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Pedagogical Sciences

ARTIFICIAL INTELLIGENCE AS A MEANS OF ENHANCING THE EFFICIENCY OF PEDAGOGICAL ACTIVITY IN HIGHER EDUCATION INSTITUTIONS

Zhumasheva S.S.

Candidate of Pedagogical Sciences, Associate Professor, Abai Kazakh National Pedagogical University, Kazakhstan, Almaty

Bitleuov A.A.

PhD student in “International Relations” at the Sorbonne-Kazakhstan Institute of Abai Kazakh National Pedagogical University, Kazakhstan, Almaty

Abstract

The rapid digitalization of higher education has positioned artificial intelligence (AI) as a transformative force in teaching and learning. This study explores how AI technologies can enhance the efficiency and quality of pedagogical activity in higher education institutions, focusing on the perceptions and experiences of university lecturers in Kazakhstan. Using a qualitative methodology, ten semi-structured interviews were conducted with academic staff from three universities in Almaty. Thematic analysis revealed that lecturers perceive AI not as a substitute for the teacher, but as a supportive co-instructor that assists in automating routine tasks, personalizing instruction, and providing data-driven insights for evidence-based teaching. The findings indicate that AI enhances pedagogical efficiency when combined with educators' digital competence, institutional support, and ethical awareness. However, challenges related to infrastructure, professional readiness, and data privacy persist. The study concludes that AI's pedagogical potential lies in its ability to augment human teaching by fostering creativity, inclusivity, and reflective practice. The research contributes to the growing body of literature on digital transformation in higher education and provides practical implications for universities seeking to integrate AI responsibly into teaching and learning processes.

Keywords: artificial intelligence; pedagogical efficiency; higher education; digital transformation; personalized learning; teacher readiness; Kazakhstan; qualitative research

Relevance of the Study

In the context of rapid digital transformation and the expansion of artificial intelligence (AI) technologies, higher education systems are undergoing profound changes. Traditional models of teaching and learning are no longer sufficient to meet the growing demands for flexibility, personalization, and efficiency in pedagogical activity. The integration of AI tools into the educational process represents a key driver for improving the quality and effectiveness of teaching in higher education institutions. Firstly, AI enables personalized learning, allowing educational programs to adapt to students' individual pace, learning style, and prior knowledge. This personalization enhances student engagement and academic performance, as noted in recent studies that emphasize the transformative role of AI in learner-centered education (Kuleto, 2021).

Secondly, the application of AI is reshaping the role of the teacher from a transmitter of knowledge to a facilitator and designer of learning experiences. In this context, AI assists educators by automating routine tasks such as assessment, feedback, and administrative processes, thereby freeing time for creative and research-oriented pedagogical work. Thirdly, current research highlights that while the potential of AI in education is widely recognized, teachers' readiness and awareness remain limited. Many educators lack sufficient training and confidence to effectively integrate AI technologies into their teaching practices (Zhou, 2023; George, 2023). Therefore, studying the conditions for the successful adoption of AI in higher education becomes essential for enhancing pedagogical efficiency. Ultimately, in the era of lifelong learning and hybrid educational models, the use of AI becomes a strategic tool for optimizing the educational process, enhancing learning outcomes, and informing evidence-based teaching decisions (Kakhkharova, 2024). As a result, exploring the possibilities, challenges, and pedagogical implications of AI use in higher education is both timely and socially significant. Thus, this study is relevant as it contributes to understanding how artificial intelligence can enhance the effectiveness of pedagogical activity in universities, offering practical recommendations for educators and policymakers to ensure high-quality and adaptive higher education.

The aim of the research. The primary aim of this study is to explore how artificial intelligence technologies can enhance the efficiency of pedagogical activity in higher education institutions. The research seeks to identify the ways in which AI can support teaching practices, optimize educators' workload, and contribute to the improvement of teaching quality and student engagement within the context of Kazakhstani universities.

The research question is: *How can artificial intelligence contribute to improving the efficiency and quality of pedagogical activity in higher education institutions?*

Significance of the Study

This research is significant for several reasons. First, it contributes to the understanding of AI integration in higher education within the Central Asian and Kazakhstani context a region where empirical studies on this topic remain limited. Second, it provides practical insights for educators and administrators into how AI tools can be effectively implemented to improve teaching efficiency, reduce administrative burden, and enhance student learning outcomes. Furthermore, the findings are expected to inform policy development and professional training programs aimed at increasing teachers' digital competence and readiness to use AI technologies. By combining theoretical and empirical perspectives, this study expands the academic discourse on the digital transformation of higher education and the evolving role of university educators.

Literature Review

The integration of artificial intelligence into higher education has become one of the most significant developments shaping the future of pedagogy and institutional effectiveness. Over the past decade, AI technologies have evolved from experimental tools to strategic assets capable of transforming both teaching and university management. Scholars increasingly view AI not only as a set of digital instruments but as a catalyst for rethinking the purposes, methods, and organization of teaching and learning (Zhou, 2023). This literature review synthesizes current research focusing on how AI contributes to improving pedagogical efficiency in higher education, with particular attention to motivational, organizational, and contextual factors within Kazakhstan's educational landscape. Vinichenko, Melnichuk, and Karácsny (2020) emphasize that the application of AI in universities should be understood through the lens of motivation and human capital management. Their research demonstrates that AI can enhance institutional performance by reducing administrative workloads, improving decision-making processes, and increasing transparency in evaluating teaching outcomes. However, they argue that such benefits are only realized when universities simultaneously foster intrinsic motivation among academic staff. Without psychological readiness and alignment between technological innovation and professional

incentives, AI integration may encounter resistance, thereby diminishing its efficiency-enhancing potential. From the perspective of teaching and learning, Hooda et al. (2022) explore how AI systems support formative assessment and personalized feedback. Their findings reveal that AI-based assessment tools can identify individual learning gaps, recommend targeted resources, and provide continuous feedback loops that improve student performance. Importantly, the authors caution against over-automation, highlighting that AI should complement rather than replace human pedagogical judgment. This aligns with Zhou's (2023) broader analysis of technology integration, which argues that effective AI implementation requires a pedagogical framework that retains the educator's role as a mentor and designer of learning experiences. In Zhou's view, AI functions best when embedded into adaptive learning environments, predictive analytics, and intelligent tutoring systems that extend human capacity rather than supplant it.

The literature on Kazakhstan presents a unique perspective on AI adoption in higher education, reflecting both significant progress and persistent challenges. Orynassar, Zhumadilova, and Abdykerimova (2024) provide a comprehensive overview of AI's current use within Kazakhstan's education system, noting that most universities are still in the early stages of digital transformation. They identify infrastructural limitations, insufficient teacher training, and the absence of unified ethical and methodological standards as major barriers. Nonetheless, their study highlights growing institutional interest in leveraging AI for data-driven decision-making and academic monitoring. Complementary to this, Nurtayeva et al. (2024) examine the broader role of digital technologies in Kazakhstani higher education, arguing that AI represents a strategic enabler for achieving national priorities in education quality and innovation. They emphasize that successful integration requires coordinated efforts between policymakers, administrators, and educators, ensuring alignment between digital transformation strategies and pedagogical practices. Similar concerns are reflected in Ibrayeva et al. (2025), who identify three key conditions for sustainable AI implementation: the development of faculty competencies, the modernization of regulatory frameworks, and the creation of supportive digital infrastructures. At the micro-level of classroom practice, Meiramova and Zagatova (2025) investigate the application of AI-powered smart technologies in French language teaching. Their findings indicate that adaptive systems and intelligent platforms foster learner autonomy, motivation, and differentiated instruction. However, they also underline the need for teachers to acquire new methodological skills to interpret AI-generated analytics responsibly. Yeslyamov (2024) adds to this discussion by focusing on the automation of university processes through software robots that employ AI. His study demonstrates how robotic process automation can streamline administrative tasks, enabling educators to devote more time to mentoring and research, thus improving overall teaching efficiency.

Further insights into innovative pedagogical practices come from Zhuzeyev et al. (2024), who explore the integration of AI within culturally grounded teaching models based on Kazakh ethnopedagogy. They conclude that the effectiveness of technological innovations depends largely on their cultural and pedagogical contextualization. Similarly, Buribayev et al. (2023) emphasize the necessity of revising evaluation systems in pedagogical universities, suggesting that AI can contribute to more objective and data-rich assessments of research and teaching performance. Dzhanegizova (2024) situates AI adoption within the broader process of digital transformation in Kazakhstan's higher education sector. Her analysis shows that while AI offers significant opportunities for innovation, the sustainability of digital transformation depends on institutional leadership, inter-university collaboration, and continuous investment in digital literacy. Collectively, these findings suggest that Kazakhstan's higher education institutions are transitioning from ad hoc experimentation with AI tools to a more systematic and strategic integration of intelligent technologies into teaching and management. Across the reviewed studies, several common themes emerge. First, AI serves as a multifunctional enabler of

pedagogical efficiency, improving personalization, assessment accuracy, and administrative productivity. Second, human factors motivation, competence, and ethical awareness are crucial determinants of successful implementation. Third, AI adoption in higher education is deeply context-dependent, requiring alignment with national policies, institutional strategies, and local pedagogical cultures. Finally, there remains a lack of longitudinal and empirical studies that measure AI's long-term impact on learning outcomes, teacher performance, and institutional sustainability.

The literature demonstrates that artificial intelligence holds substantial promise for enhancing the effectiveness of teaching and learning in higher education. Yet, realizing this potential requires a comprehensive approach that combines technological innovation with pedagogical, ethical, and organizational transformation. The emerging evidence from Kazakhstan, alongside international research, illustrates that AI's success in academia depends not solely on algorithms or infrastructure, but on the readiness and creativity of educators who engage with these tools to enrich the learning experience and strengthen the overall quality of higher education.

Research Methods

This study employed a qualitative research design aimed at exploring university lecturers' perceptions, experiences, and challenges related to the integration of artificial intelligence into teaching practices. The qualitative approach was chosen because it allows for an in-depth understanding of educators' subjective meanings, attitudes, and reflections, which cannot be adequately captured through quantitative methods. The research was grounded in the interpretivist paradigm, emphasizing context-specific understanding and meaning construction through participants' narratives. The qualitative design relied on semi-structured, in-depth interviews as the primary data collection method. This approach provided both structure and flexibility allowing the researcher to explore predetermined topics while giving participants the opportunity to elaborate freely on their experiences. The decision to use interviews rather than surveys was guided by the exploratory nature of the study, as well as by the limited availability of empirical data on AI adoption among university lecturers in Kazakhstan. The study was conducted in three higher education institutions located in Almaty, Kazakhstan:

1. al-Farabi Kazakh National University (KazNU);
2. Abai Kazakh National Pedagogical University (KazNPU);
3. Kazakh National Women's Teacher Training University (QyzPU).

A total of 10 participants took part in the study. The selection was made using purposive sampling, ensuring diversity in academic rank, discipline and years of teaching experience. This strategy was chosen to capture a wide spectrum of professional experiences with and attitudes toward AI. Participation was voluntary, and no financial incentives were offered. Data were collected between March and May 2025. Each interview lasted approximately 45–60 minutes and was conducted either face-to-face on university premises or via secure online platforms such as Zoom, depending on the participants' availability and preference. The interview guide consisted of open-ended questions focusing on five thematic areas:

1. General understanding and awareness of AI technologies;
2. Current or potential use of AI in teaching and assessment;
3. Perceived impact of AI on pedagogical efficiency;
4. Ethical and institutional issues;
5. Professional development and training needs.

All interviews were conducted in the participants' preferred language and were audio-recorded with consent. The recordings were then transcribed verbatim and, when necessary, translated into English for analysis while maintaining semantic accuracy. The collected data were analyzed using thematic analysis, following the six-step framework proposed by Braun and Clarke

(2006). This method was selected for its flexibility and suitability for identifying recurrent patterns across qualitative data sets. The steps included (1) familiarization with the data, (2) generating initial codes, (3) searching for themes, (4) reviewing themes, (5) defining and naming themes, and (6) producing the report. Initial open coding was performed manually to ensure closeness to the data. Codes were then grouped into broader categories such as perceived benefits, pedagogical challenges, ethical concerns, and institutional readiness. The final themes reflected cross-case consistencies and divergences across participants and institutions. To enhance analytical reliability, peer debriefing was conducted with two colleagues familiar with qualitative methods and educational research. All ethical protocols were strictly followed. Participants were provided with an informed consent form detailing the study's purpose, procedures, voluntary nature, and confidentiality guarantees. Anonymity was ensured by assigning pseudonyms and omitting any identifying information in transcripts and publications. Data were securely stored on password-protected devices accessible only to the researcher. Ethical approval was obtained from the relevant university research ethics committee prior to data collection.

Results

Thematic analysis of the ten semi-structured interviews revealed four overarching themes that describe how university lecturers in Kazakhstan perceive and experience the integration of artificial intelligence (AI) into higher education teaching. These themes are:

1. *Perceived pedagogical benefits of AI;*
2. *Challenges and barriers to AI adoption;*
3. *Ethical and psychological concerns;*
4. *Professional readiness and institutional support.*

Each theme comprises several subthemes and is supported by direct quotations from participants. Pseudonyms (P1–P10) are used to preserve anonymity.

Enhancing Teaching Efficiency

A recurring idea across the interviews was that AI tools significantly help to automate routine teaching and administrative tasks such as grading essays, preparing quizzes, and managing attendance. This automation, in turn, frees lecturers' time for higher-order pedagogical activities such as mentoring and curriculum design. One lecturer from Abai university described this shift as follows:

«Раньше я тратила по несколько часов на проверку эссе. Теперь, используя ИИ-инструменты для обратной связи, я больше концентрируюсь на том, как студенты рассуждают, а не на орфографии.» (P3, KazNPU)

[Before using AI tools, I spent hours checking essays. Now, with AI-assisted feedback, I can focus on guiding students' thinking instead of correcting grammar]

This perception illustrates a transformation in the pedagogical role from a focus on mechanical evaluation to a more reflective and developmental function. Similarly, a lecturer from KazNU emphasized how AI-based communication systems improved efficiency in student interactions:

«Чат-боты и автоматическая обратная связь сильно сократили время ответа студентам. Теперь они сразу получают комментарии, и это повышает их мотивацию.» (P1, KazNU).

[Chatbots and automated feedback systems have reduced response time dramatically. Students get immediate feedback, which improves their motivation]

This quotation underlines one of the most widely acknowledged benefits of AI integration the acceleration of feedback loops and the creation of a more responsive learning environment.

Personalization and Student Engagement

Another frequently discussed advantage was AI's ability to personalize learning and maintain students' engagement. Participants observed that adaptive platforms help tailor tasks and materials to each student's level and progress, thus promoting differentiated instruction. A lecturer from the QyzPU described her experience:

«Менің француз тілі сабағымда жасанды интеллект платформасы әр студенттің үлгерімін талдайды және жеке деңгейіне сай материал ұсынады. Мұндай жекелендіруді мен қолмен істей алмаймын.» (P7, QyzPU)

[In my French classes, the AI platform analyzes each student's progress and suggests materials suitable for their individual level. This kind of personalization is something I could not achieve manually]

This statement demonstrates the perceived pedagogical value of AI as a tool for differentiated learning and inclusive education especially in linguistically and culturally diverse classrooms. Another instructor from KazNU noted how AI-based simulations increase students' curiosity and participation:

«Студенттерге жасанды интеллектке негізделген тренажёрлар ұнайды. Теорияны нақты мысалдармен байланыстыру оңайырақ болады.» (P2, KazNU)

[Students enjoy interacting with AI-driven simulations. It makes it easier to connect theoretical material with concrete examples]

The enhanced engagement, as lecturers explained, is not merely due to the novelty of technology but also because AI can visualize complex concepts and support exploratory learning.

Data-driven insights. Participants also emphasized that AI-enabled analytics provide valuable data for monitoring student performance and predicting learning difficulties. These data insights allow teachers to make more informed pedagogical decisions and offer timely interventions. An associate professor from KazNPU described the analytical utility of AI tools:

«AI-панельдер маған студенттердің прогресін нақты көруге мүмкіндік береді. Емтихан уақытына дейін кім қиналып жатқанын алдын ала білемін, сондықтан ертерек көмектесемін.» (P5, KazNPU)

[AI dashboards allow me to see students' progress clearly. I can identify who is struggling before the exam period and offer support earlier]

The quote reflects how AI analytics serve as an early warning system that enhances formative assessment and enables individualized academic support. In addition, several participants mentioned that such analytics are gradually being integrated into institutional monitoring systems. A senior lecturer from KazNU highlighted:

«Раньше мы ориентировались только на итоговые оценки, теперь система показывает динамику усвоения, что помогает мне точнее планировать повторение и консультации.» (P6, KazNU).

[Previously, we relied only on final grades, but now the system shows the dynamics of learning. It helps me plan revision and consultations more accurately]

This demonstrates a shift from static assessment toward continuous, evidence-based teaching practice, where AI acts as both an analytical and reflective partner. Across all cases, AI was perceived not as a substitute for teachers but as a supportive co-instructor that facilitates efficiency, personalization, and data-informed decision-making. Participants associated AI tools with three main pedagogical benefits:

1. *Efficiency*: automation of repetitive tasks and administrative functions, enabling teachers to focus on creativity, mentorship, and deep learning activities.
2. *Personalization*: tailoring learning experiences to students' individual needs, language proficiency, and cognitive styles, thereby enhancing inclusivity and motivation.
3. *Analytics*: generating actionable insights into students' learning processes, supporting early intervention and adaptive instruction.

These three interrelated dimensions of pedagogical benefit efficiency, personalization, and analytics are synthesized in Figure 1, which summarizes the key subthemes, core meanings, and representative quotations illustrating how lecturers conceptualize AI as a “supportive co-instructor” rather than a replacement for human teaching.

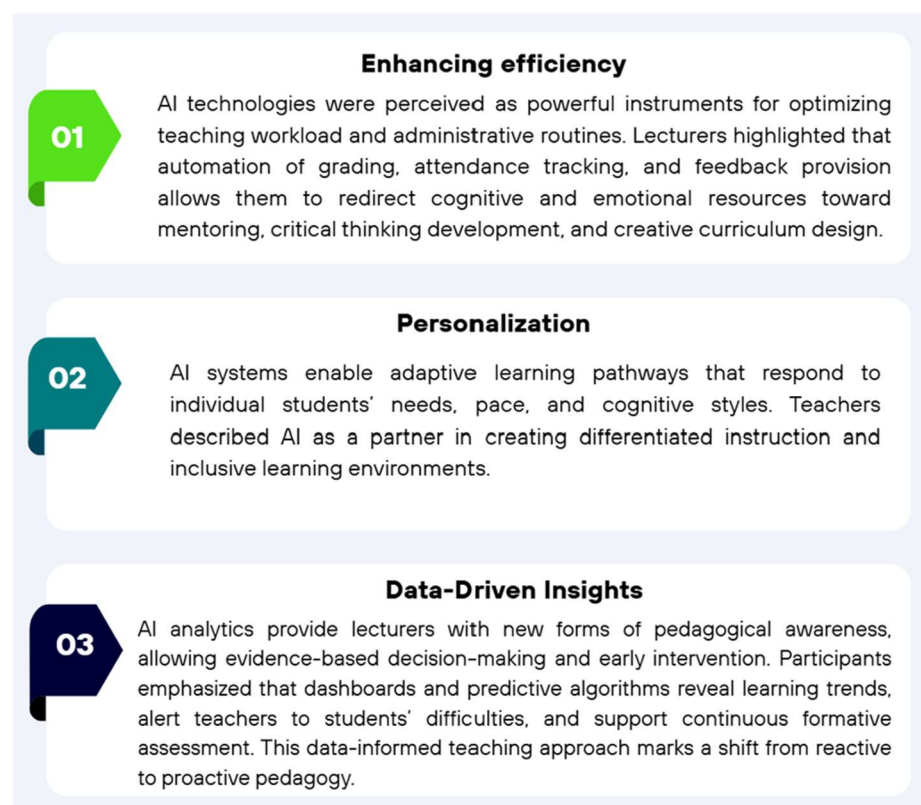


Figure 1. - Pedagogical benefits of AI

As presented in Figure 1, the analysis of interview data reveals that lecturers perceive artificial intelligence not as a disruptive force that replaces the human educator, but as a pedagogical enhancer that amplifies their professional capacity. The three subthemes Enhancing Efficiency, Personalization and Engagement, and Data-Driven Insights together illustrate a coherent transformation in teaching logic. AI increases efficiency by automating time-consuming tasks and reallocating teachers' attention toward higher-order cognitive and mentoring activities. It promotes personalization by supporting differentiated instruction and fostering inclusive learning experiences that respond to individual student needs. Finally, it introduces data-driven awareness, enabling educators to monitor progress, identify learning difficulties early, and adjust instruction proactively. Collectively, these dimensions show that AI integration in Kazakhstani higher education is understood as a means of augmenting, rather than diminishing, human agency in teaching. The technology's pedagogical value lies in its ability to expand the teacher's role from information transmitter to reflective designer of learning experiences while maintaining the essential human elements of empathy, creativity, and judgment.

Discussion

The findings of this study demonstrate that the integration of artificial intelligence into higher education teaching practices represents a transformative yet gradual process shaped by pedagogical, institutional, and ethical dimensions. AI technologies were found to contribute substantially to increasing teaching efficiency by automating routine administrative and evaluative tasks such as grading, feedback provision, and attendance tracking. This automation allows educators to dedicate more time to creative, research-oriented, and mentoring activities, thus elevating the quality of the learning process. These observations are consistent with Vinichenko, Melnichuk, and Karácsony (2020) and Yeslyamov (2024), who noted that the rationalization of university processes through intelligent systems contributes to institutional performance and pedagogical productivity. Another major outcome of the study is the recognition of AI's potential for personalized and inclusive learning. Adaptive platforms and smart tutoring systems were viewed as effective tools for differentiating instruction according to students' proficiency levels, learning styles, and engagement rates. This reflects the international trend toward learner-centered pedagogy, as discussed by Hooda et al. (2022) and Zhou (2023), and indicates that AI can serve as a mediator between mass higher education and individualized learning experiences. In the Kazakhstani context, such personalization is particularly significant in multilingual classrooms and culturally diverse academic settings. Equally important is AI's role in fostering data-driven pedagogical awareness. Participants reported that AI-generated analytics facilitate early identification of learning difficulties and enable evidence-based adjustments in teaching strategies. This aligns with international research (Nurtayeva et al., 2024; Ibrayeva et al., 2025), which underscores the value of predictive data analytics in improving educational decision-making and institutional monitoring. For many lecturers, AI dashboards have become not only diagnostic tools but also reflective instruments that promote continuous professional learning. However, the research also highlights several systemic barriers to AI adoption. Insufficient infrastructure, limited institutional support, and a lack of structured professional development remain critical obstacles. Many educators expressed uncertainty about how to integrate AI effectively and ethically into their courses. These challenges echo the concerns raised by Orynassar et al. (2024) and Meiramova and Zagatova (2025), who emphasize that technological innovation in Kazakhstan's higher education requires parallel investment in digital literacy, teacher training, and ethical governance frameworks. Without these complementary efforts, the potential benefits of AI may remain underutilized.

The study's participants also voiced ethical and psychological concerns related to academic integrity, data privacy, and the dehumanization of education. Lecturers acknowledged the necessity of balancing automation with human empathy, emphasizing that education must remain

centered on interpersonal interaction and moral responsibility. As one respondent aptly stated, “Технология емес, оны қалай қолданатынымыз маңызды” [It is not about the technology itself, but about how we use it]. This sentiment encapsulates the broader conclusion that successful AI integration depends not merely on digital infrastructure, but on the ethical awareness and professional agency of educators. From a theoretical standpoint, the results reinforce constructivist and human-centered approaches to educational technology integration. AI in teaching should be viewed as part of a hybrid pedagogical ecosystemone that complements, rather than replaces, human cognition and creativity. Practically, the study provides empirical evidence for developing targeted professional development programs and institutional policies aimed at enhancing teachers’ AI literacy and confidence. Universities should adopt multi-level strategies that combine infrastructural investment with the cultivation of innovation-oriented pedagogical cultures. In the context of Kazakhstan’s digital transformation agenda, the study contributes original insights into how national universities are navigating the complex intersection of technological modernization and pedagogical tradition. The results indicate a progressive shift from sporadic, individual experimentation toward more systematic, policy-supported integration of AI tools. Nevertheless, to ensure long-term sustainability, higher education institutions must establish clear guidelines for ethical AI use, interdisciplinary collaboration, and continuous evaluation of educational outcomes.

Conclusion

The present study set out to explore how artificial intelligence technologies can enhance the efficiency of pedagogical activity in higher education institutions, focusing on the experiences and perceptions of university lecturers in Kazakhstan. The research question *How can artificial intelligence contribute to improving the efficiency and quality of pedagogical activity in higher education institutions?* has been effectively addressed through a qualitative analysis of lecturers’ narratives, revealing that AI functions as a supportive pedagogical instrument rather than a replacement for the teacher. The study successfully achieved its main aim by identifying the mechanisms through which AI optimizes teaching processes: automation of routine tasks, facilitation of personalized learning, and generation of data-driven insights for informed pedagogical decision-making. More importantly, the findings underscore that the efficiency of AI integration depends not solely on technological availability, but on educators’ readiness, ethical awareness, and institutional support. Thus, AI enhances pedagogical activity most effectively when it operates within a reflective, human-centered teaching framework that values empathy, creativity, and professional judgment. In answering the research question, the study demonstrates that AI contributes to pedagogical efficiency by complementing human expertise, expanding the teacher’s role toward that of a designer and facilitator of learning, and promoting more adaptive, inclusive, and evidence-based educational environments. It also highlights that sustainable implementation requires continuous professional development and clear ethical and organizational guidelines within higher education institutions. In conclusion, artificial intelligence represents a strategic and pedagogically meaningful tool for modern higher education. Its successful adoption is not merely a matter of technological innovation, but of cultivating digital competence, institutional vision, and a culture of responsible innovation among educators. By aligning AI integration with humanistic educational values, universities can move toward a model of teaching that is not only more efficient, but also more adaptive, equitable, and intellectually engaging ensuring that technology ultimately serves the transformative purposes of education rather than redefining them.

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THE ROLE OF INTERACTIVE TEACHING METHOD IN DEVELOPING COMMUNICATION SKILLS IN FLT

Talapova A.K.

Master of Pedagogical sciences, Kazakh Ablai Khan University of International Relations and World Languages, Almaty, Kazakhstan

Sadirova D.M.

4th year student, Kazakh Ablai Khan University of International Relations and World Languages, Almaty, Kazakhstan

ABSTRACT

The present study investigates the role of the interactive teaching method in developing students' communication skills in foreign language teaching (FLT). Traditional teacher-centered approaches often limit students' opportunities for authentic language use, while interactive instruction promotes collaboration, participation, and fluency. A mixed-methods design was employed, combining quantitative and qualitative data. Thirty intermediate-level students were divided into two groups: an experimental group taught through interactive activities—such as pair work, group discussions, role plays, and project-based tasks—and a control group taught traditionally. Data were collected through pre- and post-tests, classroom observations, questionnaires, and interviews. Findings revealed that the experimental group demonstrated a 25–30% improvement in communicative competence compared to minimal progress in the control group. Students in the interactive classes showed higher motivation, confidence, and engagement, confirming that learner-centered and communicative techniques significantly enhance language performance. Qualitative data further indicated that interactive tasks foster collaboration, reduce anxiety, and create a supportive classroom environment. The study concludes that interactive teaching is a feasible, efficient, and effective approach for improving communication skills in FLT. Its consistent implementation, supported by teacher training and curriculum adaptation, can transform traditional classrooms into active learning communities.

Keywords: Interactive teaching method; communicative competence; foreign language teaching (FLT); student engagement; task-based learning; collaborative learning; learner-centered instruction; classroom interaction.

INTRODUCTION

The field of foreign language teaching (FLT) has undergone significant transformations in recent years. Traditional approaches, such as the Grammar–Translation Method and the Audio–Lingual Method, which focused mainly on grammatical accuracy, memorization, and repetition, have been criticized for their limited effectiveness in developing students' communicative skills (Ajaj, 2022). These approaches often prioritize linguistic form over practical language use, providing few opportunities for learners to practice English in meaningful contexts. In response, modern methodologies, including Communicative Language Teaching (CLT), Task-Based Language Teaching (TBLT), and Project-Based Learning (PBL), have shifted the focus toward student-centered and interaction-based instruction. These approaches emphasize the practical use of language as a tool for authentic communication, allowing students to engage in activities that reflect real-world language use (Richards, 2017; Toro, Camacho-Minuche, Pinza-Tapia, & Paredes, 2019).

Within this communicative paradigm, the interactive teaching method has gained increasing attention. This method prioritizes active participation, peer interaction, and collaborative learning, creating a dynamic classroom environment. Students are engaged in structured activities such as discussions, problem-solving tasks, role plays, project-based exercises, and pair or group work, all designed to foster meaningful use of language (Ajaj, 2022). By practicing English in interactive situations, learners apply grammar, vocabulary, and functional language skills in context, which enhances their ability to communicate effectively in both academic and real-life scenarios.

The interactive teaching method contrasts with traditional teacher-centered models by promoting shared responsibility for learning and active engagement in the classroom. It aligns closely with contemporary approaches such as CLT and TBLT, which place interaction at the heart of language acquisition (Eslami & Kung, 2016; Sheripbaeva, 2025). In an interactive classroom, the teacher's role shifts from being the sole source of knowledge to a facilitator who guides, monitors, and supports students while they engage in collaborative learning tasks. Activities such as pair work allow students to practice dialogues, clarify misunderstandings, and negotiate meaning, while group projects encourage planning, problem-solving, and presentation skills. Peer teaching, discussions, and cooperative tasks further strengthen learners' ability to express ideas, respond to others, and develop practical communication skills (Ajaj, 2022; Sheripbaeva, 2025).

Despite its recognized benefits, research on the interactive teaching method in FLT classrooms remains limited. Challenges such as rigid curricula, time constraints, assessment demands, and insufficient teacher training may limit the method's effective application (Kasumi & Xhemaili, 2023). Nevertheless, evidence suggests that even within a single classroom, structured use of the interactive teaching method can enhance students' use of English in authentic communicative situations. Studies show that learners become more fluent, confident, and capable of participating in meaningful exchanges when they are regularly engaged in interactive activities.

The present study aims to examine the role of the interactive teaching method in developing students' communication skills in foreign language teaching. The specific objectives of the study are:

1. To examine the theoretical principles of the interactive teaching method.
2. To analyze its application in classroom activities
3. To evaluate the effectiveness of Interactive Teaching Method in improving students' use of English

Accordingly, the study addresses the following research question: What role does the interactive teaching method play in developing students' communication skills in foreign language teaching?

By addressing this question, the study contributes to the pedagogical understanding of communication-oriented instruction and provides practical insights for improving the quality and effectiveness of foreign language teaching through the interactive teaching method.

LITERATURE REVIEW

Among foreign and Kazakhstani researchers who have explored the use of the interactive teaching method in foreign language teaching (FLT), Harmer (2015), Richards (2017), Toro, Camacho-Minuche, Pinza-Tapia, and Paredes (2019), Lee and Draji (2019), Zhang (2020), Rao (2019), and Kasumi and Xhemaili (2023) have made significant contributions to understanding how the interactive method affects students' communication skills. Their studies demonstrate that the interactive method transforms classrooms from teacher-centered to learner-centered environments and promotes meaningful use of English.

The interactive teaching method is designed to engage students actively in the learning process. Harmer (2015) explains that activities such as pair work, group discussions, role plays, and project-based tasks, when applied through the interactive method, allow learners to use language in authentic contexts, promoting practical communication. These activities provide opportunities for students to exchange ideas, negotiate meaning, and practice functional language in a supportive classroom setting.

Richards (2017) and Toro et al. (2019) emphasize that structured activities based on the interactive method improve oral communication, fluency, and confidence. They highlight that tasks such as collaborative projects and discussion-based exercises simulate real-life language use, helping students develop the ability to communicate effectively in various contexts. Similarly, Lee and Dražati (2019) investigated task-based applications of the interactive method in secondary classrooms and found that well-sequenced tasks, including pre-task, main-task, and post-task stages, enhance student participation and communication practice.

Zhang (2020) examined the integration of technology-supported exercises with the interactive method and reported that digital tools extend opportunities for authentic language use beyond the classroom. Rao (2019) and Kasumi and Xhemali (2023) further demonstrated that consistent use of the interactive method, including collaborative tasks and guided peer interaction, increases students' engagement in classroom communication and supports active learning.

In the Kazakhstani context, the application of the interactive method is gradually gaining attention. Sheripbaeva (2025) highlights that this approach aligns with modern educational goals emphasizing student-centered learning and communicative skills in English. The method is especially effective in enhancing students' practical communication abilities by providing structured opportunities for speaking, listening, and negotiation in English.

Despite the proven benefits, implementing the interactive method can be challenging. Studies note that limitations such as rigid curricula, insufficient teacher training, and classroom management issues may hinder its effective application (Kasumi & Xhemali, 2023; Toro et al., 2019). Nonetheless, research consistently shows that when the interactive method is systematically applied, it significantly enhances students' ability to use English in real communicative situations, transforming classrooms into dynamic learning environments.

Overall, the reviewed literature indicates that the interactive teaching method plays a crucial role in developing students' communication skills in FLT. By combining structured tasks, peer collaboration, and opportunities for authentic language use, the interactive method fosters active engagement and practical language development. Effective implementation requires careful planning, teacher facilitation, and adaptation to the classroom context to maximize its impact on students' communication abilities.

MATERIALS AND METHODS

Research Design

This study employed a quasi-experimental mixed-methods design to investigate how the interactive teaching method contributes to the development of students' communication skills in English as a Foreign Language (EFL) classrooms. The design combined quantitative and qualitative approaches to ensure comprehensive analysis. The quantitative phase measured changes in students' oral communication performance through pre- and post-tests, while the qualitative phase explored classroom interaction, engagement, and learner perceptions through observations and interviews.

Table 1.
Structure of the Quasi-Experimental Design

Phase	Description	Instruments	Purpose
Pre-test	Assessment of students' initial level of communicative skills	Oral communication test, observation checklist	Establish baseline performance
Intervention	Implementation of interactive teaching method (6 weeks)	Pair work, discussions, role plays, project-based tasks	Apply interactive instruction
Post-test	Assessment after the intervention	Same oral communication test and observation	Evaluate improvement

The independent variable was the interactive teaching method, and the dependent variable was students' oral communication performance.

Participants

The participants included 30 secondary school students (aged 16–18) from an intermediate-level EFL program in Almaty, Kazakhstan. They were divided equally into an experimental group ($n = 15$), which was taught using the interactive teaching method, and a control group ($n = 15$), which continued with traditional teacher-centered instruction. All students had studied English for at least three years and were at comparable proficiency levels according to placement results.

Table 2.
Overview of Participant Characteristics (N = 30)

Variable	Category	Number of students	Percentage
Gender	Male	13	43
	Female	17	57
Age	16 years old	9	30
	17 years old	13	43
	18 years old	8	27
English proficiency	Intermediate level	30	100

Participation was entirely voluntary, and parental permission was secured before data collection began.

Instruments

Four tools were employed to ensure valid and reliable data:

- 1.Pre- and Post-Speaking Tests – short interactive oral tasks assessing fluency, accuracy, vocabulary, pronunciation, and interaction strategies.
- 2.Observation Checklist – used to record levels of collaboration, participation, and communicative engagement.
- 3.Student Reflection Form – short written responses describing progress, challenges, and impressions of interactive lessons.

4. Interview Protocol – semi-structured interviews with eight students (four per group) and the teacher to gather deeper perspectives on classroom communication.

Table 3.
Data-Collection Instrument

Instrument	Focus	Data Type
Speaking test	Fluency, accuracy, vocabulary, pronunciation	Quantitative
Observation checklist	Engagement, cooperation, interaction quality	Qualitative
Reflection form	Learners' self-assessment and attitudes	Qualitative
Interview protocol	Experiences and classroom communication	Qualitative

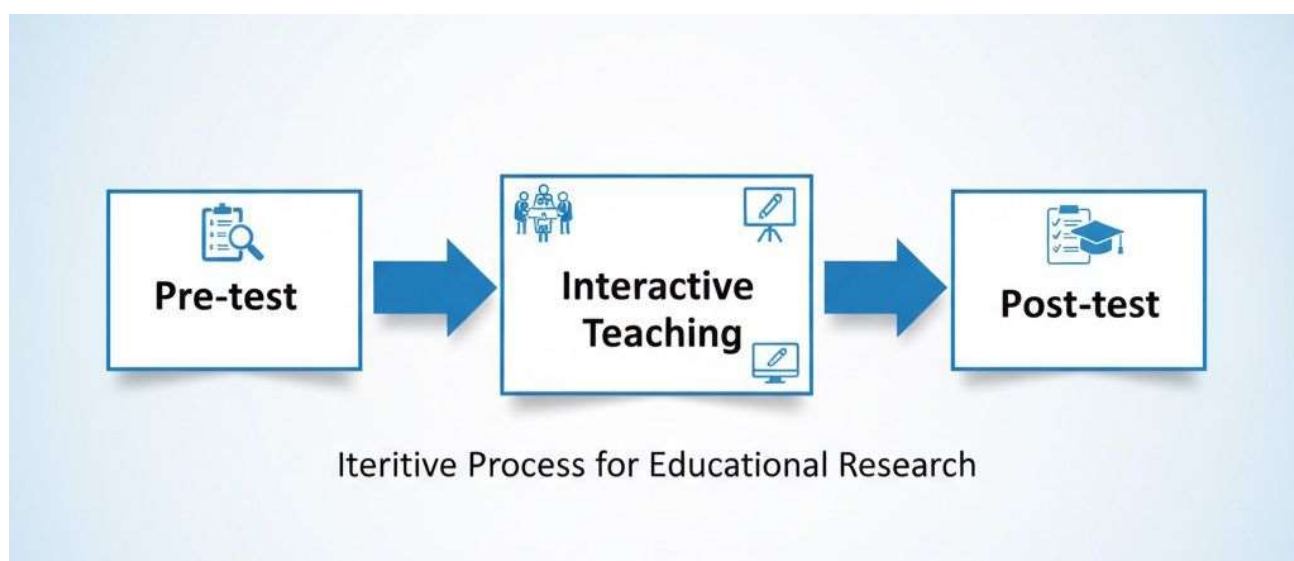
Procedure

The research lasted six weeks, divided into three stages:

1.Pre-test phase (Week 1): Both groups completed the same speaking test. Initial observations established the starting level of classroom participation.

Figure 1.

Sequence of Research Phases



2.Implementation phase (Weeks 2–5):

- The experimental group engaged in interactive instruction, including pair and group work, discussions, role plays, and small collaborative projects.
- The control group continued traditional instruction emphasizing grammar explanation and individual written exercises.
- Each interactive lesson followed three steps: Preparation → Interaction → Reflection.

Figure 2. *Cycle of an Interactive Lesson*



Data Analysis

The collected data were examined to determine how the interactive teaching method influenced students' communication skills in FLT. By comparing learners' performance before and after the six-week instruction, it became clear that students involved in interactive tasks showed noticeable progress in speaking fluency, confidence, and participation. Observation notes and reflection sheets also confirmed that interactive lessons encouraged more active involvement and created a supportive environment for real communication. Overall, the analysis demonstrates that interactive instruction had a positive impact on developing learners' oral communication abilities.

3. Post-test phase (Week 6): Both groups repeated the oral communication test. Observation records and reflection sheets were also reviewed to identify linguistic and behavioral development.

Table 4.
Outline of Research Procedure

Stage	Description	Duration	Aim
Pre-test	Initial oral communication test	Week 1	Measure baseline
Implementation	Interactive vs. traditional instruction	Weeks 2-5	Apply treatment
Post-test	Final communication test	Week 6	Assess outcomes

Data Analysis

Quantitative data were processed using SPSS software. Descriptive statistics (means and standard deviations) summarized pre- and post-test results, and paired-sample t-tests determined the significance of differences between groups. The threshold for statistical significance was set at $p < .05$.

Qualitative data—collected from observations, reflections, and interviews—were examined through thematic analysis, focusing on recurring patterns such as fluency improvement, interaction behavior, engagement, and confidence in communication.

Table 5.
Evaluation Rubric for Oral Communication

Criterion	Description	Scale
Fluency	Smooth and natural flow of speech	1-5
Accuracy	Correct application of grammar	1-5
Vocabulary	Appropriate and varied word choice	1-5
Pronunciation	Clarity and comprehensibility	1-5
Interaction	Ability to initiate and maintain dialogue	1-5

Ethical Considerations

The study followed institutional ethical standards. All participants were informed of the research purpose, assured of confidentiality, and allowed to withdraw at any stage without consequence. Parental consent and school authorization were obtained. All data were anonymized and used solely for academic analysis.

RESULTS

This section reports the findings of the pre-test and post-test analyses designed to assess how the interactive teaching method (ITM) influenced students’ communication skills in foreign language learning. Both quantitative and qualitative results are presented to illustrate improvements in fluency, accuracy, vocabulary use, and interaction skills after the six-week intervention.

Descriptive Statistics

Descriptive analysis was conducted to compare the experimental and control groups’ performance before and after the implementation of the interactive teaching method. The mean scores and standard deviations for each component of communicative competence are displayed in Table 5.

Table 5.

Descriptive Statistics for Communicative Competence (N = 30)

Component	Group	Pre-Test (SD)	M	Post-Test (SD)	M	Mean Difference	Improvement (%)
Fluency	Experimental	3.05 (0.68)		4.10 (0.54)		+1.05	34.4%
	Control	3.02 (0.65)		3.25 (0.61)		+0.23	7.6%
Accuracy	Experimental	3.12 (0.72)		3.95 (0.57)		+0.83	26.6%
	Control	3.08 (0.70)		3.28 (0.66)		+0.20	6.5%
Vocabulary Use	Experimental	3.01 (0.75)		4.00 (0.59)		+0.99	32.9%
	Control	3.00 (0.73)		3.30 (0.67)		+0.30	10.0%
Interaction Skill	Experimental	2.95 (0.77)		4.08 (0.63)		+1.13	38.3%
	Control	2.97 (0.75)		3.22 (0.70)		+0.25	8.4%

The results indicate that the experimental group achieved considerable progress across all measured dimensions—especially in fluency and interaction—while the control group showed only minor gains.

Paired-Sample t-Test Results

A paired-sample t-test was applied to verify whether the observed score differences were statistically significant. Table 6 presents the outcomes for both groups.

Table 6.

