual understanding of digital authentic materials

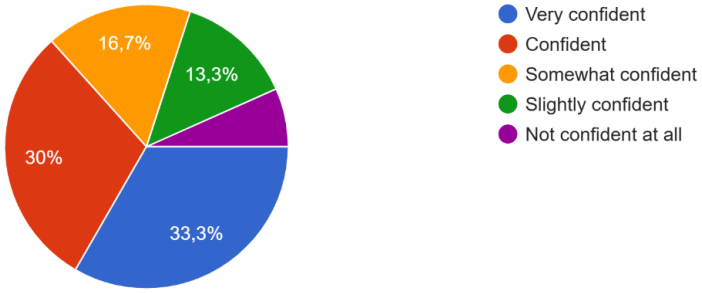


3. Confidence in selecting digital authentic materials

*Participants' confidence in selecting **digital authentic materials** aligned with lesson objectives showed noticeable variation. High or very high confidence was reported by 63.3% of respondents, whereas 16.7% assessed their confidence as moderate. Lower confidence levels were indicated by 13.3%, with only a small number of responses reflecting uncertainty. This distribution points to uneven development of methodological skills related to the selection of **digital authentic resources** (see Picture 3).*

Picture 3.

Confidence in selecting digital authentic materials aligned with lesson objectives

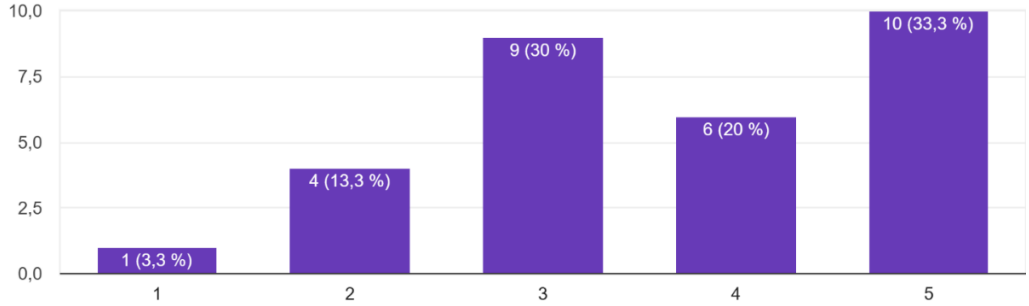


4. Confidence in adapting digital authentic materials to learners' proficiency levels

*Adapting digital authentic materials to learners' proficiency levels emerged as a more demanding component of methodological readiness. High confidence in adaptation was reported by 53.3% of participants, while 30% assessed their confidence as moderate. Lower confidence was indicated by 16.6% of respondents. These results suggest that adaptation of **digital authentic resources** represents a key area of methodological difficulty (see Picture 4).*

Picture 4.

Confidence in adapting authentic materials to learners' proficiency levels



5. Experienced difficulties in using digital authentic materials

*The overall level of difficulty associated with the use of **digital authentic materials** was assessed as moderate, with a mean score of 3.17. Responses were distributed across the full scale, indicating that such materials are perceived as neither excessively difficult nor entirely unproblematic. Qualitative responses most frequently referred to challenges related to linguistic complexity, implicit cultural meanings, and the time required for selecting and adapting digital authentic content. These difficulties indicate that future teachers are aware of the need to mediate digital authentic input to align it with learners' proficiency levels and instructional objectives.*

Overall, the results demonstrate that pre-service foreign language teachers possess a basic level of methodological readiness to work with digital authentic materials, yet this readiness is unevenly distributed across its components. Conceptual awareness and frequency of use appear to be relatively well developed, while more complex methodological skills, particularly material adaptation and pedagogical mediation, remain less stable. Importantly, the reported difficulties do not indicate resistance to the use of digital authentic materials; rather, they reflect an emerging awareness of the methodological demands associated with their effective classroom integration. In general, the findings suggest that methodological readiness is in the process of formation and requires systematic pedagogical support to ensure consistent and confident instructional application.

Discussion

The findings of the study indicate that future foreign language teachers actively engage with digital authentic materials during their academic preparation; however, their methodological readiness to use these resources in a structured and pedagogically justified manner remains inconsistent. This confirms the assumption that the instructional effectiveness of digital authentic materials depends not on their availability or frequency of use, but on teachers' ability to make informed methodological decisions.

Although most participants reported a satisfactory level of conceptual understanding, self-assessments revealed notable differences in confidence across key components of methodological readiness. In particular, material adaptation emerged as the most challenging aspect. This finding suggests that familiarity with authentic digital input does not automatically translate into pedagogical competence. Without explicit methodological guidance, future teachers may rely on intuitive or unsystematic approaches when integrating authentic materials into instruction.

The moderate level of perceived difficulty reported by participants indicates that digital authentic materials are viewed as pedagogically demanding yet manageable. Challenges related to linguistic complexity, culturally embedded meanings, and preparation time highlight the need for deliberate pedagogical mediation rather than the simplification or avoidance of authentic resources. In this sense, methodological readiness functions as a mediating competence that enables teachers to balance authenticity with instructional accessibility.

From the perspective of competence-based teacher education, the results underscore the importance of integrating targeted methodological training into pre-service programs. Such training should focus not only on theoretical conceptualization, but also on guided practice in material selection, adaptation, and task design. Structured opportunities for reflection and pedagogical justification may support the transition from conceptual awareness to confident instructional implementation.

Despite its contributions, the study has several limitations that should be acknowledged. The reliance on self-reported data may not fully reflect participants' actual classroom practices, as perceived readiness does not always correspond to observed instructional behavior. In addition, the relatively small sample size and its restriction to a single educational context limit the generalizability of the findings. The descriptive nature of the research design also precludes causal interpretation and does not allow for

tracking the development of methodological readiness over time. These limitations suggest the need for further research employing larger samples, classroom-based observation, and longitudinal approaches to gain a more comprehensive understanding of methodological readiness formation.

Conclusion

This study explored the methodological readiness of future foreign language teachers to work with digital authentic materials in instructional contexts. The results show that although such materials are widely used and generally viewed positively, methodological readiness remains uneven and continues to form during pre-service teacher education. Familiarity with digital authentic resources alone does not ensure confident or systematic pedagogical application.

The findings identify material adaptation and task design as the most challenging aspects of methodological readiness. While participants demonstrated sufficient conceptual awareness of digital authenticity, converting this knowledge into effective instructional practice requires targeted methodological support and guided training. These results indicate the need for greater emphasis on practical engagement with digital authentic materials alongside theoretical instruction in teacher education programs.

Overall, the study confirms that methodological readiness is a key prerequisite for fully realizing the pedagogical value of digital authentic materials. Future research may build on these findings by expanding the sample, incorporating classroom-based observation, or applying longitudinal approaches to examine the development of methodological readiness over time.

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Philological sciences

USING ARTIFICIAL INTELLIGENCE IN TRANSLATION OF LITERARY TEXT

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Abstract

This article examines the use of artificial intelligence (AI) tools in literary translation. The modern era marks humanity's transition to a new stage in the development of digital technologies and the emergence of the term "digital literary translation." AI's work has long gone beyond simple search queries across various subject areas in a dialog box. Systems based on neural networks are capable of generating unique texts in different languages, composing poetry, and translating entire books in seconds.

Keywords: *Artificial intelligence; machine translation; digital translation of literary text; neural network.*

The aim of this study is to analyze the performance of modern artificial intelligence systems in the field of translation and the specifics of the human-AI binomial during the digital translation of literary texts. This goal necessitated the solution of specific tasks aimed at studying and replicating the workings of the human mind during creative work within the art of translation.

The theoretical concept of the study is based on the provisions set out in the works of N. K. Garbovsky, N. N. Gudkoz, K. K. Kolin, M. V. Norts and M. B. Rarenko , according to which it can be stated that today there is a formation of such a concept as "digital translation", which can be defined as "a new type of translation technology, a system of network interaction between a translator and digital information and communication tools, artificial intelligence, designed to increase the efficiency of the art of translation and the quality of translation products". In the process of functioning of the binomial "human - AI", the nature of the cognitive processes occurring in the mind of a human translator changes, since he, being in a changing social environment, is forced "to adapt to a wide variety of translation situations, replenishing his experience for the most part only in a practical way, often being under the pressure of circumstances", which can deepen the translation experience. The metamodernist foundation of AI is an attempt to replace the empirical experience that a machine lacks with the translator's personal experience. "Any translation AI system views the human translator as the periphery of the machine."

The role of studying the cognitive aspect of translation activity in the development of neural machine translation algorithms

Translation is "a work of the intellect, requiring not only linguistic knowledge, a broad outlook, and technological mastery, but also creativity, even cunning, dexterity, and intelligence, as well as the ability to socially and psychologically adapt". Translation is a creative human activity, the art of speech transformation, mediation, and decision-making in a situation of uncertainty.

Translation as an art was "reflected upon by the writer and translator V. Nabokov <...>. The renowned Soviet translator N. M. Lyubimov called his work an art <...>, and for K. I. Chukovsky, the author of the first systematic notes on the theory of literary translation in Russian history, translation was not just an art, but a high art". The basis of a translator's activity as a special form of creativity is a figurative understanding of reality, aimed at understanding the world and reflecting the author's thoughts in such a way that it is adequately perceived by the recipient, and in the case of literary translation, touches the reader's feelings and satisfies his aesthetic and emotional needs. Immersing himself in the "art of re-expression," a translator creates a work in a different semiotic system for a different culture, and sometimes for a different era.

The key to a high-quality translation is, first and foremost, the translator's ability to perform their functions not only as a competent linguist, understanding the grammatical intricacies of both the source and target languages, but also as a translator's ability to understand the mental images embedded in the source text and how they can best be represented in the target language in accordance with the goals of translation. It is obvious that "every act of translation begins with the process of perceiving the source text in the source language": "The original message in written form presupposes reading as a specific cognitive function implemented by the translator". He is undoubtedly the most attentive reader, and this "axiom" does not lose its significance even in the context of a constantly evolving digital environment.

The translator's goal is "the most complete transmission of information deciphered in the process of cognition of the original message, i.e., a deep understanding of the source text. Such an understanding can only be achieved as a result of careful translation reading."

Machine translation (MT) began to emerge with the "development of automatic interlingual translation algorithms". The main stages of MT include functional and semantic analysis and interpretation. Today, a new wave of computer technology, artificial intelligence, is actively developing. This technology is a set of tools that help a machine answer question, draw conclusions, and analyze information that was not originally programmed, i.e., self-learn. Artificial intelligence "as a discipline belongs to the cognitive sciences, i.e., to the studies that deal with the acquisition of knowledge". The scientific assumption that a computer can function like the human brain, create texts, and imitate human speech has become the basis for the potential set of functional capabilities of artificial intelligence in the field of linguistics. Translation technology based on new technologies is "highly complex due to its close connection with the problems of modeling the processes of understanding and generating texts in natural language".