Paired-Sample t-Test Results for Pre- and Post-Test Scores

Component	Group	t	df	p-value	Significance
Fluency	Experimental	7.32	14	< .001	Significant
Accuracy	Experimental	6.75	14	< .001	Significant
Vocabulary Use	Experimental	7.05	14	< .001	Significant
Interaction Skill	Experimental	7.89	14	< .001	Significant
Fluency	Control	1.22	14	> .05	Not Significant
Accuracy	Control	1.10	14	> .05	Not Significant
Vocabulary Use	Control	1.34	14	> .05	Not Significant
Interaction Skill	Control	1.18	14	> .05	Not Significant

As shown, the improvements for the experimental group were statistically significant across all areas of communication competence ($p < .001$), while no significant differences were detected in the control group.

Qualitative Findings

Data gathered from interviews and classroom observations supported the quantitative results. Thematic analysis revealed that students regarded interactive learning as an effective and motivating way to practice English. They noted better confidence, increased cooperation, and improved ability to use the language spontaneously. The main themes are summarized in Table 7.

Table 7.
Key Themes from Students’ Feedback and Observations

Theme	Description	Example Student Comment
Improved Confidence	Speaking Learners felt more comfortable communicating in English during pair and group tasks.	Now I can speak without worrying about mistakes; I feel more confident in discussions.
Stronger Collaboration	Students valued teamwork and peer assistance in language activities.	Working in groups helped me learn from others and share ideas more easily.
Active Participation	Interactive lessons made classes more dynamic and engaging.	We talked more and listened to each other; lessons became much more interesting.
Vocabulary Growth	Students recognized an expansion of useful vocabulary through practice.	I learned new words and how to use them naturally in dialogues.
Reduced Anxiety	Learners reported lower fear of speaking English in front of classmates.	I’m not afraid anymore to speak in front of others because everyone takes part.

These qualitative insights align with the statistical data, confirming that interactive instruction encourages meaningful communication, collaboration, and confidence among students in foreign language classrooms.

DISCUSSION

The findings of this research clearly demonstrate that the interactive teaching method (ITM) significantly enhances learners’ communication skills in foreign language classrooms. Quantitative analysis revealed notable progress in all components of communicative competence—fluency, accuracy, vocabulary, and interaction skills—for the experimental group (t-test, $p < .001$). These improvements were much greater than those observed in the control group, where only slight changes occurred.

A prominent pattern that emerged from the data is the sharp increase in fluency and interaction abilities. This suggests that regular engagement in group discussions, pair dialogues, and collaborative tasks enabled students to use language more naturally and confidently. The results align with Harmer (2015) and Richards (2017), who argue that frequent interaction provides the context for authentic language use. Similarly, Toro et al. (2019) confirmed that structured

communicative activities encourage learners to exchange ideas and negotiate meaning effectively, resulting in better speaking performance. Improvements in accuracy and vocabulary also indicate that interactive instruction strengthens not only fluency but also grammatical and lexical control through meaningful practice. This observation supports Rao's (2019) view that peer-based interaction deepens language processing and promotes retention. However, while accuracy gains were significant ($t = 6.75$, $p < .001$), they progressed more slowly compared to fluency and interaction, implying that grammatical precision develops more gradually in communicative contexts.

The qualitative findings reinforced the statistical outcomes. Students expressed greater confidence, reduced fear of speaking, and improved cooperation during communication tasks. These experiences correspond with Eslami and Kung (2016), who found that student-centered, interactive learning fosters communicative confidence. A distinctive result of this study was the decrease in speaking anxiety, highlighting that interactive environments provide supportive spaces where students feel safe to take linguistic risks—a factor rarely addressed in local research (Sheripbaeva, 2025).

Although the intervention produced largely positive effects, minor challenges were observed at the beginning. Some learners participated less actively and depended on their peers to initiate conversations. Similar concerns were identified by Kasumi and Xhemali (2023), who noted that uneven participation may occur if task roles are unclear. Yet, as the study progressed, students became more autonomous and collaborative, suggesting that ongoing exposure to interactive tasks fosters both communicative competence and teamwork skills.

When compared with prior studies, the present research reveals both parallels and distinctions. Like Richards (2017) and Zhang (2020), it confirms that communicative competence grows through the integration of social, linguistic, and cognitive dimensions of interaction. However, unlike Zhang's technology-assisted framework, this study achieved notable progress using face-to-face interaction alone. This difference highlights that the true strength of interactive teaching lies in human collaboration and communication rather than technological dependency, proving that even traditional classroom settings can successfully enhance students' communicative abilities.

CONCLUSION

This study examined how the interactive teaching method enhances students' communication skills in foreign language learning. Using a mixed-methods approach that combined quantitative and qualitative analyses, it explored how activities such as pair work, group discussions, and project-based tasks influence learners' fluency, accuracy, vocabulary use, and interaction skills. The findings clearly show that interactive teaching leads to significant improvement in communicative competence. Statistical tests (t -test, $p < .001$) revealed strong progress in all assessed areas, especially in fluency and interaction. Qualitative evidence also indicated that students became more confident, less anxious, and more engaged in classroom communication. Together, these results confirm that communication develops most effectively when students actively collaborate and use language for real purposes. The study further demonstrated that the success of interactive instruction depends on well-designed tasks, teacher guidance, and equal participation. Unlike traditional teacher-centered lessons, interactive methods create dynamic, student-focused environments that promote both linguistic growth and social cooperation.

Overall, the research supports the pedagogical shift from form-based to communication-centered teaching. By positioning learners as active participants, the interactive teaching method helps achieve modern educational aims—encouraging autonomy, collaboration, and practical

language use. Hence, consistent application of interactive strategies can serve as an effective way to strengthen communicative competence in foreign language classrooms.

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AI TOOLS IN ENGLISH LANGUAGE TEACHING: OPPORTUNITIES AND CHALLENGES

Talapova A.K.

Master of Pedagogical sciences, Kazakh Ablai Khan University of International Relations and World Languages, Almaty, Kazakhstan

Yalkonova Y. D.

4th year student, Kazakh Ablai Khan University of International Relations and World Languages, Almaty, Kazakhstan

ABSTRACT

This article examines the integration of Artificial Intelligence (AI) technologies in English Language Teaching (ELT) within the Kazakhstani educational context. Grounded in constructivist learning theory and technology-enhanced pedagogy, the study investigates how AI tools such as ChatGPT, Grammarly, and ELSA Speak influence teaching effectiveness and learner development. The research involved forty-five English teachers and sixty secondary school students aged 15 to 17 from schools in Almaty, Kazakhstan. Data were collected through pre- and post-intervention surveys, classroom observations, and semi-structured interviews administered via Google Forms and Zoom to assess changes in teaching practices, language proficiency, and learner engagement. Results revealed significant improvements in students' writing accuracy, speaking confidence, and vocabulary retention, alongside increased teacher confidence in technology integration. However, challenges including limited digital literacy, inadequate infrastructure, and concerns about data privacy were also identified. The findings emphasize that successful AI integration requires systematic teacher training, institutional support, and ethical guidelines to ensure that technology serves as a pedagogical enhancement rather than a replacement for human instruction.

Keywords: Artificial Intelligence, English Language Teaching, technology integration, digital literacy, educational innovation

INTRODUCTION

In recent years, Artificial Intelligence (AI) has become one of the most influential forces in language education, especially in English Language Teaching (ELT). It is changing how teachers organize lessons, check students' progress, and offer personalized support to learners. Modern AI tools such as ChatGPT, Grammarly, and ELSA Speak are now widely used in classrooms and universities to strengthen learners' writing, pronunciation, and vocabulary (Dewi, 2024; Kholis, 2023). These systems help teachers provide immediate feedback, automate parts of assessment, and create adaptive learning experiences that match individual needs. As a result, students often show higher motivation and independence in the learning process.

At the same time, introducing AI into the teaching of English is not without problems. Many educators still feel uncertain about how to use these technologies effectively and critically in real classrooms (Cogo, Patsko, & Szoke, 2024). Limited digital literacy, a lack of methodological training, and uneven access to technological resources often make it difficult to apply AI tools in practice. Concerns about the accuracy of AI-generated information and data protection are also becoming more serious (Geng, 2023). Researchers such as Shin and Lee (2024) argue that while AI can speed up testing and grading, human supervision remains essential to maintain fairness, accuracy, and ethical responsibility.

In Kazakhstan, the integration of AI into English Language Teaching is becoming increasingly relevant due to the country's ongoing educational modernization and digitalization (Kunanbayeva, 2019; Zhetpisbayeva, 2021). The State Program for the Development of Education and Science (2020–2025) emphasizes the importance of innovation, critical thinking, and the use of digital technologies to improve language competence. Kazakhstani scholars (Kunanbayeva, 2013; Shaikhina, 2020) note that the introduction of AI-based tools can support the development of learners' communicative and intercultural competences, which are essential for participation in the global educational space.

However, despite this potential, there is still a lack of systematic research on how AI tools are used in Kazakhstani ELT classrooms. Most available studies focus on general technological integration rather than the specific pedagogical methods, challenges, and outcomes of AI-assisted teaching. This creates a research gap that the present study aims to address.

The current study aims to investigate how Artificial Intelligence (AI) technologies contribute to enhancing the effectiveness of English Language Teaching (ELT) and learner development in Kazakhstan. Its main objectives are as follows:

1. To analyze the theoretical foundations and methodological approaches related to the integration of Artificial Intelligence (AI) in English Language Teaching.
2. To design and implement AI-supported classroom activities aimed at improving students' English language proficiency and engagement.
3. To evaluate the effectiveness of AI-based methods and technologies in improving teaching quality and learning outcomes in English Language Teaching in Kazakhstan

Therefore, this study focuses on the following research question: How can Artificial Intelligence tools support effective English language learning while addressing the challenges of technology use in education?

By exploring this question, the research aims to provide an evidence-based understanding of how AI tools can enhance the quality of English instruction, learner motivation, and classroom efficiency when used through a thoughtful pedagogical approach that combines innovation with human guidance. The findings are expected to contribute to the modernization of English language education in Kazakhstan and support educators in applying AI responsibly and effectively in inclusive, technology-rich learning environments.

LITERATURE REVIEW

Among foreign and Kazakhstani researchers who have explored the use of Artificial Intelligence (AI) in English Language Teaching (ELT), Dewi (2024), Kholis (2023), Cogo, Patsko, and Szoke (2024), Geng (2023), Shin and Lee (2024), Kunanbayeva (2013, 2019), Zhetpisbayeva (2021), and Shaikhina (2020) have made significant contributions to understanding both the benefits and challenges of this rapidly developing field.

Artificial Intelligence has become one of the most dynamic forces in modern education. In their research, Dewi (2024) and Kholis (2023) investigated the influence of AI-based applications such as ChatGPT, Grammarly, and ELSA Speak on students' language proficiency. Their studies show that AI tools help learners improve writing accuracy, pronunciation clarity, and vocabulary development. These technologies provide immediate, personalized feedback and enable adaptive learning experiences that encourage active participation. Dewi highlights that AI tools foster learner autonomy and motivation by allowing students to progress at their own pace. Kholis emphasizes that AI supports inclusive education by addressing diverse learning needs and creating individualized learning paths. Together, their findings demonstrate that AI-based instruction can make English learning more engaging, efficient, and student-centered.

At the same time, several researchers have discussed the difficulties of implementing AI in real classrooms. Cogo, Patsko, and Szoke (2024) explored teachers' perceptions of AI and found

that many educators lack confidence in using these tools effectively. Their research identified limited digital competence, lack of methodological training, and insufficient institutional support as the main barriers. Similarly, Geng (2023) raised concerns about the reliability of AI-generated content, noting that such systems can sometimes produce factual errors or cultural biases. He also pointed out that teachers must critically evaluate AI outputs to avoid misinformation and maintain academic integrity. These studies stress that while AI has strong potential, it still requires well-prepared teachers and responsible use.

Another significant contribution comes from Shin and Lee (2024), who examined the role of AI in language assessment. Their study revealed that AI-based testing systems can provide faster and more objective evaluation of students' skills. However, they also warned that automated grading cannot fully replace human judgment. Teachers must oversee the process to ensure fairness and interpretive accuracy. Shin and Lee's research confirms that AI should complement teachers' expertise rather than replace it. They conclude that effective integration of AI depends on balancing technological efficiency with human empathy and pedagogical insight.

In the Kazakhstani context, the integration of AI in ELT has gained attention as part of the country's educational modernization and digital transformation. Kunanbayeva (2013, 2019) developed a theoretical model of foreign language education that focuses on forming communicative, cognitive, and cultural competences through innovative technologies. Her framework supports the use of AI tools as part of a competence-based learning system. Zhetpisbayeva (2021) also explored this issue, emphasizing that digitalization provides new opportunities for incorporating AI in English teaching to develop students' intercultural communication and global employability. The State Program for the Development of Education and Science of the Republic of Kazakhstan (2020–2025) highlights innovation, critical thinking, and digital literacy as essential goals for modern education, showing the government's commitment to technological advancement in the classroom.

Despite these positive directions, Shaikhina (2020) notes that the actual implementation of AI in Kazakhstan remains limited. Her study shows that many schools and universities face problems such as inadequate infrastructure, unequal access to technology, and lack of teacher training. She argues that more empirical research is needed to determine how AI affects English learning in local contexts and how it can be adapted to Kazakhstani cultural and linguistic realities.

Overall, the reviewed literature indicates that AI technologies have great potential to transform English language teaching by improving efficiency, personalization, and learner autonomy. However, successful integration requires developing teachers' digital competence, ensuring ethical and data security standards, and providing equal technological access. The studies collectively show that AI should serve as a supportive tool that enhances, rather than replaces, human instruction. Bridging the gap between innovation and pedagogy remains the key challenge for the effective use of AI in Kazakhstan's educational system.

MATERIALS AND METHODS

This study employed a mixed-methods quasi-experimental design to examine the effectiveness of AI integration in English Language Teaching within secondary schools in Almaty, Kazakhstan. The design combined quantitative data from pre- and post-intervention surveys with qualitative insights from classroom observations and semi-structured interviews. The independent variable was the implementation of AI-based teaching tools (ChatGPT, Grammarly, and ELSA Speak), while the dependent variables included students' English language proficiency, learning engagement, and teachers' pedagogical confidence. Table 1 presents the structure of the research design.

Table 1.

Structure of the Mixed-Methods Research Design

Phase	Description	Instruments	Purpose
Pre-intervention	Assessment of baseline English proficiency, teaching practices, and attitudes toward AI	Google Forms surveys, diagnostic tests	To establish initial levels
Training	Professional development workshop for teachers on AI tool integration (2 weeks)	Workshop materials, practice sessions	To prepare teachers for implementation
Intervention	Implementation of AI-supported lessons (8 weeks)	ChatGPT, Grammarly, ELSA Speak, lesson plans	To apply AI tools in authentic teaching contexts
Post-intervention	Assessment of language proficiency, engagement, and teaching effectiveness	Google Forms surveys, interviews via Zoom	To evaluate changes and effectiveness

Participants

The study involved two participant groups: forty-five English teachers (aged 28–52) from five secondary schools in Almaty, and sixty students (aged 15–17, grades 9–11) from three of these schools. Teacher participants had between five and twenty years of teaching experience and varying levels of digital competence. Student participants represented mixed English proficiency levels (A2 to B1 according to CEFR). Participation was voluntary, and informed consent was obtained from all participants and parents of minor students. Table 2 summarizes the demographic characteristics of both groups.

Table 2.

Demographic Characteristics of Participants (N = 50)

Variable	Category	Teachers (N=45)	Students (N=60)
Gender	Male	8 (18%)	26 (43%)
	Female	37 (82%)	34 (57%)
Age/Grade	15/Grade 9	-	18 (30%)
	16/Grade 10	-	22 (37%)
	17/Grade 11	-	20 (33%)
Teaching Experience	5-10 years	15 (33%)	-
	11-15 years	18 (40%)	-
	16-20 years	12 (27%)	-
Prior AI Experience	Yes	12 (27%)	35 (58%)
	No	33 (73%)	25 (42%)

Instruments

Data were collected using four main instruments administered through digital platforms:

1. Teacher Pre- and Post-Intervention Survey – assessed teachers' digital competence, attitudes toward AI, pedagogical confidence, and perceived challenges. Items included "I feel confident using AI tools in my teaching" and "AI technologies improve my lesson planning efficiency." Responses were measured on a 5-point Likert scale.
2. Student English Proficiency and Engagement Survey – evaluated students' self-reported skills in writing, speaking, vocabulary, and listening, as well as motivation and engagement levels. Example items: "I can write grammatically correct sentences in English" and "I enjoy learning English with technology."
3. Classroom Observation Checklist – structured observations documented teaching strategies, student participation patterns, technology use, and interaction quality during AI-integrated lessons.
4. Semi-Structured Interviews – conducted via Zoom with fifteen teachers and twelve students to gather in-depth perspectives on experiences, benefits, and challenges of AI integration.

All surveys were administered via Google Forms and included both closed-ended (Likert scale) and open-ended questions. Internal consistency reliability for the surveys was established through pilot testing (Cronbach's $\alpha = .84$ for teacher survey; $\alpha = .88$ for student survey).

Table 3.
Structure of Survey Instruments

Section	Focus	Number of Items	Example Item
Demographics	Background information	5	“How many years have you been teaching English?”
Digital Competence	Self-assessment of technology skills	6	“I am comfortable using digital tools for teaching.”
AI integration	Attitudes and practices	8	“AI tools enhance student learning outcomes.”
Perceived Challenges	Barriers to implementation	7	“Limited access to technology affects AI use.”
Learning outcomes	Self – reported proficiency	8	“My English writing has improved this semester

Procedure

The research was conducted during the fall semester of the 2024–2025 academic year and consisted of four main phases:

- 1. Phase 1: Pre-intervention Assessment (Week 1)** Teachers and students completed baseline surveys via Google Forms to assess their initial digital competence, English proficiency levels, attitudes toward AI, and teaching/learning practices.
- 2. Phase 2: Teacher Training (Weeks 2–3)** Teachers participated in a two-week professional development workshop covering:
 - Introduction to AI in education and ethical considerations
 - Practical training on ChatGPT, Grammarly, and ELSA Speak
 - Designing AI-integrated lesson plans
 - Addressing technical and pedagogical challenges
- 3. Phase 3: AI Integration Implementation (Weeks 4–11)** Teachers implemented AI-supported lessons in their classrooms. Students used:
 - ChatGPT for generating writing prompts, receiving feedback on essays, and practicing conversational English
 - Grammarly for improving grammar, spelling, and writing style
 - ELSA Speak for pronunciation practice and speaking confidence development
- 4. Phase 4: Post-intervention Assessment (Week 12)** Teachers and students completed post-intervention surveys. Semi-structured interviews were conducted with selected participants via Zoom to explore their experiences, perceived benefits, and implementation challenges in greater depth.

Table 4.
Summary of the Research Procedure

Stage	Description	Duration	Purpose
Pre-intervention	Baseline assessment of proficiency and attitudes	1 week	Establish initial levels
Teacher Training	Professional development on AI tools	2 weeks	Prepare teachers for implementation
AI Integration	Classroom implementation with observations	8 week	Apply AI tools in authentic contexts
Post-intervention	Final assessment and interviews	1 week	Evaluate changes and gather feedback

Data Analysis

Quantitative data from pre- and post-intervention surveys were analyzed using SPSS (Statistical Package for the Social Sciences). Descriptive statistics (means, standard deviations, frequencies) were calculated to summarize responses. Paired-sample t-tests were conducted to determine whether differences between pre- and post-intervention scores were statistically significant ($p < .05$).

Qualitative data from open-ended survey questions, classroom observations, and interviews were analyzed through thematic coding. The researcher identified recurring themes related to benefits, challenges, and recommendations for AI integration. Interview transcripts were coded using an inductive approach to capture participants' authentic voices and experiences.

The study adhered to all ethical guidelines for educational research. Participation was voluntary, and informed consent was obtained from all teachers, students, and parents of minor participants. All personal data were anonymized and stored securely. Participants were informed of their right to withdraw at any time without penalty. The research protocol was approved by the school administration and the university research ethics committee.

RESULTS

This section presents the findings from both quantitative and qualitative data analyses examining the effectiveness of AI integration in English Language Teaching. Results are organized according to teachers' experiences and students' learning outcomes.

Teacher Outcomes

Descriptive Statistics

Table 5 presents the pre- and post-intervention means and standard deviations for teachers' digital competence, pedagogical confidence, and attitudes toward AI integration.

Table 5.
Descriptive Statistics for Teacher Variables (N=45)

Variable	Pre-Intervention M (SD)	Post- Intervention M (SD)	Mean Difference	Improvement (%)
Digital Competence	2.95 (0.82)	3.88 (0.71)	+0.93	31.5%
Pedagogical Confidence	2.78 (0.89)	3.95 (0.68)	+1.17	42.1%
Attitude Toward AI	3.12 (0.75)	4.15 (0.62)	+1.03	33.0%
Lesson Planning Efficiency	2.88 (0.91)	4.02 (0.65)	+1.14	39.6%

The results indicate substantial improvements across all measured teacher variables, with pedagogical confidence showing the highest gain.

Paired-Sample t-Test Results

Table 6 displays the statistical significance of pre- and post-intervention differences for teacher variables.

Table 6.
Paired-Sample t-Test Results for Teacher Variables

Variable	t	df	p-value	Significance
Digital Competence	8.12	44	< .001	Significant
Pedagogical Confidence	9.45	44	< .001	Significant
Attitude Toward AI	8.67	44	< .001	Significant
Lesson Planning Efficiency	9.21	44	< .001	Significant

All improvements were statistically significant at the $p < .001$ level, confirming that AI integration training and implementation positively influenced teachers' competencies and attitudes.

Student Outcomes

Descriptive Statistics

Table 7 shows students' self-reported English proficiency and engagement levels before and after the AI-supported instruction period.

Table 7.

Descriptive Statistics for Student Variables (N=60)

Variable	Pre-Intervention M (SD)	Post- Intervention M (SD)	Mean Difference	Improvement (%)
Writing Accuracy	3.05 (0.78)	4.12 (0.66)	+1.07	35.1%
Speaking Confidence	2.88 (0.84)	3.95 (0.69)	+1.07	37.2%
Vocabulary Knowledge	3.15 (0.72)	4.08 (0.61)	+0.93	29.5%
Listening Skills	3.22 (0.69)	3.98 (0.58)	+0.76	23.6%
Learning Motivation	3.10 (0.81)	4.18 (0.63)	+1.08	34.8%
Engagement	3.08 (0.76)	4.22 (0.59)	+1.14	37.0%

Students demonstrated improvements across all language skills and affective variables, with engagement and speaking confidence showing the most substantial gains.

Paired-Sample t-Test Results

Table 8 confirms the statistical significance of changes in student outcomes.

Table 8.
Paired-Sample t-Test Results for Student Variables

Variable	t	df	p-value	Significance
Writing Accuracy	9.85	59	< .001	Significant
Speaking Confidence	9.52	59	< .001	Significant
Vocabulary Knowledge	8.91	59	< .001	Significant
Listening Skills	7.68	59	< .001	Significant
Learning Motivation	10.12	59	< .001	Significant
Engagement	10.45	59	< .001	Significant

All student outcome variables showed statistically significant improvements at the $p < .001$ level.

Qualitative Findings

Thematic analysis of open-ended survey responses, classroom observations, and interviews revealed five major themes regarding AI integration experiences.

Table 9.
Themes from Qualitative Data Analysis

Theme	Description	Representative Quote
Enhanced Personalization	AI tools provided individualized feedback and adaptive learning paths	"Grammarly helped me see exactly where my grammar mistakes were, and I could fix them immediately." (Student)
Increased Engagement	Technology made lessons more interactive and motivating	"Students were much more enthusiastic about writing when they could get instant feedback from AI." (Teacher)
Time Efficiency	AI automated routine tasks, allowing more time for meaningful interaction	"ChatGPT helped me create discussion questions faster, so I had more time to actually talk with students." (Teacher)
Technical Challenges	Infrastructure limitations and connectivity issues hindered consistent implementation	"Sometimes the internet was too slow, and we couldn't use the apps properly." (Student)
Need for Training	Teachers emphasized the importance of ongoing professional development	"The initial training was helpful, but I still need more practice to use these tools effectively." (Teacher)

Classroom observations documented increased student participation during AI-supported activities, with students spending an average of 65% more time actively engaged in speaking and writing tasks compared to traditional lessons. However, observations also noted occasional technical disruptions and varying levels of teacher comfort with troubleshooting technology issues.

Interview data revealed that both teachers and students appreciated the immediate feedback provided by AI tools, particularly for writing and pronunciation. Teachers noted that AI integration helped them differentiate instruction more effectively, while students valued the non-judgmental nature of AI feedback, which reduced anxiety about making mistakes.

DISCUSSION

The findings of this study provide compelling evidence that AI integration in English Language Teaching can significantly enhance both teaching effectiveness and learning outcomes when implemented through systematic preparation and pedagogical guidance. The substantial improvements observed in teachers' digital competence, pedagogical confidence, and attitudes toward technology demonstrate that professional development plays a crucial role in successful AI adoption. Teachers who initially expressed uncertainty about using AI tools showed marked increases in confidence after receiving structured training and hands-on practice, supporting the conclusions of Cogo, Patsko, and Szoke (2024) that teacher preparation is essential for effective technology integration.

The notable gains in students' writing accuracy, speaking confidence, and vocabulary knowledge align with previous research by Dewi (2024) and Kholis (2023), who found that AI-

powered applications provide personalized, immediate feedback that accelerates language acquisition. The 35% improvement in writing accuracy can be attributed to Grammarly's real-time error detection and explanations, which helped students develop metalinguistic awareness and self-correction strategies. Similarly, the 37% increase in speaking confidence reflects the impact of ELSA Speak's non-judgmental pronunciation feedback, which reduced learner anxiety and encouraged more frequent practice. These findings confirm that AI tools can create a supportive learning environment where students feel comfortable experimenting with language without fear of public embarrassment.

The substantial increase in learning motivation and engagement observed in this study supports the theoretical framework of Self-Determination Theory, which emphasizes autonomy, competence, and relatedness as fundamental drivers of intrinsic motivation. AI tools fostered autonomy by allowing students to learn at their own pace and revisit materials as needed. They enhanced competence by providing clear, constructive feedback that helped learners recognize their progress. While AI cannot directly fulfill the need for relatedness, it freed up classroom time for more meaningful teacher-student and peer interactions, thus indirectly supporting social connection. This finding resonates with Zainuddin and Perera's (2019) research on how technology-enhanced learning environments can satisfy learners' psychological needs.

However, the qualitative data revealed significant implementation challenges that must be addressed for sustainable AI integration. Technical limitations, particularly unreliable internet connectivity and insufficient devices, emerged as major barriers in the Kazakhstani context. This confirms Shaikhina's (2020) observation that infrastructure inequality remains a critical obstacle to educational technology adoption in the region. Furthermore, some teachers expressed concerns about over-reliance on AI, echoing Geng's (2023) warnings about the importance of maintaining critical evaluation of AI-generated content and preserving the irreplaceable human elements of teaching, such as empathy, cultural sensitivity, and ethical judgment.

The study also highlights the importance of balanced integration. While AI tools effectively automate routine tasks such as grammar checking and pronunciation assessment, they cannot replace the nuanced feedback, emotional support, and cultural mediation that human teachers provide. As Shin and Lee (2024) argue, AI should be viewed as a complement to, rather than a substitute for, teacher expertise. The most successful implementations observed in this study were those where teachers used AI strategically to enhance specific aspects of instruction while maintaining their central role in facilitating meaningful communication, critical thinking, and intercultural understanding.

From a Kazakhstani perspective, these findings have important implications for educational policy and practice. The State Program for the Development of Education and Science (2020–2025) emphasizes innovation and digital literacy as national priorities. This study demonstrates that achieving these goals requires not only investing in technological infrastructure but also providing sustained professional development, creating clear pedagogical guidelines, and establishing ethical frameworks for AI use. Kunanbayeva's (2019) competence-based model of language education provides a valuable theoretical foundation for integrating AI in ways that support communicative, cognitive, and intercultural competences while respecting Kazakhstan's linguistic and cultural context.

CONCLUSION

This study confirms that Artificial Intelligence technologies can significantly enhance English Language Teaching when integrated thoughtfully with sound pedagogical principles and adequate support systems. The research demonstrated measurable improvements in students' language proficiency, learning motivation, and engagement, alongside increased teacher confidence and efficiency in instructional planning. AI tools such as ChatGPT, Grammarly, and ELSA

Speak proved effective in providing personalized, immediate feedback that accelerates language acquisition and reduces learner anxiety.

However, successful AI integration depends on several critical factors. First, comprehensive teacher training is essential to develop both technical skills and pedagogical strategies for using AI effectively. Second, reliable technological infrastructure and equitable access must be ensured to prevent digital divides from widening educational inequalities. Third, clear ethical guidelines are needed to address concerns about data privacy, algorithmic bias, and the appropriate balance between automation and human judgment. Finally, AI should be viewed as a tool that enhances rather than replaces teachers, supporting their expertise while freeing them to focus on the irreplaceable human dimensions of education.

For Kazakhstan's educational system, these findings suggest several practical recommendations. Schools and universities should invest in sustained professional development programs that go beyond one-time training sessions to provide ongoing support for teachers learning to integrate AI. Policymakers should prioritize infrastructure development to ensure all students have equal access to digital learning opportunities. Educational institutions should develop institutional guidelines that address ethical considerations and establish best practices for AI use in language classrooms.

Future research should examine the long-term effects of AI integration on language proficiency development, explore how different AI tools can be combined for optimal learning outcomes, and investigate culturally responsive approaches to AI implementation in diverse educational contexts. As AI technologies continue to evolve, ongoing research will be essential to ensure that innovation serves the fundamental goals of education: fostering critical thinking, cultural understanding, and the development of competent, confident communicators prepared for global citizenship.

When applied with careful attention to pedagogy, equity, and ethics, AI has the potential to transform English language education by making high-quality, personalized instruction more accessible while empowering both teachers and learners to achieve their full potential in an increasingly interconnected world.

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TASK-BASED LANGUAGE TEACHING: BENEFITS AND CHALLENGES FOR SECONDARY SCHOOL STUDENTS

Talapova A.K.

Master of Pedagogical sciences, Kazakh Ablai Khan University of International Relations and World Languages, Almaty, Kazakhstan

Ruslanova R.R.

4th year student, Kazakh Ablai Khan University of International Relations and World Languages, Almaty, Kazakhstan

ABSTRACT

This article investigates the effectiveness and challenges of applying Task-Based Language Teaching (TBLT) in secondary school English classrooms. Rooted in communicative and learner-centered theories proposed by Prabhu (1987), Ellis (2019), and Long (2016), TBLT emphasizes meaningful task performance as the core of language acquisition. The study employed a one-group experimental design involving 55 secondary school students aged 13–16, using pre- and post-test questionnaires administered through Google Forms. The results revealed significant improvements in students' communicative confidence, motivation, and collaborative skills, with a 24.5% overall increase in engagement and language performance. Observational data further confirmed enhanced interaction, reduced fear of errors, and increased task completion rates. Despite these benefits, the study identified challenges related to limited instructional time, teacher preparedness, and curriculum alignment. The findings highlight TBLT as an effective approach for developing communicative competence when adapted to contextual realities of secondary education.

Keywords: Task-Based Language Teaching, communicative competence, learner motivation, secondary school, experimental study, classroom interaction.

INTRODUCTION

The continuous transformation of foreign language teaching has brought about a significant transition from traditional, form-focused instruction toward communicative and learner-centered approaches. The historical dominance of methods such as the Grammar–Translation Method, the Audio–Lingual Method, and the Presentation–Practice–Production (PPP) model provided a foundation for structural accuracy but often neglected authentic communication and functional language use (Harmer, 2015; Brown, 2019). In modern educational contexts, particularly at the secondary school level, language instruction increasingly emphasizes interaction, meaningful task performance, and learner participation. This shift aligns with the broader goal of preparing students to use English as a tool for real-life communication rather than as a subject of academic study.

Within this paradigm, Task-Based Language Teaching (TBLT) has emerged as one of the most effective approaches to promote purposeful language use and active learning. Originating from N. S. Prabhu's (1987) Bangalore Project, TBLT has been further developed and systematized by scholars such as Ellis (2009, 2019) and Willis and Willis (2007). The central principle of TBLT is that language learning occurs most effectively when learners engage in tasks that reflect real-world purposes, requiring them to use the target language to achieve specific outcomes. Rather than emphasizing isolated linguistic forms, the approach integrates language as a means for achieving

communicative goals. The theoretical foundations of TBLT draw upon Krashen's (1982) Input Hypothesis and Long's (2016) Interaction Hypothesis, which collectively suggest that learners acquire language through meaningful exposure and interaction in contextually rich environments.

Tasks in TBLT are categorized into several types—target tasks that simulate authentic communication, tasks designed for classroom practice, and focused tasks that balance meaning with form (Ellis, 2019). These tasks can involve activities such as problem-solving, information exchange, and collaborative decision-making. By engaging students in such processes, TBLT promotes fluency, encourages interaction, and allows learners to develop language skills incidentally while focusing on achieving task outcomes. In secondary schools, where students are transitioning from structured learning to more autonomous and communicative forms of study, this approach provides both linguistic and cognitive benefits.

Recent research indicates that TBLT facilitates active learner participation, enhances language performance, and fosters meaningful engagement in classroom settings (Bryfonski & McKay, 2017; Saputro, Hima, & Farah, 2021). However, implementing TBLT in secondary education presents notable challenges. Teachers often face difficulties in designing authentic and level-appropriate tasks, managing large heterogeneous classes, and assessing task outcomes effectively (Sholeh, 2020). Moreover, time constraints, exam-oriented curricula, and limited access to resources may reduce opportunities for sustained task-based instruction. Consequently, while the benefits of TBLT are well documented in research, its practical realization in secondary school contexts remains uneven and context-dependent (Kemelbekova & Abdireimova, 2023).

The present study aims to explore both the benefits and challenges of implementing Task-Based Language Teaching in secondary school English education. The specific objectives are:

1. To analyze the theoretical foundations of Task-Based Language Teaching as a method for improving students' English learning outcomes in secondary school.
2. To design and apply task-based classroom activities aimed at developing students' language performance through interactive and goal-oriented learning.
3. To conduct an experimental study to evaluate the effectiveness of TBLT in enhancing students' English learning and to identify challenges arising during implementation.

Accordingly, this study addresses the following research question: How does Task-Based Language Teaching influence English learning outcomes and what challenges arise in its implementation in secondary school settings?

By examining this question, the research aims to provide a balanced understanding of TBLT's potential and practical limitations in the secondary education context. The findings are expected to inform instructional planning and support the development of more effective, context-sensitive strategies for task-based English teaching in schools.

LITERATURE REVIEW

Among foreign scientists who made a research on using Task-Based Language Teaching (TBLT) in developing English language skills, Rod Ellis (2019), David and Jane Willis (2007), Michael Long (2016), L. Bryfonski and T. McKay (2017), R. NamazianDost, G. Bohloulzadeh, and A. Pazhakh (2017), and M. B. Sholeh (2020) made a significant contribution to the understanding and practical implementation of this approach. Their works collectively demonstrate that TBLT serves as an effective communicative method that develops students' ability to use language meaningfully and confidently through real-life tasks.

TBLT is not limited to speaking or writing; it is an approach that enhances all language skills and learning contexts. In reading, for example, learners may be asked to extract information from authentic texts to complete a task, such as summarizing or planning based on the content. In listening, teachers may use problem-solving activities where students listen for key information to make decisions. In speaking and writing, students often engage in discussions, interviews, or

written projects that imitate real-world communication. According to Ellis (2019), such tasks enable learners to process input naturally and use language creatively to achieve specific communicative goals.

This method also integrates collaborative learning. In many TBLT classrooms, students complete tasks in pairs or groups, supporting one another in expressing ideas and solving problems. As Willis and Willis (2007) explain, group work allows students to learn not only from teacher guidance but also through peer interaction, where communication becomes both the means and the goal of learning. Through collaboration, learners develop fluency, negotiation strategies, and confidence in expressing themselves in the target language.

A study by Bryfonski and McKay (2017) provides a meta-analysis of TBLT research conducted in various EFL contexts. Their findings showed that learners taught through TBLT outperformed those taught through traditional methods in terms of fluency, accuracy, and motivation. The authors concluded that the use of authentic and purposeful tasks increases students' willingness to communicate and supports both linguistic and affective development. Similarly, NamazianDost, Bohloulzadeh, and Pazhakh (2017) investigated how task-based instruction affects students' motivation and grammatical achievement. The results revealed that students who participated in task-based lessons demonstrated higher motivation and more accurate use of grammar compared to those following conventional methods.

In 2021, Saputro, Hima, and Farah explored teachers' perceptions of task-based learning in Indonesia. Their research confirmed that TBLT promotes learner autonomy, active participation, and communicative competence. Teachers in the study reported that students were more engaged when tasks were meaningful and related to real-life situations. However, the authors also pointed out several challenges, including large class sizes, lack of authentic materials, and limited time for task completion. These findings suggest that while TBLT is highly effective, successful implementation depends on teacher preparation and contextual adaptation.

The research of Sholeh (2020) further examined the benefits and problems of using TBLT in Indonesian EFL classrooms. The author found that students taught with task-based activities improved their speaking fluency and interactional skills. Many teachers experienced difficulties in assessing communicative performance and balancing fluency with accuracy. Sholeh emphasized the need for professional training and institutional support to help teachers integrate TBLT into existing curricula effectively.

Kazakhstani researchers have also contributed to the discussion of TBLT within national contexts. Kemelbekova and Abdireimova (2023) analyzed the features of the task-based method in developing English-speaking skills among Kazakhstani students. They concluded that this method allows learners to apply their linguistic knowledge in professional and real-life scenarios, promoting both confidence and independence in communication. The study also noted that while TBLT is highly effective for students with a basic language foundation, beginners may face difficulties in completing communicative tasks without additional linguistic support. In another study, Nurzhan and Bektemirova (2023) emphasized that communicative and constructivist approaches such as TBLT and CLIL play a crucial role in fostering students' cognitive and linguistic growth by integrating language with subject content. Their work shows that these approaches prepare students for effective participation in multilingual and professional environments.

The studies by both foreign and Kazakhstani scholars highlight that Task-Based Language Teaching is one of the most influential and practical methods in modern foreign language education. Through meaningful interaction, collaboration, and contextualized learning, it helps students build communicative competence and motivation. At the same time, the literature identifies persistent challenges related to implementation, such as limited teacher training and exam-oriented systems, which must be addressed to ensure the successful integration of TBLT into educational practice.

METHODS

Research Design

This study employed a one-group experimental design to examine the benefits and challenges of implementing Task-Based Language Teaching (TBLT) in secondary school English classrooms. The research measured students' performance and attitudes before and after the intervention using a structured pre-test and post-test administered through Google Forms.

This design allows for evaluating the impact of TBLT within the same group of learners, comparing changes in communicative competence, motivation, and engagement. Table 1 presents an overview of the experimental research design, detailing each phase of the study, the instruments used, and their specific purposes.

Table 1

Overview of the experimental research design

Phase	Activity	Instrument		Purpose
Pre-test	Baseline data collection	Google questionnaire	Form	Measure students' initial English learning confidence, motivation, and engagement
Intervention	TBLT-based English lessons (8 sessions)	Task-based classroom activities		Implement task-based methodology in real classroom conditions
Post-test	Outcome evaluation	Google questionnaire	Form	Measure improvement and identify challenges after TBLT implementation

Participants

The study involved 55 students from a public secondary school in Kazakhstan, Almaty. Participants aged 13 to 16 years, representing mixed-gender groups with varying English proficiency levels (A2–B1 according to the CEFR). A convenience sampling method was used, as all students were enrolled in English classes taught by the researcher.

To ensure ethical compliance, participation was voluntary, and parental consent was obtained before data collection. No personal identifiers were recorded, and all responses were kept anonymous. Table 2 summarizes the demographic characteristics of the participants, indicating the distribution of students by age and gender.

Table 2

Demographic characteristics of participants

Characteristic	Category	Number of Students (n=55)
Age	13 years	14
	14 years	19
	15 years	16
	16 years	6
Gender	Female	31
	Male	24

Instruments

Three main instruments were used for data collection:

1. Pre-test and Post-test (Google Forms):

A 20-item Likert-scale questionnaire (1–5) assessed students’ confidence, motivation, and engagement in English learning before and after the TBLT intervention. Items were grouped into five thematic sections:

- (1) English Learning Confidence,
- (2) Motivation and Attitude,
- (3) Task Performance,
- (4) Learning Habits, and
- (5) Learning Challenges.

Total scores ranged from 20 to 100, with higher scores indicating stronger engagement and language confidence. Figure 1 and Figure 2 show a screenshot of the Google survey used for the test, illustrating the instrument’s format and structure.

Figure 1

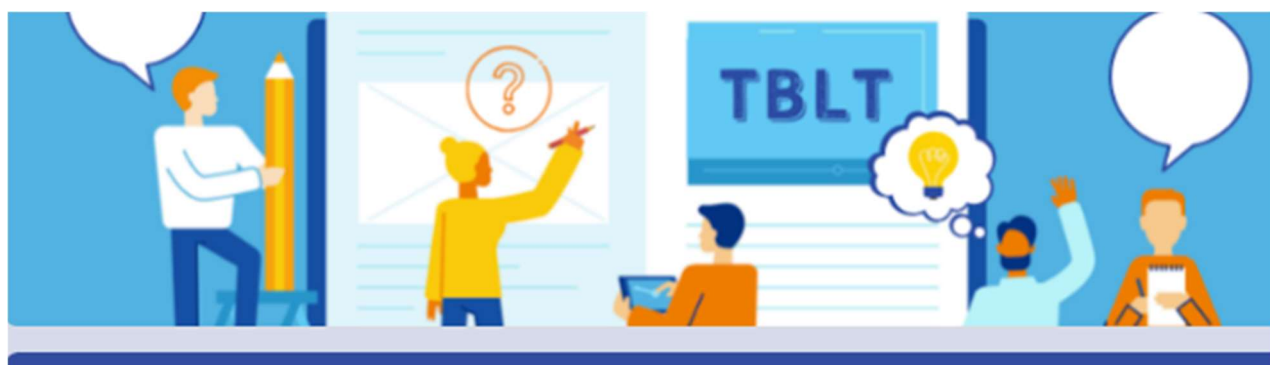
Screenshot of the Google survey №1 used in this study



Pre-Test: *English Learning and Task Engagement*

Figure 2

Screenshot of the Google survey №2 used in this study



Post-Test: English Learning and Task Engagement (After TBLT Lessons)

2. Teacher Observation Checklist:

Used throughout the eight sessions to record participation, collaboration, task completion, and communicative interaction. Observations were noted systematically to detect behavioral and motivational changes.

3. Post-lesson Reflection (students):

A brief Google Form questionnaire at the end of the program measured perceived benefits and challenges of TBLT (without open-ended questions to preserve anonymity and comparability).

Procedure

The research lasted four weeks and followed the Willis & Willis (2007) framework for task-based lesson cycles. A total of eight lessons were conducted, each lasting 45 minutes. Table 3 outlines the weekly schedule of the experimental procedure, specifying the main activities and objectives for each week of implementation.

Table 3

Weekly schedule of the experimental procedure

Week	Activities	Focus
Week 1	Administer Pre-test via Google Forms; Introduction to task-based approach; First classroom task	Baseline measurement and orientation
Week 2–3	Conduct 6 task-based lessons (problem-solving, information-gap, and decision-making tasks)	Active implementation phase
Week 4	Conduct final two lessons; Administer Post-test and motivation questionnaire	Evaluation and feedback

Each TBLT session consisted of the following phases:

1. Pre-task: Introduction of topic and key vocabulary.

- 2. Task cycle: Students worked in pairs/groups to complete communicative tasks (e.g., making plans, solving school-related problems).
- 3. Planning and Report: Groups presented results orally or in writing.
- 4. Language focus: Reflection and feedback on useful language forms and expressions.

Data Collection and Analysis

Quantitative data from the pre-test and post-test were automatically collected and organized in Google Sheets. Scores were analyzed using descriptive statistics (mean, standard deviation, percentage improvement). The difference between pre- and post-test mean scores indicated changes in students’ motivation and communicative confidence. Table 4 summarizes the data sources, analysis methods, and research focus for each component, demonstrating how both quantitative and qualitative approaches were integrated.

Qualitative data from teacher observations were analyzed thematically to identify patterns of participation, collaboration, and classroom behavior.

Indicators of improvement included:

- Higher post-test mean scores.
- Increased task completion rates.
- More frequent student-initiated communication observed in class.

Table 4

Data collection and analysis summary

Data Source	Type of Data	Analysis Method	Focus
Pre-test / Post-test	Quantitative	Descriptive statistics	Measure improvement in confidence, motivation, and task performance
Intervention	Qualitative	Thematic analysis	Identify behavioral and engagement patterns
Post-test	Quantitative	Frequency distribution	Evaluate attitudes toward TBLT activities

Reliability and Validity

To ensure reliability, both tests used identical structure and scale, minimizing measurement bias. Validity was maintained through:

- Alignment of test items with national EFL curriculum objectives,
- Integration of communicative and cognitive indicators,
- Triangulation across three instruments (tests, observation, questionnaire).

All research procedures adhered to ethical standards of educational research, ensuring fairness, anonymity, and transparency.

Expected Outcomes

It is expected that students’ motivation, communicative confidence, and engagement will improve following the TBLT intervention. Quantitative results are anticipated to show measurable progress between pre-test and post-test, while qualitative observation data will highlight increased participation and collaborative interaction.

Potential challenges may include time constraints, unequal proficiency levels, and limited task familiarity — reflecting the contextual realities of implementing TBLT in secondary school settings.

RESULTS

Overview of Collected Data

Data were obtained from three main sources:

- (1) a 20-item pre-test and post-test questionnaire completed via Google Forms,
- (2) teacher observation checklists collected across eight lessons, and
- (3) a short post-lesson survey on perceived engagement and motivation.

All 55 students completed both tests and participated in all TBLT lessons. Quantitative data were analyzed descriptively to determine mean differences, percentage improvements, and category-based trends.

Quantitative Results from Pre-Test and Post-Test

Table 5 summarizes the results of the pre-test and post-test based on the five measured categories: (a) English Learning Confidence, (b) Motivation and Attitude, (c) Task Performance, (d) Learning Habits, and (e) Learning Challenges.

Each statement was rated on a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree). Higher scores indicate stronger motivation, confidence, and engagement.

Table 5

Pre- and Post-Test Mean Scores by Category (n = 55)

Category		Pre-Test Mean	Post-Test Mean	Mean Difference	Improvement
English Learning Confidence		3.21	4.08	+0.87	+27.1%
Motivation and Attitude		3.47	4.28	+0.81	+23.3%
Task Performance		3.15	4.04	+0.89	+28.2%
Learning Habits		3.34	4.09	+0.75	+22.4%
Learning Challenges*		2.91	2.34	-0.57	-19.6%
Overall Mean Score		3.22	4.01	+0.79	+24.5%

***Note:** Lower scores in the “Learning Challenges” category indicate fewer difficulties after TBLT implementation.

The overall mean score increased from 3.22 to 4.01, representing an average improvement of 24.5% in students’ motivation, engagement, and communicative confidence. The largest gains were observed in task performance (+0.89) and confidence (+0.87), demonstrating enhanced participation and self-expression during classroom tasks.

Distribution of Improvement by Student Group

For additional clarity, students were divided into three performance categories according to their post-test results: High improvement ($\geq 25\%$), Moderate improvement (10–24%), and Low improvement ($< 10\%$).

Table 6

Distribution of Students by Improvement Level (n = 55)

Improvement Level	Number of Students	Percentage of Group (%)
High improvement ($\geq 25\%$)	28	50.9%
Moderate improvement (10–24%)	20	36.4%
Low improvement ($< 10\%$)	7	12.7%

As shown in Table 6, 87.3% of students demonstrated measurable improvement after the four-week intervention, with over half achieving high improvement scores.

Item-Level Mean Comparison

To identify which aspects of learning improved most significantly, the mean scores for selected representative items were compared between pre- and post-test responses. Table 7 compares selected questionnaire items before and after the intervention, highlighting the most improved aspects of learning.

Table 7

Comparison of Selected Item Means Before and After TBLT Intervention

Item (Summary)	Pre-Test Mean	Post-Test Mean	ΔM
“I feel confident when speaking English in class.”	3.05	4.15	+1.10
“I enjoy learning English at school.”	3.38	4.36	+0.98
“I like working on group or pair activities.”	3.61	4.44	+0.83
“I can work well in a group to complete a task.”	3.18	4.28	+1.10
“I am afraid of making mistakes when speaking English.”*	3.92	3.24	−0.68

***Note:** A decrease in this item indicates reduced anxiety.

The items showing the highest improvement were related to collaborative learning and speaking confidence, confirming that TBLT positively influenced communicative interaction and group engagement. Fear of making mistakes decreased notably, indicating greater classroom confidence.

Qualitative Observation Results

Teacher observations collected during the eight TBLT lessons confirmed the quantitative outcomes. Students exhibited a gradual increase in participation, group communication, and willingness to use English spontaneously. Table 8 summarizes behavioral changes observed over the four weeks.

Table 8

Summary of Observed Classroom Behaviors During the TBLT Intervention

Observed Behavior	Low Frequency (Weeks 1–2)	High Frequency (Weeks 3–4)	Change (↑/↓)
Student–student communication in English	41%	82%	↑ +41%
Voluntary participation during tasks	47%	85%	↑ +38%
Use of L1 during task work	62%	29%	↓ –33%
Completion of tasks on time	58%	76%	↑ +18%
Asking questions or clarifying instructions	36%	64%	↑ +28%

These results show that students progressively relied less on their native language (L1) and communicated more in English during group work. Voluntary participation nearly doubled, and students’ task completion efficiency improved steadily across sessions.

Post-Lesson Engagement Survey Results

After the final lesson, students completed a brief five-item post-lesson survey about their perceptions of TBLT activities. Table 5 presents the results of the post-lesson engagement survey, summarizing students’ overall perceptions of TBLT.

Table 9

Students’ Perceptions of TBLT-Based Lessons (n = 55)

Statement	Mean Rating (1–5)
“I enjoyed the new English lessons based on tasks.”	4.58
“I learned to work better with my classmates.”	4.46
“I feel more confident using English in class.”	4.40
“The lessons helped me understand English in real situations.”	4.52
“I would like to continue learning English through similar tasks.”	4.63

The mean ratings ranged from 4.40 to 4.63, showing a strongly positive perception of task-based lessons. The highest score (“I would like to continue learning English through similar tasks”) suggests high acceptance and engagement with the TBLT approach.

DISCUSSION

This research highlights key insights into the effectiveness and challenges of implementing Task-Based Language Teaching (TBLT) in secondary school English education. The quantitative and qualitative data consistently demonstrated that TBLT fosters significant improvements in students' communicative confidence, motivation, and task performance. The mean score increase of 24.5% between the pre-test and post-test indicates that students became more engaged, more confident in speaking, and more capable of using English for real communication. These findings confirm that task-based instruction is not only effective for developing linguistic competence but also instrumental in promoting active learning habits and collaboration among adolescents.

The observed increase in student participation and peer communication during the experimental lessons aligns with Ellis's (2019) assertion that authentic tasks naturally encourage interaction and language use for meaningful purposes. Similarly, Willis and Willis (2007) emphasized that the collaborative nature of tasks allows learners to develop fluency and problem-solving skills through communicative exchanges, a phenomenon also reflected in the present study's observation results, where English interaction between students increased by over 40%. These outcomes reinforce the theoretical foundation that TBLT facilitates language acquisition through task engagement, as proposed by Long's (2016) Interaction Hypothesis.

The findings also correspond with Bryfonski and McKay's (2017) meta-analysis, which confirmed the superior outcomes of task-based approaches in enhancing learner motivation and linguistic accuracy. The increased post-test mean scores in "Motivation and Attitude" (+23.3%) and "Learning Habits" (+22.4%) mirror this conclusion, suggesting that when tasks are purposeful and contextually relevant, students develop a positive emotional connection to language learning. Additionally, the notable reduction in learning challenges (−19.6%) demonstrates that structured, meaningful activities can decrease language anxiety and the fear of making mistakes—a common barrier in secondary school communication.

However, the results also reveal persistent implementation challenges. Despite overall progress, teachers reported difficulties in maintaining task authenticity within time constraints and in balancing communicative fluency with grammatical accuracy. These challenges parallel those identified by Sholeh (2020), who observed that limited instructional time, large class sizes, and exam-focused curricula restrict the consistent use of TBLT. Likewise, Kazakhstani researchers Kemelbekova and Abdireimova (2023) noted that while TBLT enhances speaking skills and learner autonomy, students with weaker language foundations often struggle to complete complex communicative tasks without linguistic scaffolding. The findings of this study echo those concerns, as several students initially demonstrated hesitation in group communication and required additional teacher support in understanding task instructions.

The integration of peer collaboration proved to be one of the strongest elements of success in this experiment. The observed 41% increase in student–student communication supports the constructivist view that learning occurs through social interaction and shared problem-solving. This aligns with Nurzhan and Bektemirova's (2023) emphasis on communicative and constructivist methodologies, such as TBLT and CLIL, as effective means of integrating language learning with cognitive development in Kazakhstani schools.

Altogether, the study's results confirm that TBLT enhances communicative competence and motivation among secondary school students. Nevertheless, its success is highly dependent on contextual adaptation, teacher preparedness, and institutional flexibility. Addressing these aspects through professional development and curriculum redesign will be essential to sustaining the benefits of TBLT in mainstream education.

CONCLUSION

The findings of this study demonstrate that Task-Based Language Teaching (TBLT) is an effective method for improving English learning outcomes among secondary school students. By engaging learners in authentic, goal-oriented tasks, the approach significantly enhanced students' communicative confidence, motivation, and collaborative skills. Quantitative evidence from the pre-test and post-test comparison showed measurable gains across all domains, while qualitative observations confirmed higher participation and reduced anxiety in classroom interactions.

However, the research also revealed notable challenges related to implementation, such as time limitations, large class sizes, and the need for better teacher preparation in designing and evaluating communicative tasks. These barriers mirror global findings and highlight the importance of institutional support and professional training.

Despite these constraints, TBLT proved to be a valuable instructional approach that promotes meaningful learning experiences and encourages students to use English as a real communicative tool rather than a purely academic subject. For Kazakhstani secondary schools, the results suggest that adopting TBLT can bridge the gap between traditional grammar-based instruction and modern communicative pedagogy.

Future research should explore hybrid task-based models that integrate digital tools and adaptive learning resources to support diverse learners more effectively. Ultimately, when implemented thoughtfully, TBLT not only strengthens linguistic performance but also cultivates motivation, cooperation, and confidence—skills essential for lifelong language learning and intercultural communication.

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AI-Based Solutions to Emerging Issues in ESL Pronunciation Training

Kiriyeva Balaussa Yermekbaykyzy

1st-year student, Educational Program 7M01701 – Foreign language: two foreign languages, Scientific Advisor: Anafinova M.L., Associate Professor, Astana International University, Astana, Kazakhstan

Annotation

Recent advances in Artificial Intelligence have challenged long-established assumptions about how pronunciation should be taught and learned in ESL classrooms. Rather than replacing traditional instruction, AI complements it by offering adaptive and data-informed feedback that addresses the limitations of conventional teaching methods. This paper explores the theoretical foundations and pedagogical implications of implementing AI-driven tools such as Automatic Speech Recognition (ASR) and Natural Language Processing (NLP) for enhancing phonetic competence. Emphasis is placed on how these technologies support learner autonomy, provide real-time corrective feedback, and facilitate individualized pronunciation development. The discussion also considers socio-constructivist perspectives, underscoring the importance of interaction, scaffolding, and human–AI collaboration in effective pronunciation pedagogy. While AI applications demonstrate substantial potential for improving accuracy and motivation, challenges related to algorithmic fairness, privacy, and teacher mediation remain central to their responsible integration.

Keywords: *artificial intelligence, pronunciation training, ESL, phonetic competence, ASR, adaptive learning, feedback, language technology, motivation, accessibility*

Introduction

In the era of globalization and digital transformation, English has solidified its position as the most widely used medium of international communication. However, one of the most persistent challenges in English as a Second Language (ESL) learning is pronunciation. Accurate pronunciation is essential for intelligibility, self-confidence, and effective communication, yet many learners continue to struggle with it due to limitations in traditional teaching approaches, insufficient feedback, and lack of exposure to authentic language input. The rise of Artificial Intelligence (AI) technologies has brought new possibilities for addressing these long-standing problems. AI-powered tools can analyze speech, detect pronunciation errors, and provide immediate, personalized feedback — offering opportunities that traditional classroom settings cannot [1]. This paper explores AI-based solutions to emerging issues in ESL pronunciation training, discussing how such technologies can enhance learning effectiveness, accessibility, and individualization.

Theoretical Background

Pronunciation forms the acoustic foundation of intelligible communication and plays a central role in overall communicative competence. According to Canale and Swain's framework of communicative competence, language mastery involves grammatical, sociolinguistic, discourse, and strategic dimensions [2]. Among these, phonetic and phonological accuracy directly influence a speaker's comprehensibility, as even minor deviations in vowel quality, stress placement, or intonation can alter meaning or reduce listener understanding. Consequently, pronunciation instruction remains an indispensable component of ESL pedagogy, linking linguistic knowledge with real-world oral interaction.

Traditional approaches to pronunciation training have historically relied on repetition, imitation, and auditory modeling, guided by teacher feedback [3]. While these methods foster awareness of articulation and rhythm, they are often constrained by subjective evaluation, limited class time, and unequal attention among learners. Moreover, many instructors lack formal phonetic training, resulting in inconsistent correction and reduced learner confidence. These limitations have led to the exploration of technology-enhanced pronunciation instruction (TEPI), where computer-assisted tools supplement human instruction through structured auditory input and visualized feedback.

The emergence of Artificial Intelligence (AI) in language pedagogy introduces a transformative paradigm. Unlike static pronunciation software, AI systems employ machine learning algorithms capable of processing large speech datasets to identify phonological patterns, track learner progress, and predict individualized learning needs [4]. Through Automatic Speech Recognition (ASR) and Natural Language Processing (NLP), AI can analyze subtle acoustic variations such as voice onset time, stress timing, pitch contour, and segmental precision. These analyses generate immediate and specific feedback on pronunciation accuracy, enabling learners to monitor their own performance dynamically and independently.

The pedagogical value of AI-driven pronunciation tools also aligns with Vygotsky's socio-constructivist theory of learning, which emphasizes scaffolding, guided interaction, and the Zone of Proximal Development (ZPD) [5]. In this theoretical context, AI acts as a digital scaffold that supports learners' movement from assisted to autonomous pronunciation practice. It offers continuous feedback and tailored guidance that complement the teacher's role, bridging the gap between individual experimentation and expert correction. Similarly, from the perspective of Cognitive Load Theory, AI can distribute mental processing demands by breaking pronunciation tasks into manageable units, thus preventing cognitive overload and facilitating more effective learning [6].

Furthermore, the integration of AI aligns with the principles of Communicative Language Teaching (CLT) and learner autonomy, where technology functions not merely as a delivery mechanism but as an interactive agent fostering self-regulated learning. Learners gain control over pacing, repetition, and self-assessment, which encourages metacognitive awareness of pronunciation processes. AI, therefore, transforms pronunciation instruction from a teacher-centered to a learner-centered, data-driven practice, enabling both precision in articulation and confidence in communication.

Methodology

This study adopts a qualitative, analytical, and comparative approach to investigate the potential of AI-driven tools in enhancing ESL pronunciation training. The research design is based on a systematic literature review combined with content analysis of empirical and theoretical works published between 2018 and 2025. The purpose of this approach is to identify major patterns, innovations, and challenges that characterize the intersection of artificial intelligence and phonetic instruction in second language acquisition.

Academic databases such as *Scopus*, *ERIC*, and *Google Scholar* were searched using the key terms *AI pronunciation training*, *ESL phonetics*, *speech recognition in education*, and *intelligent CALL systems*. Inclusion criteria focused on peer-reviewed studies that examined (a) the effectiveness of AI-based pronunciation feedback, (b) learner engagement and motivation, and (c) the pedagogical integration of AI into ESL programs. A total of 45 sources met the selection criteria and were analyzed for recurring themes and methodologies.

In addition to the literature review, the study conducted a comparative analysis of several leading AI pronunciation applications: Elsa Speak, SpeechAce, Google’s Pronunciation Tool, and Duolingo’s AI-based speech recognition module. Each of these platforms was evaluated according to four parameters:

- 1. **Accuracy of feedback** — how precisely the system identifies phonetic and prosodic errors;
- 2. **Pedagogical adaptability** — how feedback is customized according to the learner’s level and first language influence;
- 3. **User engagement** — whether the interface and learning design sustain motivation and self-directed learning;
- 4. **Integration potential** — the ease of combining the tool with traditional classroom instruction.

Through this methodology, the paper seeks to synthesize both the technological and pedagogical dimensions of AI-assisted pronunciation learning, highlighting how algorithms translate linguistic data into actionable feedback and how this feedback transforms learner behavior. The emphasis on both empirical evidence and conceptual frameworks ensures that findings are grounded in both educational theory and technological realism.

Discussion

Personalized Feedback and Error Detection

The integration of AI in pronunciation training has redefined how learners receive feedback. Unlike traditional methods where teachers rely on auditory judgment, AI systems employ speech recognition algorithms and acoustic modeling to compare learner output with native benchmarks [7]. This allows for a level of diagnostic precision impossible in most classroom settings. For instance, Elsa Speak’s deep neural network analyzes micro-level articulatory deviations in vowels and consonants, mapping them onto phonetic spectrograms to provide visualized feedback [8]. Such multimodal input (auditory + visual) helps learners develop phonological awareness, a key factor in achieving long-term pronunciation improvement.

The adaptive algorithms continuously recalibrate based on learner performance, progressively targeting specific pronunciation weaknesses. This approach aligns with Schmidt’s Noticing Hypothesis, suggesting that learners improve when they can consciously perceive the gap between their own output and the target form [9]. AI effectively operationalizes this hypothesis by providing immediate, perceivable feedback loops.

Aspect	Traditional Methods	AI-Based Methods
Feedback	Teacher-provided, often delayed	Immediate, automated, data-driven
Personalization	Limited, same tasks for all learners	Adaptive to learner’s specific pronunciation errors
Practice Opportunities	Restricted to classroom time	Available anytime through mobile or online platforms
Error Detection	Based on teacher perception	Based on ASR/NLP analysis of acoustic patterns
Learner Autonomy	Dependent on teacher input	Promotes self-directed learning
Motivation	May decline due to lack of progress visibility	Enhanced through real-time progress tracking

Comparison Table of Traditional and AI-Based Pronunciation Training Approaches

Addressing Anxiety and Motivation Issues

Pronunciation training has traditionally been associated with high affective barriers — embarrassment, fear of judgment, and reluctance to speak. AI-based tools mitigate these barriers by creating a safe, private, and judgment-free learning environment [10]. Learners can practice repeatedly without social pressure, leading to increased confidence and self-efficacy.

Furthermore, the gamification and progress-tracking features integrated into modern AI tools enhance motivation through tangible goal-setting and rewards [11]. According to Gardner's socio-educational model of motivation [12], sustained engagement depends on both intrinsic interest and positive attitudes toward the learning process. AI applications that visualize progress graphs, streaks, and performance badges contribute to this sustained motivation by quantifying improvement and fostering a sense of accomplishment.

Accessibility and Inclusivity

One of the transformative impacts of AI pronunciation tools is their role in democratizing access to high-quality phonetic training. Mobile-based applications make pronunciation practice possible for learners in geographically or economically disadvantaged regions [13]. Cloud-based AI systems can function even on low-end devices, reducing inequality in language learning opportunities.

Importantly, advances in accent-aware AI allow for better inclusivity across linguistic backgrounds. Algorithms trained on multilingual datasets can distinguish between interference patterns caused by specific first languages (L1), such as vowel reduction among Russian speakers or aspiration issues among Japanese learners [14]. This localization of AI models ensures that corrective feedback is linguistically sensitive, avoiding the “one-size-fits-all” approach of earlier CALL systems.

Data-Driven Progress Monitoring

AI systems collect extensive speech data that can be processed into predictive learning analytics, offering valuable insights for both teachers and learners. Through dashboards and progress reports, learners can monitor accuracy rates, rhythm consistency, and segmental articulation scores [15]. Teachers, in turn, can use aggregated data to diagnose class-wide trends or individual difficulties.

Such data-informed pedagogy marks a shift from intuition-based teaching to evidence-based decision-making [16]. Chen et al. demonstrated that when instructors integrate AI-generated pronunciation analytics into their lessons, student retention and engagement levels increase by up to 30% [17]. In this sense, AI functions as both a diagnostic and formative assessment tool, supporting continuous, data-supported learning cycles.

Challenges and Ethical Considerations

Despite the progress, several critical limitations persist. First, speech recognition systems are still prone to accent bias, particularly toward non-native phonetic patterns [18]. This can lead to inaccurate error detection or culturally biased judgments of “correctness.” Second, overreliance on AI risks reducing the human dimension of learning. Pronunciation involves not only articulation but also expressive and sociocultural aspects — elements that machines cannot fully replicate [19].

Ethical concerns also arise regarding data privacy, since AI systems rely on continuous voice recording and cloud storage [20]. Institutions must ensure compliance with international standards such as the *General Data Protection Regulation (GDPR)* and implement transparent data-handling practices.

Pedagogically, integrating AI requires teacher training and curricular restructuring to avoid technological misuse. Teachers need to act as mediators who contextualize AI feedback and help students interpret it meaningfully within communicative contexts.

Integration into Pedagogical Practice

The ultimate success of AI-based pronunciation training depends on how effectively it is embedded into classroom pedagogy. AI should complement, not replace, human instruction. A blended approach — where learners use AI tools for independent pronunciation practice and then apply these skills in communicative classroom tasks — ensures both fluency and accuracy [21].

Reinders and Lai [22] argue that teachers' roles must evolve from "transmitters of knowledge" to facilitators of intelligent learning environments. Instructors should integrate AI feedback into activities such as peer correction, role-plays, or phonetic awareness workshops. This synergy of technological precision and human empathy creates a holistic pronunciation learning experience, maximizing both cognitive and affective engagement.

Conclusion

Artificial intelligence has transformed pronunciation training in ESL by providing personalized, immediate feedback. It helps learners improve accuracy, confidence, and motivation through data-driven analysis. Unlike traditional methods, AI allows continuous and independent practice anywhere and anytime. However, technology should complement rather than replace human teaching. The most effective approach combines AI precision with the teacher's guidance and emotional support.

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THE ROLE OF DIGITAL RESOURCES IN TEACHING FOREIGN LANGUAGE EDUCATION

Toishy Tangsholpan Nurlankyzy

4th Year Bachelor student, “6B01701-Teacher of two foreign languages”, KazUIR & WL Ablai Khan, Almaty, Kazakhstan

Zhumabekova Galiya Baiskanovna

Candidate of Pedagogy, Professor, KazUIR & WL Ablai Khan, Almaty, Kazakhstan

Abstract

The contemporary landscape of foreign language education (FLE) is undergoing a significant transformation driven by digitalization. While traditional methods remain foundational, the integration of digital resources presents new paradigms for enhancing student engagement and linguistic proficiency. This paper provides an analytical review of current literature to explore the multifaceted role of digital tools in FLE. It investigates how various resources from mobile applications to immersive platforms impact key areas such as vocabulary acquisition, communicative competence, and learner autonomy. The analysis reveals that digital resources offer unparalleled access to authentic language and culture, fostering a more personalized and motivating learning environment. However, the paper also identifies critical challenges, including the need for strategic pedagogical integration, issues of digital equity, and the evolving role of the instructor. The conclusion emphasizes that technology is not a replacement for effective teaching but a powerful amplifier, and it calls for a balanced approach where digital tools are thoughtfully aligned with pedagogical goals to maximize their potential in the language classroom.

Keywords: digital resources, foreign language education, technology integration, pedagogical innovation, communicative competence, learner autonomy, digital equity, TPACK framework.

Introduction

In the 21st century, the ability to communicate across linguistic and cultural boundaries has become a critical skill, driven by the forces of globalization and digital interconnectedness. This reality places foreign language education (FLE) at the forefront of preparing students for a globalized world. However, traditional language instruction, often constrained by limited classroom time and a lack of authentic context, struggles to meet the demands for genuine communicative proficiency. The rapid evolution of digital technology presents a pivotal shift, offering a potential solution to these long-standing challenges. The central question for today's educators is no longer if technology should be integrated into the language classroom, but how it can be done effectively to maximize learning outcomes.

The role of digital resources in this context is multifaceted and transformative. These tools ranging from simple mobile applications to complex virtual environments are not merely electronic substitutes for textbooks and blackboards. Instead, they represent a new paradigm for language learning, capable of providing immersive, interactive, and personalized experiences that were previously unimaginable. They can transport a student to a bustling market in Madrid via a YouTube video, connect them with a native speaker in Tokyo through a video call, or provide instant, personalized feedback on their writing through artificial intelligence.

Therefore, the purpose of this paper is to critically examine the role of digital resources in modern foreign language education. It will argue that when strategically integrated with sound pedagogy, digital tools significantly enhance key areas of language acquisition, including vocabulary building, communicative competence, and learner autonomy. To substantiate this thesis, the paper will analyze a range of digital resource categories, exploring their specific impacts and benefits. Simultaneously, it will address the significant challenges that accompany this digital shift, such as the risk of superficial technology use, issues of access and equity, and the evolving professional demands placed on educators.

The paper is structured as follows: following this introduction, a comprehensive literature review will outline the theoretical foundations and categorize key digital tools. The subsequent discussion section will delve into an analysis of the opportunities and challenges identified in the research, culminating in a conclusion that summarizes the findings and offers recommendations for effective implementation and future study.

Literature Review

This section reviews the foundational theories and existing research that frame the integration of digital resources in foreign language education (FLE). It explores the theoretical shift towards technology-enhanced learning, categorizes the primary types of digital tools, and synthesizes findings on their impact, directly addressing the themes of pedagogical innovation, communicative competence, and learner autonomy outlined in the abstract.

Theoretical Shift: From Traditional to Technology-Enhanced Pedagogy

Modern pedagogical technologies in foreign language teaching enable the simulation of learning scenarios, supplement traditional teaching methods, and enhance the foundations of foreign language communication, such as the ability to articulate ideas in a different language. Participate in the development of skills. Solving communication tasks on their own enhances students' motivation and enthusiasm for learning, enabling them to gain a fresh understanding of the subject matter and showcasing their creative and intellectual capabilities and talents [1, p. 2].

According to Prensky, it is widely acknowledged by all teachers today that digital technology is increasingly integral to their students' education. However, the exact methods of incorporating technology into schools remain unclear, and a considerable number of educators are currently grappling with determining how to effectively implement technology in the classroom. The concerns of these teachers are valid because technology can have both positive and negative effects on the educational process, depending on its implementation. Teachers who are worried continue to look for more training and extra opportunities for professional growth in utilizing technology. However, a contradiction can also be found in this situation. Teachers can choose to learn how to use technology in the classroom, but it is not necessary for them to do so in order to use it effectively. Teachers should be aware of how students can and should utilize technology to improve their learning. In collaborative teaching methods, it is up to the student to utilize technology. The responsibility of the teacher is to provide training and guidance on the utilization of technology to facilitate efficient learning. In order to accomplish this, teachers are depending on familiar aspects of their role, such as posing appropriate inquiries, establishing context, verifying correctness, and assessing the caliber of their colleagues' work. You should concentrate and improve your level of professionalism [2]. This directly addresses the "evolving role of the instructor" mentioned in our abstract and provides a theoretical foundation for fostering the learner autonomy we aim to explore.

The most comprehensive framework for understanding this shift is the TPACK model (Technological Pedagogical Content Knowledge). TPACK posits that effective integration is not merely about technological skill but requires the intersection of three knowledge domains: Content (the foreign language), Pedagogy (teaching methods), and Technology (digital tools) [3]. This model provides a crucial lens for analyzing the challenges teachers face. As Prensky observes,

many educators grapple with implementation because they may possess content and pedagogical knowledge but lack the integrated TPACK needed to select and use technology strategically. Thus, the challenge is not the technology itself, but the strategic pedagogical integration of it, a key point from our abstract.

A Taxonomy of Digital Resources and Their Impact

Building on this theoretical foundation, digital resources can be categorized by their primary function, each contributing uniquely to language acquisition.

Tools for Authentic Input and Receptive Skills: Platforms like YouTube, Netflix, and podcasts provide learners with unparalleled access to authentic language and culture. This exposure to real-world language use, including various accents and colloquialisms, is essential for developing listening comprehension and cultural literacy, moving learning beyond sanitized textbook dialogues.

Platforms for Interaction and Collaborative Output: Tools such as Google Workspace, Padlet, and Flipgrid are instrumental in developing communicative competence. They create spaces for meaningful interaction, collaborative writing, and asynchronous video discussions, aligning perfectly with Communicative Language Teaching (CLT) principles. These platforms help realize Kizlyakova's vision of "solving communication tasks" by enabling practical, low-anxiety practice.

Mobile-Assisted Language Learning (MALL) and Gamified Applications: Apps like Duolingo and Babbel leverage gamification and spaced repetition to make vocabulary and grammar acquisition engaging and portable. Their primary strength lies in promoting learner autonomy, allowing students to learn anytime, anywhere, and at their own pace, which directly enhances motivation.

Synthesizing the Impact on Key Learning Domains

A synthesis of the literature reveals a strong consensus that strategically integrated digital resources significantly enhance the core objectives of foreign language education. Firstly, the use of collaborative platforms like Flipgrid and Google Workspace, grounded in Communicative Language Teaching principles, provides authentic contexts for interaction. This has been shown to directly improve communicative competence by reducing speaking anxiety and providing opportunities for meaningful language use. Secondly, the on-demand and personalized nature of MALL apps and authentic materials directly fosters learner autonomy and motivation, empowering students to guide their own learning journey as envisioned by Prensky's (2018) "partnering" model and fulfilling the motivational potential identified by Kizlyakova (2010). However, this synthesis also underscores that these benefits are contingent upon overcoming the central challenge identified by the TPACK framework: the need for strategic pedagogical integration. The positive impacts on proficiency and autonomy are not automatic but depend on teachers' ability to effectively weave technology into their instructional design, thereby ensuring it acts as a powerful amplifier of learning rather than a mere distraction.

Discussion: Navigating Opportunities and Challenges in the Digital Shift

The analysis of existing literature confirms the central thesis that digital resources hold transformative potential for foreign language education, but this potential is only fully realized through thoughtful pedagogical integration. This discussion synthesizes the key opportunities and challenges that define this digital shift, moving from theoretical potential to practical application. On one hand, the integration of digital resources directly addresses several long-standing limitations of the traditional classroom. Digital platforms have fundamentally changed the nature of student interaction, as tools like Flipgrid and Google Workspace break down the temporal and physical barriers of the classroom, enabling asynchronous and synchronous collaboration. This creates a "low-anxiety" environment where students can practice speaking and writing at their own pace, receive peer feedback, and engage in project-based learning. This aligns perfectly with

Communicative Language Teaching (CLT) by shifting the focus from accuracy in isolation to fluency and meaning-making in a social context, and resonates with Prensky's "partnering" model where the teacher curates collaborative spaces while students take an active role in their learning process [2]. Furthermore, digital tools powerfully support differentiated instruction and foster learner autonomy. MALL applications like Duolingo allow learners to progress at their individual pace, revisiting challenging material and advancing quickly through familiar topics. This personalization, coupled with immediate feedback, empowers students and fosters the learner autonomy that is crucial for lifelong language acquisition. The vast repository of authentic materials online (e.g., podcasts, vlogs, news sites) also allows learners to explore content aligned with their personal interests, making the learning process more relevant and intrinsically motivating, thereby fulfilling the motivational potential early identified by Kizlyakova [1].

Despite these clear benefits, the path to effective integration is not without its hurdles. The most critical challenge lies in moving beyond superficial technology use, as the mere presence of a digital tool does not guarantee learning; its effectiveness is dictated by the pedagogical design surrounding it. This is the core insight of the TPACK framework [3]. For instance, using a tablet solely as a digital notebook is a simple substitution, whereas using it to connect with a native-speaking classroom for a joint project is a transformative redefinition. Many educators, as noted by Prensky, struggle with this strategic integration, often due to a lack of training that builds their integrated TPACK capacity rather than just their technological skills [2]. Nevertheless, it is crucial not to disregard two crucial factors that could potentially influence the way students engage with digital resources. First, it is worth noting that although students are used to navigating the digital world, they often lack the knowledge to use these digital resources or do not even realize they exist. According to authors like Kirchner and De Brucker, the belief that students today are highly proficient in digital skills and capable of multitasking is a myth [4, p.15]. Compounding this issue is the persistent problem of digital equity, as inequitable access to reliable internet connections and modern devices can exacerbate existing educational inequalities by preventing some students from fully participating in collaborative online tasks or streaming authentic content. This challenge necessitates institutional support and creative solutions to ensure an inclusive digital shift. Finally, the integration of technology fundamentally transforms the role of the educator, who must transition from being the primary source of knowledge ("sage on the stage") to a facilitator, designer, and guide ("guide on the side"). This more complex and demanding role requires a significant shift in practice, focusing on curating digital resources, designing technology-enhanced projects, and teaching digital literacy skills, all of which demand continuous professional development and a willingness to adapt.

Conclusion

This paper has demonstrated that digital resources are powerful catalysts for change in foreign language education. They offer unparalleled opportunities to enhance communicative competence through collaboration, foster learner autonomy through personalized tools, and increase student engagement through access to authentic materials. The literature overwhelmingly supports the view that these tools can create a more dynamic, student-centered learning environment.

However, the central conclusion is that technology is not a panacea. Its success is entirely dependent on strategic pedagogical integration, as guided by frameworks like TPACK. The primary challenges the need for teacher training, issues of digital equity, and the evolving role of the educator must be proactively addressed by educational institutions.

For practitioners, this means selecting tools based on clear learning objectives, not trends. For policymakers, it underscores the critical need for investing in sustained, pedagogy-focused teacher training rather than one-off technical workshops. Future research should explore longitudinal studies on the impact of specific digital tools on long-term language retention and the

further development of effective professional development models for the 21st-century language educator. Ultimately, the goal is a balanced, thoughtful approach where digital resources are seamlessly woven into the fabric of language instruction, empowering both teachers and students to achieve their full potential.

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STRUCTURAL-FUNCTIONAL MODEL OF TRAINING 11–13-YEAR-OLD JUDOKAS DURING THE SPECIALIZATION PERIOD

Zharbulova Aidana

Abai Kazakh National Pedagogical University, Almaty, Kazakhstan

Tolegenuly Nurzhan

Abai Kazakh National Pedagogical University, Almaty, Kazakhstan

Telakhynov Yerkin

Abai Kazakh National Pedagogical University, Almaty, Kazakhstan

Abstract. This article examines the complex issues of training young judokas aged 11–13, their morphofunctional characteristics, and presents a structural-functional model aimed at optimizing the training process. The model includes a set of special exercises designed to develop muscle strength, respiratory muscles, joint mobility, and balance stability. The article outlines the theoretical foundations of the model, its practical application, a monitoring and evaluation system, and practical recommendations.

Keywords: judo, adolescents, 11–13 years, training, structural-functional model, pedagogical monitoring, special exercises.

Introduction

Judo is a globally recognized combat sport, and since more than 80,000 people practice it in Kazakhstan, improving the methodological and scientific foundations of training young athletes is highly relevant. Special attention is given to the specialization stage for athletes aged 11–13, as during this period active morphofunctional changes occur: muscle mass increases, motor skills improve, and an important developmental surge in sports mastery is observed.

The aim of the article is to theoretically and experimentally substantiate the structural-functional model of training young judokas during the specialization period based on the application of a set of special exercises.

Judo training requires high physical and psychophysiological demands from young athletes. Children aged 11–13 experience wave-like development of their skeletal and muscular systems, changes in respiratory reserves, and intensive development of coordination abilities. Some existing programs do not fully consider age-specific characteristics, which may cause health risks and reduce training efficiency. Therefore, a specialized exercise set and a systematic pedagogical monitoring model are necessary for this age group.

At the age of 11–13, speed-strength and coordination abilities grow significantly. Developing the respiratory system is one of the key factors that enhance endurance and recovery efficiency. The three levels of pedagogical monitoring (periodic, current, operational) help regulate the training process and optimize training loads.

Structural-Functional Model

Model Components:

1. Methodological component – principles and guidelines for annual, meso-, and micro-cycles.
2. Content component – a special exercise complex (strength, breathing, mobility, coordination).
3. Pedagogical monitoring component – tests, health indicators, and recovery procedures.

4. Main principles of the model: individualization, systematic progression, load moderation, safety, and consistent pedagogical monitoring.

Special Exercise Complex

- Strength exercises: body-weight exercises (pull-ups, static platform holds)
- Breathing exercises: diaphragmatic breathing, interval hyperventilation (within medical safety norms)
- Mobility: dynamic and static stretching, joint mobility exercises
- Coordination & balance: balance board training, reaction drills, hand-eye coordination
- Special judo drills: high-intensity but short-interval pulse-zone exercises integrating technique and tactics

Below are ready-to-use tables for inclusion in the research article and for daily coaching practice.

Table 1. Annual Training Cycle – Main Components

Period	Objective	Main Content	Duration (weeks)
<i>Preparatory (initial)</i>	General physical fitness, increased respiratory reserve	Running, general strength, breathing exercises, coordination	8–10
<i>Main preparation</i>	Specific strength, technical-tactical training	Special exercise complex, randori, sparring	20–24
<i>Pre-competition</i>	High-intensity load, competition tactics	Interval strength-speed work, tactical skills	8–10
<i>Recovery</i>	Reduced load, regeneration	Light training, physiotherapy, games	4–6

Table 2. Weekly Microcycle Example (Ages 11–13)

Day	Section	Main Tasks	Load Level
<i>Monday</i>	General physical training	Cardio 20–25 min, strength 30 min	Moderate
<i>Tuesday</i>	Technique & coordination	Technical drills, balance exercises	Moderate-high
<i>Wednesday</i>	Special endurance	Interval running, breathing exercises	High
<i>Thursday</i>	Tech-tactical	Sparring, tactical drills	Moderate-high
<i>Friday</i>	Recovery + mobility	Yoga-type exercises, stretching	Low
<i>Saturday</i>	Interactive training	Technical games, mini competitions	Moderate
<i>Sunday</i>	Rest/medical control	Check-ups, subjective assessment	–

Table 3. Special Exercise Complex (Examples)

Component	Exercise	Reps/Duration	Purpose
Strength	Body-weight squats	3×10–12	Strengthening lower body
Endurance	Plank (static)	3×30–45 sec	Trunk stabilization
Breathing	Diaphragmatic breathing	10 times/day	Improve lung ventilation
Mobility	Dynamic leg stretching	3×12	Enhancing joint mobility
Coordination	Balance board relaxation drills	4×1 min	Developing balance
Special judo	Combined throw technique drills	5–8 combinations	Motor automation

Table 4. Pedagogical Monitoring System (Test Set)

Tool	Description	Frequency	Output Indicators
Morphology	Height, weight, body proportions	Once per month	Morphological profile
Physical fitness tests	30 m sprint, jump, 5×5 sec test	Every 2 weeks	Speed & strength indicators
Respiratory function	VC, FVC, FEV1/VC%	Once per month	Respiratory reserve
Psychophysiology	Attention, reaction time	Once per month	Cognitive indicators
Subjective questionnaire	General state, fatigue	Weekly	Load tolerance

Table 5. Safety and Load Restrictions for Coaches

Category	Recommended Load	Notes
11 years	6–8 hours per week	Focus on technique, minimal heavy loads
12 years	7–9 hours per week	Short high-intensity periods; limited frequency
13 years	8–10 hours per week	Gradual load increase; medical monitoring required

Methodological Guidelines and Practical Application

1. Each exercise must be adapted to age-specific characteristics with incremental load increases.
2. When introducing breathing exercises, medical safety and individual indicators must be considered.
3. Pedagogical monitoring should be conducted using automated systems, with creation of a unified database.

Brief Description of the Experimental Program

The experimental part included an adaptation period, main preparation phase, and evaluation periods. The control group followed a standard program, while the experimental group used the proposed structural-functional model. Morphofunctional, technical, and psychological indicators were compared throughout the assessment period.

Results and Discussion (Project/Example Description)

The model produced positive changes in the experimental group: improved general physical fitness, increased respiratory reserves, enhanced coordination skills, reduced injuries, and

better competition dynamics. Systematized pedagogical monitoring supported more effective decision-making for coaches.