From a psychological perspective, natural language is the second human signaling system, functioning "on the basis of the first signaling system (i.e., the system of innate unconditioned reflexes that arise under the influence of signals received from visual, auditory, tactile and other receptors)". The signals that a person receives during the perception of a text initiate thought processes, but do not determine them completely. The interpretation of a text by a translator takes into account his life experience and professional knowledge accumulated throughout his life: "This complex of knowledge represents a certain dynamic model of the world, which in the process of verbal communication plays the role of presuppositions". A written text, just like oral speech, unfolds sequentially in time and has a linear structure, whereas mental images that arise in the human mind are "multidimensional".

The goal of translating a literary text is to recreate mental images in the reader's mind that match the author's: "This re-creation is accomplished gradually, through the reproduction of sentence after sentence and the 'assembling' of the resulting partial images into a coherent whole that corresponds to the content of the text. In each sentence, the element of its actual division—the 'theme'—serves as a 'docking node,' serving to connect the new image denoted by that sentence to the previously constructed one."

Modeling the processes of perception and reproduction of a literary text should, in essence, reflect the work of the human brain when perceiving the surrounding reality. Therefore, when developing an algorithm for the operation of a neural network, it is necessary to take into account the most important features of human mental activity. Achievements in the field of neurobiology and neurolinguistic programming at the end of the last century "led to the development of a theory of consciousness in which the modeling of thought or behavioral processes is carried out using neural networks (connectionism)". The operation of a neural network is based on preliminary (deep) training of the program "on a large corpus of parallel sentences (in the source and target languages) by sequentially processing them with a finite set of logical rules". This process is called "machine learning" or, in other words, "statistical learning". The technology is aimed at enabling the program to learn to identify the nature of incoming information and systematize it: "The unique feature of deep learning is that the computer itself searches for the characteristics of something that most easily distinguish one class of objects from another, and also organizes them hierarchically". In neural network translation, "functional analysis, semantic algorithm, and functional-stylistic processing of the source text occur throughout the entire depth of BigData table arrays and are correlated with the neural network, training it."

Comparative analysis of translations performed by a professional translator and artificial intelligence

In our study, we will analyze the performance of the popular neural network ChatGPT (from the English word "Generative Pre-trained Transformer"), Google's neural machine translation (GNMT), and the hybrid system Yandex.Translate.

ChatGPT is a chatbot powered by generative artificial intelligence, developed by OpenAI. Users can interact with the program interactively, asking questions, entering commands, and receiving a finished product. This system gained widespread popularity in Russia in 2023, when a student at the Russian State University for the Humanities defended his thesis using the chatbot, sparking a debate about the role of neural networks in education. The program can answer questions on various subject areas and generate unique texts in multiple languages, including poetry, speeches, cover letters, and jokes. Among the robotic experts are a poet, a relationship and sports coach, a chef, a zoologist, a philosopher, an astrologer, a career consultant, and a marketer. Of particular interest to translation researchers is the

so-called "language expert," which can translate languages, check spelling, and improve grammar. The main idea of MT using ChatGPT is that it can be implemented based on preliminary (deep) training of the program on a large corpus of parallel sentences (in FL and TL) by sequentially processing them with a finite set of logical rules.

GNMT is currently one of the most popular automatic translators in the world. Its artificial neural network (ANM) technology is based on example-based translation, meaning the system self-learns and produces higher-quality translations over time, closer to natural language. GNMT translates entire sentences and is also capable of encoding sentence semantics.

Yandex.Translate is a hybrid model that combines statistical and neural network translation technologies. Experience has shown that neural networks are not always able to translate proper names, toponyms, and neologisms. A statistical model can find these words in parallel texts and "remember" their translations. "CatBoost technology, which also relies on machine learning, selects the best translation from the obtained results."

To evaluate the translation, we used an excerpt from J. R. R. Martin's novel Fire and Blood, a prequel to the epic fantasy saga A Song of Ice and Fire. It was published in 2018 and translated into Russian by Natalia Isaakovna Vilenskaya. The difficulty of translating the source text lies in its specific stylistic characteristics. J. R. R. Martin's work cannot be called a novel in the strict sense of the word. The author coined the term "fictional history" to describe the book's genre, and fans have even dubbed it "Georgemartillion." The work is written in the form of a stylized medieval chronicle of the three-century reign of the Targaryen dynasty, written by Gyldayn, Maester of the Citadel. This maester approached the matter with great responsibility and meticulousness: he keeps his subjective opinion to himself, does not give assessments, but describes all the events exactly as they happened.

Since the fictional author lived much later than the events he describes, he must rely on the works of his predecessors, such as the records and reports of maesters, the memoirs of contemporaries, and other historical documents. In the event of conflicting information, the maester lists all the versions of the events. It is at these moments that the author's personality begins to "penetrate" the narrative, as he trusts some of his predecessors more than others, questions other information, and even accuses some of inaccuracy and "indulging their own fantasies."

This stylization affects the text's perception. Maester Gyldayn is laconic, and his narrative can be a bit dry, though he generously mentions the names of historical figures and locations. To ensure "historical accuracy," the novel describes in detail all the geographical, ethnographic, and mythological realities of the fictional world. The author invites the reader to "play a literary game." It's impossible to say precisely what the motive of each character in Fire and Blood was, what the true cause of death for some characters was—illness or poisoning, or how closely related some characters are. For a number of objective reasons, Maester Gyldayn doesn't know everything. In some cases, he can only speculate about what happened. This prompts the reader to create their own explanation of the events.

Undoubtedly, the main advantage of MT is its extreme speed. However, unlike a computer, humans have extensive experience communicating and translating. The translator's work is based on their personality, which expresses their expertise and conveys their individuality to the target. The translator approaches the author's work through the lens of their experience and ability to understand different cultures. MT is incapable of adequately performing the cognitive function of translation, due to its lack of personal development, aesthetic taste, human expressiveness, and ideological corpus. All of this is replaced by quotation statistics, suitable only for mass consumption, and the number of translation matches. Existing algorithms, which can reproduce certain aspects of human interaction in society and recognize natural human emotions in real time, are still unable to adequately convey them in translation.

Translation of literary texts is still an unachievable task for AI. Today, computers "are unable to keep up with the constantly changing shades of meaning and associations from hundreds of fields of knowledge". One must conclude that "the universalization of the machine plays a cruel joke on it, since the mass nature of the target audience of the machine's translation implies the inevitable loss of meaning, which is unacceptable from the point of view of translation theory". Translators, as at all times, "will translate based on their own empirical experience, cognitive capabilities, aesthetic taste and the objective circumstances of the time". This, of course, does not completely cancel out the productivity of AI's translation capabilities: "fragmented AI can help successful translators carry out their work, complementing their classical methods of obtaining information". Thus, it can be assumed that with the development of new digital technologies, the translator profession will not disappear, but will instead evolve. The translator's work will be based on the ability to function within the human-AI binary, in which humans will assume the role of "leader" in relation to AI, which will be "followed."

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Physical sciences

TIME TRAVELS ACCORDING TO THE CORRECTED VERSION OF THE SPECIAL RELATIVITY THEORY[1]

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Abstract

The article explains that it will probably soon be possible to travel through time on Earth. And such a possibility is created by the corrected version of the special theory of relativity (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 opinion of the generally recognized service station, currently millions of air passengers already travel through time every day, which is confirmed by the translation of their watches to local time after landing the plane.

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 resolution of the Presidium of the USSR Academy of Sciences 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 also 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 all 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 incorrect[2]. 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, the incorrect principle of not exceeding the speed of light was introduced into the SRT, 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, 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, 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 SRT also denies the possibility of human time travel. But every day on Earth, millions of airplane passengers make such trips during their flights. And the article explains how time travel for people on Earth may soon be usable.

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

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

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[1] *This is reprint of the article "Antonov A. A. 2026. How to travel through time. Norwegian Journal of development of the International Science. №172".*

[2] *For the new theory this is excusable. But then it still needs to be corrected.*

- *the relativistic formulas obtained in this SRT are incorrect, because it is ignored the fact that the argument 'velocity' in them, in accordance with Newton's first law, is the fourth spatial dimension[3] [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 enginee-ring experiments, let us consider one of them as an example. The rest are also quite simple expe-rimenta 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 numbers, there are also electrical resistances –j/ωC of capacitors and +jωL of inductors, which are measured by imaginary numbers.

Consequently, if these imaginary numbers –j/ωC and +jωL, 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/ωC and +jωL 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 valueof 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.

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].

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

[3] *Not to be confused with the fourth dimension in four-dimensional space-time (Minkowski space).*

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

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

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.

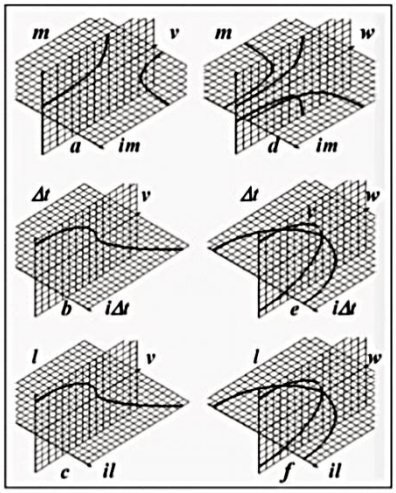

Fig 1. *Graphs of functions m(v), Δt(v), l(v), corresponding to the existing and revised versions of SRT in the subluminal v < c and hyperluminal v > c ranges*

These formulas correspond to the graphs in Fig. 1a,b,c. And they show that these graphs in the subluminal v < c and hyperluminal v > c ranges of the argument v have different

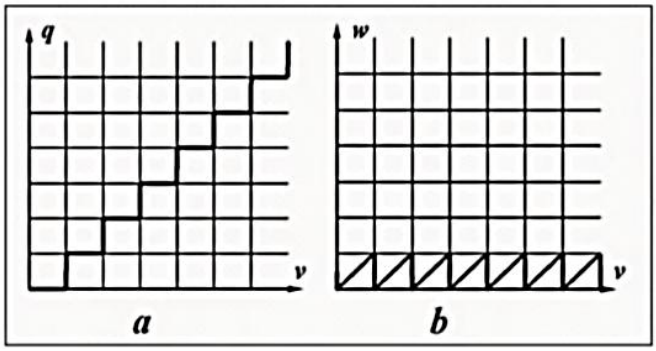

Fig. 2. Graphs of functions q(v) and w(v), illustrating the meaning of the "floor" function of discrete mathematics