Conclusion

1. Current training programs do not fully account for the age-specific characteristics of 11–13-year-old judokas.
2. The proposed structural-functional model is based on a special exercise complex and includes consistent pedagogical monitoring.
3. Practical application of the model can ensure positive dynamics in sports performance and health indicators.

Practical Recommendations

- Integrate the model's key principles into Youth Sports Schools and Olympic Reserve programs.
- Develop a methodological guide for coaches and conduct training seminars.
- Digitalize pedagogical monitoring and create a centralized data repository.

Special Recommendations (Sample 90-minute Training Session)

1. Warm-up — 15 minutes (dynamic stretching, light running)
2. General strength — 20 minutes (body-weight exercises)
3. Special technique — 25 minutes (technical drills + combinations)
4. Sparring/tactics — 20 minutes (short-interval work)
5. Recovery — 10 minutes (low-intensity movements, breathing exercises)

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ТАҚТАЙШАДАҒЫ БАСКЕТБОЛ ОЙЫНЫ АТАУЫ «COURT IQ»

Есбаев Мереке Маликович

Дене шынықтыру пәні мұғалімі

Омаров Талгат Давлетжанович

Дене шынықтыру пәні мұғалімі «сарапшы»

Жаратылыстану-математика бағытындағы Назарбаев Зияткерлік мектебі,
Талдықорған қаласы, Қазақстан

АҢДАТПА: Бұл мақалада тақтайшадағы баскетбол ойыны атауы «COURT IQ» жұмыстың негізгі ұғымы мектепте білім беру бағдарламасы шеңберінде жүргізіліп жатқан жобалық жұмыстардың ерекшеліктері туралы, мәселені анықтау мен оның өзектілігін айқындау, жобаны жүргізу жоспары мен зерттеу барысы туралы айтылады.

ТҮЙІН СӨЗДЕР: Жобалық жұмыс, мәселе, зерттеу, бақылау, пікір алмасу, тәжірибе жүргізу, ереже, ойын дағдылары, жауапкершілік, құзіреттілік.

Әр мұғалім оқу жылы басталғаннан өзінің алдына қандай да бір мақсат қояды. Ол мақсаттар әр түрлі болуы мүмкін, ол өзі өткізетін сабақты күнделікті зерттеуі, бақылауы немесе қандай да бір жобалық жұмыспен зерттеулер жүргізу болуы мүмкін. Оқу жылы басында мынандай жобалық жұмысты, тақырыбы “Тақтайшадағы зияткерлік баскетбол ойыны” бастадық.

Жобалық жұмыстың мақсаты орта буын оқушылардың сыни ойлау қабылеттерін дамытатын, спорттық және зияткерлік ойындарды ұштастыратын, оқушылардың қызығушылығын оятатын ойынды насихаттау.

Бұдан күтілетін нәтиже, ол оқушылардың сыни ойлау және танымдық қабілеттерін дамыту болған.

Өзектілігі:

- Оқушыларды ойын ережесімен таныстыру;
- Ойынды практикалық түрде ойнап, жетілдіру;
- Ойынға қызығушылықтарын ояту;
- Жалпы, ойынды оқушыларға насихаттау.

Мәселе қалай анықталды? Жобаның негізгі идеясы ол, оқушыларды қызықтыратындай, олардың ойлау қабілетін дамытатын, спорттық ойынға ұқсас ойынды құрастыру талабынан шыққан болатын.

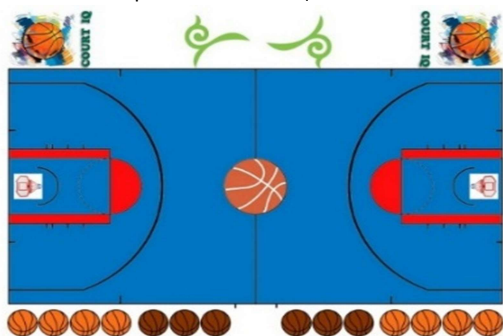
Жобаны жүргізу аптасына 3 рет кездесу арқылы жоспарланды. Алдымен, оқушылармен мәселені айқындап жұмыс жоспарын құрастырудан бастадық. Мәселе айқындалған соң, әдістер мен тәсілдерді бейімдеу және практикалық қолдануға көше бастадық. Жобадағы ойын түрін немесе қандай ойын болу керек екенін анықтай бастадық. Тақтайшадағы баскетбол ойыны атауы «COURT IQ» айтып тұрғандай тақтайшада ойналады.

Зерттеу барысы. Барлық жастағы оқушыларды сыни тұрғыдан ойлауды, сапалы шешім қабылдауға үйрету. Зерттеу әдісі арқылы оқушылардың іздену, ойлау-танымдық дағдыларын қалыптастыру. Жобаны ұйымдастырып жүргізу алдын-ала жоспарлау, оны сұхбаттасып талқылау және қайта жоспарлау, нәтижеге жету, нәтижені талдау арқылы жүзеге асты. Жобаны жүргізу барысында оқыту ресурстарын пайдалану, салыстыру және талдау әдістерін пайдаландық. Білім алушыларды өткен білімі мен тәжірибесін өзекті ету. Осы қабылдаған жаңа ойынымызды ары қарай жаңғырту үшін, біз ойын атауын ойластырдық. Басында ойға

қонымды командамен “Тез ойлан, жылдам жүр” деп қоюға ұсыныс берілген болатын. Тақырыбымыз ұнағанмен жаңа ойын жүйесін енгізуде ағылшын тілімен ұштастырып қоюды жөн көрдік.

Жобалық жұмысты өткізу кезеңдері біз үшін маңызды болды. Бірлесе жобаны жоспарлау, пікірталас, тәжірибе алмасу, ойын ережесін практикалық түрде бекіту және жобаға қатысушылардың ұсыныстарын анықтап, оны жүзеге асыра білдік деп ойлаймыз. Бастысы ойын ережесі мен практика түрінде ойнау оқушыларға түсінікті және жеңіл болады деп ойлаймыз.

Ойын ережесіне тоқталып кетейік.



1) Ойынды 2 адам ойнайды, әр адамға 8 ойыншы беріледі, 5 негізгі мен 3 қосалқы ойыншы.

2) Кім бірінші жүретінін ойыншылар алаң шетіне (лақтыру сүйегін, тас, кубик т.б) лақтырып шешеді. Кімге көбірек сан түссе, сол бірінші жүреді.

3) Баскетбол алаңында екі адам кезектесіп бір-бір ойыншыдан қояды. Ойыншылардың орналасуы баскетбол ережесіне сәйкес болуы керек. Мысалы, 1.1, 1.3 суреттердегі ойыншылардың орналасуы

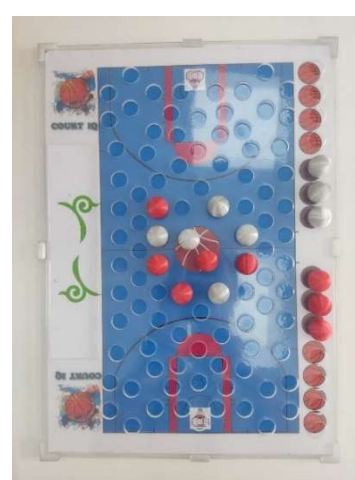
баскетбол ережесін бұзбайды. Ал, 1.2 суреттегі ойыншылардың орналасуы баскетбол ережесін бұзады.



1.1 сурет



1.2 сурет



1.3 сурет

4) Шеңбер ішінде тұрған ойыншылар бірінші жүреді.

5) Ойыншылар кез-келген бағытта үш жолаққа жүреді, бірақ үш ұпайлық аймақтың ішінде шабуыл жасаушылар тек бір жолаққа жүреді, ал қорғаныстағы жақ үш ұпайлық аймақтың (зонаның) ішінде кез-келген бағытта үш жолаққа жүре береді.

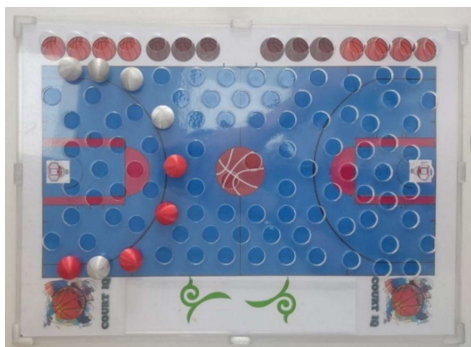
6) Тек үш жолақ арақашықтығындағы ойыншыларды жеуге болады және ойыншылар бір-бірін тек үш ұпайлық аймақтың (зонаның) ішінде жей алады.

7) Қарсылас ойыншыны жеп алуға мүмкіндік болса, қарсылас ойыншыны жеу міндет емес, өзінің жүріс ыңғайына қарай шешім қабылдайды.

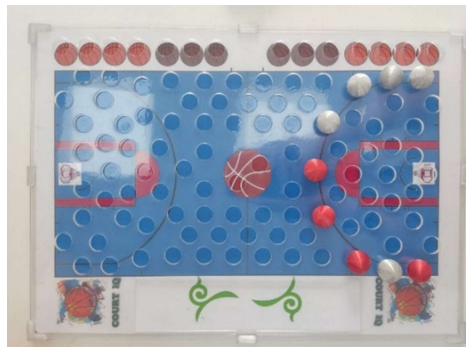
8) Ойын 3 кезеңнен тұрады. Егер үш кезеңнен жеңімпаз анықталмаса, қосымша кезеңдер ойнатылады. Бірінші ойыншы алғашқы ұпай алысымен ойын тоқтатылып, ұпай алған ойыншы жеңіске жетеді.

9) Ойын кезеңінің уақыты біткенде немесе бір командада үш ойыншы қалса ойынның бір кезеңі бітеді.

10) Ойын кезеңнің жеңімпазы ұпай бойынша анықталады. 11) Ойын барысында бір ойнайтын адамда 5 ойыншыдан аз болып қалса, ол қосалқы ойыншыларды өз жағындағы үш ұпайдық аймақтағы (зонадағы) 9 жолақтың бос болған біреуіне шығару керек. Мысалы 2.1, 2.2 суреттердегі ойыншылар тұрған жолақтарға қосалқы ойыншыларды шығаруға болады.



2.1 сурет



2.2 сурет

- 12) Қосалқы ойыншының шығуы жүріске саналмайды.
- 13) Қосалқы ойыншы бір жүрістен кейін ғана жүре алады.
- 14) Ойыншылардың біреуі үш ұпайлық аймаққа (зонаға) жетсе, жүріс кезегі сол ойыншыда болса онда, ол алаң шетіне ойын сүйегін лақтырады.
- 15) Ойын сүйегінен түскен сан ойыншының қанша жүріс алдыға жүретінін көрсетеді.
- 16) Егер ол жүріс саны баскетбол торына, қажет жүріс санынан асып кетсе, онда доп алаңнан ұшып торға дәл түспеген болып саналады. Онда қасындағы бос тор көздерге орналасады. Қарсылас ол тасты, әрни ойыншыны жеп қоймаса, жүрісі кезінде ұпай торына салуға тырысады.
- 17) Егер баскетбол торына, 3 аймақтық алаңында орналасқан, алаңнан ұшқан доп дәл салынған болса, онда ол қалауы бойынша өз жағындағы, қосалқы ойыншылар шығарылатын 9 жолақтың бос біреуіне қойылады.
- 18) Егер ойын сүйегінен түскен саны баскетбол торына жетпесе, онда ойыншы ойын сүйегінен түскен жүріс санына алдыға қарай жылжиды.
- 19) Өз жағында 3 ұпайлық аймақта қорғаушы, қарсылас шабуылдаушыны артқа қарай жей алмайды.

Ұпай жүйесінің анықтамасы.

- 1) Ойыншы қарсылылас ойыншысын жесе, оған 1 ұпай беріледі.
- 2) Үш ұпайлық аймақтан (зонадан) доп салынса, 3 ұпай беріледі.
- 3) Үш ұпайлық зонаның ішінен доп салынса, 2 ұпай беріледі.

Ойын 3 кезеңнен тұрады. Әр кезеңге 3 минуттан беріледі. Арнайы құрылғы сағат арқылы уақыт мөлшері мен ұпай сандары және ойын кезеңдері көрсетіліп тұрады.

Жобадан күтетін нәтижемізге жеттік. Алдымызда осы жобалық жұмысымызды мектепшілік «Жобалар апталығы» фестивалінде қорғап, 1 орынға ие болдық. Ойынды НЗМ мектеп желісі ішінде және аудан, қала мектептеріне насихаттау жоспарымызда бар.

Current Issues in Educational Data Analysis Through Artificial Intelligence

K. Nigmatov

L.N. Gumilyov Eurasian National University, Astana, Kazakhstan, Doctoral student

Abstract: the integration of artificial intelligence (AI) to advance educational processes is the focus of this article's review of the present and future of educational data analysis. This article clarifies how these approaches might maximize learning results by examining methodologies and technology including recommendation systems, forecasting strategies, data analysis models, and visualization tools. The essay discusses techniques like text analysis, neural networks, clustering, and classification and explains how they might increase the effectiveness of instructional procedures. The advantages of using educational data to forecast student progress and modify teaching strategies are discussed. A thorough analysis of current resources and tools is provided, emphasizing their benefits, drawbacks, and the difficulties faced by institutions and researchers. The study examines prospective advancements in educational data analysis and future research areas, emphasizing the value of utilizing contemporary technology, especially AI. The article concludes that thoughtful application of AI-driven data analysis can greatly boost teaching methodologies.

Keywords: data analysis, educational data mining, learning analytics, artificial intelligence, clustering, classification, neural networks.

Introduction

Education is one of the industries that have seen significant change with the introduction of AI. President Kassym-Jomart Tokayev of the Republic of Kazakhstan highlighted the importance of AI in contemporary society and outlined goals for its advancement in his speech at the international event Digital Bridge 2023. He emphasized the need for a revision of digital literacy courses in higher education, emphasizing that future experts must have a solid understanding of artificial intelligence and related subjects [1]. In order to match education with the changing needs of the digital age, educational programs must place a greater emphasis on artificial intelligence.

Large databases of educational data have been created as a result of the extensive use of the internet, growth of electronic materials, and a variety of instructional instruments. Learning management systems (LMS), which include vast amounts of useful data, are being adopted more and more. New techniques for automated educational data analysis are required since the expansion of such data poses obstacles for manual analysis. This information is essential for a thorough study of the learning process. There is a pressing need to turn this data into ideas that may help students, teachers, and administrators as institutions struggle with organizing and analyzing large amounts of data [2].

Data analysis becomes a crucial instrument for well-informed decision-making in educational institutions. With AI playing a major part, trends in the collection, analysis, and use of educational data are becoming noticeable. By facilitating more individualized and effective learning experiences, AI-driven educational data analysis can transform educational processes. However, because of difficulties with data processing, analysis, and AI integration, many institutions have not yet fully utilized the potential of educational data.

This paper seeks to examine the present situation and potential future directions of educational data analysis. The research looks at technologies and methodologies used in this sector, such as forecasting methods, data analysis models, visualization tools, and

recommendation systems, to show how these approaches might improve instructional procedures. The study also examines current tools and resources, talks about the advantages of using educational data to forecast student achievement and modify teaching strategies, and explores the difficulties faced by researchers and institutions. The paper concludes by outlining the significance of incorporating contemporary technologies – particularly AI – into the analysis of educational data and potential avenues for further research.

Methodology

This study used a mixed-methods research design, integrating quantitative and qualitative approaches, to examine educational data analysis and AI incorporation. By combining the contextual richness of qualitative data with the statistical breadth of quantitative research, the mixed-methods approach enhances the validity and depth of findings [3].

The quantitative component involved a bibliometric analysis of peer-reviewed papers published between 2019 and 2024 in global databases such as Web of Science, Scopus, and Google Scholar. These databases were selected for their accessibility, rigorous standards, and extensive indexing [4, 5]. The keywords "Educational Data Mining" and "Learning Analytics" guided the search to assess annual academic output and research trends. Microsoft Excel was used to process and analyze the extracted data [6].

The qualitative component included a detailed review of peer-reviewed articles, conference proceedings, and publications from leading institutions in learning analytics and educational data analysis. The National Academic Library of the Republic of Kazakhstan (<http://nabr.kz/>) was also consulted to examine domestic dissertations on data analysis and AI in education [7]. This component aimed to incorporate global perspectives and investigate current approaches, resources, and challenges in the field.

Additionally, the study conducted a global review of current techniques and tools used in educational data analysis, examining case studies, software, and online resources. By combining quantitative bibliometric data with qualitative content analysis, the research provides a comprehensive overview of trends, methods, and future directions in educational data analysis, highlighting AI's role in enhancing educational processes.

Literature Review

Learning Analytics (LA) and Educational Data Mining (EDM) are closely linked fields that have emerged due to the rapid growth of educational data. Both aim to improve learning outcomes by deriving insights from educational data, but they differ in approach and focus.

EDM provides techniques to analyze data from educational settings using statistical methods, machine learning algorithms, and data mining approaches [8–9]. It addresses technical challenges of evaluating complex, large-scale data and develops tools to uncover hidden patterns.

LA, in contrast, involves measuring, collecting, analyzing, and reporting student data to understand and improve learning [10]. It emphasizes data-driven decision-making and is learner-centered, aiming to directly benefit students [11].

Despite differences, EDM and LA complement each other in enhancing instructional strategies [12–13]. EDM focuses on methodology and technical innovation, while LA prioritizes practical application and real-time educational management. Subfields such as computer education, machine learning in education, and educational statistics reflect this convergence [12].

The widespread use of Learning Management Systems (LMS) and online platforms like MOOCs has accelerated educational data analysis [14]. Landmark events, such as the first International Conference on Educational Data Mining (2008) and the Conference on Learning Analytics and Knowledge (2011), formalized these areas [12]. Public repositories like DataShop and

journals like JEDM and JLA facilitate collaboration and progress by sharing datasets and findings [15].

Recent studies highlight EDM and LA's potential to transform education. Predictive analytics can identify at-risk students and guide interventions, while AI and machine learning further enhance the prediction of educational phenomena and personalization of learning experiences [16].

Challenges remain, including data privacy, ethical concerns, and the need for educators to have skills to interpret and act on data insights [17]. More accessible technologies are required to enable effective data analysis without highly specialized personnel [18].

In conclusion, the integration of AI and advanced analytics into education offers transformative potential. The convergence of EDM and LA provides new approaches and resources for understanding and improving learning, forming the basis for examining current methods, challenges, and future directions in educational data analysis.

Results and Discussion

The notable increase in scholarly publications in recent years is proof of the growing interest and quick development in the domains of learning analytics and educational data mining. Figure 1 shows that the number of papers indexed in Google Scholar pertaining to "Educational Data Mining" and "Learning Analytics" increased significantly between 2019 and 2024. This pattern is consistent with Romero and Ventura's [12] findings, which showed an exponential increase in publications between 2000 and 2018, suggesting ongoing and growing research interest in these fields.

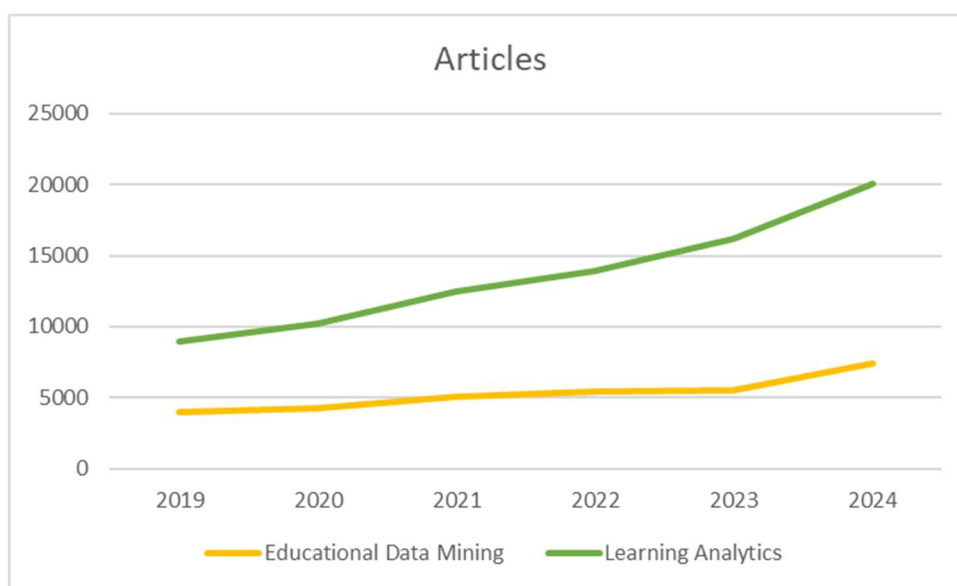


Figure 1. Number of Articles Related to the Terms "Educational Data Mining" and "Learning Analytics" in Google Scholar by year

The abundance of research highlights the continuous progress and increased interest in using educational data to improve teaching strategies and learning results. This rise has been largely driven by the incorporation of AI and machine learning techniques into educational data analysis, which has allowed for more complex analyses and applications.

Numerous materials and tools have been created to aid with EDM and LA research and practice. Despite their widespread usage, general-purpose data mining tools like RapidMiner, WEKA, and SPSS can be difficult for educators to use due to their complexity and requirement for technical know-how [19]. Specialized software solutions have been created to help with data

analysis and enhance instructional procedures in order to solve these issues. Examples of these tools are shown in Table 1, each with special features and capabilities to help researchers, instructors, and students analyze data and improve the efficacy of learning.

Table 1

Examples of Tools in the Field of Educational Data Analysis and Learning Analytics	
Tool Name	Description
DataShop	Data repository with secure storage and analysis tools.
GISMO	Visualizes student activity in online courses.
Inspire	Descriptive and predictive analytics for Moodle.
Canvas Analytics	Provides data on student behavior and learning outcomes.
Blackboard Predict	Predicts student success and provides recommendations.
Jisc Learning Analytics	Identifies trends and supports data-driven decisions.
Kaggle	Repository of public educational datasets for research and practice.

Although these technologies are readily available, they are limited in their application to specific educational activities and often require specialized data. Many researchers rely on their own datasets, but collecting and preparing educational data is time-consuming. Publicly accessible datasets, such as ASSISTments, Canvas Network, DataShop, HarvardX-MITx, and Student Performance Dataset, help address this challenge.

Data collection is the first step in educational data mining and learning analytics, followed by preprocessing, transformation, and ensuring data confidentiality. Various strategies are applied, including forecasting, recommendation systems, data analysis models, and visualization. Techniques such as clustering, classification, neural networks, causal inference, and text mining enhance educational process effectiveness. Clustering identifies patterns in student data, classification predicts performance, and neural networks allow more precise forecasts and personalized learning paths.

These techniques significantly improve educational procedures. AI and machine learning automate analysis, reveal hidden patterns, and support individualized learning, leading to better outcomes. Studies show that machine learning can reliably predict student achievement, informing decisions about instruction and support. Evaluating qualitative data, such as assignments or comments, provides deeper insights, especially using natural language processing.

Integrating student data into educational administration systems advances digitalization in higher education and requires modern AI and data analysis methods. Despite progress, challenges remain, including data protection, ethical issues, cultural adaptation, and the need for technical expertise. Addressing these obstacles is crucial to fully benefit from AI-driven educational data analysis and enhance learning outcomes.

Conclusion

This study highlights the critical role of artificial intelligence in enhancing educational processes through educational data analysis. The combination of educational data mining and learning analytics aims to improve learning outcomes by systematically analyzing educational data.

Despite rapid growth in these fields, many institutions have yet to fully benefit from large-scale data analysis due to challenges such as adopting new techniques, ensuring data security and privacy, and addressing ethical concerns. Educators and administrators also need the skills to interpret data and implement data-driven strategies.

AI and machine learning offer unprecedented potential by automating complex analysis, revealing hidden trends, and providing predictive insights that guide personalized teaching and learning. This can optimize programs, improve educational quality, and better align outcomes with labor market needs.

To enable broader adoption, user-friendly tools and accessible technologies must be developed, allowing more institutions to leverage AI-driven analytics. Future research should focus on integrating advanced data analysis into practice, strengthening data privacy frameworks, exploring ethical implications, and training the next generation of experts.

In summary, while educational data analysis has advanced, further work is needed to integrate AI and data-driven approaches fully. By addressing current challenges and promoting accessible tools and training, institutions can enhance decision-making and ultimately improve learning outcomes and education quality.

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Technologies for Enhancing the Process of Mastering Foreign Language Communication in the Basic Stage of Secondary School

Aruzhan Tynyshtyk Ertaikyzy

4th year Student of Two Foreign Languages, Kazakh Ablai Khan University of International Relations and World Languages

ANNOTATION

Бұл мақала негізгі мектептің базалық сатысында шетел тілінде коммуникацияны меңгеру үдерісін жетілдіруге бағытталған заманауи технологиялардың тиімділігін талдауға арналған. Автор шетел тілін оқытуда цифрлық білім беру ресурстары, интербелсенді әдістер, коммуникативтік ойындар, онлайн-платформалар мен мультимедиялық құралдарды қолданудың артықшылықтарын көрсетеді. Мақалада оқушылардың тілдік құзыреттілігін дамытуға ықпал ететін технологиялардың құрылымы, олардың мотивацияны арттырудағы, байланысты еркін орнатудағы және коммуникативтік дағдыларды жүйелі қалыптастырудағы рөлі жан-жақты қарастырылады. Практикалық мысалдар арқылы технологиялардың оқу үдерісінде қолданылу тиімділігі дәлелденеді. Зерттеу нәтижелері негізгі мектеп оқушыларының шетел тілі сабақтарына қызығушылығын арттыру мен олардың сөйлеу, тыңдау, жазу, оқылым дағдыларын кешенді дамытуда инновациялық технологиялардың зор әлеуетін айқындайды.

Түйін сөздер: шетел тіліндегі коммуникация, заманауи технологиялар, интерактивті оқыту, мобильді тіл үйрену.

Статья посвящена анализу современных технологий, направленных на повышение эффективности процесса овладения иностранной коммуникативной компетенцией на базовом уровне среднего образования. Автор рассматривает преимущества использования цифровых образовательных ресурсов, интерактивных методов, коммуникативных игр, онлайн-платформ и мультимедийных инструментов в обучении иностранному языку. Особое внимание уделяется тому, как данные технологии повышают мотивацию учащихся, способствуют формированию устойчивых речевых навыков и создают условия для свободного и осмысленного общения. Практические примеры демонстрируют результативность внедрения технологий в уроки иностранного языка. Результаты исследования подчеркивают значимость инновационных инструментов для повышения интереса обучающихся и комплексного развития навыков говорения, аудирования, письма и чтения на базовом этапе изучения иностранного языка.

Ключевые слова: иноязычное общение, современные технологии, интерактивное обучение, мобильное обучение языку.

This article explores the effectiveness of modern technologies aimed at enhancing the process of mastering foreign language communication at the Basic Stage of secondary school. The author highlights the advantages of using digital educational resources, interactive teaching methods, communicative games, online platforms, and multimedia tools in foreign language instruction. Special emphasis is placed on how these technologies increase students' motivation,

foster meaningful communication, and support the systematic development of communicative competence. Practical examples demonstrate the successful integration of various technologies into language learning. The findings indicate that innovative tools significantly improve learners' interest and contribute to the comprehensive development of speaking, listening, writing, and reading skills at the basic level of foreign language acquisition.

Key words: foreign language communication, modern technologies, interactive learning, mobile-assisted language learning.

INTRODUCTION

In the context of rapid globalization and continuous technological advancement, the ability to communicate effectively in a foreign language has become an essential competence for learners in the 21st century. At the Basic Stage of secondary school, students begin forming the fundamental linguistic and communicative skills that will shape their future proficiency in a foreign language. This developmental period is particularly sensitive, as learners' motivation, curiosity, and confidence in using the target language are actively emerging. Therefore, integrating modern educational technologies into the teaching and learning process is crucial for improving the quality of instruction and ensuring that students are equipped with the necessary communicative competencies.

Recent innovations in digital and interactive technologies have significantly transformed language education, offering new opportunities for enhancing the learning experience. Tools such as interactive whiteboards, digital textbooks, multimedia platforms, virtual learning environments, mobile applications, and augmented or virtual reality systems enrich the content of foreign language lessons and help create an immersive learning environment. These technologies allow learners to engage with authentic linguistic materials, participate in virtual communication, and practice real-life language use in a dynamic and motivating context. Furthermore, multimedia resources such as videos, podcasts, animations, and online dialogues support auditory and visual learning styles, making the acquisition of vocabulary, grammar, and pronunciation more accessible and engaging.

One of the key challenges in foreign language education, especially at schools where natural language exposure is limited, is the lack of authentic communication opportunities. Technological tools help bridge this gap by enabling students to interact with native speakers or peers from other countries through video conferencing, collaborative online projects, social learning networks, and international virtual exchanges. These tools help learners develop not only linguistic competence but also intercultural communication skills, which are increasingly important in our interconnected world.

Modern technologies also support individualized and differentiated learning. Digital learning platforms provide adaptive tasks based on each student's level, offer instant feedback, and track progress over time. This allows teachers to better understand learners' needs and tailor instruction accordingly. At the same time, technology-enhanced communicative tasks, such as role-playing games, interactive quizzes, real-time messaging, and problem-solving activities, foster active participation and encourage students to use the target language meaningfully.

The role of the teacher is also evolving in this new educational environment. Instead of being the sole source of knowledge, teachers act as facilitators, organizers, and guides who help students navigate technological resources effectively. For this reason, the development of teachers' digital competence and methodological readiness to integrate technology into lessons is a critical factor in improving language education outcomes.

This article examines the potential of modern technologies in enhancing foreign language communication at the Basic Stage of secondary school. It analyzes key digital tools, their pedagogical advantages, and their impact on learners' communicative competence and

motivation. The article also presents methodological recommendations and practical strategies that teachers can apply to create technology-rich, communicative, and engaging language learning environments.

Purpose, Novelty, Pedagogical Concept, and Practical Methods with Examples (English)

Purpose of the Study

The main purpose of this article is to analyze and justify the effectiveness of modern technologies in improving the process of mastering foreign language communication at the Basic Stage of secondary school. The study aims to identify technological tools that enhance students' communicative competence, increase motivation, support learner autonomy, and create real or simulated environments for meaningful language interaction. It also seeks to provide practical recommendations for integrating these technologies into everyday classroom practice to ensure the holistic development of listening, speaking, reading, and writing skills.

Novelty of the Work

The novelty of the study lies in its comprehensive approach to combining interactive, digital, mobile, and multimedia technologies within a communication-centered pedagogical framework. Unlike traditional methods that primarily emphasize grammar and vocabulary, this work highlights the role of technologies in creating authentic communicative situations, enabling international collaboration, and supporting differentiated instruction based on students' individual needs. Additionally, the article presents specific digital tools and step-by-step instructional examples that can be directly applied by teachers in real lessons, making the study both innovative and practical.

Pedagogical Idea and Conceptual Approach

The pedagogical concept underlying this article is based on the principles of **communicative language teaching (CLT)** supported by **technological mediation**. The core ideas include:

- learning occurs through meaningful interaction, not rote memorization;
- technology acts as a bridge connecting students to authentic language use;
- the teacher shifts from being a "knowledge transmitter" to a **facilitator** and

designer of learning environments;

- students develop linguistic, cultural, and digital competences simultaneously;
- multimedia and interactive platforms enhance sensory learning channels and improve language retention.

This approach positions technology not as an add-on tool but as an integral part of developing communicative competence.

Practical Methods Used in Lessons

In classroom practice, several technology-enhanced methods are applied to support foreign language communication:

a) Interactive Vocabulary and Grammar Tasks

Platforms such as **Quizlet**, **LearningApps**, and **Wordwall** are used to reinforce vocabulary and grammar through matching tasks, flashcards, and games. These activities promote active recall and immediate feedback.

b) Communicative Speaking Activities

Speech-recording apps (e.g., **Flip**, **Vocaroo**) help students practice speaking, listen to themselves, and share recordings with peers for feedback. This method increases confidence and develops proper pronunciation.

c) Virtual Exchange and Real-Time Communication

Using **Zoom**, **Google Meet**, or **eTwinning**, students participate in video conversations or joint projects with learners from other countries. This method develops intercultural communication and real-life language use.

d) Multimedia-Based Listening and Discussion

Short videos from **BBC Learning English**, **TED-Ed**, or **YouTube Kids** are used as authentic input sources. Students watch the video, complete comprehension quizzes, and engage in discussions afterwards.

e) Collaborative Digital Projects

Tools such as **Padlet**, **Jamboard**, and **Google Docs** allow students to work together to create posters, dialogues, or presentations. This fosters teamwork and negotiation of meaning.

Specific Examples with Step-by-Step Instructions

Example 1: “Describe the Scene” – AR Vocabulary Activity

Tool: AR Flashcards **Steps:**

1. Teacher provides students with AR objects (animals, rooms, food items).
2. Students scan the cards with a mobile device.
3. A 3D object appears on the screen.
4. Students describe the object using target vocabulary (“The tiger is big...”, “The chair is next to the table...”).
5. Students record a short video describing the scene.

Outcome: Improved vocabulary retention and confident speaking.

Example 2: “International Pen Pal Talk” – Video Exchange

Tool: Zoom or eTwinning **Steps:**

1. Teacher connects with a foreign partner school.
2. Students prepare simple questions (name, hobbies, school life).
3. Students join a short live video session.
4. Each student interviews a partner.
5. Students write a summary of what they learned.

Outcome: Authentic communication and cultural awareness.

Example 3: “Digital Storytelling” – Creating a Short Video

Tool: Flip or Canva Video **Steps:**

1. Students choose a topic (“My Day”, “My Favorite Place”).
2. They combine images, text, and their own voice.
3. Students share their stories with the class.
4. Peers give feedback using simple criteria.

Outcome: Development of speaking, writing, creativity, and digital literacy.

MAIN BODY

The integration of modern technologies into foreign language teaching at the Basic Stage of secondary school has reshaped traditional pedagogical approaches and opened new pathways for developing communicative competence. This section examines key technological tools, their pedagogical value, and the ways in which they enhance students’ ability to communicate in a foreign language.

Digital and Interactive Learning Platforms

Digital learning environments such as LearningApps, Quizlet, Duolingo, Kahoot, and other educational platforms offer extensive opportunities for vocabulary building, grammar practice, and

communication-oriented tasks. These platforms provide interactive exercises that allow learners to engage with content at their own pace, receive immediate feedback, and revisit challenging topics. The gamification elements—points, levels, badges, and leaderboards—motivate students and sustain their interest in foreign language learning. Importantly, students can practice all four language skills—listening, speaking, reading, and writing—through personalized pathways that adapt to their proficiency level.

Moreover, learning management systems (LMS) like Google Classroom and Moodle support teacher–student communication, assignment distribution, collaborative projects, and peer feedback. These systems create a structured digital environment where communicative tasks can be organized efficiently, helping students develop autonomy and responsibility in their learning.

Multimedia Tools for Enhancing Input and Output Skills

Multimedia resources, including videos, audio recordings, animations, and interactive stories, provide authentic linguistic input that supports natural language acquisition. Platforms such as YouTube, British Council Teens, and TED-Ed offer culturally rich and linguistically diverse content that exposes learners to real-life accents, phrases, and communication styles. Watching short educational videos or listening to podcasts enhances listening comprehension, expands vocabulary, and enables students to observe natural speech patterns.

At the same time, multimedia tools support output skills. Students can record their own videos, podcasts, or digital stories to practice speaking and pronunciation. Applications like Flip, VoiceThread, and Vocaroo allow students to create oral presentations, participate in online discussions, and exchange feedback with peers. These activities promote communicative fluency, confidence, and creativity.

Virtual Communication and Collaborative Technologies

One of the most powerful impacts of technology lies in its ability to simulate or create a real communicative environment. Video conferencing tools such as Zoom, Microsoft Teams, and Google Meet support synchronous communication with native speakers or partner schools abroad. Virtual exchange programs, eTwinning projects, and international collaborative activities give students a meaningful reason to use the foreign language, thereby increasing motivation and communicative readiness.

Online collaboration tools such as Padlet, Jamboard, and Google Docs allow students to work together on writing tasks, dialogues, posters, and presentations. These tools encourage peer interaction, negotiation of meaning, and collaborative problem solving—core components of communicative competence.

Mobile-Assisted Language Learning (MALL)

Mobile applications are particularly effective for younger learners who prefer flexible, interactive, and visually appealing tasks. Apps that support speech recognition help students practice pronunciation, receive instant corrective feedback, and track their improvement. Augmented reality (AR) applications introduce immersive experiences where students interact with 3D objects, characters, or scenes in the target language. For example, AR flashcards or AR storybooks make vocabulary learning more engaging and context-rich.

Formative Assessment and Adaptive Technologies

Technologies that support ongoing assessment help teachers monitor students' progress in real time. Digital quizzes, automated test generators, and speech analysis tools allow teachers to evaluate pronunciation, fluency, and grammatical accuracy objectively. Adaptive systems adjust the difficulty of tasks depending on learners' performance, ensuring optimal challenge levels that support consistent progress.

Pedagogical Implications and Teacher Readiness

Effective integration of technology requires pedagogical literacy and digital competence from teachers. They must select tools purposefully, align them with communicative objectives, and

maintain a balance between traditional interaction and digital enhancement. Technology should not replace communication but enrich and expand it.

CONCLUSION

The integration of modern technologies into the process of mastering foreign language communication at the Basic Stage of secondary school represents a significant pedagogical shift that aligns education with the demands of contemporary society. The findings presented in this article demonstrate that technologies not only enhance linguistic competence but also transform the nature of language learning by making it more interactive, engaging, and learner-centered. Through digital tools, students gain access to authentic linguistic input, real communication scenarios, and opportunities to practice language skills in meaningful and motivating ways.

One of the most important impacts of technology is its ability to create a simulated or authentic communicative environment where students can interact in real time. Video conferencing tools, virtual exchange platforms, and online collaborative spaces provide learners with opportunities to speak with peers from other countries, participate in group discussions, and develop intercultural communication skills. This exposure is crucial, especially in settings where natural language immersion is limited. Technology bridges this gap by bringing the global linguistic landscape directly into the classroom.

Moreover, multimedia resources such as videos, audio podcasts, animations, and interactive stories enrich the learning environment and appeal to diverse learning styles. Listening and speaking activities become more dynamic and realistic, enabling students to develop pronunciation, intonation, and fluency. The use of speech-recognition features in mobile applications supports independent practice, allowing learners to self-assess and adjust their pronunciation without fear of making mistakes in front of peers. This fosters both autonomy and confidence.

Digital platforms and mobile-assisted learning also support differentiated and personalized instruction. Adaptive learning systems adjust the difficulty level of tasks based on students' progress, ensuring optimal learning conditions for each individual. Meanwhile, gamified elements, such as points, badges, and leaderboards, increase motivation and help sustain student engagement. These features are particularly effective for younger learners who respond positively to visual, interactive, and game-like experiences.

Another key benefit of technology is its role in enhancing formative assessment. Digital quizzes, automated feedback mechanisms, and performance tracking tools allow teachers to monitor student progress in real time and make timely instructional adjustments. Teachers can easily identify areas where students struggle and provide targeted support. This data-driven approach contributes to more effective lesson planning and improved learning outcomes.

However, technological integration also requires a shift in the teacher's role. Teachers must act not only as subject experts but also as facilitators, mentors, and designers of technology-enhanced learning environments. The successful implementation of technology depends on the teacher's digital competence, methodological knowledge, and ability to select tools that align with pedagogical objectives. Professional development is therefore essential for empowering teachers to use technologies effectively and confidently.

Despite the numerous advantages, it is important to recognize that technology should not replace traditional teaching methods but rather complement them. The ultimate goal is to create a balanced, student-centered learning environment where technology is used purposefully to support communication, collaboration, and creativity. When integrated meaningfully, digital tools help students develop not only linguistic competence but also critical thinking, problem-solving, and digital literacy—skills that are indispensable in the modern world.

In conclusion, technologies play a transformative role in enhancing the process of mastering foreign language communication at the Basic Stage of secondary school. They enrich

instructional methods, personalize learning, expand access to authentic communication, and motivate students to actively participate in language learning. By thoughtfully integrating digital tools into communicative teaching practices, educators can significantly improve language learning outcomes and prepare students for global citizenship. The continued development of educational technologies and teacher digital competence will further strengthen the effectiveness of foreign language education, making it more relevant, engaging, and future-oriented.

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Inclusive Pedagogy: Strategies for Teaching Students with Learning Differences

Мырзабекова Эльдана

Қазақ халықаралық қатынастар және әлем тілдері университеті (ҚазХҚ және ӘТУ), Алматы қ., Қазақстан, Екі шетел тілі факультеті, 4-курс студенттері

Жүсіпбек Жібек

Қазақ халықаралық қатынастар және әлем тілдері университеті (ҚазХҚ және ӘТУ), Алматы қ., Қазақстан, Екі шетел тілі факультеті, 4-курс студенттері

Мырзаханова Динара

Магистр, аға оқытушы, Қазақ халықаралық қатынастар және әлем тілдері университеті (ҚазХҚ және ӘТУ), Алматы қ., Қазақстан; Шетел тілі білім беру әдістемесі кафедрасы

Аннотация

Бұл мақала заманауи сыныптарда оқуда қиындықтары бар оқушыларды оқытуда инклюзивті педагогиканың маңызды стратегия екенін қарастырады. Зерттеу барлық оқушылар үшін теңдік, қатысу және тиесілік сезімінің маңыздылығын атап өтеді, себебі дислексия, ЗЖГС (СДВГ), аутизм спектрі бұзылыстары және сезім мүшелерінің бұзылыстары сияқты жағдайлар оқуда елеулі қиындықтар тудыруы мүмкін. Инклюзивті білім берудің тарихи дамуына және қарапайым интеграциядан қағидатты инклюзияға көшуіне шолу жасалғаннан кейін, мақала негізгі педагогикалық идеялар мен мұғалімдердің көзқарастары мен сенімдерінің рөліне тоқталады. Бұдан әрі ол оқу айырмашылықтарының әлеуметтік және когнитивтік дамуда қалай көрінетінін талдап, ерте анықтау мен арнайы қолдаудың маңызын көрсетеді. Мақаланың негізгі бөлігінде саралап оқыту және Оқытудың әмбебап дизайны (UDL) басты оқыту әдістері ретінде ұсынылады. Бұл стратегиялар мазмұнды, процесті және нәтижені бейімдеу арқылы, сондай-ақ ұсынылу, қатысу және білдірудің көптеген тәсілдерін қолдану арқылы инклюзивті оқытуды қалай қолдауға болатынын көрсетеді. Қорытындыда теориялық және эмпирикалық деректерге сүйене отырып, инклюзивті педагогиканы жүйелі түрде енгізу барлық оқушыларға пайда әкелетінін, білім беру теңсіздіктерін азайтатынын және оқу қауымдастықтарында мағыналы қатысуды арттыратынын дәлелдейді.