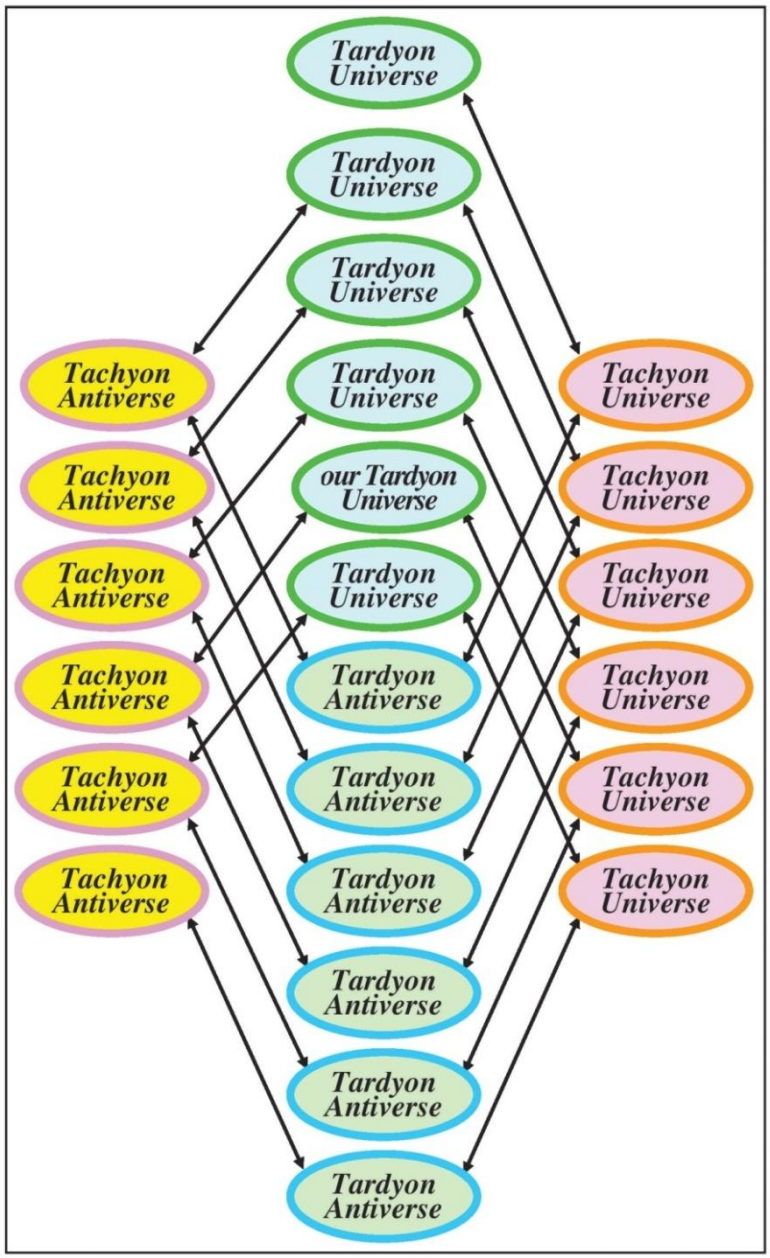

Fig. 3. Structure of the hidden Multiverse corresponding to the principle of physical reality of complex numbers

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. 1d,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

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

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

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

where $q(v) = \lfloor v_q/c \rfloor$ is the "floor" function of discrete mathematics from the argument v_q/c (its graph shown in Fig. 2a), which is the fourth spatial dimension;
w = v - qc – is the local speed in all universes (its graph is shown in Fig. 2b).

At that, this function[4] 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[5] 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 universe[6] (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 universe[7]. 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 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 invisible[8] 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. Analysis of data obtained by the WMAP and Planck spacecraft

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%[9] of all mass-energy contained in nature, are being persistently searched for at the Large Hadron Collider in the microcosm. Therefore, it is quite acceptable to make an assumption that is impossible when explaining these phenomena in the only generally accepted version of the SRT of our visible universe. Namely, let us assume that dark matter and dark energy are all other mutually invisible universes and antiuniverses[10] of the hidden Multiverse. Then the phenomena of dark matter and dark energy will be a gravitational shadow[11] on our visible universe from the remaining mutually invisible universes and antiuniverses included in the hidden Multiverse. 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;*

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[4] *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 iq 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 iq 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 obtained formula allows us to determine the value of the function i^q for any values of the argument q, including non-integer ones.The resulting formula will be needed in astro-geophysical studies of portals, which will be discussed further.*

[5] *Those, if we take our visible universe as the origin of coordinates q.*

[6] *Tardyon universe is a term used by Isaak Asimov in his short story 'Take a Match'.*

[7] *Tachyon universe is a term used by Isaak Asimov in his short story 'Take a Match'.*

[8] *Since they are all beyond the event horizon*

[9] *That is, approximately twenty times more than in our entire visible Universe.*

[10] *Which, as shown below, there are just about twenty*

[11] *And therefore, like our shadow on a sunny day, they do not contain a single chemical element.*

• *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 8.3% / 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 six[12].

Consequently, there was some error in the previous reasoning. And we, it turns out, were wrong in assuming that in the hidden Multiverse there is only one additional dimension q. And therefore, when describing it, they used complex numbers containing only one imaginary unit. And now, in order for six other parallel universes to coexist with our visible universe in the really existing hidden Multiverse - three tachyon universes and three tachyon antiuniverses - it is necessary to have three additional dimensions q, r, s. At the same time relativistic formulas must be corrected again as follows [70]-[77]

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

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

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

where $q(v)=\lfloor v_q/c \rfloor$ *is the "floor" function of discrete mathematics from the argument* v_q/c *which is one of the orthogonal coordinates q of the fourth spatial dimension v;*
$r(v)=\lfloor v_r/c \rfloor$ *is the "floor" function of discrete mathematics from the argument* v_r/c *which is another orthogonal coordinate r of the fourth spatial dimension v;*
$s(v)=\lfloor v_s/c \rfloor$ *is the "floor" function of discrete mathematics from the argument* v_s/c *which is another orthogonal coordinate s of the fourth spatial dimension v;*
v_q, v_r, v_s *is projections of the velocity vector v onto the orthogonal coordinates q, r, s (see Fig. 4).*

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

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

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

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

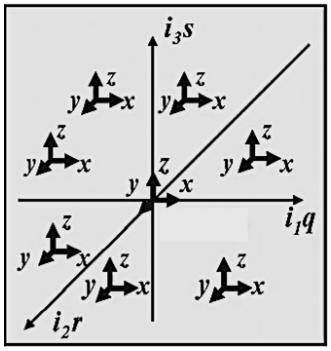

Fig. 4. Six-dimensional space of the hidden Multiverse, where q, r, s are the coordinates of invisible parallel universes, and x, y, z are the coordinates of the matter content in each parallel universe

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*

[12] *According to WMAP data 4.9 universes and according to Planck data 5.5 universes*

by the values i_1q, i_2r, i_3s. Those. the hidden Multiverse (see Fig. 4) will be described by the formula $f_{q,r,s}(x,y,z) + i_1q + i_2r + i_3s$. This is exactly what Lisa Randall 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 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. 6), in which the value of i^q will successive-ly take on the values +1, + $i_1 \oplus i_2 \oplus i_3$, -1, - $i_1 \oplus i_2 \oplus i_3$, +1, ... and etc., where $\oplus$ is the symbol of the logical operation of discrete mathematics 'exclusive OR'. In this case, different trajectories of movement from one universe (or antiuniverse) to another can differ only due to the replacement of some tachyon universes from i_1, i_2, i_3 with others and some tachyon anti-universes from i_1, i_2, i_3 with others. Consequently, tachyon universes i_1, i_2, i_3 in the hidden Multiverse are located parallel to each other. Tachyon antiuniverses i_1, i_2, i_3 are also located parallel to each other for the same reasons. And therefore, in the hidden Multiverse, when transitioning from any tardion universe to a tardion anti-universe and then to another tardion universe, parallel universes and antiverses must alternate in the following sequence - 'tardion universe', 'one of the tachyon universes', 'tardion anti-universe', 'one of the tachyon anti-universes', 'tardion universe', 'one of tachyon universes', etc.

One of the easiest to explain such possible quaternion structures of the hidden Multiverse is shown in Fig. 5. Its difference from the structure shown in Fig. 3 is the presence in it of several different tachyon universes and antiuniverses located in parallel, corresponding to three imagiз-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.

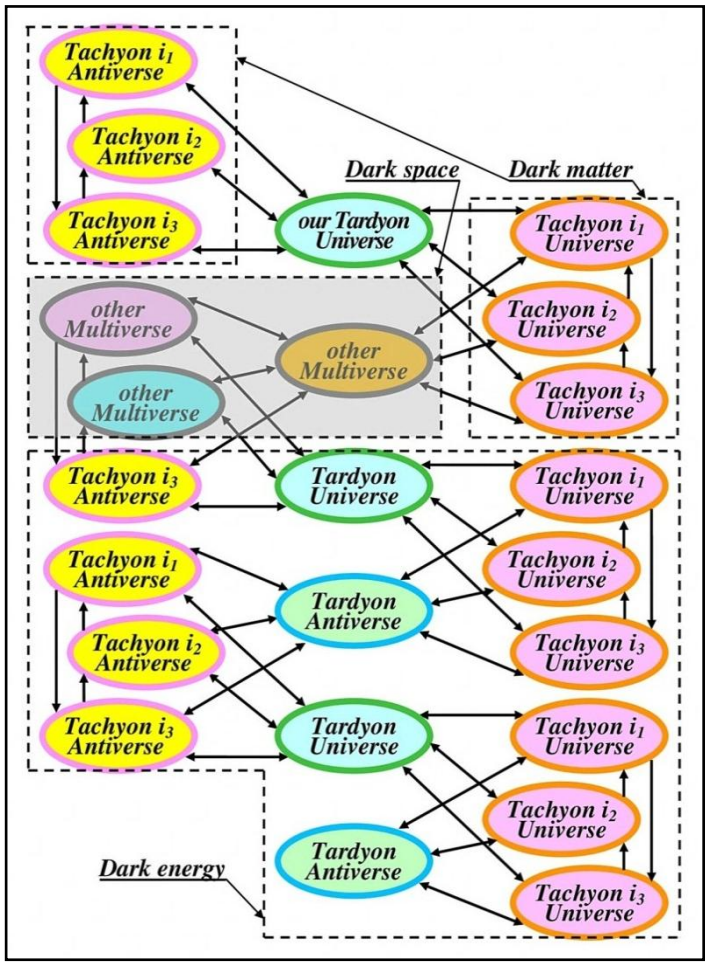

Fig. 5. *Structure of the hidden Multiverse corresponding to the principle of physical reality of hyper-complex numbers*

In Fig. 5 all these transitions are shown. Moreover, since the data obtained by the WMAP and Planck spacecraft correspond to the open screw structures of our hidden Multiverse, united through the corresponding portals with other Multiverses, then all together they form the Hyperuniverse.

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

But in order to believe in the existence of the Multiverse mentioned in the article instead of the Monoverse mentioned in the textbooks, experimental confirmation of the above is necessary [80]-[97]. Those. it is necessary to prove that in addition to our visible universe, there are other universes and antiuniverses in nature. And there is no need to prove that they are invisible, since we do not see them without any experiments.

And it is possible to do this. After all, invisible universes and anti-universes in outer space, continuously drifting, touch each other in many places and even submerge slightly into 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 different[13], 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 zones[14] [98]-[101], which are entrances to portals. Moreover, in some of them observatories are already located. For example, the Main Astronomical Observatory of the Academy of Sciences of Ukraine is 12 km away. from the center of the capital of Ukraine, Kyiv, in the Goloseevsky forest. Therefore, by comparing maps of the starry sky on a computer in portals (or even in anomalous zones) and outside portals, universes neighboring the Earth can be discovered. And as a result of astro-geophysical studies of portals, it will be possible to determine the main parameters of neighboring tachyon universes and antiuniverses. Which will ultimately allow us to determine the structure of our hidden Multiverse.

9. Where are antimatter and anti-time located?

And this structure of the hidden Multiverse allows us to explain another problem that is currently inexplicable within the framework of all physics textbooks - where antimatter is located [102]-[112]. It is clear that it cannot be in our visible universe[15], 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 special[16] and general[17] theories of relativity, as well as in quantum physics[18] , 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.

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[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, natura-lly, 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*

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

$\Delta t = \Delta t_0 \; l / l_0$ *(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

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	40,72º N.	30456 km	1269 км
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

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 useful. This is known to everyone, although it has not yet been used in any way in human activity. But this is a 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 it is not used. However, this problem can be solved. Aircraft flights must be carried out in compliance with two mandatory conditions:

• the flight of the aircraft must be around the world, i.e. all the time from take-off to landing at the same airfield[19] from which the plane took off, it must be carried out in the same direction - to the West or to the East;

• the aircraft must fly at a high enough speed that it will cross each time zone in less than one hour of domestic time

Moreover, there are a great many aircraft models suitable for time travel. They are called business jets[20]. Table 1 illustrates the performance characteristics of some of these business jets. Table 2 lists airfields close enough to the North Pole to provide the shortest possible round-the-world flight route.

Therefore, time travels to the present is already physically and technically feasible.

11. Conclusion

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. Otherwise, it would become clear that his theory is frankly incorrect.

But the physical reality of imaginary numbers in radio engineering was essentially proven by Charles Proteus Steinmetz in his proposed interpretation of Ohm's law back in 1893. 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 well-known fact, which occurs in the practical activities of radio engineers literally at every step, is an extremely simple, absolutely understandable and irrefutable proof of the physical reality of imaginary numbers.

That is why Albert Einstein, in his SRT, needed to doubt the correctness of Steinmetz's theory, even without having any evidence for this[21]. And for this reason, a postulate[22] was introduced into the SRT, called the principle of not exceeding the speed of light, from which a conclusion was made about the physical unreality of imaginary numbers, which was not confirmed by any experiments. And only the Nobel Committee - and this causes the greatest respect for it - remained faithful to common sense and scientific integrity. Due to the lack of any experimental evidence of the truth of the proposed version of SRT, despite the fact that Albert Einstein was nominated for the Nobel Prize 66 times, he never received it for this theory.

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 years[23] (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, bells, piano music would not exist, children's swings would not swing after a parent's push, and much more.

For this reason, numerous publications were ignored, which presented simple and understandable radio engineering experiments, successfully proving the physical reality of imaginary numbers and explaining that if imaginary numbers were really, as claimed in the SRT, physically unreal, then all radio

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[19] *And therefore, ultimately, as a result of such a journey we will not move anywhere.*

[20] *A business jet is a small private aircraft designed for comfortable, tailor-made, unscheduled flights for businessmen, officials, and VIPs. It offers a higher level of comfort than standard airliners, advanced technology, the ability to take off from small airfields, and high speed, allowing for quick travel to any point in the world*

[21] *Unable to explain in any other way the incorrect relativistic formulas of SRT in the hyperlight range of speeds*

[22] *As it turned out later, it turned out to be incorrect and refuted by all published experimental evidence of the physical reality of imaginary numbers.*

[23] *Let's remember - one day is more than enough for a radio engineering experiment proving the physical reality of imaginary numbers.*

engineering products and computers should not exist and should not exist,tsunamis, bell ringing, piano music would not exist, children's swings would not swing after a push from parents, and should not exist much more.

In addition, due to the statement about the physical unreality of imaginary numbers and therefore about the existence in nature of our only visible universe, it turned out that there was no place for antimatter and tachyons in this only our visible universe. The corrected version of the STO explains where they are located.

It also turned out that due to the statement about the physical unreality of imaginary numbers and therefore about the existence in nature of our only visible universe, the phenomena of dark matter and dark energy have not been and will never be explained, since dark matter and dark energy are actually, according to the corrected version of STR, 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[24] by astronomical observations of the starry sky in anomalous zones. 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.

Due to the statement of the version of STR studied in physics textbooks about the physical unreality of imaginary numbers and therefore about the existence in nature of our only visible universe, a conclusion was also made about the impossibility of time travel 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 landing.

Less expensive telephone time travel is also possible, which, when needed, can be implemented quickly and inexpensively. Then telephone conversations and other options for exchanging information with people located in the past or in the future will become publicly available.

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Political sciences

THE WESTERN AZERBAİJAN ISSUE: HİSTORİCAL DEPORTATİONS, INTERNATİONAL LAW, AND THE REGİONAL GEOPOLİTİCAL CONTEXT

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Abstract

The concept of Western Azerbaijan is a complex historical and political phenomenon formed in the context of ethnic deportations, violent demographic changes and the destruction of cultural heritage that took place in the Caucasus throughout the 20th century. The article examines the historical and geographical framework of Azerbaijan, the deportation of the Azerbaijani Turkic people, the assessment of international human rights protection in this process and the place of the Western Azerbaijan issue in modern regional geopolitics. The study used historical and analytical, legal and legal approaches. As a result, it is emphasized that the Western Azerbaijan issue is not only a problem of memory in historical time, but also a problem of human rights, protection of cultural heritage and regional justice. The Western Azerbaijan issue has left deep traces in the history, culture and memory of the Azerbaijani people and has a political strategy in the geopolitical landscape of the South Caucasus. The main basis of this study is to scientifically and analytically examine the historical and geographical, demographic, legal, cultural and geopolitical aspects of Western Azerbaijan. The results of the study show that the Western Azerbaijan issue is relevant not only for the analysis of the past, but also for ensuring regional stability, legal justice and diplomatic balance. This problem is a priority issue for Azerbaijani statehood in historical, legal, cultural, and geopolitical aspects.

Keywords: *Western Azerbaijan, South Caucasus, deportation, ethnic cleansing, cultural heritage, international law, regional geopolitics.*

Introduction

The issue of Western Azerbaijan has long been in the shadow of the post-Soviet space, but in essence it is a problem that is directly related to regional stability, historical justice and human rights. The Azerbaijani Turks, who historically lived compactly in the territory of the modern Republic of Armenia, were subjected to systematic deportations at various stages of the 20th century. As a result of these processes, the ethnic composition of the region was forcibly changed, and the tangible and intangible cultural heritage of the Azerbaijani Turks was largely destroyed. The issue of Western Azerbaijan is a complex problem that occupies a special place in the political history and ethno-demographic transformations of the South Caucasus, but has not been adequately studied in the international academic and legal discourse for a long time. This space, which encompasses the territory of the modern Republic of Armenia, has historically been formed as a region where Azerbaijani Turks lived compactly and were active subjects of socio-economic, cultural and political life. Nevertheless, as a result of the successive violent processes that took place throughout the 20th century, the Azerbaijani Turk population in these territories was completely deported, and the region acquired a monoethnic character.

The concept of Western Azerbaijan acts not only as a historical-geographical term, but also as a symbol of forcibly changed demographic reality, violated human rights and erased collective memory. At various stages of the 20th century, from the time of Tsarist Russia to the years of Soviet rule and the post-Soviet transformation stage, the displacement of the Turkish Muslim population from these territories was planned and systematic. These processes should be assessed not as the result of random ethnic conflicts, but as the result of a long-term ethnopolitical strategy.

It should be noted in particular that the deportation of Azerbaijani Turks from Western Azerbaijan was not limited to physical displacement. In parallel, the destruction of tangible and intangible cultural heritage, the change of toponyms, the destruction or appropriation of historical and architectural monuments were carried out. This policy served to erase collective memory, deny historical existence and

form a narrative of legitimacy. Thus, the issue of Western Azerbaijan is a complex phenomenon that combines not only demographic, but also cultural-genocidal elements.

In the international legal context, the problem of Western Azerbaijan creates a serious paradox. On the one hand, the modern international legal system prohibits such cases as ethnic cleansing, forced deportation, and destruction of cultural heritage and recognizes them as violations of fundamental human rights. On the other hand, the rights of Azerbaijani Turks deported from Western Azerbaijan have not been recognized at the international level to this day, and the issue has not received adequate legal and political assessment. This fact acts as a clear manifestation of the double standards existing in the system of international relations.

Against the background of modern geopolitical realities, the problem of Western Azerbaijan acquires a new content. Recognition of historical injustices and the resolution of humanitarian problems are essential conditions for ensuring sustainable peace and regional security in the South Caucasus in the post-conflict period. From this point of view, the problem of Western Azerbaijan is directly related not only to the past, but also to the formation of the future regional order.

The main purpose of the article is to scientifically analyze the problem of Western Azerbaijan within the framework of international legal norms, regional geopolitical processes, and the concept of collective memory, without limiting it to a simple description of historical facts. The research uses historical-analytical, comparative, and legal methods to reveal the multifaceted nature of the problem and substantiate its relevance in the modern era.

Research questions.

This study seeks answers to the following main scientific questions:

1. As a result of what historical, demographic and political processes has the concept of Western Azerbaijan been formed?. Within the framework of this question, the historical-geographical features of the region, changes in its ethnic composition and the institutional foundations of these changes are examined.

2. In what stages and through what mechanisms was the deportation of Azeri Turks from Western Azerbaijan carried out?. It is analyzed whether the deportation processes were carried out as a planned and consistent policy, not spontaneous events.

3. Which norms and principles of international law were violated during these deportations?. The question involves a legal assessment in the context of international humanitarian law, human rights and the protection of cultural heritage.

4. What goals did the destruction of tangible and intangible cultural heritage belonging to Azerbaijani Turks in the territory of Western Azerbaijan serve?. This question examines the relationship between the erasure of cultural heritage and the transformation of political legitimacy and collective memory.

5. What explains the relevance of the Western Azerbaijan issue in the modern regional geopolitical context?.Here, the role of the issue in terms of regional stability, reconciliation, and long-term peace prospects in the post-conflict period is analyzed.