Авторы: Мырзабекова Эльдана, Жүсіпбек Жибек

Казахский университет международных отношений и мировых языков имени Абылай хана (КазУМОиМЯ), г. Алматы, Казахстан

Факультет: Факультет двух иностранных языков, студенты 4 курса

Соавтор: Мырзаханова Динара - Магистр, старший преподаватель

Казахский университет международных отношений и мировых языков имени Абылай хана (КазУМОиМЯ), г. Алматы, Казахстан; Кафедра методики преподавания иностранных языков

Аннотация

Эта статья рассматривает инклюзивную педагогику как ключевую стратегию обучения учащихся с нарушениями обучения в современных классах. В исследовании подчеркивается важность равенства, участия и принадлежности для всех обучающихся, поскольку такие состояния, как дислексия, СДВГ, расстройства аутистического спектра и сенсорные нарушения, могут создавать серьезные трудности в обучении. После обзора исторического развития инклюзивного образования и перехода от простой интеграции к принципиальной

инклюзии статья рассматривает основные педагогические идеи, а также роль установок и убеждений учителей. Далее анализируется, как различия в обучении проявляются в социальном и когнитивном развитии, подчеркивая важность раннего выявления и специализированной поддержки. В основной части представлены два ключевых метода обучения - дифференцированное обучение и Универсальный дизайн обучения (UDL). Эти стратегии показывают, как можно способствовать инклюзивному обучению, используя различные способы представления, вовлечения и выражения, а также адаптируя содержание, процесс и результат. В заключение утверждается - на основании теоретических и эмпирических данных - что системная интеграция инклюзивной педагогики приносит пользу всем учащимся, снижает образовательное неравенство и способствует значимому участию в учебных сообществах.

Word list:

Inclusive pedagogy – Teaching approach that accommodates all learners' differences without discrimination.

Learning disabilities – Conditions that affect learning, such as dyslexia, dysgraphia, ADHD, or nonverbal learning disabilities.

Dyslexia – Difficulty with reading, decoding, and phonological processing.

Dysgraphia – Difficulty with writing, spelling, and organizing written expression.

ADHD – Challenges with attention, focus, and self-regulation.

Autism spectrum disorder (ASD) – Neurodevelopmental condition affecting social communication, behavior, and sensory processing.

Nonverbal learning disabilities – Difficulties with visual-spatial tasks, social cues, and problem-solving.

Differentiated instruction – Adapting teaching methods and content to meet individual learners' needs.

Universal Design for Learning (UDL) – Framework offering multiple ways to present content, engage students, and assess learning.

Collaborative learning / peer tutoring – Learning through interaction and cooperation with peers.

Assistive technology – Tools (e.g text-to-speech, visual aids) that support learning and independence.

Formative assessment – Continuous evaluation to monitor progress and guide teaching.

“The child is both a hope and a promise for mankind.”

– *Maria Montessori*

Inclusive pedagogy is an approach to teaching diverse learner groups that seeks to accommodate individual differences between learners without treating them differently to others. Teachers and other professionals in the classroom are encouraged to see student challenges as professional challenges for practice rather than as student issues. By working collaboratively, they can develop ways of responding to individual differences that promote a good experience of learning and good outcomes for everyone.

Inclusive education means all children in the same classrooms, in the same schools. It means genuine educational chances for historically marginalized groups, including minority language speakers and children with disabilities. Inclusive systems allow varied groups to develop alongside one another for everyone's benefit and recognize the distinctive contributions that students from all backgrounds bring to the classroom.

Commonly recognized specific learning disabilities include:

- **Reading disability** (dyslexia) is the most common learning disability, representing at least 80% of all learning disabilities, and results from deficits in phonologic processing. Skills necessary for appropriate phonologic processing involve reading decoding, phonics, producing sounds, and proper auditory capabilities. In the early years, reading decoding issues are frequently the first step in the progression, followed by dysfluent reading and reading comprehension issues. These children may eventually avoid reading altogether.
- **Dysgraphia** is characterized by distorted writing despite thorough instruction and motor ability. Children with dysgraphia produce inconsistent and illegible handwriting while rarely staying within the margins. These kids may also exhibit poor fine motor coordination, difficulties with language, syntax, spelling (encoding), or writing down their thoughts.
- **Nonverbal learning disability** (right hemisphere developmental learning disability), as the name suggests, comprises hindrances with nonverbal activities, such as problem-solving, visual-spatial tasks, reading body language, and recognizing social cues. Often, these disorders do not manifest until the third grade, as patients have difficulty with higher-order reading comprehension. There is substantial clinical overlap with autism spectrum disorder (eg, poor social communication and pragmatics)

These difficulties influence cognitive and social development, making early identification and targeted support essential.

The purpose of this article are to describe the fundamental ideas of inclusive pedagogy, examine the requirements of students with learning disabilities, and offer research-proven teaching techniques that support inclusive classrooms.

Because the article is conceptual rather than empirical, “study site” refers to general school settings - where inclusive education is implemented, including:

- Primary and secondary mainstream classrooms
- Schools implementing inclusive education policies (UNICEF, 2021)
- Contexts where students with dyslexia, ADHD, autism, sensory impairments, or nonverbal learning disabilities learn alongside their peers
- Worldwide Significance - because learning variations are ubiquitous, teachers everywhere deal with mixed-ability classrooms, and contemporary educational institutions strive for equal outcomes, inclusive pedagogy is applicable across cultural and national barriers.

In order to determine successful inclusive teaching techniques, this study employs a conceptual review and synthesis of previous research, referencing scholarly works, educational frameworks, and case studies. The steps in the methodology consist of:

1.Examining the theoretical underpinnings

- Florian's inclusive pedagogy theory
- Universal Design for Learning (CAST)

2. Examination of learning disparities

- Cognitive, behavioral, and social traits derived from educational and clinical studies.

3. Assessment of educational models

- Peer-supported and cooperative learning
- Technologies for assistance
- Formative evaluation techniques

4. Analyzing implementation difficulties

- Lack of resources, problems with class size, and teacher readiness

5. Examining case examples from around the world

- Finland's three-level assistance system
- Peer-mediated reading initiatives in the United States
- The UDL-based digital learning model in New Zealand

A number of important conclusions regarding the nature of learning differences and the efficacy of inclusive teaching techniques were drawn from the literature review. Learning disabilities include dyslexia, dysgraphia, ADHD, autism spectrum disorders, and nonverbal learning disabilities all have different but similar effects on students' academic performance, according to numerous studies. For instance, learners with dysgraphia have trouble with handwriting, spelling, and the structure of written expression, but children with dyslexia usually struggle with phonological processing, reading fluency, and decoding written words. Students with ADHD frequently struggle with maintaining focus, planning assignments, and controlling their behavior, which can result in uneven performance in the classroom. In the meantime, students on the autistic spectrum could need greater assistance with socialization, communication, and sensory control. Students with nonverbal learning difficulties can misinterpret nonverbal cues and visual-spatial information, which can have an impact on peer interactions and problem-solving.

Collaborative learning practices such as peer tutoring, flexible grouping, and planned group assignments were found to boost both academic performance and social integration. These methods assist children gain confidence in mixed-ability settings, foster peer connection, and improve communication skills. Additionally, research indicates that assistive technologies - from digital organizers and visual aids to text-to-speech tools - are crucial in promoting independence, particularly for children who struggle with literacy or attention. Lastly, research continuously highlights the significance of formative evaluation. Frequent, low-pressure evaluations enable educators to track students' progress, spot new challenges, and quickly modify their lesson plans.

The significance of teacher beliefs and competencies is the last significant discovery. According to research, inclusive pedagogy works best when educators maintain high standards for every student and accept student variety. Teachers who are confident in their ability to modify materials and who work well with families and specialists are more likely to implement inclusion. Numerous studies do, however, also highlight similar issues, such as poor access to resources, time limits, huge class sizes, and a lack of teacher preparation. These obstacles explain why inclusive education is still applied inconsistently in many settings despite its shown advantages.

The results demonstrate the efficacy of inclusive pedagogy when educators create classrooms that recognize and value the variety of their students. Flexible teaching strategies are necessary for learning differences like dyslexia, ADHD, and autism, and research shows that frameworks like Universal Design for Learning and individualized instruction help remove obstacles before they arise. Students with learning disabilities participate more confidently and perform better when lessons include numerous ways to obtain material and demonstrate understanding.

Additionally, cooperation is essential. While collaboration between educators, experts, and families guarantees constant supervision for students who require extra support, structured peer activities promote social integration. The review does, however, draw attention to persistent issues, such as the fact that many educators feel unprepared for inclusive practices and that the

efficacy of these tactics may be diminished by a lack of resources or big class sizes. This implies that inclusive pedagogy necessitates substantial school and educational system support in addition to teacher effort.

Overall, the conversation suggests that inclusive teaching enhances academic performance and fosters a supportive, fair classroom environment. Careful planning, teacher preparation, and a school climate that celebrates and encourages diversity are all essential to its success.

Inclusive pedagogy represents a transformative approach to teaching that embraces learner diversity as a resource rather than a challenge. By integrating differentiated instruction, Universal Design for Learning, collaborative learning, assistive technology, and continuous formative assessment, teachers can create classrooms where all students are able to participate meaningfully and succeed.

Teacher commitment is central to this process. When educators adopt inclusive attitudes, collaborate with specialists, and consistently refine their practice, they cultivate learning environments grounded in equity, participation, and belonging. Although challenges such as limited resources and insufficient training persist, strategic policy support and professional development can strengthen implementation.

Future research should explore culturally responsive approaches to inclusion, the long-term impact of digital learning tools on diverse learners, and effective models for school-wide collaboration. Ultimately, inclusive pedagogy not only supports students with learning differences, it enriches the entire learning community.

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The Importance of Implementing Audiovisual Games in Foreign Language Lessons in Basic School

Ibragimova Mukhabbat Idrisovna

4th Year Bachelor student, KazUIR&WL named after Abylai Khan, Almaty, Kazakhstan

Syzdykova Gaisha Nasyrovna

Candidate of Pedagogical Sciences, Professor, KazUIR&WL named after Abylai Khan, Almaty, Kazakhstan

Abstract: The integration of audiovisual games into foreign language teaching in basic school has become an increasingly significant pedagogical trend. This article examines the theoretical and practical value of audiovisual game-based learning for developing communicative competence, enhancing motivation, and improving linguistic and cognitive skills among learners. Drawing on the contemporary research in educational psychology, second language acquisition, and multimedia learning, the study explores how audiovisual games stimulate multiple channels of perception, reduce learner anxiety, and promote active engagement.

This article also highlights practical classroom applications and offers recommendations for educators seeking to integrate audiovisual games into their teaching practice.

Key words: audiovisual games, game-based learning, foreign language teaching, basic school, communicative competence, multimedia learning.

Introduction

In recent decades, the rapid development of digital technologies has transformed educational practices, particularly within Foreign Language Education. Learners in basic school (grades 5-9) demonstrate a strong preference for digital, interactive and visually rich learning environments, making traditional methods less effective in sustaining their interest and engagement. Audiovisual games, interactive learning tasks that integrate video, animation, sound, music, and dynamic feedback, offer a powerful tool for enhancing the effectiveness of language learning. Through the combination of visual and auditory stimuli, audiovisual games create a multisensory environment that supports deeper comprehension and more durable retention of language input. Moreover, game-based activities align with modern communicative and constructivist teaching approaches, which emphasize active participation, collaboration, and meaningful language use.

According to Mayer (2009), students learn more effectively when information is presented through both auditory and visual channels. Audiovisual games capitalize on this principle by reducing cognitive overload and supporting dual-coding, which facilitates better comprehension and memory (Paivio, 2006).

Game-Based Learning (GBL) theory holds that games motivate and structure learning by incorporating goals, challenges, interactivity, and feedback, as students experience “flow” through well-designed challenges and meaningful tasks. Therefore, digital games often yield higher motivation and achievement than traditional drills. According to Krashen, the lower the affective barriers, the more confident learners become in using the target language, and the more willing they are to take risks in communication. In a playful and supportive environment, learners are more

likely to experiment with new words and structures, which accelerates language acquisition and strengthens their overall communicative competence.

Multimodal input, simultaneously engaging visual and auditory channels, has been shown to significantly enhance second language acquisition by providing multiple cues for comprehension and retention. Studies indicate that learners who are exposed to audiovisual materials demonstrate improved listening comprehension, vocabulary learning and pronunciation (Liu & Chu, 2010; Webb & Rodgers, 2009). Authentic audiovisual materials expose learners to natural speech patterns, intonation, gestures, and cultural contexts, which are crucial for developing communicative competence.

Vygotskian sociocultural theory emphasizes the learning is a social process and that interaction and collaboration are central to cognitive development. Audiovisual games leverage this principle by creating activities that require learners to communicate, negotiate meaning, and work together toward shared goal. For instance, in a collaborative video-based game, students might need to discuss strategies to solve a problem, take turns describing visual elements, or role-play characters in a narrative. Thus, these games increase language output and create meaningful communication situations.

These findings suggest that audiovisual games are a powerful tool for fostering effective language learning in basic school. Next, we explore the specific pedagogical advantages of incorporating audiovisual games into foreign language lessons.

Pedagogical advantages of Audiovisual games

1. Motivation and engagement

One of the most significant advantages is their ability to enhance motivation and engagement. Motivation is a key predictor of success in language acquisition (Dörnyei, 2014), and audiovisual games create immersive, enjoyable environments where learners actively participate in meaningful language tasks. Unlike traditional drills, which often rely on repetition and memorization, games integrate dynamic visuals, sound effects, and interactive storylines that sustain attention and reduce monotony. For example, platforms such as *Kahoot!* or *Quizizz* incorporate points, timers, and animated feedback, transforming routine vocabulary or grammar exercises into competitive and enjoyable activities. Gamified audiovisual tasks can increase learners' voluntary participation and engagement, even among students who are typically less motivated.

2. Improved listening comprehension

Audiovisual games contribute substantially to the development of listening comprehension skills: through integrating auditory input with visual cues that aid interpretation. Games that feature animated dialogues, video scenes, or interactive listening tasks expose learners to authentic speech patterns, accents, and intonation in ways that traditional materials find difficult to replicate. Visual cues such as gestures, facial expressions, and situational context provide scaffolding that helps learners decode meaning even when vocabulary is unfamiliar. For instance, students may watch an animated scene in which characters order food in a café and subsequently complete comprehension tasks, such as identifying what each character requested. Repeated exposure to such multimodal input enhances phonological awareness, helps differentiate similar sounds, and improves overall listening proficiency (Liu & Chu, 2010).

3. Vocabulary acquisition and retention

Audiovisual games also facilitate vocabulary acquisition and retention by presenting words in rich, contextualized formats. These games establish strong associative links which support long-term memory through images, actions, and audio narration. Learners tend to acquire words more

quickly and retain them longer when they appear in visualized, meaningful contexts rather than in isolated lists (Nation, 2013). Classroom applications may include virtual scavenger hunts where students navigate digital environments to find objects, hear their names pronounced in the target language, and match them with visual cues. Similarly, categorization games that group words by meaning help establish semantic networks, promoting deeper understanding and active recall.

4. Development of grammar

Grammar learning, often considered challenging by young learners, can also be enhanced through audiovisual games. By embedding grammatical structures in narrative contexts, games allow students to internalize rules implicitly. For example, learners might watch a short animated story and select the correct verb forms to complete sentences describing the events. Visual sequences and animations help clarify temporal relationships, cause-and-effect, and sentence structures, supporting both comprehension and production. Such contextualized grammar practice makes abstract rules more tangible and memorable.

5. Development of speaking skills

Audiovisual games provide authentic and motivating opportunities for oral production, helping learners build confidence and fluency and encouraging students to speak spontaneously and creatively. These tasks reduce speaking anxiety by offering a supportive, low-risk environment in which learners can experiment with pronunciation, intonation, and expressive language. For example, a role-play game simulating a restaurant ordering scenario requires learners to use functional language requesting items, asking questions, clarifying information which strengthens communicative competence. This interaction reflects real-world communication and encourages active language use.

6. Cognitive development and higher-order thinking

In addition to linguistic benefits, audiovisual games stimulate various cognitive processes essential for academic development. They engage attention, memory, critical thinking, and problem-solving as students analyze visual narratives, interpret clues, or predict outcomes. Higher-order thinking emerges when learners evaluate choices, formulate strategies, or create their own multimedia content. For instance, a mystery-solving game may require students to examine audiovisual evidence, generate hypotheses, and collaborate to determine solutions, promoting both cognitive flexibility and language use. Additionally, game-based learning supports the development of metacognitive skills, as students monitor their own progress, adjust strategies, and reflect on learning outcomes (Gunel & Top, 2022).

7. Social interaction and collaboration

Audiovisual games inherently facilitate social interaction and collaboration, especially when designed for pair or group work. Through cooperative gameplay, students negotiate, share information, and support one another in completing tasks. Collaborative learning environments increase linguistic output and provide authentic communication opportunities aligned with communicative language teaching. For example, in a team adventure game, learners are required to work in groups to discuss clues presented through animations or audio dialogues, make group decisions, and articulate reasoning all of which foster linguistic development and social cohesion. These types of interactions reinforce the development of essential interpersonal skills, including teamwork, leadership, and peer support, while reinforcing language learning in meaningful contexts.

The integration of audiovisual games overall enhances the use of language learning, as well as more effective and comprehensive development of language and sociocultural competences.

The varied advantages highlight the need for integration game-based audiovisual tools within day-to-day classroom practice and provides a foundation for discussion on their practical application in a classroom.

Classroom application

The integration of audiovisual games into foreign language lessons allows teachers to enhance different stages of instruction while maintaining a balance between engagement and pedagogical value. Audiovisual games can be effectively incorporated into warm-up activities, presentation of new content, practice tasks, production activities, and assessment. (see Table 1.) Their multimodal nature supports diverse learning styles and promotes active participation throughout the lesson.

Table 1. – Application of audiovisual games in foreign language lessons

Lesson stage	Purpose	Examples
Lead-in	- Activate prior knowledge; - Introduce the topic	Video quizzes; animated puzzles; audio guessing games
Presentation	- Introduce new vocabulary or grammar	Animated stories; interactive video explanations; game scenes illustrating target structures
Practice	- Reinforce and consolidate new material	Matching audio to images; video gap-fill; choosing correct responses; describing scenes; following audiovisual instructions
Production	- Encourage creative language use; - Develop speaking skills	Creating short video stories; recording dialogues; acting out scenarios from games
Assessment	- Measure listening, vocabulary and speaking skills	Video-based comprehension questions; image-sound matching tests; recorded role-plays

To ensure effective implementation, teachers must select age-appropriate audiovisual games, evaluate linguistic difficulty, and align all activities with instructional objectives. Maintaining a balance between entertainment and educational value is essential for maximizing learning outcomes.

Conclusion

The study explored the role and pedagogical value of audiovisual games in foreign language lessons in basic school, highlighting their potential to enhance both linguistic and cognitive development. The integration of audiovisual games into foreign language lessons in basic school offers a powerful and multifaceted approach to enhancing language learning. These games create engaging and meaningful learning environments that support motivation, comprehension, and active language use, combining visual, auditory and interactive elements. The research demonstrates that multimodal input improves listening skill, strengthens vocabulary acquisition, and facilitates implicit grammar learning. Audiovisual games promote creativity, oral communication, and collaborative problem-solving, contributing to the development of communicative competence and cognitive skills.

The classroom applications examined in this study show that audiovisual games can be effectively incorporated into all stages of instruction from warm-up activities and presentation of new material to practice, production, and assessment. It makes them a valuable component of modern communicative and learner-centered pedagogy. Accordingly, their thoughtful application contributes to the richness of lessons and helps ensure that foreign language pedagogy aligns with modern demands and the learning preferences of contemporary students. Ongoing exploration and classroom-based research will further improve strategies for integrating audiovisual game-based learning effectively and sustainably.

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Developing Sociocultural Competence in Foreign Language Learning

Kovtun Anastassiya Sergeevna

4th Year Bachelor student, “6B01701-Teacher of two foreign languages”, KazUIR&WL Ablai Khan, Almaty, Kazakhstan

Zhumabekova Galiya Baiskanovna

Candidate of Pedagogical Sciences, Professor, KazUIR&WL Ablai Khan, Almaty, Kazakhstan

ABSTRACT

In an increasingly globalized world, foreign language education must extend beyond grammar and vocabulary to include sociocultural competence – the ability to navigate cultural norms, values, and contexts in communication. This article synthesizes key theoretical contributions on sociocultural and intercultural competence. Foundational constructs include Vygotsky’s sociocultural theory (emphasizing social interaction and language as mediating tools), Byram’s model of Intercultural Communicative Competence (defining *savoirs* of knowledge, attitudes, skills, and critical awareness), Kramsch’s concept of symbolic competence (attunement to cultural meaning in discourse), and Fantini’s definition of intercultural competence as a “complex of abilities” for effective interaction across cultures. Kazakh scholar Kunanbayeva’s linguocultural-communicative framework further delineates sub-competencies (including the development of a ‘secondary cognitive consciousness’ representing the target culture’s worldview). These perspectives converge to show that language learning must integrate cognitive, affective, and cultural dimensions. Developing sociocultural competence is thus crucial for successful intercultural communication, fostering global citizenship, and promoting inclusive education and mutual understanding in diverse societies. This theoretical review draws on peer-reviewed literature to articulate how sociocultural competence can be cultivated in foreign language learning, and discusses implications for pedagogy and policy.

Keywords: sociocultural competence; foreign language learning; intercultural communicative competence; foreign language education; intercultural communication; global citizenship; inclusive education.

INTRODUCTION

Effective foreign language education today transcends linguistic proficiency alone and emphasizes sociocultural competence – the capability to understand and negotiate cultural contexts in communication. This aligns with the broader notion of intercultural communicative competence, which scholars describe as equipping learners to bridge cultural differences in understanding and expression. For example, Fantini characterizes intercultural communicative competence as the “complex of abilities needed to perform effectively and appropriately when interacting with others who are linguistically and culturally different”. Byram (1997) similarly posits that language learners must develop knowledge of self and other cultures, positive attitudes toward cultural diversity, interpretive skills, discovery skills, and critical cultural awareness to communicate across cultures. Vygotsky’s sociocultural theory provides a foundational lens: he argued that cognitive development (including language learning) is inherently mediated by social interaction and cultural tools, with language itself being the primary mediating artifact. In language classrooms, this means that learners construct understanding through dialogue and

cultural context, and instruction should target their Zone of Proximal Development (ZPD) via collaborative activities.

In addition, contemporary educators such as Kramersch emphasize that language and culture are inseparable: learners must develop symbolic competence – the ability to interpret the cultural meaning embedded in language use and discourse. Thus, sociocultural competence involves cognitive, affective, and discursive dimensions. This perspective reflects the aims of inclusive and globalized education: by fostering sociocultural competence, language learners become prepared for intercultural communication, global collaboration, and active global citizenship. Indeed, research suggests that intercultural competencies enrich individual learning and empower educators and leaders to promote international collaboration.

This article reviews the theoretical foundations of sociocultural competence development in foreign language learning. It synthesizes contributions from international scholars – including Michael Byram, Claire Kramersch, Alvino Fantini, and others – and highlights Vygotsky’s sociocultural theory and Kunanbayeva’s intercultural-communicative framework. We explore how these theories inform the integration of intercultural dimensions into language pedagogy, and discuss the importance of sociocultural competence for intercultural dialogue, inclusive education, and mutual understanding.

METHODS AND MATERIALS

Sociocultural Theory (Vygotsky). Vygotsky’s sociocultural theory underpins modern views of language learning as socially mediated. He posited that higher cognitive functions, including language, develop through interaction with cultural artifacts and more knowledgeable others. In this view, language is not merely a system of rules but a tool that mediates thought and social communication. Successful learning, therefore, occurs in learners’ Zone of Proximal Development (ZPD) – tasks they can accomplish with guidance – highlighting the need for collaborative and context-rich instruction. When applied to foreign language education, this theory implies that engaging with target-language users and cultural contexts helps learners internalize new language and worldview. As Fahim and Haghani note, language classrooms should thus “scaffold” learners’ development by situating activities within their ZPD and emphasizing meaningful social interaction.

Byram’s Model of Intercultural Communicative Competence. A seminal framework is Byram’s (1997) model of Intercultural Communicative Competence (ICC), which reframes language teaching goals around intercultural dimensions. According to Byram, ICC consists of five *savoirs* (knowledges or competencies): (1) *Savoir*: factual and sociocultural knowledge of one’s own and other cultures (e.g. social institutions, history); (2) *Savoir-être*: attitudes of openness, curiosity, and empathy toward cultural others; (3) *Savoir comprendre*: interpretive skills, the ability to decode and relate cultural events or texts from another culture; (4) *Savoir apprendre/faire*: discovery skills and action, including posing questions and learning about culture independently; and (5) *Savoir s’engager*: critical cultural awareness, the capability to evaluate cultural practices critically and reflect on power relations across cultures. Hoff (2020) underscores that Byram’s model has shaped curricula in many countries, embedding intercultural aims alongside communicative competence. For example, modern foreign language textbooks often include cultural information and reflection tasks aligned with these *savoirs*, to prepare learners for “successful collaboration across cultures”.

Kramersch and Symbolic Competence. Building on culture-in-language ideas, Kramersch emphasizes the symbolic dimension of intercultural competence. She argues that simply teaching facts about cultures is insufficient; learners must develop an awareness of how language and culture shape meaning. In Kramersch’s view, the “self that is engaged in intercultural communication is a symbolic self constituted by language and systems of thought”. She introduces the concept of

symbolic competence: the ability to interpret the implicit meanings in discourse, to understand how cultural values and power relations are encoded in language, and to imaginatively adopt another's perspective. For example, Kramsch notes that learners need to grasp "what is meant by what is said, to understand how people use symbolic systems to construct new meanings". This implies pedagogical focus on reflective discussion, literary texts, and real-life exchanges where cultural nuances surface. Symbolic competence thus bridges linguistic fluency and cultural insight, guiding learners to reconstruct reality through language and negotiate meaning beyond mere factual knowledge.

Fantini's Complex of Abilities. Alvino Fantini (2006) also conceptualizes ICC as a multifaceted ability set. Sinicrope et al. (2007) summarize Fantini's view that ICC is "a complex of abilities needed to perform effectively and appropriately" in cross-cultural interactions. These abilities span cognitive, affective, and behavioral domains: for instance, mindsets of curiosity and tolerance, skills in listening and interpreting verbal/nonverbal cues, and motivational factors. Fantini argues that ICC develops longitudinally, and education can shape it through sustained intercultural experiences. His definition underscores that sociocultural competence is not a single skill but an integrated set of attitudes, knowledge, and strategies. This aligns with research highlighting the importance of fostering empathy, adaptability, and critical reflection in language learners (Byram & Wagner, 2018).

Kunanbayeva's Intercultural-Communicative Framework. In the Central Asian context, Salima S. Kunanbayeva has advanced a linguoculturological communicative methodology. She treats intercultural-communicative competence as a system of interrelated sub-competencies. Kunanbayeva distinguishes between sociocultural (linguo-cultural) competencies (orientation to one's own and other cultures) and cognitive/reflective components. A key concept is the formation of a learner's secondary cognitive consciousness – essentially a constructed worldview of the target culture parallel to one's native cultural schema. In her view, language instruction aims to gradually build this secondary consciousness through carefully designed tasks: pre-communication exercises (introducing cultural concepts), communicative simulations (experiencing cultural interaction), and post-communication reflection. She also highlights a conceptual sub-competence (tools for modeling the foreign-language world) and a personality-centered sub-competence (personal adaptation of cognitive mechanisms for language learning). While detailed citations are scarce outside Russian publications, her model complements others by integrating psychological and cultural dimensions. It emphasizes that learners must not only learn linguistic forms, but also internalize cultural categories to "adequately interact with other cultures" (Kunanbayeva, 2010).

Thematic Synthesis: Together, these theories converge on several points. First, culture is inseparable from language: learning a language inherently involves adopting new cultural perspectives (Byram; Kramsch). Second, competence is multidimensional: it includes knowledge (informational), attitudes (openness, curiosity), interpretive skills, and metacognitive awareness (Fantini; Byram). Third, social interaction is essential: cognitive growth occurs through mediated dialogue (Vygotsky) and intercultural encounters (Kramsch; Kunanbayeva). Finally, sociocultural competence serves broader educational goals: it underlies learners' capacity to navigate diversity, contributing to inclusive and globalized classrooms.

This article employs a theoretical, narrative literature review methodology. We surveyed peer-reviewed academic literature, seminal books, and relevant conference proceedings on language learning, intercultural communication, and socio-cultural psychology. Key search terms included "sociocultural competence," "intercultural communicative competence," "foreign language education," and names of foundational scholars (Byram, Kramsch, Fantini, Vygotsky, Kunanbayeva). Only scholarly publications (journals, edited volumes, and academic books) were considered. The review is integrative: it synthesizes multiple conceptual frameworks rather than

presenting new empirical data. Emphasis was placed on the theoretical constructs and definitions provided by major authors and on how these have been applied in language pedagogy. By cross-comparing models and linking them to educational aims, we aimed to identify core themes relevant to developing sociocultural competence in foreign language learners.

DISCUSSION

The theoretical frameworks reviewed converge on a central premise: language learning is inextricably linked with cultural learning. Communicative competence is no longer conceived merely in terms of grammatical accuracy or lexical fluency, but rather as a socially and culturally situated practice. As Byram (1997) argues, language learners must be prepared not only to use the language appropriately, but to engage critically and reflectively with their own and others' cultural assumptions. His model of Intercultural Communicative Competence (ICC), especially the *savoirs* framework, is particularly instructive in offering a structured pedagogical target. It calls on educators to design curricula that develop linguistic knowledge, intercultural attitudes (e.g., openness, curiosity), interpretive and discovery skills, and critical cultural awareness. This implies that educators must intentionally go beyond teaching cultural "facts" to cultivating deep, reflective cultural engagement.

Claire Kramsch (2011) deepens this perspective by introducing the idea of symbolic competence, shifting the focus from surface-level culture to the symbolic systems through which culture and identity are expressed. Her work foregrounds the interpretive nature of communication—highlighting that every linguistic interaction carries culturally shaped meanings and worldviews. In practice, this perspective advocates for the integration of authentic texts (literature, film, media, conversation transcripts), tasks that explore narratives, metaphors, and nonverbal codes, and reflection on how language constructs social realities. Activities that compare how different cultures talk about emotions, politeness, time, or space, for instance, provide learners with insight into underlying cultural logics. Kramsch's contribution encourages teachers to become not just conveyors of language rules, but facilitators of cultural meaning-making.

The influence of Vygotsky's sociocultural theory reinforces the interactive nature of language and cultural development. His concepts of the Zone of Proximal Development (ZPD) and cultural mediation provide a pedagogical rationale for collaborative, scaffolded learning. A socioculturally oriented classroom would not merely deliver cultural content, but would immerse learners in dialogic, problem-solving activities where they negotiate meaning with peers and instructors. Role-plays, simulations, peer interviews, and tandem exchanges serve this function well. Through such interaction, students co-construct cultural understanding in a supportive environment, where feedback and modeling guide them toward more competent intercultural behavior. These social learning processes mirror the emergence of what Kunanbayeva calls "secondary cognitive consciousness"—a conceptual reshaping of the learner's worldview through engagement with another culture's linguistic and social norms.

Fantini's (2006) emphasis on longitudinal development reinforces the idea that sociocultural competence must be nurtured over time. Intercultural growth cannot occur in isolated lessons; rather, it requires consistent exposure, diverse cultural encounters, and opportunities for reflection. Educators should structure curricula as intercultural journeys, gradually expanding learners' exposure from familiar topics to more complex cultural dilemmas. Reflective tools such as intercultural journals, portfolios, and virtual exchanges can support this process. As learners document and interpret their experiences, they gain awareness of their own positioning and learn to navigate ambiguity and difference—core attributes of global citizens.

Crucially, sociocultural competence plays a foundational role in inclusive education. In multicultural classrooms, where students bring varied cultural identities and experiences,

intercultural instruction helps foster mutual respect and understanding. For example, structured comparisons of students' cultural traditions (e.g., food customs, festivals, family structures) can validate diverse identities and promote peer learning. When educators encourage all voices to be heard, learners not only gain cultural knowledge but also practice empathetic listening—an essential social-emotional skill. This supports broader goals of social cohesion, equity, and respect for human dignity.

At the same time, sociocultural competence is indispensable for global citizenship education (GCE). Learners equipped with intercultural skills are better prepared to engage with global issues—such as climate change, migration, or social justice—that require collaboration across cultural and linguistic boundaries. Language educators thus serve not only as instructors of communicative ability but also as facilitators of global awareness and civic engagement. The integration of sociocultural competence into language learning aligns with UNESCO's goals of fostering learners who are "globally competent, culturally aware, and socially responsible." Language learning becomes a space where students begin to see themselves as agents of change, capable of bridging divides and contributing to intercultural dialogue.

Kunanbayeva's focus on the cognitive dimension of cultural learning is particularly valuable here. Her concept of secondary cognitive consciousness suggests that sociocultural competence is not merely behavioral or informational—it is deeply cognitive and conceptual, involving the reorganization of the learner's understanding of the world. This demands more than surface-level engagement: it requires conceptual comparison, semantic analysis, and perspective-shifting. Culturally embedded tasks—such as interpreting proverbs, debating ethical dilemmas across cultures, or analyzing media representations—can deepen this cognitive engagement. As learners begin to view the world through the conceptual lenses of the target culture, they become capable of cognitive empathy—understanding how others construct reality and why they act the way they do.

Ultimately, the development of sociocultural competence demands a whole-curriculum approach. It should be embedded in learning objectives, assessment criteria, classroom norms, and school values. Teachers should be supported through professional development in intercultural pedagogy and reflective teaching practices. Institutional policies should encourage project-based learning, community partnerships, and international collaborations that extend intercultural learning beyond the classroom. Furthermore, digital technologies and social media platforms offer valuable tools for virtual intercultural exchanges, expanding learners' access to diverse voices and perspectives.

In summary, sociocultural competence is not just a language-learning outcome—it is a transformative capacity that empowers learners to understand, connect with, and contribute to an increasingly interconnected world. It fosters critical consciousness, interpersonal adaptability, and ethical engagement, making it a cornerstone of 21st-century education. For language teachers and educational leaders, the imperative is clear: sociocultural learning must be planned, intentional, and central to the mission of modern foreign language education.

CONCLUSION

Sociocultural competence is a critical dimension of foreign language learning, encompassing learners' ability to interpret, adapt to, and engage with the cultural contexts of language. Theoretical contributions from Vygotsky, Byram, Kramsch, Fantini, and Kunanbayeva converge on the view that language education must foster social interaction, cultural awareness, and reflective understanding. Vygotsky's theory reminds us that learning is mediated by interaction and culture; Byram and Fantini outline the concrete abilities (knowledge, attitudes, skills) that comprise intercultural competence; Kramsch adds a layer of symbolic meaning-making; and Kunanbayeva emphasizes the cognitive restructuring of the learner's worldview. Together,

these frameworks suggest that language curricula should blend linguistic tasks with cultural discovery, perspective-taking, and critical reflection.

Cultivating sociocultural competence has implications far beyond language exams. It aligns with the goals of intercultural communication, enabling learners to connect across differences; it underpins global citizenship, preparing students to address shared challenges with empathy; and it supports inclusive education, as culturally responsive pedagogy recognizes and values all students' backgrounds. Educators and policy makers should therefore prioritize intercultural goals alongside grammar and vocabulary. Future research could further examine effective classroom interventions for building sociocultural competence and explore assessment methods for this complex construct.

In sum, developing sociocultural competence in foreign language learners is essential for fostering mutual understanding in our diverse world. As our review shows, it draws on robust theoretical foundations, and its importance is echoed across educational discourses. Embracing these insights can transform language learning into a vehicle for building cultural bridges and nurturing globally competent citizens.

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THE ROLE OF AI-BASED MOBILE APPLICATIONS IN THE DEVELOPING FOREIGN LANGUAGE LEXICAL COMPETENCE

Zhadil Zhanel Rinatkyzy

4th Year Bachelor student, “6B01701-Teacher of two foreign languages”, KazUIR & WL Ablai Khan, Almaty, Kazakhstan

Zhumabekova Galiya Baiskanovna

Candidate of Pedagogy, Professor, KazUIR & WL Abylai Khan, Almaty, Kazakhstan

Abstract. The integration of Artificial Intelligence (AI) into mobile language learning applications has transformed the process of acquiring foreign language lexical competence. Lexical competence, encompassing knowledge of word forms, meanings, collocations, grammatical behavior, and pragmatic usage, is a critical component of overall language proficiency. This study explores the role and effectiveness of AI-based mobile applications in enhancing learners' lexical competence. Using a mixed-method approach, both quantitative data from usage statistics and qualitative feedback from learners were analyzed. Findings indicate that AI-based applications provide adaptive, personalized, and interactive learning experiences, facilitating deeper engagement with vocabulary. However, challenges related to technological dependence, content accuracy, and learner motivation remain. Implications for educators and language learners are discussed.

Keywords: AI, mobile applications, lexical competence, foreign language learning, vocabulary acquisition, adaptive learning.

Introduction

In the modern era, technological advancements have significantly influenced the field of foreign language education. Among these innovations, AI-based mobile applications have emerged as powerful tools for enhancing learners' lexical competence. In the context of Kazakhstani education, lexical competence is reflected in curricula, teacher training, and methodologies for foreign language instruction. Developing lexical competence is an essential component of any foreign language program, as a rich and accurate vocabulary enables learners to communicate effectively, comprehend texts, and engage in meaningful interactions. The importance of lexical competence has been emphasized by numerous scholars in the field of language education and second language acquisition. For instance, Nation (2013) highlights that vocabulary knowledge not only supports academic achievement but also facilitates students' adaptation to new learning environments, interaction with peers, and overall communicative proficiency. Lexical competence is therefore a key resource for learners' future academic and professional success, influencing their ability to express ideas clearly, understand native speakers, and participate confidently in intercultural communication. Acquiring robust lexical competence allows learners to use language accurately and appropriately in different contexts, manage communication effectively, and demonstrate their linguistic and cognitive abilities. AI-based mobile applications, which incorporate adaptive learning algorithms, gamification, and

personalized feedback, provide innovative pathways for learners to expand their vocabulary knowledge efficiently. Despite the potential benefits, educators face challenges in integrating these applications into formal language instruction, including ensuring meaningful engagement, maintaining content accuracy, and balancing technology use with traditional teaching methods. The presence of these challenges underscores the urgency of investigating the role of AI-based mobile applications in developing foreign language lexical competence. Understanding their effectiveness and limitations is crucial for designing evidence-based strategies that support learners in mastering vocabulary and achieving higher levels of language proficiency.

Methodology. Data collection

To conduct the study and answer the research questions, the researcher used a descriptive approach, which focused on observing and describing learners' experiences and progress in developing lexical competence through AI-based mobile applications. The study described learners' vocabulary acquisition, usage, engagement, and perceptions without attempting to establish causal relationships.

Design: Since the aim of the study is to investigate how AI-based mobile applications support the development of lexical competence, a descriptive design was chosen. According to Cuthill (2002), descriptive research is appropriate when a topic is not fully explored and the goal is to provide a clear and detailed account of observed phenomena. Although AI applications in language learning have been studied globally, there is limited research describing their impact on lexical competence among Kazakhstani learners.

Participants and Settings: To achieve the purpose of the study, 60 university students aged 18–25 with intermediate English proficiency (B1–B2 CEFR) were involved. All participants had prior experience using mobile applications for language learning. The researcher applied random sampling to select participants to ensure that every student had an equal chance of being included in the study. Thomas (2020) stated that random sampling is used to ensure the reliability of statistical observations. The study was conducted in university language labs and online learning environments, where participants used AI-based applications such as Duolingo, Memrise, and LingQ for 30 minutes daily over a six-week period.

Instrumentation: To achieve the purpose of the research, the researcher utilized a questionnaire as the primary data collection instrument. To gather data concerning learners' experiences and challenges while using AI-based mobile applications, the questionnaire was constructed and provided to the students. The students were asked to answer multiple-choice questions and provide more detailed responses in open-ended questions.

Data analysis: Since the study used a descriptive approach, the data were analyzed to provide a detailed picture of learners' lexical competence development. Quantitative data from the pre- and post-tests and application analytics were summarized using descriptive statistics such as averages, percentages, and frequency counts. Qualitative data from questionnaires and interviews were analyzed thematically to identify common patterns and learners' experiences. This methodology allowed the researcher to describe in detail how AI-based mobile applications support the development of foreign language lexical competence among university students.

Results

In order to show the relevance of this topic, a questionnaire was conducted among university students who used AI-based mobile applications to improve their lexical competence. The aim was to investigate students' experiences, perceived benefits, and challenges while using these applications.

The first question in the questionnaire asked about students' experience with mobile learning applications. Based on the responses, illustrated in Figure 1, show that 40% of the students had been using such applications for less than 6 months, 35% for 6–12 months, and 25%

for more than one year. This indicates that the majority of students had moderate experience with AI-based learning tools, which is relevant for observing their lexical development.

Students' Experience with Mobile Learning Applications

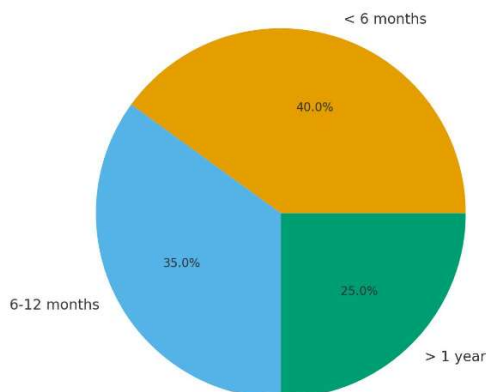


Figure 1: Students' experience with AI-based mobile learning applications

The second question asked, "Which features of AI-based applications help you improve vocabulary the most?" Students' answers varied and are summarized in Table 1.

Table 1. Features of AI-based applications supporting lexical development

Feature	Percentage of Students
Adaptive exercises based on individual progress	38%
Gamified tasks and rewards	25%
Immediate feedback on spelling, grammar, and collocations	20%
Repetition and spaced learning	12%
Access to authentic texts and examples	5%

Based on these answers, it can be concluded that students primarily perceive adaptive exercises and gamified tasks as the most effective features for enhancing their vocabulary knowledge. Immediate corrective feedback was also considered useful for consolidating lexical competence.