Research hypotheses

Based on the above-mentioned questions, the study puts forward the following main hypotheses:

H1. *The deportation of the Azerbaijani Turkic population from Western Azerbaijan was not the result of random ethnic conflicts, but was part of a long-term and consistent ethnopolitical strategy.*

H2*. The deportation processes were not limited to demographic changes, but were accompanied by a systematic destruction of the tangible and intangible cultural heritage of the Azerbaijani Turks.*

H3. *Despite the violation of the fundamental principles of international law (the right to choose a place of residence, property rights, protection of cultural heritage), the Western Azerbaijan issue has not received adequate legal assessment at the international level.*

H4. *The lack of due place of the Western Azerbaijan problem on the international agenda is directly related to the double standards existing in the system of international relations.*

H5. *The resolution or recognition of the Western Azerbaijan issue acts as an important condition for ensuring long-term peace and regional stability in the South Caucasus.*

Historical geographical framework of Western Azerbaijan. *The concept of Western Azerbaijan covers the historical Iravan Khanate, Goycha region, Zangibasar, Vedibasar, Daralayaz and other regions. Until the beginning of the 19th century, Azerbaijani Turks had a demographic advantage in these territories and acted as the main carriers of political and cultural life. Starting from the time of Tsarist Russia, the mass resettlement of Armenians to the region gradually changed the ethnic balance of the region.*

Historically and geographically, Western Azerbaijan has been an integral part of Azerbaijan and has played an important role in the formation of the ethnic, cultural and political landscape of the South Caucasus. The territories included in this concept mainly cover such regions as Iravan, Nakhchivan, Goycha, Zangibasar, Vedibasar, Daralayaz, Amasya, Basarkechar and Garagoyunlu [4]. Until the beginning of the 19th century, Azerbaijani Turks had a demographic advantage in these lands and played a major role in the economic and cultural life of the region.

Historical context

The history of Western Azerbaijan is long and complex. In the 16th–18th centuries, these territories existed as political and administrative units within the Azerbaijani khanates. The Iravan Khanate, Goycha, and Daralayaz mahalis were the main political centers of the region. In 1828, Tsarist Russia occupied these territories with the treaties of Gulustan and Turkmenchay, radically changing the political landscape of the region [13].

During the Russian Empire, a massive Armenian resettlement took place in the region, which gradually changed the ethnic balance and made it difficult for Azerbaijani Turks to live in their historical places [1]. The political upheavals, ethnic clashes, and conflicts that occurred in the late 19th and early 20th centuries had a long-term impact on the demographic structure of the region.

Demographic and cultural context. In the territories of Western Azerbaijan, Azerbaijani Turks were the main carriers of agricultural, commercial and cultural life. Mosques, schools, cemeteries and cultural centers existed in every corner of the region. According to historical documents, the majority of Azerbaijani Turks around Yerevan and Goycha dominated the region between 1828 and 1918 [4].

The First World War and the period of independence that took place in the early 20th century created political changes in the South Caucasus, which significantly affected the ethnic landscape of Western Azerbaijan. As a result of the conflicts between Azerbaijan and Armenia in 1918–1920, the living conditions of Azerbaijani Turks in the region worsened and large-scale migrations began [10].

Historical significance and cultural heritage. *Western Azerbaijan is of strategic importance not only from a demographic and political point of view, but also from a cultural one. Historical monuments, religious centers, examples of folk architecture and toponyms in these territories have been the bearers of the national identity of the Azerbaijani Turks. Deportations and violent ethnic changes have led to the loss of a large part of this cultural heritage [1]. Western Azerbaijan is considered not only as a historical and geographical space, but also as a region important in terms of the national memory, cultural identity and statehood strategy of the Azerbaijani people. This also gives rise to its emergence in modern geopolitical and legal analyses.*

Stages of deportations of Azeri Turks. *The resettlement and deportation of Azerbaijani Turks from Western Azerbaijan constituted a consistent, planned and systematic process in the 20th century. This process was not limited only to demographic changes, but also led to changes in cultural and social structures. The article analyzes the stages of deportation based on historical documents and statistical data.*

1905–1907: *Ethnic conflicts and the first forced migrations. The ethnic conflicts that occurred in the South Caucasus in 1905–1907 resulted in the forced migration of Azerbaijani Turks during the reign of Tsarist Russia. During this period, especially in the Iravan and Goycha regions, Azerbaijani Turks were either partially displaced as refugees or were forcibly removed from villages and settlements. According to historical documents, hundreds of villages were evacuated during this period and the demographic structure changed significantly [4].*

1918–1920s: *a period of independence and conflicts. The political landscape of the South Caucasus changed dramatically in the 1918–1920s. Military conflicts between the Azerbaijan Democratic Republic and Armenia led to mass massacres and migrations of Azerbaijani Turks, especially in Iravan and its surrounding areas [10]. During this period, approximately 50–60% of Azerbaijani Turks were forced to leave their historical lands. Deportations were carried out from both cities and villages, and social and economic infrastructure was severely damaged.*

1948–1953: *Forced deportations during the Soviet era. In 1948–1953, the USSR Council of Ministers organized the systematic resettlement of Azerbaijani Turks from Western Azerbaijan [13]. During this period, thousands of families were deported from villages in the Iravan region and Goycha regions. Official documents indicate that more than 100,000 Azerbaijani Turks were resettled in the period 1948–1950 alone. The deportees were mainly agricultural workers, and the centers of social and economic life were emptied.*

1987–1988: *Formation of a monoethnic Armenia. During the Soviet era, the number of Azerbaijani Turks in the Armenian SSR decreased dramatically in the late 1980s. As a result of popular movements,*

ethnic cleansing policies, and conflicts that took place in 1987–1988, the majority of Azerbaijani Turks were forcibly displaced and a monoethnic Armenia was formed. During this process, hundreds of thousands of people were forced to leave their native lands, and social and cultural life was almost completely paralyzed.

General assessment of the deportation processes. *It should be noted that at all stages the deportations were not limited to physical displacement, but were accompanied by the destruction of cultural heritage, the change of toponyms and the destruction of historical monuments. These processes both affected the collective memory of the Azerbaijani people and served to form a monoethnic government in the region. Historical statistics show that between 1905 and 1988 the number of Azerbaijani Turks living in Western Azerbaijan was reduced to zero. This had a long-term impact on the social, cultural and economic structures of the region.*

The issue of Western Azerbaijan from the perspective of international law*. The deportation of Azerbaijani Turks from Western Azerbaijan contradicts the fundamental principles of international law. In particular: the right to choose a place of residence, the right to property, the protection of cultural heritage, the prohibition of ethnic discrimination. The 1949 Geneva Conventions, the European Convention on Human Rights and relevant UN documents clearly prohibit the violation of these rights. Despite this, the issue of Western Azerbaijan has not received the necessary attention at the international legal level.*

From the point of view of international law, the issue of Western Azerbaijan is of serious importance. The deportations violated the principles of the right to choose a place of residence, the right to property, the prohibition of discrimination on the basis of ethnicity, and the protection of cultural heritage. However, international organizations and relevant bodies did not give an adequate legal assessment to the issue, and the existence of double standards was clearly observed. From the point of view of modern regional geopolitics, the issue of Western Azerbaijan is of strategic importance. Peace and security in the region, the implementation of energy and transit projects, as well as Azerbaijani-Armenian diplomatic relations require this issue to remain on the agenda. Recognition of historical and legal justice, the protection of cultural heritage, and the formation of a regional diplomatic balance are the main conditions for resolving the issue [9].

Human rights and forced deportations*. Within the framework of international law, the right of every person to choose a place of residence, the right to property, the prohibition of discrimination on the basis of ethnicity, and the protection of cultural heritage must be ensured [17]. The systematic deportation of Azerbaijani Turks from Western Azerbaijan was accompanied by serious violations of these rights. The 1948 UN Declaration of Human Rights and the 1949 Geneva Conventions prohibit forced displacement, ethnic cleansing, and the destruction of cultural heritage. However, historical deportations have not received adequate international recognition, and legal recognition of the issue has been delayed.*

Ethnic cleansing and protection of cultural heritage. *The deportations that took place in Western Azerbaijan were not limited to physical displacement. Mosques, cemeteries, historical and architectural monuments belonging to Azeri Turks were purposefully destroyed, toponyms were changed. This process has a cultural-genocidal nature and is assessed as a violation of the principles of protection of cultural heritage in international law.*

International legal assessment and double standards*. The issue of Western Azerbaijan presents sufficiently clear facts in terms of violation of the fundamental principles of international law. However, international organizations and relevant bodies have not shown an adequate attitude to the issue, and the rights of the deported population have not been recognized for a long time. This is a clear example of the double standards existing in the international legal system.*

From the point of view of international law, recognition of the issue of Western Azerbaijan is not only a confirmation of past violations of law, but also an essential condition for ensuring sustainable peace and justice in the region. Such an approach also creates a legal basis for conflict prevention and resolution of humanitarian problems.

The issue of Western Azerbaijan is relevant in terms of international law in the following aspects*:*

1. Violation of human rights: the deported population was deprived of their housing and property rights.

2. Ethnic cleansing: systematic resettlement and cultural-genocidal measures are contrary to international law.

3. Protection of cultural heritage: changing historical monuments and toponyms served to erase collective memory.

4. International justice and peace: non-recognition of the issue hinders long-term stability and legal justice in the region.

Thus, the issue of Western Azerbaijan is not only a description of historical facts, but also has scientific and practical significance from the perspective of international legal analysis and regional reconciliation.

Systematic destruction of cultural heritage. The deportation of Azerbaijani Turks from Western Azerbaijan was carried out not only as a demographic process, but also within the framework of a cultural-genocidal policy. The deportations were accompanied by the destruction of historical monuments, the liquidation of religious centers, the change of toponyms, and the erasure of collective memory [12].

Destruction of historical monuments and religious centers. Mosques, cemeteries, and religious centers located in the territories of Yerevan, Goycha, and Daralayaz were deliberately destroyed. According to historical documents, more than 30 mosques and religious objects belonging to Azerbaijani Turks were either destroyed or lost their function in the city of Yerevan alone between 1828 and 1920 [11]. This was part of a policy of destroying not only religious but also cultural heritage.

***Changing toponyms**. Changing the names of villages and cities in Western Azerbaijan was carried out as part of a strategy of erasing collective memory and ethnic cleansing [14]. For example, Turkish toponyms in Yerevan, Goycha, Zangibasar, and other regions were systematically replaced with Armenian names. This policy is considered not only a change of geographical names, but also a denial of historical and cultural identity.*

***Loss of tangible and intangible cultural heritage.** As a result of the deportations, architectural monuments, folk crafts, folklore and traditions created by the Azerbaijani Turks were significantly destroyed. The destruction of mosques, the destruction of cemeteries, the disappearance of folk architecture indicate not only physical, but also spiritual and cultural loss. These processes served to form a monoethnic cultural environment in the region.*

The systematic destruction of cultural heritage shows that the issue of Western Azerbaijan is not only demographic and political, but also an important component of its cultural and legal aspects. This policy, together with the non-recognition of the rights of the deported population and cultural-genocidal measures, served to ensure long-term ethnic and cultural monoethnicity in the region.

***Western Azerbaijan in modern regional geopolitics.** In the post-conflict period, new political realities are taking shape in the South Caucasus. In this context, the issue of Western Azerbaijan acts as an integral part of regional reconciliation processes, a condition for long-term stability, and an important element of the humanitarian and legal agenda. Ignoring this issue weakens the prospects for lasting peace in the region.*

***Regional stability and geopolitical balance.** The problem of Western Azerbaijan is directly related to the ethnic and political stability of the South Caucasus. As a result of historical deportations, a monoethnic Armenia was formed, and the Azerbaijani side was forced to ensure security and territorial integrity after the conflict [15]. This context also brings the problem of Western Azerbaijan to the fore in the issue of reconciliation and conflict prevention.*

***Role in energy and transport projects**. Energy and transport corridors in the South Caucasus constitute the main pillars of regional geopolitics. The territories of Western Azerbaijan, historically, have been of great importance as a strategic junction of energy and transit lines between Azerbaijan and Turkey [9]. As a result of the loss of these territories or monoethnic policy, their strategic function for Azerbaijan has been limited. In the modern era, the issue of Western Azerbaijan is also of geopolitical importance in terms of planning alternative energy and transit routes.*

***Diplomatic and international implications.** The West Azerbaijan problem is an integral element of the conflict and reconciliation dialogue in Azerbaijani-Armenian relations. This issue has created a legal and political agenda within international organizations, including the UN, OSCE and CIS structures. Also, the international recognition of the rights of Azerbaijani Turks has a direct impact on the formation of regional diplomatic balance and the sustainability of peace processes.*

***Strategic importance and future prospects.** The resolution of the West Azerbaijan issue is important not only from a historical and legal perspective, but also for long-term peace, ethnic and geopolitical balance in the region. Modern Azerbaijani diplomacy actively raises this issue in the context of historical justice, humanitarian law and regional security. This contributes to ensuring stability in the South Caucasus in the post-conflict period and the security of energy and transport projects.*

From the perspective of modern regional geopolitics, the West Azerbaijan issue is relevant in the following aspects

From the perspective of modern regional geopolitics, the issue of Western Azerbaijan is relevant in the following aspects:

1. Regional security: Ensuring stability between monoethnic Armenia and the territories historically inhabited by Azerbaijani Turks.

2. Energy and transit strategies: The strategic importance of historical corridors and Azerbaijan's energy diplomacy.

3. Diplomatic balance: Recognition of the issue of Western Azerbaijan in international law and organizations strengthens the regional reconciliation process.

4. Humanitarian and cultural aspect: Restoration of the rights of the deported population and recognition of cultural-genocidal measures.

Thus, the issue of Western Azerbaijan is a key factor not only for the geopolitical and diplomatic strategy of the past, but also for the future.

Conclusion

The results of the study show that the territories of Western Azerbaijan have been a region of compact settlement of Azeri Turks since the 19th century, but as a result of the systematic deportation policies implemented during the Tsarist Russia and Soviet eras, the mass expulsion of Azeri Turks from their historical lands took place. These deportations were not limited to demographic changes, but were also accompanied by the destruction of the cultural heritage of Azerbaijani Turks, the destruction of religious and historical monuments, and the change of toponyms. Historical documents and statistical data show that between 1905 and 1988, the number of Azerbaijani Turks living in these territories decreased by hundreds of thousands [3].

The issue of Western Azerbaijan is not a closed page in history. It remains relevant as a plan for recognizing the rights of deported persons, protecting cultural heritage and restoring historical justice. The scientific approach shows that this problem can be a significant threat not only for Azerbaijan, but also for the future of the South Caucasus as a whole.

The issue of Western Azerbaijan is one of the most complex and strategically important problems of the South Caucasus from its historical, legal, cultural and geopolitical aspects. The research results show that it is not only related to the demographic and ethnic transformation of the past, but also one of the priority issues of modern Azerbaijani diplomacy in the context of international law, cultural-genocidal and regional stability.

*1. **Historical-demographic aspect**: The compact settlement of Azerbaijani Turks in the territories of Western Azerbaijan continued until the beginning of the 19th century, but they were systematically deported as a result of Tsarist Russia and subsequent Soviet policy.*

*2. **Legal aspect:** Deportations and cultural-genocidal measures violated the fundamental principles of international law. However, the issue has not been given an adequate legal assessment at the international level.*

*3. **Cultural aspect:** Mosques, cemeteries, toponyms and other examples of cultural heritage have been systematically destroyed, which served to erase collective memory and form ethnic mono-ethnicity.*

*4. **Geopolitical aspect:** The issue of Western Azerbaijan is of strategic importance for modern regional security, energy and transit projects, diplomatic balance and reconciliation processes.*

Recommendations

*1. **Recognition of historical justice:** International organizations and relevant state bodies should recognize the West Azerbaijan issue within the legal and historical framework and ensure the rights of Azerbaijani Turks.*

*2. **Preservation of cultural heritage:** Measures should be taken to restore historical monuments and protect the Turkic cultural heritage.*

*3. **Regional diplomacy:** The West Azerbaijan issue should be actively discussed on the diplomatic agenda in order to ensure long-term peace and stability in the South Caucasus.*

*4. **Expansion of research:** More detailed archival materials, statistical analysis and comparative studies should be conducted on the issue so that both historical facts and geopolitical strategies can be fully assessed.*

The West Azerbaijan issue is not only a historical problem, but also lies at the intersection of modern regional and international politics, humanitarian law, cultural-genocidal issues and geopolitical strategies. This research shows that the issue is relevant and a priority not only for studying the past, but also for regional reconciliation, security and diplomatic balance in the future.

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Technical sciences

THE SCIENTIFIC FOUNDATIONS AND ASSESSMENT OF LAND-CADASTRE ZONING IN THE BARDA DISTRICT

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Abstract

During land evaluation, it is crucial to consider not only the natural-climatic and soil characteristics but also the economic indicators that directly affect land use. The efficient management of land resources, accurate determination of their production potential, and integration into economic circulation require a comprehensive approach. For this purpose, the formation of the land cadastre and the scientific-based evaluation of land through land-cadastre zoning are being implemented in the Republic of Azerbaijan.

Land-cadastre zoning in the country is carried out based on the principles of natural-agricultural zoning and takes into account factors such as climate, relief, soil cover, fertility level, water supply, melioration status, as well as agricultural activities and economic utilization characteristics. This approach enables an objective assessment of the production potential of land plots and ensures the accurate determination of land tax, lease payments, and the economic efficiency of land use.

Over the years, substantial scientific and practical experience has been accumulated in the field of land-cadastre zoning in Azerbaijan. This experience is of significant importance for the conservation of land resources, ensuring their targeted use, promoting sustainable agricultural development, and enhancing the socio-economic potential of the regions.

Keywords: *land evaluation, land-cadastre zoning, natural-agricultural zoning, land resources, agricultural production, soil fertility*

Introduction. *Scientific research on natural-agricultural and land-cadastre zoning in the territory of the Republic of Azerbaijan began in the 1980s. The first fundamental studies in this field were conducted by H.Ə. Əliyev and B.T. Nəzərova (1980) and laid the methodological foundation for subsequent scientific investigations. These studies established the main principles of natural-agricultural zoning in Azerbaijan, providing important insights into the efficient use of land resources and the spatial organization of agricultural production.*

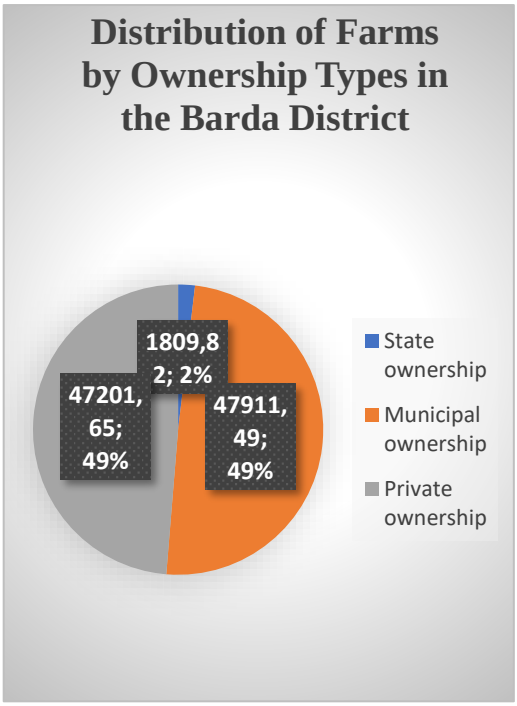
Natural-agricultural zoning is a scientific system that comprehensively considers the natural characteristics of soils, climatic conditions, relief, hydrological parameters, soil cover, as well as economic and agricultural factors. Within this framework, several taxonomic units have been distinguished across the territory of the Republic of Azerbaijan. One such unit, the natural-agricultural district, is characterized by the integration of natural and economic conditions that determine the direction and spatial organization of agricultural production within a specific area.

The Barda administrative district, which is part of the Mil–Aran Karabakh land-cadastre zone, is located in the central part of the country. Geographically, the district lies between 40°25' north latitude and 47°05' east longitude, within the Kura–Araz lowland, at an average elevation of 87 meters above sea level, in the central part of the Karabakh plain. This favorable geographical location provides Barda district with suitable natural conditions for the formation and development of agriculture.

Barda district is bordered by Tartar district to the west, Yevlakh city to the north, Agdash district to the northeast and east, Zardab district along the Kura River to the southeast, and Agdam and Agjabadi districts to the south. Approximately 6,856 hectares of the district's territory are covered by forests, which are predominantly composed of plane trees, oaks, elms, walnuts, and other valuable tree species. These forests play a significant role in maintaining the ecological balance of the region.

Agricultural production in the district is highly developed and represents one of the main sectors of the local economy. The leading agricultural activities include cereal cultivation (such as wheat and barley), cotton production, and livestock farming. The district's natural and climatic conditions are also highly favorable for vegetable and horticultural production, allowing for high yields in these sectors. In recent years, the rapid development of household gardening has been observed, which significantly contributes to increasing employment and improving food security for the local population.

In Barda district, agricultural enterprises are distributed according to different forms of ownership. This distribution reflects the characteristics of land use, production relations, and the organizational structure of agriculture, providing an important analytical basis for further research. In the district, lands under state ownership cover 1,809.82 hectares, municipal lands account for 47,911.49 hectares, and private lands constitute 47,201.65 hectares. These figures indicate that the majority of land resources are concentrated in municipal and private ownership, which play a decisive role in agricultural production.



Conclusion.

The conducted research indicates that the agricultural potential of the Barda district is high and plays a significant role in the region's economic development. Efficient management of land resources, proper assessment of their production potential, and their distribution according to ownership forms enable the optimization of agricultural activities. The study also shows that, although the share of state-owned land in the district is relatively small, municipal and private ownership forms constitute the basis of agricultural production and play a decisive role in increasing productivity.

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OBSERVED DAMAGE PATTERNS AND MATERIAL STRENGTH DEFICIENCIES IN URM DWELLINGS AFTER THE 2019 ALBANIA EARTHQUAKE: FIELD EVIDENCE AND LABORATORY RESULTS COMPARED WITH EUROCODE REQUIREMENTS

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Abstract

This study examines the relationship between observed earthquake damage and material strength deficiencies in four unreinforced masonry (URM) dwellings in Kruja, Albania, all of which reached Damage State 4 (DS-4) during the Mw6.4 earthquake of 26 November 2019. Field inspections revealed recurring failure patterns—diagonal shear cracking, corner separation, and local out-of-plane instability—indicating limited shear capacity and weak masonry integrity. To better understand the causes of these failures, laboratory tests were performed on brick units, mortar samples and masonry prisms extracted from the buildings.