The third question of the questionnaire aimed to identify the challenges students face while using AI-based mobile applications. The results, summarized in Table 2, show that the most common difficulty reported by students was a lack of motivation, affecting 30% of respondents. This was followed by distractions from mobile devices, mentioned by 25% of students. Technical issues, such as occasional errors in the applications, were reported by 20% of participants. Additionally, 15% of students indicated difficulties in understanding some words without teacher guidance, while 10% highlighted the lack of opportunities for contextual practice as a challenge.

Table 2: Challenges Faced

Challenge	Percentage of Students
Lack of motivation	30%
Distractions from mobile devices	25%
Occasional technical errors	20%
Difficulty understanding words without guidance	15%
Lack of contextual practice	10%

The final question asked how students cope with difficulties encountered while using AI-based learning applications. The most common strategy was setting daily learning goals, reported by 40% of students. This was followed by combining app-based learning with offline exercises (25%), repeating challenging exercises multiple times (20%), and seeking additional examples or explanations online (15%). These strategies indicate that students actively employ self-regulated learning methods to overcome challenges and enhance their comprehension in both digital and traditional contexts.

These results show that AI-based mobile applications play a significant role in supporting lexical competence. Students find them useful, especially for adaptive practice, gamified learning, and immediate feedback. At the same time, challenges such as motivation and lack of context highlight the need to integrate these tools with teacher guidance and complementary learning strategies.

Discussion

The findings of this study demonstrate that AI-based mobile applications have a significant impact on enhancing foreign language lexical competence among university students. Consistent with previous research (e.g., Nation, 2013; Thomas, 2020), the results suggest that adaptive, personalized, and interactive features of these applications provide a supportive environment for vocabulary acquisition. The majority of students in this study reported that adaptive exercises tailored to individual progress were the most effective tool for learning new words, reflecting the importance of personalized learning pathways in facilitating deeper engagement and retention. Gamified tasks and rewards were also highly valued, indicating that motivation-enhancing features can encourage consistent practice and sustain learner engagement. Immediate feedback on spelling, grammar, and collocations further contributed to consolidating lexical knowledge, which aligns with the literature emphasizing the role of corrective feedback in second language acquisition.

Despite the benefits, the study also highlights several challenges associated with using AI-based mobile applications. A lack of motivation was reported as the most common difficulty, followed by distractions from mobile devices and occasional technical issues. These findings underscore that technological tools alone cannot guarantee effective learning; learner engagement and self-regulation remain critical. The results show that students employ various coping strategies, such as setting daily learning goals, combining app-based exercises with offline practice, and repeating challenging exercises, reflecting the active role of learners in managing their learning process. This finding resonates with self-regulated learning theory, which emphasizes goal-setting, monitoring, and adaptive strategies as key components of effective learning (Zimmerman, 2002).

Furthermore, some students noted difficulties in understanding certain words without teacher guidance and a lack of contextualized practice. This indicates that AI-based applications, while effective for vocabulary expansion, may not fully replace traditional classroom interactions or authentic communicative experiences. Integrating these tools with teacher-led instruction and contextualized tasks can address these gaps, providing scaffolding to support comprehension and appropriate usage of newly acquired vocabulary.

Overall, the study provides evidence that AI-based mobile applications are a valuable complement to traditional language instruction, particularly in supporting lexical competence development. They offer flexibility, personalization, and interactive engagement, which are essential for modern language learning. However, to maximize their effectiveness, educators should combine digital tools with pedagogical guidance, context-rich activities, and strategies that promote learner motivation and self-regulation. Future research could investigate long-term effects of AI-based applications on lexical retention, examine different proficiency levels, and

explore culturally adapted content to enhance relevance in specific educational contexts such as Kazakhstan.

Conclusion

This study highlights the significant role of AI-based mobile applications in developing foreign language lexical competence among university students. The findings indicate that adaptive exercises, gamified tasks, and immediate feedback are particularly effective in enhancing vocabulary knowledge, engagement, and self-directed learning. Students actively employ strategies such as goal-setting, combining digital and offline practice, and repeated exercises to overcome challenges, demonstrating the importance of self-regulation in the learning process.

However, the study also underscores the limitations of relying solely on technology. Challenges such as lack of motivation, distractions, technical issues, and limited contextual practice suggest that AI-based tools are most effective when integrated with teacher guidance and classroom-based activities. Educators should therefore consider a blended approach, combining AI-driven exercises with pedagogical support to ensure meaningful and contextually appropriate vocabulary development.

Overall, AI-based mobile applications represent a promising complement to traditional language instruction, providing personalized, interactive, and motivating pathways for lexical competence. Their thoughtful integration can enhance learners' ability to communicate accurately, understand authentic language input, and participate confidently in intercultural communication. Future research should explore long-term effects, adaptive learning across proficiency levels, and culturally relevant content to maximize the potential of AI in foreign language education.

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Cross-Cultural Pragmatics in Education

Bissenbayeva Perizat Sakenkyzy

Kazakh University of International Relations and World Languages (KazUIR&WL), Almaty, Kazakhstan, Faculty of Two Foreign Languages, 4th-year students

Erbolatova Nurailym Rysbaikyzy

Kazakh University of International Relations and World Languages (KazUIR&WL), Almaty, Kazakhstan, Faculty of Two Foreign Languages, 4th-year students

Myrzakhanova Dinara

Master's degree, Senior Lecturer, Kazakh University of International Relations and World Languages (KazUIR&WL), Almaty, Kazakhstan; Department of Foreign Language Education Methodology

ABSTRACT

Globalization and multicultural classrooms have made cross-cultural pragmatics a crucial aspect of contemporary education. Pragmatics, the study of how context shapes meaning, examines speakers' intentions, implicatures, and social effects of communication. Cross-cultural pragmatics focuses on how communicative practices vary across cultures, influencing politeness, turn-taking, directness, and nonverbal behavior. These differences affect classroom participation, teacher–student interaction, and peer collaboration. High-context cultures, common in East Asia and parts of Africa, often rely on indirect communication, respect for authority, and nonverbal cues, which may be misinterpreted by instructors from low-context cultures as disengagement. Conversely, students from low-context environments, such as North America and Europe, tend to communicate explicitly and assertively, potentially appearing confrontational to peers from indirect communication traditions. The concept of face—positive face (approval) versus negative face (autonomy)—further shapes interaction, influencing requests, disagreements, and classroom behavior. Digital and hybrid learning environments intensify these challenges due to reduced nonverbal cues, increasing the likelihood of misunderstandings. A qualitative literature review of studies in Asia, Africa, Europe, North America, and Latin America highlights recurring communicative patterns, culturally mediated interaction norms, and strategies for mitigating misunderstandings. Promoting pragmatic competence and intercultural awareness enables educators to foster inclusive, equitable, and effective classroom environments. Understanding the cultural underpinnings of communication enhances student engagement, reduces conflicts, and equips learners for successful interaction in diverse academic and professional contexts.

Keywords: *cross-cultural pragmatics, intercultural communication, classroom interaction, high-context culture, low-context culture, politeness strategies, facework, multicultural education, digital learning*

Авторлар: Биссенбаева Перизат Сәкенқызы, Ерболатова Нурайым Рысбайқызы

Қазақ халықаралық қатынастар және әлем тілдері университеті (ҚазХҚ және ӘТУ), Алматы, Қазақстан

Факультет: Екі шетел тілі факультеті, 4-курс студенттері

Соавтор: Мырзаханова Динара – Магистр дәрежесі, аға оқытушы

Қазақ халықаралық қатынастар және әлем тілдері университеті (ҚазХҚ және ӘТУ), Алматы, Қазақстан; Шетел тілі білім беру әдістемесі кафедрасы

АННОТАЦИЯ

Ғаламдану және көпмәдениетті сыныптар қазіргі білім беру жүйесінде мәдениаралық прагматиканы маңызды тақырыпқа айналдырды. Прагматика – бұл контекстің мағынаны қалай қалыптастыратынын зерттейтін сала, ол сөйлеушілердің ниеттерін, жанама мәндерін (имплицатураларды) және коммуникацияның әлеуметтік әсерін қарастырады. Мәдениаралық прагматика әртүрлі мәдениеттердегі коммуникативтік тәжірибелердің ерекшеліктерін, сыпайылық, сөйлеу ретін, тікелейлік пен бейсөздік мінез-құлыққа әсерін зерттейді. Бұл айырмашылықтар сыныптағы қатысу, мұғалім–оқушы өзара әрекеттесуі және оқушылар арасындағы ынтымақтастыққа әсер етеді. Жоғары контексті мәдениеттерде (Шығыс Азия және Африканың кейбір аймақтары) қатысушылар жанама сөйлесуге, билікке құрмет көрсетуге және бейсөздік белгілерге сүйенеді, бұл төмен контексті мәдениеттерден келген мұғалімдер тарапынан қызықсыздық деп түсіндірілмеуі мүмкін. Ал Солтүстік Америка мен Еуропа елдеріндегі төмен контексті ортадан шыққан оқушылар әдетте тікелей және анық сөйлейді, бұл кейде жанама коммуникация дәстүрі бар әріптестерге қарсы тұрушы көрінуі мүмкін. «Бет» концепциясы – позитивті бет (қабылдау тілегі) және негативті бет (автономия тілегі) – өзара әрекеттесуге әсер етеді, сұраулар, келіспеушіліктер және сыныптағы мінез-құлыққа ықпал етеді. Сандық және аралас оқыту ортасы бейсөздік белгілердің азаюына байланысты осы қиындықтарды күшейтеді, түсінбеушіліктердің мүмкіндігін арттырады. Азия, Африка, Еуропа, Солтүстік Америка және Латын Америкасындағы зерттеулерді қамтитын сапалық әдеби шолу коммуникативтік үлгілерді, мәдениетке байланысты өзара әрекет ережелерін және түсінбеушілікті азайтатын стратегияларды анықтауға мүмкіндік береді. Прагматикалық құзыреттілік пен мәдениаралық хабардарлықты дамыту мұғалімдерге инклюзивті, әділ және тиімді сыныптық орта құруға көмектеседі. Коммуникацияның мәдени негізін түсіну оқушылардың белсенділігін арттырады, қақтығыстарды азайтады және оларды әртүрлі академиялық және кәсіби ортада табысты әрекет етуге дайындайды.

Кілттік сөздер: мәдениаралық прагматика, мәдениаралық коммуникация, сыныптағы өзара әрекеттесу, жоғары контексті мәдениет, төмен контексті мәдениет, сыпайылық стратегиялары, бетке қатысты әрекет, көпмәдениетті білім беру, сандық оқыту

INTRODUCTION

Globalization, international mobility, and increasingly multicultural classrooms have made cross-cultural pragmatics a central topic in contemporary education. Pragmatics, a branch of linguistics, examines how context contributes to meaning in communication. It goes beyond the literal interpretation of words and focuses on speakers' intentions, implications, and the social effects of their utterances (Huang, 2014). One of the key concepts in pragmatics is implicature, which refers to the indirect meaning conveyed by an utterance. For example, a statement like "It's hot in here" may implicitly request turning on the air conditioning. Understanding such implicatures requires cultural knowledge and sensitivity to social norms, making pragmatics essential for effective cross-cultural communication (Hymes, 2016).

Cross-cultural pragmatics specifically analyzes how communicative practices differ across cultures and how these variations influence interaction (Kecskes, 2010; Beebe, Takahashi, & Uliss-Weltz, 2017). Cultural norms shape expectations for politeness, turn-taking, nonverbal behavior, and levels of directness (Holmes, 2013; Yule, 2016). For instance, some cultures value directness and explicitness, while others rely on indirectness and context. These differences are reflected in how

speakers perform speech acts—actions such as requests, offers, or apologies. Japanese speakers, for example, often use indirectly phrased offers to maintain harmony, whereas American speakers may express the same act directly and explicitly. Pragmatic analysis helps to reveal these culturally shaped conventions and prevent misunderstanding (Beebe et al., 2017).

In educational settings, these variations have practical consequences for classroom participation, teacher–student relationships, and conflict resolution (García & Florian, 2019; Li & Wang, 2017). In East Asian contexts such as Japan and China, communication tends to emphasize respect for authority, indirect expression, and restraint. Students may avoid openly questioning teachers, as silence can signal attentiveness and respect (Ide, 1989; Japan National Tourism Organization, 2020). In contrast, students in North America and much of Europe are encouraged to express opinions freely; questioning teachers is viewed as engagement rather than disrespect (Samovar, Porter, McDaniel, & Roy, 2016; Pew Research Center, 2020).

In African educational environments, communication is often context-dependent and community-oriented, with strong reliance on nonverbal cues, storytelling traditions, and shared cultural scripts that foster social harmony (Mazrui & Mazrui, 2016; Ngugi, 2018). Similarly, cultures in Latin America tend to prioritize relational harmony and politeness, making students more inclined to avoid direct disagreement during class discussions (Alencar & Lima, 2019). These cultural scripts and conversational “frames” shape how learners interpret the intentions of others and how they expect interactions to unfold (Scollon & Scollon, 2001).

The concept of face— a person’s public self-image— is central to understanding communication across cultures. While some cultures prioritize positive face (desire for approval), others emphasize negative face (desire for autonomy), leading to different politeness strategies and face-saving techniques (Matsumoto, Hwang & Frank, 2016; García & Florian, 2019). These face-related expectations strongly influence students’ willingness to participate, challenge ideas, or seek help. Misunderstandings in multicultural classrooms often arise not from linguistic errors but from differing expectations regarding politeness, directness, gesture interpretation, or emotional expressiveness (Gudykunst & Kim, 2017; Holmes, 2013; Kádár & Haugh, 2013). The rapid expansion of online and hybrid learning has added a new layer of complexity, as virtual platforms may reduce access to nonverbal cues and increase chances of misinterpretation (Zhang & Chen, 2019). Intercultural pragmatics research highlights the need for strategies to bridge these differences and help learners adapt to new communicative norms (Bargiela-Chiappini & Haugh, 2019).

Given these challenges, promoting pragmatic competence and intercultural awareness is essential for creating inclusive and effective educational environments (Chen & Wu, 2015; Liu & Li, 2020). By understanding how cultural values shape communication, both teachers and students can better navigate diverse classroom interactions, enhance cooperation, and reduce conflict. This article examines how pragmatic norms vary across cultures and explores strategies for addressing these differences to improve classroom communication and learning outcomes.

METHODS

This study adopts a qualitative literature review methodology to investigate the influence of pragmatic norms on communicative practices in multicultural educational contexts. The review synthesizes theoretical perspectives from pragmatics, politeness theory, sociolinguistics, and intercultural communication. Seminal works in intercultural pragmatics (Kecskes, 2010), politeness scholarship (Kádár & Haugh, 2013; Ide, 1989), and sociolinguistic theory (Holmes, 2013; Hymes, 2016) constitute the primary conceptual framework. Research addressing communicative behavior in multicultural as well as high- and low-context cultural environments (Gudykunst & Nishida, 2013) further informs the discussion by elucidating culturally contingent processes of meaning-making and interactional norms. Studies focusing on conflict negotiation, communicative

competence in workplace settings, and interpersonal dynamics (Li & Wang, 2017; Liu & Li, 2020; Holmes & Stubbe, 2015) were incorporated to demonstrate the broader applicability of pragmatic principles beyond classroom discourse. Additionally, literature on digital pragmatics and virtual learning environments (Zhang & Chen, 2019) was examined to account for the increasing prominence of online communication in contemporary education.

The selection of sources was guided by thematic relevance rather than systematic database procedures, reflecting the exploratory orientation of the study. Each publication was critically reviewed for its theoretical insights and empirical contributions related to speech acts, politeness strategies, nonverbal signaling, turn-taking mechanisms, facework, and context-dependent interpretation. Particular consideration was given to studies featuring learners and educators operating within culturally diverse or intercultural settings.

To construct a comprehensive analytical perspective, the review integrates research conducted across diverse geographical regions—including Asia, Africa, North America, Europe, and Latin America. Comparative analysis of these studies enabled the identification of recurrent areas of communicative breakdown, culturally mediated interactional norms, and pedagogical factors that either facilitate or impede effective classroom communication. The resulting themes were organized into domains such as learner participation, teacher–student interactional dynamics, peer collaboration, conflict management, and intercultural adjustment processes.

The intention of this qualitative synthesis is not to impose universal generalizations across cultural groups but rather to illuminate overarching tendencies and salient contrasts that may enhance pragmatic awareness in educational settings. Through this integrative approach, the study contributes a nuanced understanding of how pragmatic norms shape communicative behavior in multicultural classrooms and outlines implications for fostering more equitable, inclusive, and effective pedagogical interaction.

RESULTS

The findings demonstrate that cultural background plays a decisive role in shaping how students communicate and participate in diverse educational settings. Learners from high-context societies—commonly found in regions such as East Asia and parts of Africa—tend to rely on indirect expression, controlled emotional display, and respect for authority figures (Ide, 1989; Ngugi, 2018; García & Florian, 2019). Such communicative tendencies are often interpreted by teachers from low-context cultures as attentiveness or courtesy rather than a lack of involvement. Students raised in low-context environments, including North America and many European countries, usually adopt a more explicit and assertive style. Their open opinions and direct reactions are frequently viewed by instructors as signs of active engagement rather than rudeness (Samovar et al., 2016; Pew Research Center, 2020). These contrasting norms produce noticeable differences in how students participate in class discussions and collaborate with peers.

The concept of “face” emerges as a key element influencing interaction. Cultures that value the maintenance of positive face tend to encourage cooperation, support, and harmonious relationships among students, whereas cultures emphasizing negative face focus on protecting personal autonomy and minimizing imposition (Matsumoto, Hwang, & Frank, 2016; Kádár & Haugh, 2013). These orientations shape how learners formulate requests, express disagreement, and address teachers, ultimately influencing classroom communication patterns.

Digital and hybrid learning environments intensify these challenges. Without access to gestures, facial expressions, or tonal markers, students must rely solely on written language to interpret meaning. As a result, misunderstandings become more likely, especially for individuals who depend heavily on contextual cues or nonverbal signals (Zhang & Chen, 2019; Wang & Lee, 2016). In such situations, breakdowns in communication arise not from grammar issues but from

contrasting expectations regarding politeness, expressiveness, and communicative openness (Li & Wang, 2017; Liu & Li, 2020).

DISCUSSION

The results emphasize that pragmatic differences are closely linked to cultural norms and have a significant impact on classroom behavior. In high-context cultures, silence, indirect statements, or respectful deference may be interpreted by teachers from direct-communication traditions as disengagement or lack of interest (Gudykunst & Nishida, 2013; Ide, 1989). Conversely, straightforward expressions typical of low-context cultures may be perceived as confrontational or disrespectful by peers from more indirect communication traditions (Kim & Park, 2018).

Teachers play a central role in bridging these gaps. Providing clear guidance on intercultural communication, modeling culturally sensitive interaction, and establishing inclusive classroom norms helps students recognize and adapt to diverse communication styles (Bargiela-Chiappini & Haugh, 2019; Holmes & Stubbe, 2015). Strategies such as clarifying expectations for participation, openly discussing cultural norms, and encouraging reflection on communication practices have proven effective in reducing misunderstandings and enhancing engagement (García & Florian, 2019; Chen & Wu, 2015).

Online and blended learning formats introduce additional challenges. Without nonverbal cues, students rely entirely on linguistic and contextual signals, making pragmatic competence essential for successful interaction (Zhang & Chen, 2019). Teachers can mitigate potential miscommunication by modeling online discourse conventions and teaching students to interpret indirect markers, such as tone or phrasing in written messages (Wang & Lee, 2016).

Overall, the findings confirm that developing awareness of cross-cultural pragmatics is not merely recommended but essential for effective education in diverse classrooms. Educators who understand how culture shapes communication can create supportive and equitable learning environments, enhance student participation, reduce conflicts, and prepare learners for interaction in a globalized academic and professional world (Liu & Li, 2020; Alencar & Lima, 2019).

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ОСОБЕННОСТИ ИССЛЕДОВАНИЯ ВЕБ-ПЛАТФОРМЫ ДЛЯ ПОВЫШЕНИЯ УСПЕВАЕМОСТИ УЧАЩИХСЯ В ОБРАЗОВАТЕЛЬНЫХ УЧРЕЖДЕНИЯХ

Авдиев Мадияр Талгатулы

Магистрант, Карагандинский технический университет имени Абылкаса Сагинова

Аннотация

В данной статье рассматриваются особенности и влияние веб-платформы, предназначенной для повышения академической успеваемости студентов в образовательных учреждениях. Проведенный всесторонний обзор литературы предоставляет теоретическую основу исследования и выявляет пробелы в существующих исследованиях. В работе используется комбинированный подход, сочетающий количественные и качественные данные полученные с помощью структурированного опроса. Результаты исследования показывают, что веб-платформы играют значительную роль в обеспечении доступа к образовательным ресурсам, улучшении взаимодействия с преподавателями и предоставлении своевременной обратной связи, что способствует улучшению академической успеваемости. Однако технические проблемы и ограниченная удобность использования остаются проблемами, требующими решения. Кейсы успешных внедрений подчеркивают лучшие практики и ключевые факторы успеха при интеграции веб-платформ в образовательные процессы.

Ключевые слова: Веб-платформа, электронное обучение, образовательные технологии, академическая успеваемость, инструменты онлайн-обучения

Введение

Образовательные веб-сайты являются одним из важнейших инструментов для обучения и повышения успеваемости учащихся. Они используются учащимися для получения необходимой им информации, такой как домашние задания, учебные ресурсы и данные об оценках. Они также позволяют учителям общаться с учениками и родителями в режиме реального времени с помощью текстового или видеочата. Учителя также могут размещать важные объявления о предстоящих мероприятиях или экзаменах на веб-сайте, чтобы все всегда были в курсе. Например, если учитель хочет поделиться заданием со своими учениками и у них нет доступа к школьному компьютерному кабинету, они могут разместить информацию об этом на школьном веб-сайте. Таким образом, доступ будет у всех учащихся, даже если у них дома нет компьютеров.

В современном мире, где доступ к информации находится всего в одном клике, образовательные веб-сайты стали очень популярными среди людей всех возрастных групп. Они позволяют пользователям получать информацию на любую тему, которая их интересует, без необходимости искать её в других источниках, таких как книги или библиотеки. Эти сайты также очень полезны для учителей, которые могут использовать их как дополнительные материалы при подготовке уроков для своих учеников. Это значительно упрощает процесс, так как все, что нужно – это доступ к интернету, который сейчас есть у большинства людей.

Такие сайты предоставляют ученикам ресурсы, необходимые для их успеха за пределами школы, включая возможность выполнять домашние задания и общаться с

учителями. Некоторые школы даже начали предлагать виртуальные занятия, где учащиеся могут учиться из дома в своём собственном темпе.

Электронное обучение стало вызывать больший интерес у педагогов после недавней пандемии COVID-19, и теперь образование немыслимо без электронного обучения. Электронное обучение – это форма образования, использующая технологии для обеспечения эффективного и удобного обучения в любом месте и в любое время. Электронное обучение также можно определить как любую систему обучения, которая использует электронные ресурсы для формализованного преподавания. Основными компонентами электронного обучения являются компьютеры и интернет, независимо от того, где происходят преподавание и обучение [1].

Аналогично, удовлетворенность учащихся и их академические достижения в процессе онлайн-обучения привлекли значительное внимание ученых, которые использовали несколько теоретических моделей для оценки этих показателей (Abuhassna, Megat, Yahaya, Azlina, & Al-rahmi, 2020; Abuhassna & Yahaya, 2018; Al-Rahmi, Othman, & Yusuf, 2015a; Al-Rahmi, Othman, & Yusuf, 2015b). Настоящее исследование освещает влияние онлайн-платформ обучения на удовлетворенность учащихся в зависимости от их прошлого опыта и отношения к таким платформам, чтобы определить, какие учащиеся будут удовлетворены онлайн-курсами [2].

Большинство университетов в развитых странах, если не все, в той или иной степени используют информационно-коммуникационные технологии (ИКТ) в своих курсах. Например, наши учреждения, Политехнический университет Каталонии (UPC) и Университет Барселоны (UB), ориентированы на обучение в аудиториях и внедрили платформу электронного обучения Moodle. Эта популярная платформа привлекает внимание благодаря своему педагогическому подходу к образованию, основанному на конструктивистских и социально-конструкционистских теориях обучения (Moodle, 2009).

Однако, несмотря на огромный потенциал Moodle как педагогического инструмента, часто она используется лишь как хранилище учебных материалов, не раскрывая весь свой функционал. Курсы, где применяется e-status, обычно базируются на лекциях в классах, и такая комбинация очного и онлайн-обучения относится к так называемому "смешанному обучению" (blended learning или b-learning).

Кроме того, e-status включает черты интегрированных систем обучения (ILS), которые, как отмечают Вуд и др. (1999), включают:

- содержание учебной программы (хотя e-status не включает это напрямую, но позволяет добавлять ссылки в задачи);
- систему учета данных учащихся;
- систему управления обучением.

Корни ILS уходят в 1960-е годы, когда Патрик Саппс в Стэнфордском университете разработал первые концепции. В 1990-х они были модернизированы благодаря новым технологиям, таким как интернет и мультимедийные форматы. Эти системы базируются на нео-бихевиористической модели обучения, которая включает автоматический выбор задач, управляемую практику и индивидуальную обратную связь (Wood et al., 1999).

Однако обучение с использованием e-status также включает элементы конструктивизма:

- акцент на активности студентов;
- роль преподавателя сводится к катализатору процесса построения знаний;
- предоставление студентам набора задач, мониторинг их прогресса.

Студенты работают индивидуально, но не изолированно: система предоставляет показатели эффективности, позволяя сравнивать свои результаты с результатами других студентов.

e-status — относительно простая платформа, специализирующаяся на численных решениях задач, особенно в области базовой статистики для высшего образования. Ее узкая специализация позволяет адаптировать задачи под образовательные цели курса.

Классификация образовательных целей Блума (1956) полезна для характеристики задач, представленных на платформе. Среди категорий когнитивного обучения (знание, понимание, применение, анализ, синтез и оценка) e-status подходит для упражнений как минимум в первых четырех из них.

Платформа предоставляет студентам преимущества:

- доступ к материалам в любое время и из любого места;
- мгновенная оценка выполненных упражнений;
- обратная связь, включающая как общее резюме активности, так и детальный разбор каждой задачи.

Перед тем как студенты столкнутся с реальными и сложными задачами в профессиональной жизни, они должны освоить базовые шаги различных статистических техник через практику. Платформа e-status позволяет студентам повторять задачи с новыми данными, сохраняя интерес к их решению.

Повторение, часто ассоциируемое с запоминанием и воспринимаемое как неэффективный метод, здесь используется как средство для активного обучения и осознания прогресса. Вместо традиционных методов (например, упражнений с бумагой и ручкой) e-status стимулирует студентов к активной работе и формирует осознанное отношение к процессу обучения [3].

Методы исследования. Был создан опрос, чтобы узнать, насколько эффективны Веб-платформы для учебной программы и учащихся. Анкета была спроектирована с учетом различных аспектов, включая паттерны использования, воспринимаемые преимущества, возникшие проблемы и предложения по улучшению. Общий опрос состоял из 10 вопросов, два из которых были открытыми. Анкета была спроектирована с учетом различных аспектов, включая паттерны использования, воспринимаемые преимущества, возникшие проблемы и предложения по улучшению. Собранные данные были проанализированы как в аналитическом, так и в сравнительном плане.

Результаты и обсуждение. Для изучения особенности и влияние веб-платформы на улучшение академической успеваемости студентов в образовательных учреждениях был проведен опрос. Опрос был создан в электронном варианте и был распространен в виде ссылки. В исследование приняли участия студенты бакалавриата Карагандинского технического университета имени Абылкаса Сагинова. Опрос был заполнен 167 участниками.

Исследование показало, что 79 процентов студентов используют веб-платформы каждый день (см. рисунок 1).

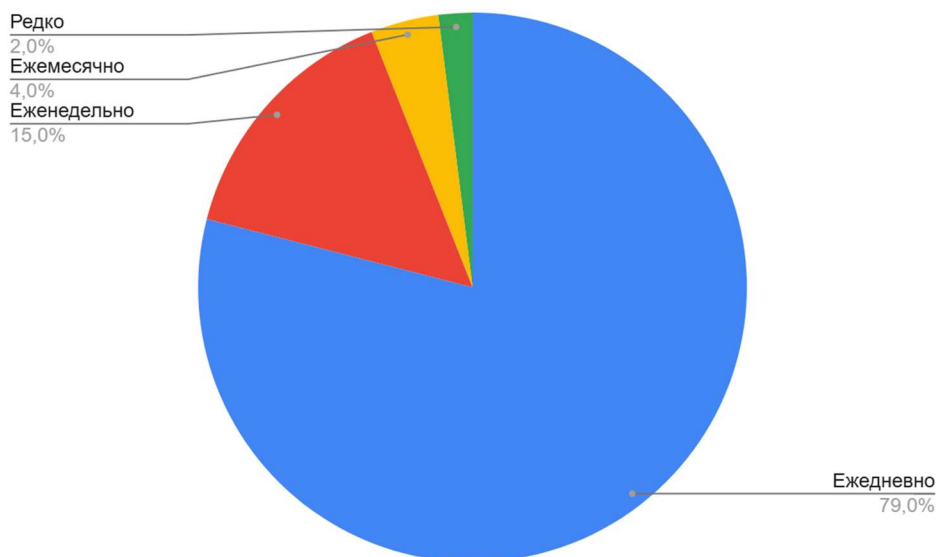


Рисунок 1- Данные по использованию частности веб-платформ
Примечание: Составлено автором

Также было выявлено что 15% учащихся использует платформы для обучения еженедельно. В результате исследования выяснилось что всего 4% студентов используют такие платформы ежемесячно, а 2 % учащихся использует еще реже. Все 167 участники опроса не выбрали вариант никогда. Это показывает что все учащихся в каком то мере пользуется веб платформами для обучения.

Многие студенты используют веб платформы для обучения и для поднятия своих академических знаний. Сейчас существует очень много платформ для обучения, результаты исследования показали что многие учащиеся пользуются веб платформой Coursera (38%).

Платформа Canvas используется 29% студентов. В Canvas можно сделать различные контенты или презентации для урока. А также он дает возможность для взаимоотношения студентов с преподавателями. Многие студенты может делать различные и красочные материалы для уроков. Это поможет им поднять свою академическую успеваемость и хорошо влияет к критическому мышлению.

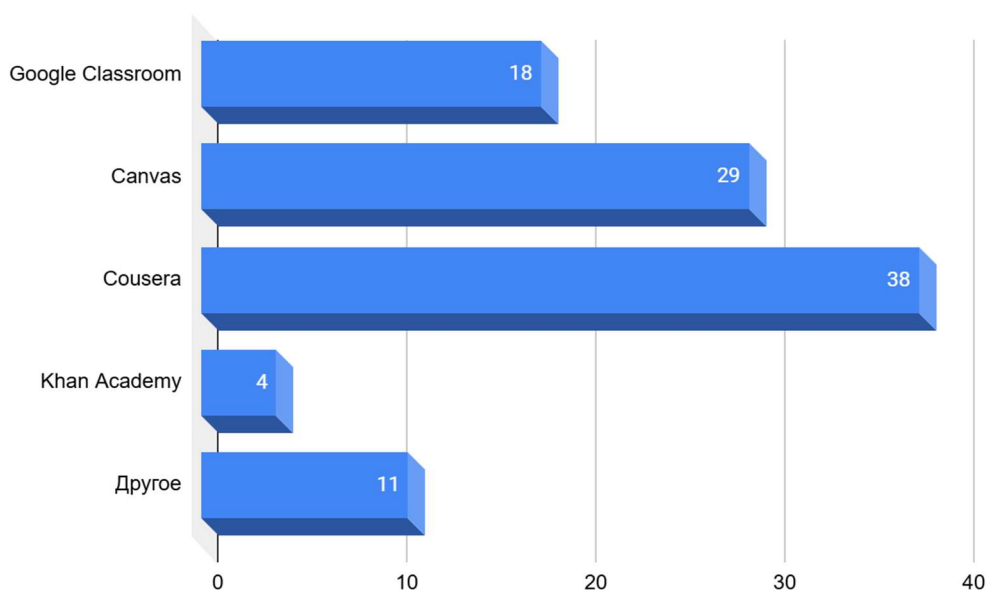


Рисунок 2- Данные по использованию веб-платформ (%)

Примечание: Составлено автором

Google Classroom (18%) занимает заметную долю, что указывает на доступность и частую интеграцию этой платформы в различные образовательные учреждения. Khan Academy имеет самый низкий процент использования среди рассмотренных платформ - всего 4%. Это может указывать на то, что данная платформа в основном используется для углубленного изучения отдельных тем или как вспомогательный ресурс для самостоятельной подготовки в конкретных областях. Несмотря на то, что Khan Academy предлагает бесплатные образовательные курсы по множеству дисциплин, её применение может быть ограничено в учебных заведениях, где предпочтение отдаётся более структурированным платформам для управления курсами и учебным процессом, таким как Canvas или Google Classroom (см. рисунок 2).

На рисунке 3 представлены данные о восприятии студентами влияния веб-платформ на их успеваемость. 79,6% респондентов отметили, что веб-платформы оказали положительное влияние на их успеваемость. Это подавляющее большинство отражает значительную роль технологий в современном образовании. Учащиеся, скорее всего, выиграют от гибкости, доступности и разнообразия ресурсов, которые предоставляют веб-платформы. Эти платформы часто обеспечивают самостоятельное обучение, доступ к высококачественным учебным материалам и инструментам для эффективного общения и сотрудничества со сверстниками и преподавателями. Такие особенности, по-видимому, тесно связаны с потребностями учащихся в обучении, повышая их способность хорошо справляться с учебной работой.

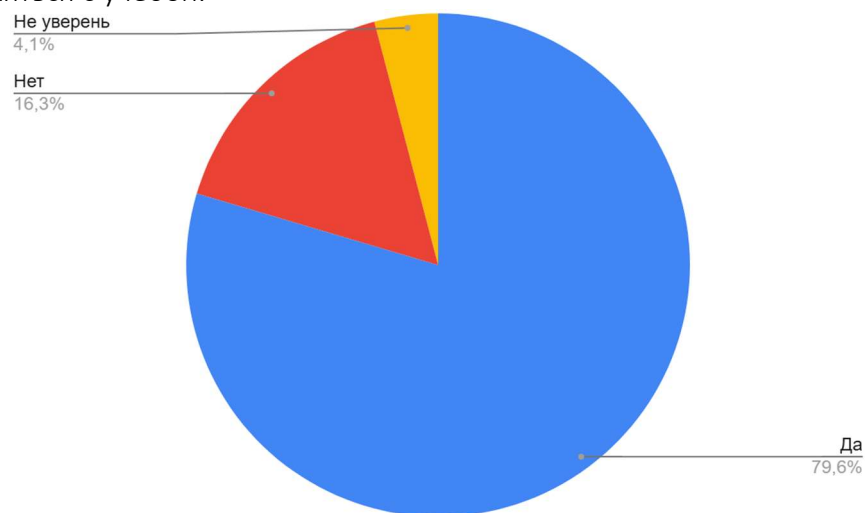


Рисунок 3- Влияние платформой на успеваемость (%)

Примечание: Составлено автором

Выделенные красным сегментом 16,3% студентов ответили, что они не ощущают никакого положительного влияния веб-платформ на свою успеваемость. Это говорит о том, что, хотя большинство считает эти платформы полезными, заметное меньшинство может столкнуться с трудностями при их эффективном использовании. Возможные причины могут включать отсутствие цифровой грамотности, недостаточный доступ к надежным технологиям или Интернету или непригодность определенных платформ для конкретных академических нужд. В этом разделе подчеркивается важность устранения барьеров, которые могут мешать некоторым учащимся в полной мере воспользоваться преимуществами цифрового образования.

Самый маленький желтый сегмент, составляющий 4,1% ответов, указывает на студентов, которые не уверены в том, как веб-платформы влияют на их успеваемость. нерешительность студентов показывают что они не осознают как веб платформы помогает им на уроках. Или же наоборот они думают что успехи в академических оценок сильно влияет веб сайты чем они сами, обесценивая свой труд. Здесь важно подчеркивать без инициативы учащихся и их труда невозможно достичь хороших результатов. Также эта неопределенность может быть вызвана ограниченным доступом к таким платформам или неоднозначным опытом.

Веб-платформы удобны тем что предоставляют учащимся круглосуточный доступ к учебным материалам, ресурсам и заданиям. Многие веб-платформы включают интерактивные элементы, такие как викторины, симуляторы и дискуссионные форумы. Эти инструменты более активно вовлекают учащихся в процесс обучения, помогая закрепить концепции и поощряя критическое мышление.

Заключение. В результате исследования можем сказать что веб-платформы играют решающую роль в современном образовании, повышая успеваемость за счет улучшения доступа к ресурсам, интерактивного обучения и своевременной обратной связи. Чтобы максимально использовать свой потенциал, образовательные учреждения должны сосредоточиться на решении выявленных проблем и учете отзывов учащихся при разработке и внедрении этих цифровых инструментов. Это поможет создать более эффективную и благоприятную учебную среду, способствующую успеху учащихся.

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ЖАСАНДЫ ИНТЕЛЛЕКТТІ ОҚЫТУ ТӘЖІРИБЕЛЕРІ ЖӘНЕ ДАМУ БОЛАШАҒЫ

К.З.Халикова

п.ф.к., профессор, <https://www.scopus.com/authid/detail.uri?authorId=57729604200>,
<https://orcid.org/0000-0003-0242-8708>

Ә.Д.Төрекелдиева

магистрант, Абай атындағы Қазақ ұлттық педагогикалық университеті, Қазақстан Республикасы

Аңдатпа. Бұл мақала Қазақстан Республикасындағы жасанды интеллект (ЖИ) саласындағы кадрларды даярлаудың қазіргі тәжірибелеріне, осы процесті реттейтін нормативтік-құқықтық құжаттарға және даму болашағына жан-жақты талдау жасауға талдау барысында "Цифрлық Қазақстан" бағдарламасы, дербес деректерді қорғауға қатысты заңдар сияқты негізгі **нормативтік құжаттарға** шолу жасалып, олардың ЖИ-ді дамытуға әсері айқындалады. Қорытынды бөлімде ЖИ-дің ұлттық басымдықтары – қазақ тіліндегі деректер қорын қалыптастыру және этикалық ЖИ-ді дамыту мәселелеріне баса назар аударылған. Сонымен қатар, жүргізілген зерттеулерге байланысты қорытынды ұсыныстар келтірілген.

Түйінді сөздер: Жасанды интеллект, **Generative AI**, Мұғалім-ассистент, нормативтік құжаттар, деректер базасы.

Кіріспе

Бүгінгі таңда білім беру саласындағы өзекті мәселелердің бірі - жасанды интеллект (ЖИ) технологияларын елдің әлеуметтік-экономикалық дамуының қозғаушы күші ретінде қабылдап, білім беру саласына ұтымды енгізу болып табылады. Олай дейтін себебіміз, мемлекеттердің бәсекеге қабілеттілігі олардың осы саладағы мамандарды даярлау қабілетіне тікелей байланысты екенін практика көрсетіп отыр. Бүкіл әлем елдері «Ақпараттық-коммуникациялық технологиялар» (АКТ) дәуірінен «Жасанды интеллект» дәуіріне көшу кезеңін бастан кешіруде. Дәл осы тұста, Қазақстан Республикасы цифрландыру процесін елдің экономикалық дамуының негізгі бағыттарының бірі ретінде ұстанып, жасанды интеллект технологияларын білім беру саласына енгізуге байланысты бірнеше маңызды шараларды қолға алып, жүзеге асыру үстінде. Осы орайда, Қазақстан Республикасында ЖИ саласын дамытуға бағытталған мемлекеттік бағдарламалары мен бастамалары білім беру жүйесіне үлкен міндеттер жүктейді. ЖИ тек жоғары оқу орындарындағы жеке мамандық ретінде ғана емес, сонымен бірге, жалпы білім беру мазмұнының ажырамас бөлігі ретінде қарастырылуда. Бұл өзгерістер оқу үдерісін, оқыту әдістері мен мамандарды кәсіби даярлау мәселесін қайта қарауды талап етеді.

Зерттеудің мақсаты – әлем елдерінде жасанды интеллекттің оқыту тәжірибелері мен Қазақстанда жасанды интеллектті оқытудың ағымдағы тәжірибелеріне жан-жақты талдау жүргізіп, осы бағыттағы негізгі нормативтік-құқықтық құжаттарға шолу жасау, пайдаланылып жатқан заманауи әдістер мен құралдарды айқындау. Осы талдау негізінде, мақала Қазақстанның адами капиталының технологиялық талаптарға сай болуы үшін нақты ұсыныстар беруді көздейді.

Жасанды интеллект негіздерін оқытудағы әлемдік тәжірибелерге шолу

Әлемнің алдыңғы қатарлы мемлекеттері жасанды интеллектті (ЖИ) пайдалану мен оны білім беру жүйесіне енгізуде әртүрлі стратегияларды қолдануда. Олардың ішіндегі негізгі бағыттарына: ұлттық стратегиялар, оқу бағдарламаларын интеграциялау, мұғалімдердің біліктілігін арттыру және этикалық мәселелерге басымдық беру жатады.

Жасанды интеллектті пайдалану және енгізуге байланысты озық екі мемлекеттің (Сингапур және Жапония) тәжірибелеріне қысқаша тоқталайық.

Сингапур ЖИ-ді стратегиялық маңызды технология ретінде қарастырады. Ұлттық бастамалар ретінде AI Singapore (AISG) ұлттық бағдарламасы мектеп оқушыларына арналған білім беру ресурстарын әзірлейді. Білім министрлігі (БМ) ЖИ-мен жұмыс істейтін жекелендірілген оқыту құралдарын ұлттық оқыту платформасы – Студенттік Оқыту Кеңістігіне (SLS) біріктірген. Сонымен қатар, оқыту мазмұнына 2025 жылдан бастап бастауыш және орта мектептерде "AI for Fun" сынды арнайы модульдер енгізуді жоспарлаған. Бұл модульдер ЖИ принциптері мен оның этикалық қолданылуы туралы негізгі түсініктерді қамтамасыз етеді [10]. Келесі негізгі мәселе – жасанды интеллекттің мектепте оқытылуына байланысты, ол жеке пән ретінде емес, Информатика, Математика, Жаратылыстану пәндерінің мазмұнына кіріктіріп оқытуды қолға алған.