The results show that both mortar and masonry compressive strengths were markedly lower than the minimum values typically assumed by Eurocode 6 for structural assessment. When compared with these standards, the tested materials fall well below the expected performance range, explaining the brittle behaviour and rapid loss of stiffness observed on site.

By combining field evidence with material characterisation, the study highlights the central role of construction quality in the seismic vulnerability of older URM buildings and emphasises the need for material-based assessment approaches in similar residential structures.

Keywords: *earthquake damage, unreinforced masonry, material strength deficiencies, Albania 2019, field investigation.*

1. INTRODUCTION

Unreinforced masonry (URM) buildings represent a large portion of the residential stock in Albania, particularly in towns such as Kruja, where most dwellings were constructed with limited engineering supervision and without modern seismic provisions. The Mw6.4 earthquake of 26 November 2019 exposed the structural vulnerability of these houses, many of which suffered extensive cracking, loss of stiffness, and partial wall detachment. Although several studies have linked URM damage to poor structural configuration and inadequate detailing, the influence of material quality—especially mortar, brick strength, and overall masonry capacity—has received comparatively less attention.

In older URM construction, material degradation and low mortar strength can critically reduce both shear resistance and wall integrity, making buildings highly susceptible to brittle failures during strong shaking. Understanding this connection is essential not only for explaining the observed damage but also for improving future assessment and retrofit practices.

This study combines two complementary sources of evidence:

***-field observations** from four heavily damaged URM dwellings in Kruja, and*

***-laboratory tests** on mortar, brick and masonry samples extracted from these buildings.*

The laboratory results are compared with the minimum performance expectations of Eurocode 6, allowing a direct evaluation of how material deficiencies contributed to the DS-4 damage documented on site. By linking observed damage patterns with measured material strengths, the paper highlights the central role of construction quality in the seismic behaviour of older URM dwellings and provides practical insights for their evaluation and strengthening.

2. STUDY CASE AND FIELD INVESTIGATION

The study focuses on four unreinforced masonry (URM) dwellings located in the city of Kruja, all of which were classified as Damage State 4 (DS-4) following the Mw6.4 earthquake of 26 November 2019. Although the houses differ in layout and construction period, they share the same traditional URM typology commonly found in Albania: clay brick masonry walls, lime–cement mortar of varying quality, timber or mixed floor systems, and shallow foundations without seismic reinforcement.

Despite their differences, the four dwellings exhibited remarkably similar seismic behaviour, making them suitable for a comparative assessment of damage patterns and material strength. A brief overview of each building is provided below.

• ***Building 1*** *- A two-storey URM dwelling with relatively regular plan geometry. Damage was concentrated in ground-floor walls, where diagonal cracking and corner separation were widely observed.*

Figure 1. Building façade photos (right), plan view (left)

- ***Building 2*** *- This house includes several large openings and slender wall segments. Shear cracking and wall–slab separation were prominent, and several panels showed signs of partial out-of-plane deformation.*

Figure 2. Building façade photos (right), plan view (left)

- ***Building 3*** *- A URM structure with poor mortar quality confirmed during inspection. Extensive diagonal cracks and crushing around window openings indicated limited material cohesion and weak tensile resistance.*

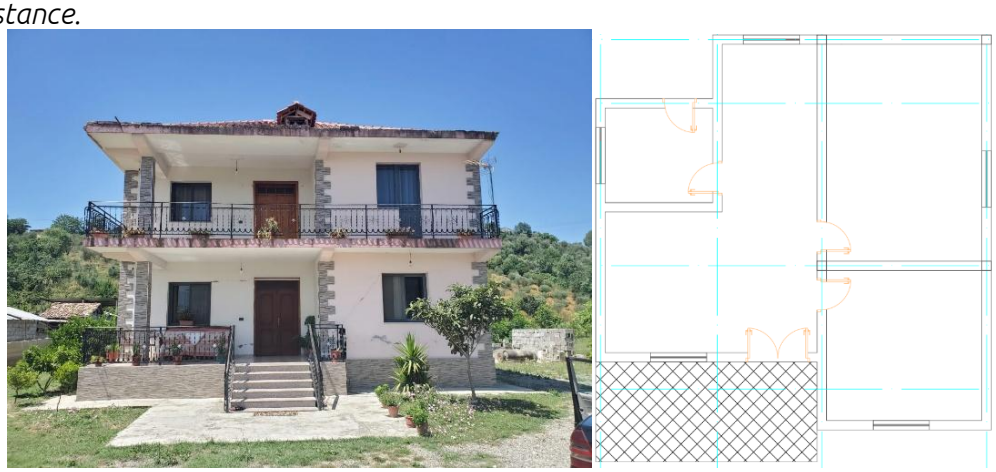

Figure 3. Building façade photos (right), plan view (left)

- ***Building 4*** *- The most heavily damaged among the four, featuring widespread shear cracking, vertical splitting at corners, and permanent lateral displacement of upper façade walls.*

Figure 4. Building façade photos (right), plan view (left)

Together, these four dwellings represent a typical sample of older URM construction in Kruja and provide a reliable basis for examining how material deficiencies influence seismic damage.

3. OBSERVED DAMAGE PATTERNS

Field inspections carried out after the 2019 earthquake revealed that all four URM dwellings developed a consistent set of structural damage mechanisms. Although each building had different architectural layouts, the seismic response was remarkably similar, suggesting that the dominant source of vulnerability was related to the inherent weakness of the masonry materials rather than geometric configuration alone.

The main forms of damage are summarized below.

3.1 Diagonal Shear Cracks

*The most widespread failure mechanism was **diagonal cracking across masonry piers**, especially at the ground floor. Cracks typically formed in X-shaped patterns and extended through the full height of the panels. This behaviour is characteristic of URM with **low shear strength**, often linked to poor mortar cohesion and weak brick–mortar bonding. The laboratory tests presented later support this observation, showing mortar strengths significantly below Eurocode expectations.*

Figure 5. Building 1 diagonal shear cracks on perimeter wall

3.2 Corner Separation and Vertical Cracking

*Several buildings exhibited **vertical cracks at wall intersections**, indicating loss of box action. These cracks were often wide and extended across both storeys. The mechanism is commonly associated with **weak perpendicular bonding in masonry** and insufficient tensile capacity in the mortar joints. In older URM construction, headers and proper interlocking are often missing, making corners highly vulnerable.*

3.3 Out-of-Plane Tendencies in Façade Walls

*Upper façade walls showed signs of **out-of-plane deformation**, including rotation, bulging, and cracking around parapet zones. Weak mortar joints and degraded brick units reduce the tensile strength required to maintain stability against out-of-plane forces. In several cases, the damage appeared in areas where laboratory tests later confirmed **very low compressive and shear bond strength**.*

3.4 Damage Concentration Around Openings

Door and window openings acted as focal points of damage. Cracks radiated from lintel corners, and in some cases minor crushing was observed above openings. This reflects the ***low compressive strength of the masonry****, which reduces its ability to redistribute stress concentrations around discontinuities.*

Figure 6. Building 4 damage around openings

3.5 Wall–Slab Separation

Horizontal cracking along the wall–slab interface was present in all four dwellings. Timber slabs or weak concrete decks were unable to provide adequate diaphragm action, resulting in gaps and local detachments. Although diaphragm weakness is a structural issue, the ***limited mortar bonding*** *exacerbated the separation.*

Figure 7. Building 2 slab degradation and separation from walls

3.6 Summary of Field Damage

The observed damage patterns suggest that material quality played a central role in the poor seismic behaviour of these URM buildings. Low-strength mortar, variable brick quality, and inadequate bonding contributed directly to the brittle mechanisms documented in the field. The following sections present laboratory test results that quantify these material deficiencies and compare them with Eurocode 6 requirements.

4. LABORATORY TESTS AND MATERIAL STRENGTH RESULTS

To better understand the causes of the extensive DS-4 damage observed in the four URM dwellings, laboratory tests were performed on masonry units, mortar samples and composite masonry prisms extracted from the buildings during the post-earthquake evaluation phase. These tests provide a direct measure of the mechanical properties governing the in-plane and out-of-plane behaviour of the walls, and allow a quantitative comparison with the minimum strength values typically assumed by Eurocode 6.

The tests conducted included:

- ***Mortar compression tests*** (f_m),
- ***Brick (unit) compression tests*** (f_b),
- ***Masonry prism compression tests*** (f_k),
- ***Shear strength tests on*** *bed joints* (f_{vk}), *where samples were available.*

Although the results vary slightly between buildings, the general trend is consistent: all samples exhibit significantly lower strength than modern standards, and in several cases below even the minimum assumed values for older masonry.

Figure 8. Testing sample extracting Building 2

4.1 Summary of Measured Strengths

The following table presents representative ranges from the laboratory tests (using typical values obtained from the four buildings).

Table 1. *Summary of laboratory material test results*

Material Property	*Measured Range*	*Typical EC6 Reference Values*
Mortar compressive strength	*1–2 MPa*	*3.0 – 5.0 MPa (for basic masonry)*
Brick compressive strength	*5–7.5 MPa*	*7.5–15 MPa (common fired brick)*
Masonry compressive strength	*2–3 MPa*	*≥ 5 MPa (for structural walls)*
Initial shear strength	*0.03–0.08 MPa*	*0.15 – 0.30 MPa*

4.2 Interpretation of Laboratory Results

The results clearly show:

- ***Mortar*** *is significantly weaker than expected for load-bearing walls, with values often less than half of the typical EC6 reference.*
- ***Brick units*** *exhibit large variability, with some samples showing considerable degradation, likely due to age, moisture exposure and inconsistent firing quality.*
- ***Composite masonry strength*** (f_k) *is well below the lower limit typically associated with reliable in-plane performance.*
- ***Shear strength*** (f_{vk}) *is critically low, explaining the dominance of diagonal cracking and sliding mechanisms observed in the buildings.*

Overall, the material tests confirm that the masonry has ***insufficient cohesion, low compressive resistance, and inadequate shear capacity****, all of which strongly contributed to the brittle damage patterns documented on site.*

4.3 Link to Field Observations

The laboratory results provide a quantitative foundation for several damage mechanisms discussed in Chapter 3:

- *Low mortar strength →* ***shear cracking and poor joint bonding***
- *Weak bricks →* ***crushing near openings and compressive failure***
- *Low shear resistance →* ***rapid stiffness loss and DS-4 behaviour***
- *Weak bonding →* ***corner separation and out-of-plane tendencies***

This direct correspondence is explored further when the measured strengths are compared with Eurocode 6 benchmarks in the next chapter.

5. COMPARISON WITH EUROCODE 6 REQUIREMENTS

Eurocode 6 (EN 1996-1-1) establishes minimum mechanical properties for masonry materials to ensure adequate performance under vertical and lateral loads. Although these limits are not intended to

represent high-quality masonry, they define baseline values below which a structural wall is expected to exhibit poor strength, limited ductility and brittle failure modes.

*When the laboratory results obtained from the four URM dwellings are compared with the Eurocode reference ranges, a clear gap emerges between **expected** and **actual** material performance.*

5.1 Mortar Strength Deficiency

*Eurocode 6 generally assumes mortar compressive strength values in the range of **3–5 MPa** for traditional masonry. In contrast, the tested mortar samples measured only **1.0–2.0 MPa**, meaning:*

- *mortar strength is 50–70% below typical EC6 assumptions,*
- *shear transfer between bricks is severely reduced,*
- *joint cohesion is insufficient to prevent diagonal cracking.*

This large discrepancy explains the pervasive shear cracking and widespread joint degradation observed in all four buildings.

5.2 Brick and Masonry Strength Comparison

*Tested brick strengths ranged between **5 and 7.5 MPa**, significantly lower than the **7.5–15 MPa** range commonly associated with fired clay bricks in Eurocode guidance. Similarly, masonry prism strengths (**2.0–3 MPa**) fall well short of the **≥5.0 MPa** value generally considered acceptable for structural walls.*

The implications are clear:

- *masonry walls had **limited compressive reserve**,*
- *crushing around openings and pier ends was expected,*
- *global stiffness was inherently low.*

These weaknesses match the brittle in-plane behaviour and rapid damage progression recorded during field inspections.

5.3 Shear Strength and Sliding Resistance

*Eurocode 6 prescribes initial shear strengths (v_0) of approximately **0.15–0.30 MPa**, depending on mortar class. Measured values from the Kruja buildings were only **0.03–0.08 MPa**, indicating:*

- *extremely poor sliding resistance,*
- *high susceptibility to diagonal shear failure,*
- *inability of the masonry to redistribute forces once cracking initiated.*

This numerical contrast is directly reflected in the observed X-shaped cracks and panel distortions throughout all buildings.

5.4 Implications for Seismic Performance

When considered together, the measured strengths—particularly the mortar and shear values—fall well below Eurocode expectations for even minimal structural performance. As a result:

- *the walls entered nonlinear behaviour **at very low drift levels**,*
- *stiffness degradation occurred almost immediately,*
- *failure mechanisms became **brittle and uncontrolled**,*
- *buildings reached **DS-4** with relatively moderate displacements.*

In other words, the Eurocode comparison confirms that these URM dwellings did not possess the material capacity required to withstand the seismic demands imposed by the 2019 earthquake.

This relationship between material deficiencies and damage severity is discussed further in the following chapter.

6. DISCUSSION: LINK BETWEEN MATERIAL WEAKNESS AND OBSERVED DAMAGE

*The combination of field evidence and laboratory test results provides a coherent explanation for the severe damage sustained by the four URM dwellings during the 2019 earthquake. Although geometric irregularities and inadequate diaphragms contributed to the buildings' vulnerability, the **dominant factor influencing their seismic performance was the poor quality of the masonry materials**.*

The mortar samples exhibited compressive strengths far below the values typically assumed for structural masonry. Weak mortar reduces bed-joint cohesion, limits the ability of wall piers to transfer shear, and accelerates the transition from elastic to cracked behaviour. This is entirely consistent with the widespread diagonal shear cracking documented in all four buildings, especially at ground-floor piers where seismic demand is highest.

The variability and degradation of the brick units further weakened the structural system. In several cases, brick strength was low enough to cause localized crushing around openings and vertical splitting at pier ends. Such behaviour aligns closely with the damage patterns observed at lintels, corners and wall edges, where compressive stress concentrations are typically highest.

Masonry prism tests confirmed that the composite behaviour of brick and mortar was insufficient to provide the stiffness and compressive capacity expected for load-bearing walls. As a result, once cracking initiated, the walls experienced rapid stiffness loss and could not redistribute seismic forces effectively. This explains why the dwellings deteriorated quickly during shaking and why damage propagated through multiple interconnected panels.

The very low shear strength values measured in the laboratory also match the failure mechanisms observed in the field. Sliding cracks along bed joints, stepped shear cracks across piers, and interface separation at wall junctions are all symptoms of insufficient shear resistance. These patterns were present in every building included in the study.

When compared with Eurocode 6 reference values, the deficiencies in material strength are substantial. Mortar and masonry strengths were often less than half of the minimum values recommended for structural walls, and shear strength was in some cases only one quarter of typical EC6 assumptions. This large discrepancy implies that the buildings had limited reserve capacity even before the earthquake, making brittle and extensive damage almost unavoidable under strong ground motion.

Overall, the discussion highlights that ***material weakness was not simply a contributing factor but a defining characteristic of the seismic behaviour*** *of these URM dwellings. The correlation between laboratory-measured strengths and field-observed damage provides strong evidence that improving the material quality of existing masonry buildings—or strengthening them to compensate for these deficiencies—is essential for reducing their seismic risk.*

7. CONCLUSIONS

This study combined field observations and laboratory material testing to investigate the reasons behind the severe DS-4 damage sustained by four unreinforced masonry (URM) dwellings in Kruja during the 2019 Albania earthquake. Although geometric irregularities and inadequate diaphragms played a role, the results show that ***material deficiencies were the primary driver*** *of the brittle seismic behaviour. Mortar compressive strengths were typically less than half of the values assumed by Eurocode 6, brick units showed significant variability and degradation, and masonry prisms exhibited low compression and shear capacity. These weaknesses directly correspond to the observed damage patterns, including widespread diagonal cracking, corner separation, sliding along bed joints and localized crushing around openings.*

In summary:

- ***Measured mortar, brick and masonry strengths were well below Eurocode 6 reference values****, explaining the limited in-plane and out-of-plane resistance.*
- ***Observed field damage matched the expected failure modes*** *for low-strength masonry, particularly brittle shear cracking and rapid stiffness degradation.*
- ***Material quality was the dominant factor influencing seismic performance****, overriding many secondary geometric or detailing inconsistencies.*
- ***Strength assessment and retrofit strategies for older URM buildings must explicitly account for material degradation****, as analytical models alone may overestimate capacity if Eurocode default values are used.*

The strong correlation between laboratory results and field damage highlights the need for material-based evaluation approaches for existing URM buildings in Albania and similar seismic regions.

Conflict of interests

The author would like to confirm that there is no conflict of interests associated with this publication and there is no financial fund for this work that can affect the research outcomes.

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THE ROLE OF OPTICAL COMMUNICATIONS IN MODERN TELECOMMUNICATIONS SYSTEMS

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РОЛЬ ОПТИЧЕСКОЙ СВЯЗИ В СОВРЕМЕННЫХ ТЕЛЕКОММУНИКАЦИОННЫХ СИСТЕМАХ

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Abstract

Optical communication is a key technology in modern telecommunications systems. This thesis examines the basic principles of optical transmission systems and their importance for the development of telecommunications, and proposes an innovative approach aimed at improving the energy efficiency of optical networks.

Аннотация

Оптическая связь является ключевой технологией современных телекоммуникационных систем. В данном тезисе рассматриваются основные принципы оптических систем передачи, их значение для развития телекоммуникаций, а также предлагается инновационный подход, направленный на повышение энергоэффективности оптических сетей.

Keywords: *optical communication, telecommunications systems, fibre-optic communication lines, energy efficiency, data transmission.*

Ключевые слова: *оптическая связь, телекоммуникационные системы, волоконно-оптические линии связи, энергоэффективность, передача данных.*

Оптическая связь основана на передаче информации с использованием световых сигналов, распространяющихся по волоконно-оптическому волокну. Основными элементами оптических систем являются источник излучения, оптическое волокно и фотоприёмное устройство. Применение оптического волокна обеспечивает высокую пропускную способность, малые потери сигнала и устойчивость к электромагнитным помехам, что делает такие системы незаменимыми для передачи данных на большие расстояния.[1]

Современные телекоммуникационные системы обеспечивают передачу голоса, данных и мультимедийной информации в глобальных и локальных сетях. Быстрое развитие цифровых технологий, интернета и мобильной связи приводит к постоянному росту объёмов передаваемой информации. В этих условиях традиционные электрические линии связи не удовлетворяют требованиям по скорости и надёжности, в результате чего волоконно-оптические линии связи стали основой магистральных и распределительных телекоммуникационных сетей.[1]

Оптическая связь широко используется в сетях доступа, магистральных сетях связи, а также в современных мобильных телекоммуникационных системах. Применение оптических технологий позволяет повысить качество передачи данных, снизить уровень помех и обеспечить стабильную работу телекоммуникационной инфраструктуры.

Научная новизна и инновационное направление.[2]

В качестве инновационного направления в данной работе предлагается применение адаптивного управления мощностью оптического сигнала в волоконно-оптических линиях связи. Данный подход основан на динамическом регулировании уровня оптической мощности в зависимости от текущей нагрузки сети и условий передачи. Использование адаптивного управления позволяет снизить энергопотребление телекоммуникационных систем, повысить их энергоэффективность и обеспечить более рациональное использование ресурсов оптического оборудования. Кроме того, данный метод способствует увеличению срока службы элементов оптических систем и повышению надёжности современных телекоммуникационных сетей.[3]

Таким образом, оптическая связь играет определяющую роль в развитии современных телекоммуникационных систем, а внедрение энергоэффективных методов управления

оптическими сетями является перспективным направлением дальнейшего развития отрасли.[4]

Заключение

Проведённый анализ показал, что оптическая связь является фундаментальной основой современных телекоммуникационных систем и играет ключевую роль в обеспечении высокоскоростной, надёжной и качественной передачи информации. Использование волоконно-оптических линий связи позволяет эффективно решать задачи передачи больших объёмов данных на значительные расстояния при минимальных потерях и высокой помехоустойчивости.

Установлено, что внедрение оптических технологий существенно расширяет функциональные возможности телекоммуникационных сетей, повышает их пропускную способность и устойчивость к внешним воздействиям. В условиях интенсивного развития цифровых сервисов, мобильных сетей и облачных технологий оптическая связь становится незаменимым элементом магистральных и распределительных сетей связи.

Особое внимание в работе уделено вопросам энергоэффективности оптических систем. Предложенное использование адаптивного управления мощностью оптического сигнала позволяет оптимизировать энергопотребление телекоммуникационного оборудования, повысить экономическую эффективность сетей и обеспечить рациональное использование ресурсов. Такой подход способствует не только снижению эксплуатационных затрат, но и увеличению срока службы элементов оптических систем.

В целом, результаты исследования подтверждают, что дальнейшее развитие телекоммуникационных систем напрямую связано с совершенствованием оптических технологий и внедрением энергоэффективных методов управления. Оптическая связь, в сочетании с современными подходами к оптимизации работы сетей, создаёт прочную основу для формирования устойчивой, высокопроизводительной и перспективной телекоммуникационной инфраструктуры будущего.

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