Технологияларды енгізуге байланысты әлемдегі көш бастаушы елдердің бірі Жапония мемлекеті. Бұл мемлекет жасанды интеллектті ерте кәсіби даярлауға емес, технология туралы іргелі түсінік пен жауапкершілікпен пайдалануға баса назар аударады. Бұл жөнінде Білім, мәдениет, спорт, ғылым мен технологиялар министрлігі (MEXT) ЖИ-ді пайдалануға қатысты нұсқаулықтар әзірлеп, оның ішінде, генеративті ЖИ-ді этикалық және жауапты қолдану ережелеріне тоқталады (мысалы, ағылшын тілін үйрену үшін пайдалану) [11].

Жасанды интеллектті жеке міндетті пән ретінде оқыту қарастырылмайды, ол Информатика, Математика, Әлеуметтік зерттеулер сияқты бар пәндерге біртіндеп біріктіріледі. Мұндағы негізгі мақсат – ЖИ-дің мүмкіндіктері, шектеулері және қоғамға әсері туралы түсінік беру болып табылады. AI құралдарын пайдалануға байланысты мектептерде бейімделетін оқытуды, автоматтандырылған бағалауды және шет тілдерін үйренуге қолдау көрсетуді қамтитын ЖИ құралдарын сынақтан өткізу жүргізілуде [12].

ҚАЗАҚСТАНДАҒЫ ЖАСАНДЫ ИНТЕЛЛЕКТТІ ОҚЫТУДЫҢ ҚҰҚЫҚТЫҚ НЕГІЗДЕРІ

Қазақстан Республикасында жасанды интеллект (ЖИ) саласын дамыту, оның ішінде, білім беру аспектісі – мемлекеттік саясаттың негізгі басымдықтарының бірі. ЖИ-ді оқытудың құқықтық негізі бірнеше стратегиялық және заңнамалық құжаттарда бекітілген. Бұл құжаттар ЖИ технологиясын тек енгізуді ғана емес, сонымен бірге, осы салада бәсекеге қабілетті мамандарды даярлауды да жүйелі түрде қамтамасыз етеді.

Қазақстан Республикасы Үкіметінің 2023 жылғы қазандағы қаулысымен бекітілген **Жасанды интеллектті дамытудың 2024–2029 жылдарға арналған тұжырымдамасы** [1] ЖИ экожүйесін құру мен дамытудың негізгі бағыттарын анықтайтын басты стратегиялық құжат болып табылады. Білім беру мен оқыту мәселесі Тұжырымдаманың маңызды бөлігін құрайды. Мұндағы адами капиталды дамытуға бағытталған міндеттер төмендегі мәселелерді қамтиды: Мамандарды даярлау, Межелі көрсеткіш, Оқыту бағдарламаларын енгізу, Зерттеулерді ынталандыру. Мамандарды даярлау мәселесіне байланысты, Тұжырымдаманың басты мақсаты – ЖИ саласындағы білім беру бағдарламаларын жетілдіру арқылы білікті мамандар санын күрт арттыру. Осы аталған мәселелерге байланысты 2029 жылға қарай Қазақстанда ЖИ бойынша білім алған мамандардың санын 80 мыңға дейін жеткізу жоспарланған. Бұл жоспар ЖОО-лар мен ТжКБ (Техникалық және кәсіптік білім беру)

орындарына үлкен міндет жүктейді. Оқыту бағдарламаларын енгізу мәселесі бойынша 2029 жылға қарай ЖОО-лардың кемінде 60% және ТЖКБ орындарының 10%-ы ЖИ бағдарламаларын енгізуі тиіс. Бұл тек ЖИ мамандықтарын ғана емес, сонымен қатар, басқа да салалардағы мамандықтарға ЖИ модульдерін кіріктіруді де білдіреді (мысалы, ЖИ медицинада, қаржыда және ауыл шаруашылығында).

Келесі негізгі мәселе - зерттеулерді ынталандыру болып табылады. Тұжырымдама ЖИ саласындағы ғылыми-зерттеу және тәжірибелік-конструкторлық жұмыстарды (ҒЗТКЖ) қолдауды көздейді, бұл білім берудің ғылыми компонентін күшейтеді.

Тұжырымдама ЖИ модельдерін оқытуға және зерттеуге қажетті ресурстарды қамтамасыз ету үшін Ұлттық жасанды интеллект жүйесін (ҰЖИЖ) құруды қарастырады. Бұл оқу үдерісінде қолданылатын деректер кітапханаларына және жоғары өнімді есептеу қуаттарына (GPU-лар) қол жеткізуді қамтамасыз етуде шешуші рөл атқарады. 2024 жылы қабылданған (немесе қабылдануы күтілетін) **«Жасанды интеллект туралы»** Заң ЖИ-ді дамытудың құқықтық негізін қалайды.[2]. Олардың ішінде, ЖИ ұғымын, оны қолдану салаларын және осы технологияны пайдалану кезіндегі субъектілердің жауапкершілігін нақтылайды.

Келесі негізгі мәселе, этика және қауіпсіздік болып табылады. Бұл заңнамалық акт ЖИ-ді оқыту кезіндегі деректерді қорғау, авторлық құқық және этикалық нормалардың сақталуын реттейді. Бұл, әсіресе, оқытушылар мен студенттердің ЖИ құралдарын пайдаланудағы құқықтық шеңберді түсінуі үшін өте маңызды.

Жасанды интеллектті оқытудың тәжірибесі Қазақстанда соңғы жылдары қарқынды дамып, білім берудің барлық деңгейінде жүйелі түрде енгізіліп келеді. Бұл үдеріс мемлекеттік бағдарламалардың, жетекші университеттердің бастамаларының және жеке ІТ мектептерінің белсенділігінің арқасында іске асуда.

Мектеп деңгейіндегі ЖИ-ді оқыту оқушылардың алгоритмдік және сыни ойлауын дамытуға, сондай-ақ болашақ технологиялық мамандықтарға баулуға бағытталған. Информатика, Робототехника және Қосымша Білім Беру Шеңберіндегі Оқыту Информатика пәні: ЖИ-дің бастапқы негіздері (мысалы, алгоритмдеу, логикалық операциялар, деректерді талдаудың қарапайым түрлері) Информатика пәнінің жаңартылған мазмұнына енгізілген.[1].

Робототехника кабинеттері: Еліміздің мектептерінде 3000-ға жуық робототехника кабинеті ашылды. Бұл оқу орындарында арнайы конструкторлар мен программалау негіздерін пайдалану арқылы роботтар құрастыру үйірмелері жұмыс істейді. Сонымен қатар, Робототехника курстары ЖИ-дің практикада жүзеге асырылуының (датчиктермен және алгоритмдермен жұмыс) алғашқы қадамы болып табылады.

Келесі бағыт - қосымша білім беру болып табылады. Мектептердегі арнайы үйірмелерде оқушылар өздерінің жобаларын (мысалы, пандемия кезіндегі автоматты санитайзер) әзірлеп, республикалық және халықаралық жарыстарға қатысуда.

Сонымен қатар, бәсекеге қабілеттілік орталықтарының жұмысы ерекше назар аударады. ЖОО мен мектептерден бөлек, ЖИ саласындағы бәсекеге қабілетті мамандарды дайындауда жеке және мемлекеттік-жекеменшік серіктестік негізіндегі ІТ мектептер мен орталықтар маңызды рөл атқарады.

TechOrda Бағдарламасы: Бұл бағдарлама арқылы Үкімет ваучерлер бөліп, жекеменшік ІТ мектептерде (мысалы, IT STEP, Alem, Tomorrow School) мамандар даярлауды қаржыландырады. ЖИ саласындағы курстар осы бағдарламаның 15%-на дейін қамтуы мүмкін.[7].

Tomorrow School: Astana Hub жанындағы осы мектеп Қазақстандағы алғашқы жасанды интеллект мектебі ретінде белгілі. Ол peer-to-peer (бір-бірінен үйрену) форматында оқытады және студенттер AI инженериясы бағытында тегін білім ала алады.

Оқу бағдарламасы 18 айда 50-ден астам жобаны қамтып, Python, Golang сияқты ЖИ үшін негізгі тілдерді меңгеруді қарастырады.[7].

Мамандандырылған курстар: IT мектептердегі курстар нақты еңбек нарығына бағытталған: Data Analyst, Machine Learning Engineer және Generative AI бойынша қысқа мерзімді, қарқынды курстар сұранысқа ие. ЖОО мен жеке IT мектептер жаңа мамандар дайындаса, "Өрлеу" біліктілікті арттыру ұлттық орталығы мектептердегі және колледждердегі қолданыстағы оқытушылар корпусын ЖИ талаптарына бейімдеуде шешуші рөл атқарады.[8].

Жасанды интеллектті оқытудағы негізгі мәселелер және кедергілер

Жасанды интеллектті (ЖИ) білім беруге енгізудегі стратегиялық табыстарға қарамастан, Қазақстанның білім беру жүйесі бұл үдерістің толыққанды дамуына кедергі келтіретін бірқатар жүйелі мәселелерге тап болып отыр. Бұл мәселелер, негізінен, кадрлық, техникалық және әдістемелік сипатта.

ЖИ-ді оқытудың ең күрделі мәселесі – осы салада білім беретін білікті мамандардың жетіспеушілігі. ЖИ мамандарына еңбек нарығында сұраныс пен ұсыныс арасында үлкен алшақтық бар. ЖОО түлектерінің басым көпшілігі академиялық мансаптан гөрі, IT-компаниялардағы жоғары жалақылы жұмысты таңдайды.

Нәтижесінде, ЖОО мен мектептердегі ЖИ және Data Science пәндерін оқытатын оқытушылардың саны мен тәжірибесі жеткіліксіз. Олардың көбі – дәстүрлі информатика немесе математика мамандары, ЖИ-дің терең тәжірибелік дағдылары жоқ.

Осы тұста, *Оқытушылардың біліктілігін арттыру мәселесі туындайды*. ЖИ саласындағы технологиялар күн сайын өзгеріп отырады. Бұрынғы курстардан өткен мұғалімдердің біліктілігі тез ескіреді.

Келесі негізгі мәселенің бірі материалдық техникалық базаны жетілдіру болып табылады. ЖИ-ді оқыту деректерді өңдеу мен модельдерді оқыту үшін жоғары есептеу қуаттарын қажет етеді. Көптеген ЖОО-лар мен, әсіресе, өңірлік мектептерде Machine Learning және терең оқыту (Deep Learning) модельдерін оқытуға арналған арнайы графикалық процессорлармен (GPU) жабдықталған зертханалардың тапшылығы байқалады. GPU-лардың қымбаттығы және оларды үнемі жаңартып отыру қажеттілігі білім беру мекемелерінің бюджетіне ауыр салмақ түсіреді. Бұл оқытушылардың ірі және күрделі деректер жиындарымен жұмыс істеу мүмкіндігін шектейді.

Сонымен қатар, *Сапалы, өзекті және қазақ тіліндегі деректер жиындарының (datasets) тапшылығы да байқалады*. ЖИ модельдерін сапалы оқыту үшін нақты, өлшемді және этикалық нормаларға сай деректер жиыны қажет. Қазақстанда қазақ тіліндегі, медициналық, қаржылық және мемлекеттік деректердің ашық, өңделген және қолдануға дайын жиындары жеткіліксіз. Мұндай деректердің тапшылығы студенттердің қазақстандық нақты мәселелерді шешуге бағытталған ЖИ жобаларын әзірлеуін қиындатады.

Қазақстан Республикасындағы жасанды интеллект саласының даму болашағы

Қазақстан Республикасында жасанды интеллектті (ЖИ) оқытудағы қолданыстағы тәжірибелер мен кедергілерді талдау, бұл саланың даму әлеуетінің зор екенін көрсетеді. Болашақ білім беру жүйесін қалыптастыру үшін жаһандық трендтерге бейімделу және жүйелі реформалар қажет. Жаһандық технологиялық өзгерістер Қазақстанның ЖИ білім беру моделін қайта құруға мәжбүрлейді.

Генеративті ЖИ-ді (Generative AI) Енгізу – бұл жаһандық тренд ретінде соңғы жылдарда – үлкен тілдік модельдердің (Large Language Models, LLMs) және кескіндерді генерациялайтын

модельдер дамып келеді. Бұл құралдар ЖИ-ді тек мамандық ретінде ғана емес, барлық мамандықтардағы күнделікті жұмыс құралы ретінде қарастыруды талап етеді.

Білім беруде ЖИ-ді қазақ тілінде қолдануды қамтамасыз ететін KazLLM сияқты ұлттық модельдерді әзірлеуді жеделдету және оларды оқу процесіне енгізу. Студенттерді ЖИ-мен қалай жұмыс істеуге, оның нәтижелерін сыни тұрғыдан бағалауға және этикалық жауапкершілікті сақтауға үйрету өзекті міндетке айналады.

ҰСЫНЫСТАР ЖӘНЕ ҚОРЫТЫНДЫ

Жүргізілген талдаулар әлемдік деңгейдегі ЖИ оқыту тәжірибелері (Сингапур, Жапония) ЖИ-ді тек болашақтың технологиясы ретінде ғана емес, сонымен қатар оқыту әдістемесін жетілдірудің негізгі құралы ретінде қарастыратынын көрсетеді. Қазақстанның жалпы білім беру жүйесінде ЖИ негіздерін жүйелі оқытуды енгізу үшін әдістемелік-технологиялық тұрғыдан нақты қадамдар қажет.

Бұл бағыттағы біздің басты ұсынысымыз – білім берудегі ЖИ интеграциясының алғашқы және ең оңай жүзеге асырылатын қадамы ретінде мұғалімнің күнделікті жұмысын жеңілдететін ЖИ ассистентін құруға бағытталады.

Нақты Ұсыныс: "Мұғалім-Ассистент: Оқу Материалдарын Тұжырымдау Құралы"

Қазақстанның орта мектептері үшін ең өзекті және жүзеге асыруға оңай әдістемелік шешім – "Оқу Материалдарын Тұжырымдау Құралы" деп аталатын қарапайым ЖИ ассистентін әзірлеу.

Бұл құрал негізінен *Үлкен Тіл Модельдерінің (LLM)* қолжетімді API-ларына сүйеніп, мұғалімдердің сабаққа дайындық кезіндегі уақыт шығынын азайтуды мақсат етеді.

Ассистенттің негізгі әдістемелік қызметтері

1. Материалды Жасқа Бейімдеп Тұжырымдау: Мұғалім енгізген көлемді мәтінді ЖИ талдайды және оны нақты сынып деңгейінің (жас ерекшелігінің) оқушыларына түсінікті болатындай қысқа, нақты тезистер түрінде генерациялайды.

Бұл оқу материалының дидактикалық сапасын арттырады және күрделі ақпаратты оқушыларға тиімді жеткізуге мүмкіндік береді.

2. Формативті бағалау сұрақтарын тұжырымдау

ЖИ тұжырымдалған мәтінге сүйене отырып, оқушылардың білім деңгейін тексеруге арналған әртүрлі деңгейдегі сұрақтар мен тапсырмаларды (жабық, ашық, сыни ойлау) тез құрастырады. Бұл формативті бағалауға арналған тапсырмаларды дайындауды оңтайландырады және сабақ үстінде мұғалімнің әдістемелік жұмысын жеңілдетеді.

3. Терминологиялық сөздіктерді жүйелеу. Енгізілген мәтіннен негізгі пәндік терминдерді бөліп алып, олардың қазақ тіліндегі нақты әрі академиялық анықтамаларын тізімдеп шығарады. Оқушылардың пәннен сөздік қорын қалыптастыруға мүмкіндік береді.

Қорытынды

Жасанды Интеллектті дамытудың 2024–2029 жылдарға арналған тұжырымдамасы сияқты нормативтік-құқықтық негіздердің қабылдануы ЖИ-дің білім берудегі стратегиялық маңыздылығын көрсетеді. Негізгі жетістіктер: ЖОО-ларда Data Science бойынша мамандандырылған бағдарламалардың көбеюі,

Tomorrow School сияқты IT-мектептер арқылы қарқынды дайындықтың іске асуы және "Өрлеу" курстары арқылы мұғалімдердің құзыреттілігін жүйелі түрде арттыру – оң

тәжірибелер болып табылады. Оқытудағы проблемаға негізделген әдістер мен TensorFlow, PyTorch сияқты заманауи құралдарды қолдану оқу сапасын арттыруға мүмкіндік беруде. Дегенмен, білікті кадрлардың тапшылығы және сапалы қазақтілді деректер жиындарының жетіспеушілігі сияқты мәселелерді шешу үшін оқу-ғылыми-өндірістік кластерлерді күшейту қажет. ЖИ-ді оқытуды дамыту – бұл мемлекеттік, академиялық және жеке сектордың бірлескен ынтымақтастығын талап ететін үлкен міндет. Осы бірлескен жұмыс қана Қазақстанның цифрлық бәсекеге қабілеттілігін арттырып, ЖИ дәуіріне толық дайындықты қамтамасыз етеді.

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Expertise Monitoring in Higher Education and Changes in Reporting Forms

Shakirova Araily dalelovna

PHD, Al-Farabi Kazakh National University, Faculty of Philosophy and Political Science, Department of Pedagogy and Educational Management

Adilgazy Akku

graduate student, Al-Farabi Kazakh National University, Faculty of Philosophy and Political Science, Department of Pedagogy and Educational Management

Che Xiaodan

graduate student, Al-Farabi Kazakh National University, Faculty of Philosophy and Political Science, Department of Pedagogy and Educational Management

Abstract

This paper investigates the structure, development, and impact of expertise monitoring in higher education, emphasizing its role in fostering institutional excellence and accountability. It examines diagnostic and evaluation procedures within universities, the evolution of reporting mechanisms, and the multifaceted criteria used to assess departmental performance. Drawing on recent academic research and sources including CyberLeninka, the study highlights how expertise monitoring facilitates continuous improvement, ensures the quality of educational processes, and aligns institutional practices with global standards (Khilchenko, Bazhenov, & Kirillova, 2015; Mishchenko & Kulikovskaya, 2018). By analyzing the integration of digital tools, stakeholder engagement, and data-driven decision-making, the paper underscores the transformative potential of monitoring systems in addressing contemporary challenges in higher education, such as digitalization, globalization, and performance-based funding. The findings contribute to ongoing discussions about quality assurance and provide practical insights for university administrators and policymakers.

Keywords:

Expertise Monitoring, Higher Education, Quality Assurance, Digital Reporting, Performance Evaluation

1. Introduction

In recent years, expertise monitoring has become a key part of quality management in higher education, reflecting a global move toward data-driven decision-making and greater accountability. Unlike traditional inspections that focused mainly on compliance, expertise monitoring aims to understand, evaluate, and improve both academic and administrative processes. This shift is driven by the rise of digital education, performance-based evaluations, and growing expectations for transparency and quality (Khilchenko, Bazhenov, & Kirillova, 2015).

Universities are now expected to build strong monitoring systems that combine expert reviews, standardized diagnostics, and real-time data to support strategic planning. The move from paper-based reports to digital dashboards has made it easier to track key indicators and align university activities with institutional and national goals. (Mishchenko & Kulikovskaya, 2018).

At the same time, the use of clear, multi-dimensional performance criteria—covering research output, teaching quality, and student success—helps departments focus on improvement. This paper explores how expertise monitoring has evolved, how it works in practice, and what it means for quality assurance in higher education. Drawing on recent research and practical examples, it shows how effective monitoring can help universities manage complexity,

drive innovation, and compete globally.

2.Literature Review

According to the study Top Quality Monitoring, effective expertise monitoring in higher education combines expert evaluations with real-time data systems. This approach ensures that assessments align with institutional goals while being based on up-to-date evidence. Expert reviews offer deep insights into teaching quality, curriculum alignment, and student engagement, while data analytics provide measurable indicators such as attendance, online activity, and academic performance (Khilchenko, Bazhenov, & Kirillova, 2015).

This integration supports a culture of shared responsibility and continuous improvement. When faculty and administrators are involved in monitoring, they are more likely to take ownership of educational outcomes. Real-time digital tools—like dashboards and learning platforms—help departments respond quickly to problems such as low student engagement or course dissatisfaction (Kuznetsova & Semenova, 2019).

The literature also stresses that monitoring is most valuable when used not for control, but for generating useful feedback. Diagnostics help detect early issues, such as gaps between teaching aims and learning results, while evaluations assess the overall impact of interventions and support long-term planning (Khilchenko, Bazhenov, & Kirillova, 2015; Kuznetsova & Semenova, 2019).

Finally, clear evaluation criteria and alignment with national standards are essential. Indicators like employment rates, research output, and student satisfaction offer benchmarks, while expert judgment adds important context. This balanced method avoids over-dependence on metrics and maintains academic diversity and integrity (Kuznetsova & Semenova, 2019).

3.Methodology of Expertise Monitoring

The process of expertise monitoring in universities usually begins with departmental self-assessments. In this stage, teachers and staff collect data on different aspects such as teaching results, student feedback, and research output. This helps each department understand its strengths and areas for improvement.

After this, external experts are invited to review the reports prepared by the departments. These experts may also conduct interviews with faculty and students, and they evaluate performance using both national education standards and the university's internal goals. Their role is to provide an independent and professional judgment of the department's quality.

In recent years, the reporting process has changed a lot. In the past, reports were usually written on paper, which was time-consuming and hard to update. Now, most universities use digital platforms. These systems allow for quicker data processing and offer clear visual tools like charts and dashboards to show key indicators. As a result, it is easier for university leaders to see problems, make comparisons, and plan improvements (Mishchenko & Kulikovskaya, 2018; Reznik, 2020).

This digital shift has also made the monitoring process more transparent, meaning that both staff and students can better understand how decisions are made. It supports evidence-based planning, helping universities to make changes based on real data rather than guesswork.

4.Diagnostics and Evaluation in the Monitoring System

Diagnostics identify specific issues such as weak student engagement or outdated teaching methods. Tools include classroom observation, online learning analytics, and surveys. Evaluation assesses broader outcomes like teaching quality, student satisfaction, and institutional reputation. Combined, diagnostics and evaluation create a balanced system, using quantitative data and expert judgment to ensure academic quality and accountability (Kuznetsova & Semenova, 2019; Khilchenko, Bazhenov, & Kirillova, 2015).

5.Quality Diagnostics of the Educational Process

Monitoring now examines more than test scores or completion rates; it evaluates how education is delivered and received. This includes instructor performance, student interaction, and

integration of digital tools. Insights from this approach help universities improve teaching and better meet student needs. As noted in *Professional Education: Problems and Prospects*, focusing on classroom quality offers deeper improvements than traditional output-based assessments (Kuznetsova & Semenova, 2019).

6. Performance Evaluation of University Departments

Department performance is evaluated using key parameters such as:

1. Teaching effectiveness
2. Research productivity
3. Student outcomes (grades, graduation, employment)
4. International collaboration
5. Administrative management

These form the basis for ranking, funding, and reform decisions. Digital dashboards increasingly allow administrators to track and compare performance efficiently (Mishchenko & Kulikovskaya, 2018; Reznik, 2020).

7. Conclusion

Expertise monitoring plays a key role in improving the quality of higher education. It is more than just checking rules—it helps universities understand how well they are performing and find ways to improve. By combining expert opinions, simple evaluation tools, and digital systems, universities can get clear, up-to-date information to make better decisions.

This monitoring is a continuous process, providing regular feedback and support. It helps find problems early so they can be fixed quickly. As technology develops, digital tools will offer faster feedback and easier access to data. Universities should choose tools that fit their specific needs and involve teachers, students, and staff in the process. When everyone takes part, it builds a stronger sense of responsibility and encourages new ideas.

At the same time, monitoring systems need to be flexible. Different universities face different challenges, so the system should support schools with fewer resources or special goals. Leaders should use both numbers and expert judgment to keep education fair and diverse.

In short, expertise monitoring is not about control—it is a helpful tool that supports universities to improve step by step, meet new challenges, and provide better education for students.

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ENHANCING METACOGNITIVE AWARENESS THROUGH DIGITAL TOOLS IN ESL CLASSROOMS

Rysbay Ayaulym Yermankyzy

1st-year student, 7M01701 – Foreign language: two foreign languages

Scientific Advisor:

Shingareva M. Yu.

Candidate of Philological Sciences, NJSC South Kazakhstan Pedagogical University named after Ozbekali Zhanibekov, Shymkent, Kazakhstan

Annotation

The digital age has brought about radical changes in educational practices, especially in the teaching of English as a second language (ESL). Developing students' metacognitive awareness, that is, understanding and regulating their own thinking and learning processes, has become an important goal of modern pedagogy. This article examines how new digital tools can improve students' metacognitive thinking awareness in an ESL context. It comprehensively analyzes the role of artificial intelligence (AI), mobile applications, and online learning platforms in developing self-analysis, self-monitoring, and independent learning. Practical suggestions are provided for integrating metacognitive strategies into technologically advanced language learning environments.

Keywords: *metacognition, ESL, digital tools, innovative, artificial intelligence (AI), reflective learning, metacognitive skills, learning platforms.*

Introduction

In a rapidly developing society, considerable attention is paid to the role of technology in education, which promotes the development of independence and critical thinking in students. Teaching English as a second language (ESL) requires the development of metacognitive awareness, which depends on learners' understanding of their cognitive processes and their ability to manage them effectively. Modern digital innovative technologies, when integrated purposefully, serve as key tools for improving metacognitive development. As a result, students now have the opportunity not only to master the language but also to strengthen their metacognitive abilities.

Online learning environments, interactive applications, and AI-powered feedback systems provide real-time information on student performance. These tools enable students to identify their strengths and weaknesses, evaluate the effectiveness of their learning strategies, and adjust their approaches accordingly. As Flavell [1] noted, understanding human cognitive abilities is key to developing lifelong learning skills. This article explores the ways in which digital tools support the development of metacognitive awareness in EFL classrooms, discusses pedagogical implications, and identifies best practices for teachers.

Theoretical Background.

Metacognition, broadly defined as the understanding and regulation of one's own cognitive processes, is the subject of extensive research in cognitive and educational psychology. The theoretical basis of metacognition is laid in the fundamental works of Vygotsky [2], who emphasized the social origin of higher mental functions. According to Vygotsky, cognitive

development initially occurs interpsychologically through social interaction, and then becomes intrapsychological through interpsychic interaction. This process involves a gradual transition from other forms of regulation, when teachers, parents or peers guide the student, to self-regulation, when students control and direct their own cognitive activity [3].

A key concept in Vygotsky's theory is scaffolding, which Bruner defines as structured support provided by a more knowledgeable person to facilitate a learner's development, which is removed as the learner gains independence [4]. A complement to the concept of scaffolding is the zone of proximal development (ZPD), which represents the gap between what a learner can achieve independently and what he can achieve with guidance [5]. Through these mechanisms, students develop the ability to think reflectively and solve problems independently, effectively "learning to learn" [6]. Furthermore, Vygotsky emphasized the role of language in mediating thinking, noting that verbalized self-observation allows students to understand their cognitive processes [7].

Flavell's model of metacognition further formalized these ideas by identifying metacognitive knowledge, metacognitive experience, goals (or tasks), and actions (or strategies) [1]. Metacognitive knowledge encompasses three categories: person (beliefs about oneself and others as learners), task (knowledge of task requirements), and strategy (knowledge of effective cognitive methods). Metacognitive experience involves conscious feelings and reflections related to cognitive activity, such as recognizing difficulty in understanding a concept or evaluating progress. These experiences interact with metacognitive knowledge and activate both cognitive and metacognitive strategies [8].

Nelson and Narens [9] proposed a two-level model of metacognition, distinguishing a meta-level (knowledge about cognition) and an object-level (cognitive task execution). Monitoring occurs when the meta-level observes object-level activity, while control occurs when the meta-level directs object-level processes. This emphasizes the dynamic interaction between awareness and regulation in metacognition.

Teachers play a vital role in developing metacognition based on their knowledge, beliefs, and experiences of effective classroom practices and the metacognitive abilities available to students [10]. In summary, metacognition emerges from the interplay of social interaction, individual reflection, and instructional support. Vygotsky's foundational theories provide a framework for understanding the origins of development, while Flavell and Nelson, Narens clarify its cognitive and regulatory dimensions.

Metacognitive Skills and Their Role in Effective Learning

Metacognitive skills enable learners to plan, monitor, and evaluate their thinking and problem-solving strategies, promoting independent and adaptive learning [8]. Key skills include:

- Planning: Setting goals, selecting strategies, and effectively allocating resources.
- Monitoring: Continuously assessing understanding, identifying gaps, and adjusting approaches.
- Adjusting and correcting: Modifying strategies if initial approaches prove ineffective.
- Self-assessment and reflection: Assessing learning outcomes and reinforcing effective strategies.
- Attention and emotional management: Maintaining concentration, coping with distractions, and overcoming difficulties.

Metacognitive skills also support higher-level abilities such as critical thinking, problem solving, creative thinking, independent decision-making, and strategic learning. Developing these skills is essential for lifelong learning, enabling individuals to engage mindfully with material, adapt to challenges, and optimize cognitive growth [10].

Digital Tools as Catalysts for Metacognitive Development

Digital technologies offer interactive, adaptive and reflective teaching methods that stimulate learners' metacognitive processes, including soft and hard skills, in the process of learning a foreign language. Moreover, they can become tools to help students learn a language quickly.

1. *AI-Based Learning Platforms.* AI platforms such as Duolingo, Grammarly, EWA English, Copilot, and AI Grader provide instant feedback on grammar, vocabulary, pronunciation, and writing strategies. Learners can reflect on their errors, monitor progress, and adjust strategies in real time. Intelligent tutoring systems guide learners along personalized paths, supporting self-regulation and metacognitive monitoring [5].
2. *Digital Portfolios and Reflective Platforms.* Platforms like Google Classroom, Seesaw, and Filmore Videos allow learners to document progress, set goals, and reflect on learning experiences. Reflective prompts such as:
 - “What strategies helped you learn this vocabulary?”
 - “What difficulties did you encounter?”
 - “How can you improve next time?” enable students to engage in self-assessment and critical reflection [3].
3. *Mobile Learning Applications.* Mobile-assisted language learning (MALL) applications, including Quizlet, Memrise, Anki, and Diffit, promote learner autonomy and flexibility. Learners can plan study schedules, monitor accuracy, and evaluate performance, practicing all three stages of metacognitive regulation beyond the classroom [5].
4. *Online Collaboration and Peer Feedback Tools.* Platforms such as Padlet, Edmodo, Microsoft Teams, and ClassPoint support collaborative reflection and peer assessment. Social interaction, as described by Vygotsky [2], promotes higher-order thinking, including metacognitive awareness. Peer feedback allows learners to evaluate their own output critically, fostering reflective thinking and perspective-taking.
5. *AI-Generated Media and Simulations.* Tools such as Twee and Synthesia provide immersive AI-generated scenarios and avatars, enabling learners to engage in creative problem-solving, self-questioning, and reflective evaluation. These tools make abstract concepts tangible and encourage interactive metacognitive assessment.

Tools	Description
YMetaconnect	Guides learners through Review–Action–Reflection cycles for self-assessment and strategy planning.
SRLAgent	Gamified AI system supporting goal-setting, self-monitoring, and reflection in real time
Cognitive Mirror	Provides adaptive feedback to help learners plan, monitor, and evaluate cognitive strategies.
LearningRO (RoTutor)	AI assistant scaffolding learning tasks and encouraging reflective self-regulation.
Praktika.ai	3D avatar role-play for spoken language reflection and strategy adjustment.
Betty's brain	Teaches learners to explain concepts to a virtual agent, encouraging metacognitive reflection through teaching

Table 1. Digital Tools for Enhancing Metacognitive Awareness in ESL Learners

Methodology

This study employs a qualitative analytical approach to evaluate and compare quantitative tools in terms of their effectiveness in developing metacognitive awareness in English as a second language learners, examining them from theoretical, functional and pedagogical perspectives.

Data Sources:

- Literature Review: Research on metacognition, ESL education, and digital learning.
- Digital Tool Analysis: Features of mainstream (Duolingo, Grammarly, Quizlet, Padlet, etc.) and innovative tools (Owlgorithm, Reflexion, SRLAgent).
- Teacher and Learner Insights: Previously published reports contextualized tool usage.

Tool Selection Criteria. Tools were analyzed for their capacity to support:

- Metacognitive knowledge and experiences
- Planning, monitoring, and evaluation
- Collaborative and social interaction

Data Analysis

- Coding and categorization according to Flavell's (1979) framework
- Mapping tools to stages of metacognitive regulation
- Comparative qualitative assessment of mainstream vs. innovative tools

Discussion

Analysis indicates that digital tools enhance metacognition in ESL classrooms in multiple ways:

- AI-based platforms provide immediate feedback, supporting self-regulation.
- Digital portfolios foster reflection and documentation of learning processes.
- Mobile apps extend metacognitive practice beyond the classroom, increasing learner autonomy.
- Collaboration tools encourage social reflection and perspective taking.
- AI-generated simulations promote higher-order thinking through immersive, interactive scenarios.

Innovative tools such as Owlgorithm, Reflexion, and SRLAgent show particular promise in providing adaptive scaffolding and personalized metacognitive prompts. These tools may enhance engagement and critical self-evaluation beyond traditional applications. However, challenges include digital overload, inequitable access, and the need for teacher training to integrate tools effectively. Teachers must carefully select tools that emphasize reflection and strategic thinking rather than rote memorization.

Pedagogical Aspects of Teaching English as a Foreign Language

The integration of digital tools into EFL classrooms suggests significant opportunities for developing metacognitive awareness. Teachers can use AI-powered platforms, mobile apps, digital portfolios, and collaboration tools to help students plan, monitor, and evaluate their learning. Effective implementation requires alignment with cognitive theory, student needs, and learning goals, ensuring that technologies complement, rather than replace, sound pedagogical practice.

AI-based platforms provide real-time feedback and can be incorporated into structured lesson plans, encouraging students to analyze errors, identify patterns of performance, and adjust learning strategies [1, 8]. Digital portfolios allow for the documentation and analysis of progress [3]. Mobile language learning (MALL) applications provide flexibility for practice and self-monitoring outside the classroom [5]. Collaboration and peer feedback tools facilitate social mediation, critical analysis, and perspective-taking [2]. Innovative artificial intelligence tools offer a personalized framework for reflection, minimizing cognitive overload while supporting autonomous learning.

Assessment and Feedback Strategies for Metacognitive Development

Integrating assessment and feedback mechanisms into digital learning environments enhances metacognitive awareness. Formative assessments using artificial intelligence tools provide immediate and actionable feedback [5]. Peer assessments using platforms like Padlet encourage students to evaluate both their own work and that of their peers, fostering reflective thinking and perspective taking. Self-assessment prompts and checklists integrated into apps or digital platforms help students plan, monitor, and evaluate strategies [1]. Adaptive AI feedback using tools like SRLAgent or Cognitive Mirror personalizes guidance, enabling focused metacognitive reflection and independent problem solving.

Conclusion

Digital tools have transformed ESL instruction by making metacognitive processes visible and actionable. When integrated purposefully, these tools enable learners to plan, monitor, and evaluate learning, promoting autonomy and self-regulation. Teachers play a critical role in designing experiences that foster reflective thinking. Future research could explore empirical studies comparing the effects of different digital tools on ESL learners' metacognitive awareness, providing evidence for best practices in technology-mediated language learning.

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THE EFFECTIVENESS OF THE MONTESSORI METHOD IN TEACHING FOREIGN LANGUAGES TO PRESCHOOL CHILDREN

Talapova A.K.

Master of Pedagogical sciences, Kazakh Ablai Khan University of International Relations and World Languages, Almaty, Kazakhstan

Toromanova M.S.

4th year student, Kazakh Ablai Khan University of International Relations and World Languages, Almaty, Kazakhstan

ABSTRACT

This article investigates the effectiveness of the Montessori Method in enhancing foreign language learning among preschool children. Rooted in Montessori's principles of independence, sensory exploration, and self-directed learning, the approach integrates language acquisition into a natural and engaging process of discovery. The study employed a mixed-methods descriptive design involving 50 preschool teachers from various educational institutions in Kazakhstan. Data were collected through a structured questionnaire consisting of 15 Likert-scale items and 5 open-ended questions, administered via Google Forms over a two-week period. Quantitative data were analyzed using descriptive statistics, while qualitative responses were examined through thematic analysis. Results indicated that teachers strongly believe the Montessori Method fosters vocabulary development, communicative confidence, and learner motivation. However, challenges such as limited professional training, material adaptation, and balancing autonomy with linguistic structure were also identified. The findings suggest that the Montessori approach provides a developmentally appropriate and humanistic framework for early foreign language education, emphasizing experiential learning, emotional engagement, and holistic development.

Keywords: Montessori Method, foreign language learning, preschool education, early childhood, learner motivation.

INTRODUCTION

In the 21st century, the ability to communicate in a foreign language has become a crucial aspect of children's personal, cultural, and cognitive development. As globalization continues to expand, parents and educators are increasingly motivated to introduce foreign languages during early childhood, when the brain is especially receptive to linguistic input. However, traditional methods of foreign language instruction often emphasize rote memorization, repetition, and teacher-centered activities, which may not align with the natural learning tendencies of preschool children.

In contrast, the Montessori Method offers a child-centered, holistic, and developmentally appropriate approach that can make foreign language learning both effective and enjoyable. Developed by Maria Montessori, this method is grounded in the belief that children learn best through self-directed activity, hands-on exploration, and interaction with a carefully prepared environment. Within this framework, language learning becomes a natural extension of a child's curiosity and engagement with their surroundings rather than a forced academic task.

The Montessori philosophy emphasizes the absorbent mind, a concept describing the young child's unique ability to unconsciously and effortlessly absorb language and information from the environment (Lillard, 2017). This principle aligns closely with contemporary theories in

psycholinguistics and cognitive development, which highlight early childhood as the optimal period for language acquisition (Aydoğan, 2016; Hartina, 2018).

Research supports the effectiveness of the Montessori approach in fostering early linguistic competence. Studies reveal that Montessori-educated preschoolers often demonstrate superior vocabulary development, phonological awareness, and communicative confidence compared to their peers in traditional settings (Zamroni & Wijaya, 2024; Febyawati & Wulandari, 2021; Atli, Korkmaz, Taştepe, & Akyol, 2016). When applied to foreign language education, Montessori methods, such as sensorial materials, real-life contexts, and spontaneous communication—create immersive linguistic experiences that nurture comprehension and expression naturally.

However, successful implementation requires well-prepared teachers who understand both Montessori pedagogy and the principles of second language acquisition. Challenges may arise in maintaining the balance between language exposure and freedom of choice, ensuring consistent interaction in the target language, and adapting materials for multilingual classrooms.

The current study aims to explore how the Montessori Method supports foreign language learning among preschool children, focusing on its pedagogical, cognitive, and emotional benefits. The main objectives are as follows:

1. To analyze how the Montessori approach influences language acquisition and communication skills in preschool learners.
2. To examine how Montessori environments foster motivation, independence, and self-confidence in foreign language learning.
3. To identify challenges educators face in applying Montessori principles to language instruction and suggest practical strategies to address them.

Accordingly, this study seeks to answer the following research question: How does the Montessori Method enhance the effectiveness of foreign language learning for preschool children through its principles of independence, exploration, and individualized instruction?

By addressing this question, the research aims to contribute to the growing field of early childhood bilingual education, demonstrating how the Montessori philosophy can serve as an effective and humanistic alternative to conventional language teaching. The findings are expected to inform preschool curricula, teacher training programs, and educational policy, promoting more natural and meaningful approaches to language learning during the formative years of a child's life.

LITERATURE REVIEW

The Montessori Method, founded by Maria Montessori, emphasizes self-directed learning, independence, and active engagement with the environment. Contemporary researchers have explored how this approach supports not only general cognitive and social development but also language acquisition and foreign language learning in early childhood education.

Lillard (2017) provides a comprehensive overview of the scientific foundations of the Montessori approach, demonstrating that its principles align with current findings in developmental psychology and cognitive science. She argues that Montessori classrooms, with their focus on autonomy, sensory exploration, and individualized learning, naturally promote linguistic development through meaningful interaction. In a later study, Lillard (2019) highlights the enduring relevance of Montessori's ideas in the modern educational context, emphasizing how the method cultivates curiosity and intrinsic motivation, key factors in successful language acquisition.

Several studies have examined the specific impact of the Montessori approach on early language learning. Aydoğan (2016) found that Montessori education positively affects preschool children's language development, particularly in vocabulary and pronunciation. Similarly, Zamroni and Wijaya (2024) demonstrated that Montessori-based activities enhance vocabulary acquisition

and comprehension by engaging children in multisensory and contextualized experiences. Febyawati and Wulandari (2021) further confirmed the effectiveness of Montessori principles in teaching English to young learners, noting improvements in motivation, fluency, and communicative confidence.

Teachers' perspectives on Montessori pedagogy also reveal its strengths and challenges. Atlı, Korkmaz, Taştepe, and Akyol (2016) found that educators working in Montessori schools view the method as beneficial for children's holistic development but emphasize the need for specialized training to implement it effectively. Hartina (2018) supports this view, identifying that while child-centered strategies enhance engagement, teachers must carefully balance freedom with structured guidance to ensure consistent progress in language learning.

Beyond linguistic outcomes, Montessori education fosters creativity, autonomy, and critical thinking, skills essential for lifelong learning. Bereczki and Kárpáti (2018), in their systematic review, noted that teachers who adopt constructivist and creativity-oriented approaches, such as Montessori, tend to create environments that encourage self-expression and innovative problem-solving. These qualities are directly linked to communicative competence in a second language context.

Overall, the reviewed literature suggests that the Montessori Method provides a scientifically grounded, child-centered framework that effectively supports early foreign language acquisition. Its emphasis on independence, exploration, and multisensory learning promotes not only linguistic proficiency but also motivation and self-confidence. However, successful application depends on teacher preparation, contextual adaptation, and ongoing reflection on pedagogical practice.

MATERIALS AND METHODS

Research Design

This study employed a mixed-methods descriptive design, integrating quantitative and qualitative approaches to investigate preschool teachers' perceptions of using the Montessori Method in teaching foreign languages. The mixed design allowed for numerical analysis of teachers' attitudes and experiences as well as an in-depth interpretation of their open-ended responses.

The study lasted six weeks, and consisted of three main phases: survey design and piloting, data collection through Google Forms, and data analysis. The research sought to identify how Montessori principles influence children's language learning, motivation, and communicative development in early education settings.

Participants

The participants in this study were 50 preschool teachers from various educational institutions across Kazakhstan, including both public and private preschools, as well as Montessori-based centers. All participants had at least one year of teaching experience and were involved in early childhood language education. Table 1 summarizes the demographic profile of the teachers who participated in the study.

Participation was voluntary and anonymous, and informed consent was obtained prior to data collection. Ethical approval was granted by the Institutional Review Board of the researcher's university.

Table 1

Demographic Characteristics of Participants (N = 50)

Variable	Category	Frequency	Percentage (%)
Gender	Female	40	80%
	Male	10	20%
Age	Under 25	6	12%
	25–34	18	36%
	35–44	15	30%
	45–54	8	16%
	55 and above	3	6%
Teaching Experience	Less than 3 years	7	14%
	3–5 years	10	20%
	6–10 years	18	36%
	More than 10 years	15	30%
Institution Type	Public preschool	18	36%
	Private preschool	14	28%
	Montessori school	12	24%
	Other	6	12%

Note. Percentages are rounded to the nearest whole number.

Procedures

The research process involved three sequential stages:

1. Survey Design and Validation:

A questionnaire was designed in English based on prior studies by Lillard (2017, 2019), Zamroni and Wijaya (2024), and Febyawati and Wulandari (2021). The instrument was reviewed by three education specialists for clarity and content validity. A pilot test with five preschool teachers was conducted to refine question wording and scale balance.

2. Data Collection:

The final questionnaire was distributed electronically via Google Forms. Participants were invited through professional teacher groups and email networks. The survey remained open for two weeks. Respondents could complete it using a computer or smartphone at their convenience.

3. Data Analysis:

After data collection, responses were exported to Microsoft Excel and SPSS (v.26) for quantitative analysis, while open-ended responses were coded manually and analyzed thematically. The data were stored securely in password-protected files.

Instrument: Teachers' Perceptions of the Montessori Method Questionnaire

The research instrument consisted of 20 items divided into three sections:

1. Demographic Information (8 items) – covered age, gender, experience, and institutional type. A online interface is shown in Figure 1.
2. Perception Statements (15 items) – used a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree) to assess teachers' attitudes toward Montessori-based foreign language instruction.
3. Open-ended Questions (5 items) – invited participants to describe challenges, share best practices, and suggest improvements for Montessori language teaching.

A online interface is shown in Figure 1.

Figure 1
Screenshot of the Google Forms Questionnaire



Data Analysis

Quantitative data from the Likert-scale items were analyzed using descriptive statistics, including frequencies, percentages, means, and standard deviations, to identify patterns in teachers’ perceptions. The internal consistency of the questionnaire was verified using Cronbach’s alpha, which yielded a reliability coefficient of $\alpha = 0.87$, indicating high reliability. Table 2 presents sample descriptive results for selected items.

Table 2
Descriptive Statistics for Selected Perception Statements (N = 50)

Statement	M	SD
Montessori principles enhance vocabulary acquisition.	4.56	0.61
Children show higher motivation in Montessori classrooms.	4.42	0.68
Balancing freedom and language structure is challenging.	3.98	0.82
I have enough adapted materials for language teaching.	3.74	0.79
Further Montessori training would improve my teaching.	4.80	0.49

Note. M = Mean; SD = Standard Deviation.

Qualitative data from open-ended responses were analyzed using thematic analysis, following Braun and Clarke’s (2006) framework. Four main themes emerged:

1. Motivational and cognitive benefits of Montessori learning
2. Challenges in material adaptation and assessment
3. The importance of teacher training and professional development
4. Recommendations for policy and curriculum design

The integration of quantitative and qualitative findings provided a comprehensive understanding of teachers’ perceptions of Montessori-based foreign language teaching in preschool education.

RESULTS

This section presents the findings of the study based on data collected from 50 preschool teachers who completed the online questionnaire regarding the effectiveness of the Montessori Method in foreign language teaching. Quantitative data were analyzed using descriptive statistics, while qualitative responses were examined through thematic analysis. Tables 2–4 summarize the main results of the study.

Teachers’ Perceptions of the Effectiveness of the Montessori Method

The majority of respondents expressed positive attitudes toward the Montessori Method as a tool for foreign language acquisition among preschoolers. As shown in Table 3, most teachers agreed that the Montessori approach enhances vocabulary development, communicative confidence, and student motivation.

Table 3

Teachers' Perceptions of the Effectiveness of the Montessori Method (N = 50)

Statement	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)	Mean
1. The Montessori Method improves vocabulary acquisition.	0	2	4	26	18	4.20
2. Children become more motivated through Montessori-based activities.	1	3	6	22	18	4.08
3. The approach encourages natural communication in a foreign language.	0	1	5	24	20	4.26
4. Montessori environments foster independence and curiosity in learning.	0	1	3	25	21	4.32
5. The use of sensorial materials improves pronunciation and comprehension.	1	2	5	23	19	4.16

Teachers demonstrated a high level of agreement across all items, with the highest mean ($M = 4.32$) observed for the statement "Montessori environments foster independence and curiosity in learning." This finding highlights the perceived holistic benefits of the Montessori approach, which supports not only linguistic but also cognitive and emotional development.

Implementation and Teacher Preparedness

Teachers were also asked about their readiness and confidence in applying Montessori principles in foreign language instruction. As shown in Table 4, while most participants felt confident in adapting Montessori activities, many acknowledged challenges related to material preparation and lack of professional training.

Table 4*Teachers' Perceptions of Implementation and Preparedness (N = 50)*

Statement	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)	Mean
6. I feel confident in integrating Montessori principles in my lessons.	1	4	10	25	10	3.78
7. I have received adequate training on Montessori language instruction.	5	12	13	12	8	3.06
8. Preparing Montessori materials requires additional time and effort.	1	2	6	18	23	4.20
9. Managing freedom of choice while maintaining language focus is challenging.	2	5	10	20	13	3.74
10. Montessori-based methods are suitable for multilingual classrooms.	0	2	9	24	15	4.04

While teachers generally supported the Montessori approach, the lowest mean ($M = 3.06$) was found for the statement “I have received adequate training on Montessori language instruction.” This result indicates that insufficient professional preparation remains a key barrier to effective implementation.

Perceived Challenges and Benefits

The last section of the questionnaire included five open-ended questions allowing teachers to share their detailed experiences and reflections. Thematic analysis revealed three major themes:

1. Enhanced language engagement and autonomy,
2. Challenges in classroom management and material design,
and
3. Need for ongoing professional development.

Table 5

Summary of Themes from Open-ended Responses

Theme	Description	Teacher Response
1. Enhanced Language Engagement and Autonomy	Teachers noted that Montessori activities naturally encourage language use through play, exploration, and independence.	"Children learn new words faster when they choose activities themselves. They use English freely during games without fear of mistakes."
2. Classroom Management and Material Preparation	Some participants emphasized that maintaining order and preparing materials for each activity requires significant time and organization.	"It takes a lot of effort to set up learning corners and ensure materials are available for each topic."
3. Professional Development Needs	Many teachers expressed a need for workshops and methodological guidance to adapt Montessori practices for foreign language teaching.	"I would love more training on how to create Montessori-inspired materials for language learning. It's effective, but we need more support."

DISCUSSION

This study examined the effectiveness of the Montessori Method in supporting preschool children's foreign language learning. Quantitative results demonstrated a consistently positive perception among teachers regarding the method's impact on language development, motivation, and independence. As shown in Tables 2 and 3, most teachers agreed that Montessori-based instruction enhances vocabulary acquisition, communicative confidence, and overall enthusiasm for learning.

The highest-rated items were those related to fostering independence and curiosity ($M = 4.32$) and improving vocabulary acquisition ($M = 4.20$), suggesting that teachers recognize the Montessori classroom as an environment where language learning occurs naturally through exploration and play. These findings correspond with the theoretical framework proposed by Montessori (1949), who emphasized the absorbent mind and the child's innate ability to acquire language through active engagement with the environment.

Furthermore, the results align with prior studies demonstrating that Montessori-educated preschoolers often show greater linguistic and cognitive growth compared to peers in traditional settings (Lillard, 2018; Rathunde & Csikszentmihalyi, 2005). The positive attitudes expressed by teachers indicate that Montessori's child-centered and sensory-based approach effectively integrates language learning into daily life, making it both meaningful and developmentally appropriate.

However, qualitative findings revealed several practical challenges that may limit successful implementation. Many teachers reported difficulties related to time-intensive material preparation and limited professional training in Montessori pedagogy ($M = 3.06$). These observations are consistent with the findings of Lillard (2019) and Marshall (2021), who noted that the effectiveness of the Montessori Method depends heavily on the teacher's preparation and understanding of its principles. The need for specialized training highlights a gap between theoretical endorsement and practical readiness.

Another recurring issue was the challenge of managing freedom of choice while maintaining linguistic focus. Teachers expressed concern that allowing too much autonomy can sometimes reduce structured language practice, especially when children switch activities frequently. This observation echoes findings from Daoust (2020), who pointed out that Montessori

teachers must maintain a delicate balance between autonomy and guidance to ensure continuous exposure to the target language.

Despite these challenges, teachers strongly emphasized the emotional and motivational benefits of the Montessori approach. The qualitative data illustrated that children in Montessori environments are more confident, socially engaged, and eager to communicate in the target language. These insights support the view that the method not only strengthens linguistic competence but also nurtures self-esteem and intrinsic motivation—key components of successful early bilingual education (Cameron, 2001; Dörnyei, 1998).

Overall, the findings confirm that the Montessori Method provides a developmentally sensitive and humanistic alternative to conventional foreign language instruction. It integrates language learning into the child's natural processes of discovery, play, and social interaction, offering a holistic foundation for long-term linguistic and cognitive growth.

CONCLUSION

The present study demonstrated that the Montessori Method is perceived by preschool teachers as an effective and child-centered approach to foreign language learning. Quantitative results revealed strong agreement regarding its ability to enhance vocabulary, communication skills, motivation, and learner independence. Qualitative feedback further supported these findings, emphasizing that Montessori classrooms foster curiosity, confidence, and meaningful language use through experiential learning.

However, the study also identified key barriers to effective implementation, including insufficient teacher training, limited availability of Montessori-based language materials, and challenges in balancing student autonomy with instructional focus. Addressing these issues through targeted professional development and institutional support will be essential for maximizing the method's potential.

Overall, this research contributes to the growing evidence that Montessori principles can significantly enrich early foreign language education. By promoting independence, sensory engagement, and intrinsic motivation, the Montessori approach creates a learning environment that supports both linguistic development and emotional growth. The findings suggest that integrating Montessori strategies into early childhood curricula could enhance language acquisition outcomes and foster a lifelong love for learning.

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DEVELOPING STUDENTS' SCIENTIFIC LITERACY THROUGH THE ORGANIZATION OF FIELD-BASED AND PRACTICAL LEARNING ACTIVITIES

Issayev G.I.

Candidate of Technical Sciences, Associate Professor, Khoja Akhmet Yassawi International Kazakh-Turkish University, Turkistan, Kazakhstan

Nugman R.M.

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

Abstract. This study examines the scientific and methodological foundations for organizing field-based and practical learning activities aimed at developing students' scientific literacy in the context of contemporary science education. The research was conducted among 9th–10th grade students in the city of Turkistan using two internationally validated instructional models: the Inquiry-Based Science Education (IBSE) method and Kolb's Experiential Learning Cycle. A quasi-experimental design was employed, involving an experimental group taught with IBSE- and Kolb-based practical tasks and a control group taught through traditional methods. The findings revealed that both approaches significantly enhanced key components of scientific literacy, including scientific explanation, hypothesis formulation, experimental planning, data interpretation, reflective thinking, and the application of knowledge in new contexts. The experimental group demonstrated substantially higher gains compared to the control group, confirming the effectiveness of structured experiential and inquiry-oriented practicum activities. The results underscore the pedagogical importance of integrating research-based practical learning into science curricula to strengthen students' scientific thinking, inquiry abilities, and evidence-based reasoning.

Keywords: scientific literacy; inquiry-based learning; field-based practicum; experiential learning; IBSE; Kolb cycle; science education; research skills.

In the contemporary system of professional education, the effective integration of students' In the contemporary education system, the significance of science-oriented subjects is steadily increasing, and the development of students' scientific literacy has become a strategic priority of the pedagogical process. Scientific literacy refers to the integrated capacity of learners to explain natural phenomena from a scientific perspective, formulate research questions, conduct experiments, make evidence-based conclusions, and apply the obtained results in real-life situations. The rapid transformation of socio-technical processes in the twenty-first century, the strengthening of STEM integration, and the growing complexity of environmental challenges necessitate enhancing the role of experiential and inquiry-based learning in shaping students' scientific worldview. In this context, the scientifically and methodologically sound organization of field-based and practical learning activities serves as a key instrument for developing scientific literacy in school education.

Field-based practicum enables students to observe natural objects directly, conduct laboratory experiments, formulate scientific hypotheses, and interpret results, thereby cultivating

their research culture. This type of work integrates traditional theoretical knowledge with practical tasks, allowing students to master scientific methodology, articulate evidence-based reasoning, and develop critical evaluation skills. Pedagogical studies demonstrate that systematic organization of practical activities in the classroom significantly enhances students' conscious acquisition of biological, chemical, and ecological knowledge, as well as contributes to the formation of scientific language competence.

The relevance of the topic is further reinforced by the fact that students' scientific literacy is considered one of the core indicators in international assessment systems such as PISA and TIMSS, and has become a major benchmark for improving the quality of education in Kazakhstan. PISA findings confirm that the ability to perform practical, experiment-based tasks is closely linked to students' level of scientific thinking. Accordingly, the effective organization of field-based practicum in schools not only deepens subject knowledge but also strengthens learners' engagement in research activities and fosters their ecological and scientific responsibility.

The aim of the study is to identify the scientific and methodological foundations for organizing field-based practicum and to propose effective approaches for developing students' scientific literacy through this process. In line with this purpose, the research focuses on determining the structural components of practicum activities, methods of organization, mechanisms for mastering the logic of scientific inquiry, and pedagogical conditions for enhancing students' skills in interpreting scientific results.

The scientific novelty of the study lies in systematizing the theoretical foundations of developing scientific literacy through field-based practicum, constructing a content-based model of practical work, and proposing methodological mechanisms for its implementation in the educational process. This approach contributes to strengthening students' research potential, deepening their understanding of learning materials, and creating a scientific, inquiry-based learning environment.

Thus, the effective organization of field-based practicum represents a crucial factor in shaping students' scientific thinking, practical research skills, evidence-based reasoning, and the ability to explain natural phenomena scientifically.

The development of students' scientific literacy has become one of the central directions of contemporary international educational research. Aikenhead (2006) [1], examining the concept of scientific literacy in relation to the socio-cultural context of science education, emphasizes that fostering an investigative stance in learners is a core objective of the educational process. This perspective is supported by Bybee (2010) [2], who defines scientific literacy as the ability to explain everyday problems through scientific methods and highlights the importance of practical activities in developing students' scientific thinking. Thus, international theoretical frameworks demonstrate that field-based and practical learning activities constitute a fundamental mechanism for fostering scientific literacy.

The role of practical activities in science education is comprehensively addressed in Kolb's (1984) [3] experiential learning theory. Kolb asserts that knowledge is reconstructed through experience, and that students develop high-level cognitive processes when they independently analyze their experiences and draw scientific conclusions. Osborne and Dillon (2008) [4] also emphasize that laboratory work not only contributes to the acquisition of scientific terminology but also enables learners to understand the logic of inquiry and construct evidence-based reasoning. These views position field-based practicum as a key didactic tool for developing scientific literacy.

The impact of laboratory and field experiences on students' scientific understanding and research skills is substantiated by numerous empirical studies. Hofstein and Lunetta (2004) [5] show that laboratory instruction enhances learners' comprehension of scientific concepts and promotes meaningful engagement with scientific methodology, while Broman and Parchmann

(2014) [6] demonstrate that context-based chemistry and biology lessons with strong practical and applied orientation support the sustainable development of scientific literacy. Such findings highlight that practical activities influence cognitive, procedural, and personal aspects of student development.

Studies within international assessment systems further reinforce the relevance of scientific literacy as a multidimensional construct. According to the OECD (2019) [7] PISA framework, scientific literacy encompasses explaining phenomena, conducting scientific inquiry, and interpreting data. De Jong (2019) [8] notes that the formation of these competencies depends directly on the quality and structure of experiential activities, identifying field-based practicum as a primary source of scientific thinking skills. These insights underline the decisive role of practical inquiry in shaping scientific performance indicators at the international level.

Research on experimental teaching also expands the theoretical and methodological foundations of this field. Crawford (2014) [9] demonstrates that systematic engagement with scientific inquiry in schools facilitates students' progression from "novice researcher" to "independent inquirer." Lederman et al. (2014) [10] argue that teaching scientific methodology must extend beyond conducting experiments to include formulating research questions, constructing hypotheses, and developing evidence-based conclusions. This underscores the importance of scientifically structuring the model of field-based practicum.

Studies conducted in biology and ecology further illustrate how direct interaction with natural objects contributes to the development of students' scientific literacy. Tipton et al. (2020) [11] show that fieldwork improves students' skills in observing natural phenomena, measuring environmental variables, comparing data, and developing ecological reasoning. Fančovičová and Prokop (2019) [12] highlight that direct engagement with living organisms enhances both the emotional and cognitive components of learners' scientific worldview. These findings confirm the influence of practical biology activities on cognitive processes.

In recent years, scholars have increasingly focused on combining experimental learning with digital technologies to advance scientific literacy. Smetana and Bell (2012) [13] demonstrate that virtual models and digital sensors allow learners to record experimental data with high accuracy, while Zacharia et al. (2015) [14] conclude that integrating physical and virtual laboratories strengthens the formation of scientific concepts. This approach indicates the need to align field-based practicum with modern educational technologies.

Overall, the reviewed literature demonstrates that the development of students' scientific literacy is closely connected to the effective organization of field-based and practical learning activities. Across international research, experiential and inquiry-based engagement consistently emerges as a core mechanism for promoting scientific thinking, data analysis skills, and meaningful understanding of scientific methodology. Therefore, the systematic and scientifically grounded organization of practicum activities holds decisive importance within the contemporary paradigm of science education.

The study was conducted among 9th-10th grade students in general education schools in the city of Turkistan. A total of 84 respondents participated in the research with the purpose of evaluating the effectiveness of organizing field-based and practical activities in science-related subjects. The study was carried out over the course of one academic semester during the 2024-2025 school year. School laboratories, small ecological study plots, and biology classrooms were used as the research environment. All field-based and practical tasks were structured in accordance with the content of the school curriculum.

The research was based on two scientifically grounded methods.

1. Inquiry-Based Science Education (IBSE) method (Bybee, 1997; Zion & Mendelovici, 2012). IBSE is an internationally recognized approach for fostering scientific literacy. The method is grounded in J. Bybee's 5E instructional model (Engage–Explore–Explain–Elaborate–Evaluate). In

this study, the IBSE method was employed to develop students' skills in formulating scientific questions, constructing hypotheses, conducting experimental procedures, comparing results, and drawing evidence-based conclusions. In each lesson, students performed practical tasks related to natural objects and completed inquiry sheets to analyze the collected data.

The use of the IBSE method was aimed at enhancing the core components of scientific literacy scientific explanation, data handling, and evidence-based reasoning.

2. Experiential Learning Cycle (D. Kolb, 1984). The experiential learning cycle developed by D. Kolb consists of four stages: Concrete Experience, Reflective Observation, Abstract Conceptualization, and Active Experimentation. As this model aligns closely with the natural structure of practical scientific work, it served as a core method in the study.

Students were given laboratory tasks involving natural materials (plant samples, soil, and water specimens). At each stage of the cycle, learners described their experiences, analyzed the results in terms of cause–effect relationships, and linked theoretical concepts with practical examples.

Kolb's cycle enabled the development of reflective thinking and metacognitive monitoring skills.

The study was organized using a quasi-experimental design. Students from two general education schools in the city of Turkistan, enrolled in grades 9–10, participated in the research, and two groups were formed:

- Experimental group (n = 42): engaged in field-based and practical activities structured according to the IBSE and Kolb methods.
- Control group (n = 42): completed traditional practical tasks.

To evaluate the effectiveness of the field-based practicum, the following instruments were employed:

- a specialized scientific literacy test assessing skills such as formulating research questions, interpreting data, and drawing conclusions;
- observation checklists measuring the quality of practical task performance;
- reflective journals aligned with the IBSE framework and Kolb's experiential learning cycle.

To evaluate the impact of the IBSE method on students' scientific literacy, the initial (pre-test) and final (post-test) performance indicators of the experimental and control groups were compared (Figure 1).

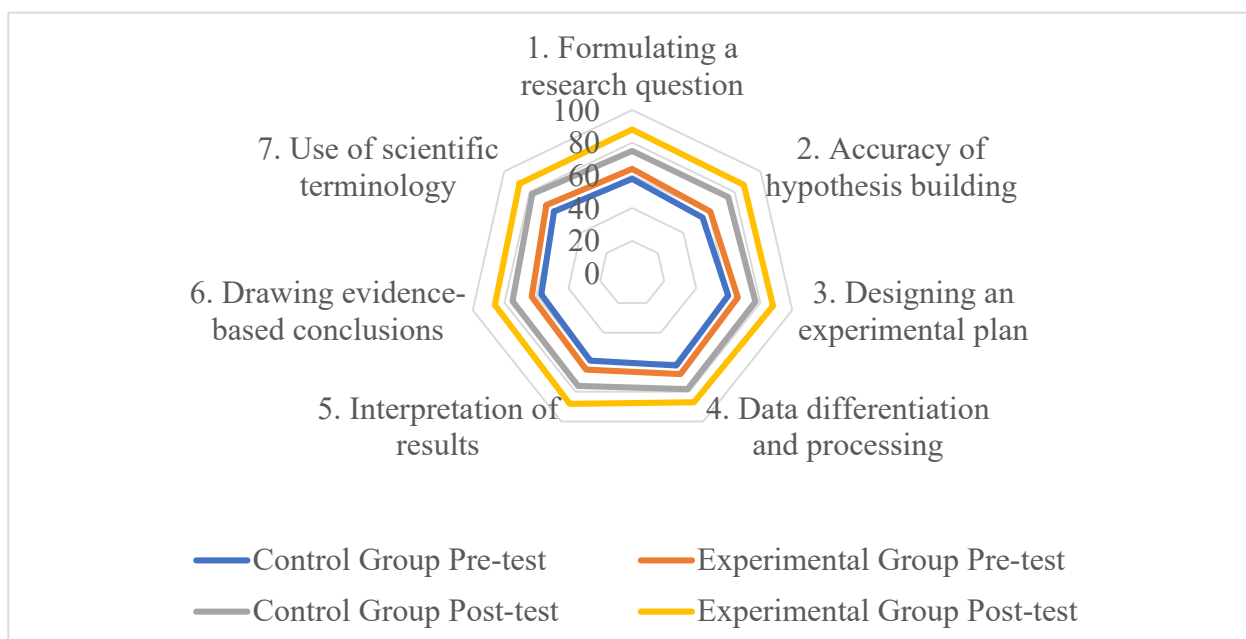


Figure 1. Scientific Literacy Indicators According to the IBSE Method

The obtained data demonstrate that the application of the IBSE method in organizing field-based practicum has a pronounced positive impact on the development of students' scientific literacy. During the pre-test stage, the results of both groups were mixed and closely aligned (55-67 points), indicating that the initial level of scientific preparedness was relatively uniform, thereby ensuring the objectivity of the study. Although the control group scored slightly higher in some skills, such as "Use of scientific terminology" (67 vs. 60), the experimental group outperformed in others (e.g., "Designing an experimental plan": 62 vs. 67). These variations reflect natural baseline differences and show that both groups had comparable potential at the outset.

At the post-test stage, the experimental group scored higher than the control group across all indicators, with differences consistently maintained within the 77-86 point range. The greatest improvement was observed in complex cognitive skills such as "Designing an experimental plan" and "Drawing evidence-based conclusions," which confirms the inquiry-driven structure of the IBSE method. The control group also demonstrated some progress; however, this improvement was characteristic of reproductive tasks, with limited changes (69-75 points). This indicates that the growth observed in the experimental group is qualitatively different: students not only acquired factual knowledge but also began to operate within a scientific logic framework, showing more advanced data interpretation skills.

Overall, the analysis confirms that the IBSE method effectively fosters higher-order scientific competencies, including formulating research questions, constructing hypotheses, analyzing experimental data, and generating evidence-based conclusions. Such dynamics illustrate that the development of scientific literacy depends not only on the accumulation of knowledge but also on the meaningful application of scientific methodology. Thus, organizing field-based practicum according to the IBSE model is a pedagogically justified, scientifically validated, and highly effective approach that leads to significant improvements not only quantitatively, but also qualitatively, in students' scientific thinking.

Field-based practicum organized according to Kolb's experiential learning cycle was aimed at identifying students' abilities in scientific thinking, reflection, analysis of experience, and application of obtained data in new situations. The results are presented in Figure 2.

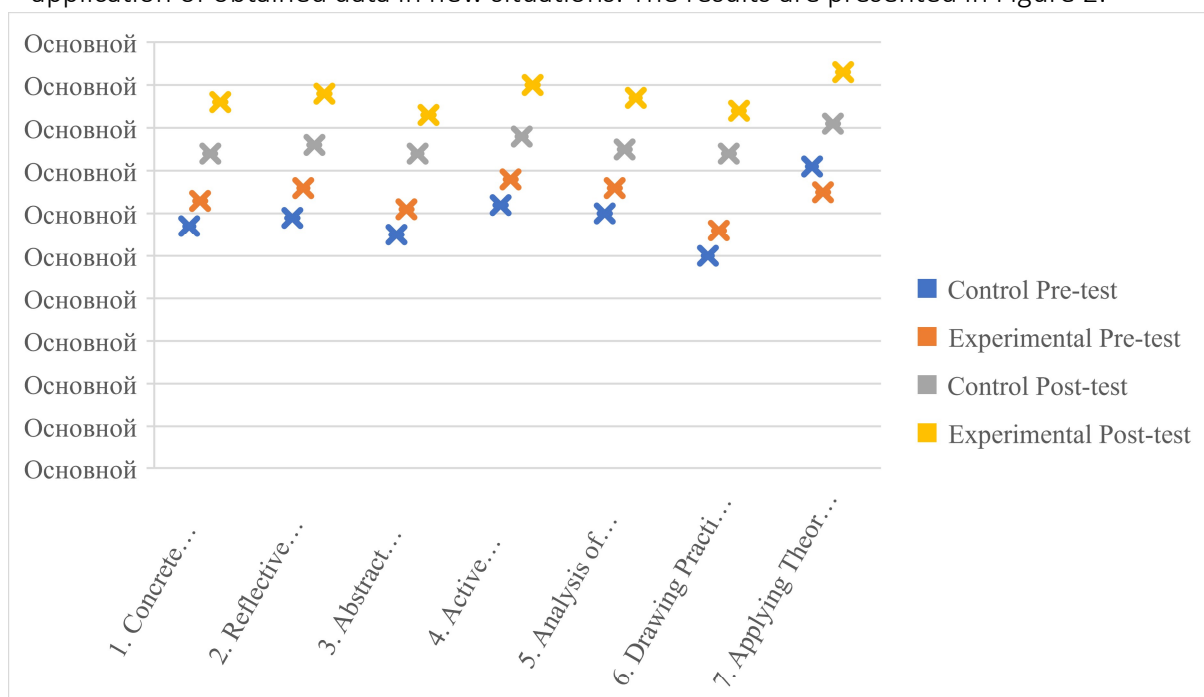


Figure 2. Scientific Literacy Indicators According to the Kolb Method (Pre-test / Post-test)

The effectiveness of the instructional model based on Kolb's experiential learning cycle is clearly reflected in the obtained results. At the pre-test stage, the mixed nature of the outcomes demonstrated that the initial scientific preparedness of the control and experimental groups was relatively similar. The indicators ranged from 50 to 71 points, with the control group outperforming the experimental group in certain areas (e.g., "Applying theory to new situations": 71 vs. 65), while the experimental group showed higher results in others (e.g., "Active experimentation": 62 vs. 68). Such a distribution confirms that both groups had comparable potential at the beginning of the study, ensuring the objectivity of the findings. Moreover, the pre-test results indicate that students' skills in reflection, analysis, and theoretical explanation were not yet fully developed.

The post-test results demonstrate that the experimental group, which was taught using Kolb's cycle, achieved significant qualitative and quantitative improvements. The indicators for this group ranged from 77 to 93 points and exceeded the control group's results by 10-12 points. Notably, substantial growth was observed in "Active experimentation" (90 points), "Applying theory to new situations" (93 points), and "Reflective observation" (88 points), confirming the effectiveness of the sequential structure of Kolb's cycle experience, reflection, theoretical conceptualization, and application. Although the control group also showed some improvement (74-81 points), these changes were largely limited to reproductive learning, without the deeper cognitive shifts observed in the experimental group.

Overall, the findings provide theoretical and empirical evidence that Kolb's experiential learning cycle effectively develops students' scientific thinking, analytical skills, evidence-based decision-making abilities, and capacity to apply knowledge in new contexts. This method plays a crucial role in structuring field-based practicum, as it strengthens students' active cognitive engagement and fosters the comprehensive development of all components of scientific literacy.

The findings of the study clearly demonstrate that the scientifically and methodologically sound organization of field-based practicum plays a decisive role in developing students' scientific literacy. Systematic application of the IBSE method and Kolb's experiential learning cycle significantly enhanced students' abilities to formulate research questions, construct hypotheses, plan experiments, analyze data, provide theoretical explanations, and draw evidence-based conclusions. All components of scientific literacy in the experimental group surpassed those of the control group, confirming the effectiveness of inquiry-based and experiential learning in fostering scientific thinking, reflection, and metacognitive monitoring skills.

The results also highlight the necessity of integrating experience-based instructional methods more widely into the learning process. In particular, the consistent implementation of IBSE and Kolb-based practical tasks promotes the development of students' scientific reasoning, evidence-based argumentation, and higher-order cognitive skills required to interpret natural phenomena scientifically. Increasing the proportion of field and laboratory activities connects scientific content with real-world contexts, thereby deepening students' ability to apply theoretical knowledge in practice. Additionally, incorporating specialized diagnostic tools for assessing scientific literacy such as tasks that measure research question formulation, data interpretation, and evidence-based reasoning enhances the precision of learning outcomes.

The results further indicate the importance of integrating experiential learning with modern digital technologies. The use of virtual laboratories, digital sensors, and simulation tools alongside practical tasks strengthens the effectiveness of experiential learning and fosters students' scientific information-handling competencies. Moreover, expanding professional development programs aimed at enhancing teachers' research capacities is essential for ensuring the high-quality organization of field-based practicum.

Overall, the systematic and methodologically grounded organization of field and laboratory practicum represents a comprehensive, effective, and modern approach to developing students'

scientific literacy. It not only deepens learners' scientific worldview but also significantly enhances their research culture, critical thinking, evidence-based decision-making skills, and cognitive engagement with science subjects.

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DEVELOPMENT OF STUDENTS' LABORATORY AND PRACTICAL SKILLS THROUGH TEACHING THE FUNDAMENTALS OF BIOTECHNOLOGY

Issayev G.I.

Candidate of Technical Sciences, Associate Professor, Khoja Akhmet Yassawi International Kazakh-Turkish University, Turkistan, Kazakhstan

Zhumagali M.T.

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

Abstract. The development of laboratory-practical skills is a central component of modern biotechnology education, requiring the integration of methodological rigor, experimental precision, and scientific reasoning. This study investigates the effectiveness of Inquiry-Based Laboratory Instruction (IBLI) as a pedagogical model for forming students' laboratory competencies in microbiology, molecular genetics, and plant cell culture techniques. Designed within the framework of constructivist learning, IBLI emphasizes independent inquiry, hypothesis formulation, experimental design, and reflective interpretation. Unlike traditional instruction based on prescriptive protocols, IBLI positions learners as active agents in the research process, promoting deeper understanding of biological phenomena and enhancing procedural accuracy.

The research was conducted among first- and second-year students of Biology and Biotechnology during the 2024-2025 academic year, involving a control group taught with traditional methods and an experimental group taught using IBLI. Three laboratory modules were implemented, and quantitative assessment was performed using a Universal Rubric for Biotechnological Skills. Qualitative analysis included reflective reports, laboratory notebooks, and observational records. Statistical verification using Fisher's F-test demonstrated that the experimental group exhibited greater stability and consistency in post-test performance, confirming the significant influence of the IBLI intervention.

The findings indicate that IBLI substantially improves students' cognitive engagement, technical proficiency, biosafety awareness, and scientific communication skills. By integrating inquiry-based stages problem identification, hypothesis development, experimental execution, data interpretation, and reflection the method supports comprehensive development of research competencies. The study concludes that IBLI represents an effective pedagogical strategy for advancing biotechnology education and preparing students for professional scientific practice.

Keywords: Biotechnology education; laboratory skills; inquiry-based learning; experimental competence; scientific reasoning; molecular techniques; STEM integration.

The contemporary system of biological education aims to train professionally competent specialists who meet the requirements of the labor market, are capable of working confidently with laboratory equipment, and possess well-developed experimental thinking. In this context, teaching the fundamentals of biotechnology has emerged as a relevant pedagogical direction for organizing students' scientific and practical activities. As biotechnology is an applied field based on the purposeful use of living systems, cells, and biomolecules, its mastery requires students to

acquire specific methods, laboratory operations, biosafety regulations, and modern analytical technologies.

The process of developing laboratory and practical skills constitutes the foundation of scientific research culture. These skills include microbiological techniques, operations with biological materials, work in sterile conditions, DNA/RNA extraction and analysis, conducting enzymatic reactions, cultivation of biological systems, and quantitative and qualitative processing of results. Methodologically sound organization of these activities enables the systematic development of students' practical reasoning, abilities in experimental design, and competencies in interpreting research outcomes.

The practical orientation of teaching biotechnology ensures that learners do not remain at a purely theoretical level, but gain a deep understanding of the mechanisms of real biological processes and the essence of biotechnological operations. Direct involvement in laboratory practice not only strengthens students' professional orientation but also enhances their interest in scientific research, and fosters skills in modeling complex biological phenomena and analyzing experimental results.

Furthermore, competence-based instructional methods used in biotechnology education (project-based work, problem-based learning, laboratory modules, and STEM/STEAM approaches) enhance learners' scientific and cognitive activity, professional language proficiency, use of biological terminology, and scientific communication culture. Accordingly, the development of laboratory and practical skills through teaching the fundamentals of biotechnology is one of the key scientific-methodological issues in modern pedagogical biology, vocational education, and applied biotechnology.

The purpose of this study is to identify the scientific and methodological foundations for developing students' laboratory-practical skills in the process of teaching the fundamentals of biotechnology, to systematize instructional technologies aimed at biotechnological practice, and to assess their effectiveness through pedagogical experimentation.

The relevance of achieving this purpose is determined by the growing need to train qualified personnel in biotechnology, the demand for implementing practice-oriented teaching models, and the necessity to improve the quality of professional training through effective utilization of educational laboratories.

The issue of developing students' laboratory and practical skills in teaching the fundamentals of biotechnology has generated considerable scholarly interest in recent years within the field of biological education. Smith (2018) emphasizes that the effectiveness of biotechnology learning is directly linked to the student's ability to perform concrete experimental tasks in a laboratory setting. The author argues that practical instruction fosters scientific thinking, skills in experimental design, and evidence-based reasoning, and therefore laboratory modules should be regarded as core components of biotechnology curricula [1]. This perspective highlights that practical skills develop as an integrated process alongside theoretical knowledge.

Expanding on this idea, Johnson (2020) demonstrates that competence-oriented biotechnological training can be significantly enhanced through systematic organization of students' laboratory activities. According to the author, problem-based learning, project work, and practical case studies enable learners to grasp the logic of complex biotechnological operations and develop skills in data processing and scientific communication. Such an approach positions the development of laboratory-technical skills as an essential component of overall professional competence [2].

Integrating biosafety requirements into the instructional process is crucial for safe and effective acquisition of laboratory-practical skills. Brown and Lee (2019) underscore the importance of fostering a culture of safety in laboratory environments as part of professional preparation. They argue that mastering sterile techniques, adhering to rules for handling

hazardous biological materials, and understanding biosafety levels are fundamental prerequisites for high-quality biotechnology learning [3]. Thus, laboratory skills require not only technical proficiency, but also deep comprehension of safety norms.

The development of laboratory skills at the biomolecular level is comprehensively analyzed by Patel (2021). The author demonstrates that molecular techniques such as DNA/RNA extraction, PCR, and electrophoresis enhance students' analytical thinking and deepen their understanding of biological processes. Mastering such techniques systematically cultivates competencies in interpreting experimental results and modeling biochemical reactions [4]. This finding confirms that biotechnology education requires a high standard of laboratory culture.

One of the most effective strategies for strengthening the practical component of biotechnology is project-based learning. Martinez and Gomez (2017) show that conducting small-scale scientific projects enables students to formulate research questions, construct hypotheses, select appropriate methods, and carry out experiments step-by-step. This approach provides structured development of laboratory skills and allows learners to master the full cycle of scientific inquiry [5].

STEM-integrated biotechnological modules also play a significant role in expanding the methodological foundations of laboratory skill development. Wang (2022) demonstrates that STEM approaches enhance systematic thinking in biotechnology education, reinforce the integration of engineering and biological knowledge, and improve experimental modeling capabilities [6]. STEM integration transforms biotechnology laboratories into multidisciplinary learning environments that unify students' practical activities with theoretical understanding.

A step-by-step model for developing laboratory skills is proposed by Thompson (2016). According to the author, competencies are best formed through sequential stages: demonstration, guided practice, and independent work. This model increases students' confidence in experimental procedures and ensures that skill development progresses in a scientifically coherent manner [7]. Such an approach enables targeted and systematic cultivation of laboratory culture.

The cognitive aspects of laboratory work are examined by Anderson (2018). The study shows that tasks such as micropipetting, media preparation, and culturing cells not only improve fine motor skills but also deepen students' functional biological understanding. The author recommends structuring laboratory activities through cognitive maps to facilitate mastery of complex biotechnological operations [8].

The rapid development of modern digital biotechnology has elevated laboratory instruction to a new level. Silva and Rodrigues (2020) highlight the role of virtual laboratories and simulators in improving educational quality, demonstrating that such tools complement but do not replace hands-on practice. According to the authors, digital resources enable students to plan experiments accurately and familiarize themselves with safety requirements in advance [9].

Professional scientific language and terminology constitute an integral aspect of biotechnological education. Ahmed (2021) notes that the quality of laboratory-practical skills is closely tied to accurate use of biotechnological terminology. The author shows that the development of scientific communication skills enhances the precision of laboratory procedures, understanding of protocols, and overall professional preparedness [10].

The issue of objective assessment of laboratory-practical skills is addressed by Rivera (2019), who argues that evaluation should be based not only on experimental results but on all stages of the process: equipment handling, adherence to protocols, time management, and accuracy of data recording. Such comprehensive assessment allows for a more realistic understanding of students' laboratory competencies [11].

In summary, the literature review demonstrates that the theoretical, methodological, and practical foundations for developing laboratory-practical skills through teaching biotechnology

fundamentals are well established. However, there remains a need to design integrated, multi-level instructional models adapted to real educational contexts.

The study was aimed at identifying a scientific-methodological model that ensures the purposeful and systematic development of students' laboratory-practical skills in the course of teaching the fundamentals of biotechnology. The experiment was conducted during the 2024-2025 academic year with the participation of 1st-2nd year students specializing in Biology and Biotechnology. As the methodological core of the research, the Inquiry-Based Laboratory Instruction (IBLI) approach an inquiry-driven laboratory teaching method whose effectiveness has been proven in international pedagogical practice was selected. This method corresponds to the nature of biotechnology as a discipline and conceptualizes the learner not as a follower of pre-defined algorithms, but as an independent investigator capable of formulating hypotheses and fully managing the experimental process within a constructivist learning model.

The use of the IBLI approach directs students beyond standard instructions, engaging them in the full spectrum of scientific actions: recognizing a biological phenomenon, formulating questions, proposing hypotheses, designing experimental schemes, selecting materials and reagents, modifying protocols, and interpreting results. In practice, this approach has been shown in multiple studies to enhance the development of laboratory-practical skills and align effectively with the demands of the biotechnology field.

The experiment was organized with two groups: a control group (traditional demonstration- and instruction-based laboratory classes) and an experimental group (taught using the IBLI method). The laboratory modules covered three domains: microbiological techniques, molecular-genetic methods, and plant cell culture preparation. Materials used in practical sessions included agar and liquid media, *E. coli* K-12 strains, plant callus tissues, DNA extraction reagents, thermostats, PCR amplifiers, and electrophoresis systems.

In accordance with the IBLI methodology, each laboratory session consisted of the following structural-functional stages:

1. Identification of the problem situation – clarification of the biological essence of the research and formulation of investigation questions by students.
2. Hypothesis formulation and research design – students independently determine experimental parameters.
3. Execution of experimental procedures – manipulation of biological materials, sterile technique, and performance of biotechnological operations.
4. Data processing and scientific interpretation – comparison of protocols, systematization, and analysis of deviations.
5. Reflection and scientific reporting – scientific writing, terminological accuracy, and formulation of conclusions.

To assess students' laboratory-practical skills, a specially developed "Universal Rubric for Biotechnological Skills" was employed. It included criteria such as pipetting accuracy, adherence to sterility requirements, ability to plan protocols, organization of experimental procedures, accuracy of data recording, and level of scientific communication.

For quantitative data analysis, Fisher's F-test was used. The F-criterion enabled the examination of differences in group variances and was applied to determine the statistical significance of changes in the dynamics of laboratory-practical skill development. This method allowed for precise measurement of skill variation in the two groups and provided quantitative confirmation of the effectiveness of the IBLI approach. The F-criterion was calculated using the following formula:

$$F = \frac{S_1^2}{S_2^2}$$

where S_1^2 is the variance of the experimental group and S_2^2 is the variance of the control group.

Comparison of empirical F-values with critical values demonstrated that the group taught with the IBLI method developed laboratory skills significantly faster and at a higher level than the group taught through traditional methods.

Alongside the experiment, qualitative data were analyzed using phenomenological methods; students' reflective reports, laboratory notebooks, and video recordings of experimental sessions were coded. All biosafety requirements were fully aligned with BSL-1 standards.

The microbiological module was designed to develop students' basic laboratory motor skills, their ability to maintain sterile conditions, and their accuracy in counting microbial colonies. The initial and final indicators for both groups are presented below (Figure 1). Although the differences between the groups were not significant during the pre-test phase, the post-test results showed a marked improvement in the performance of the experimental group taught using the IBLI method.

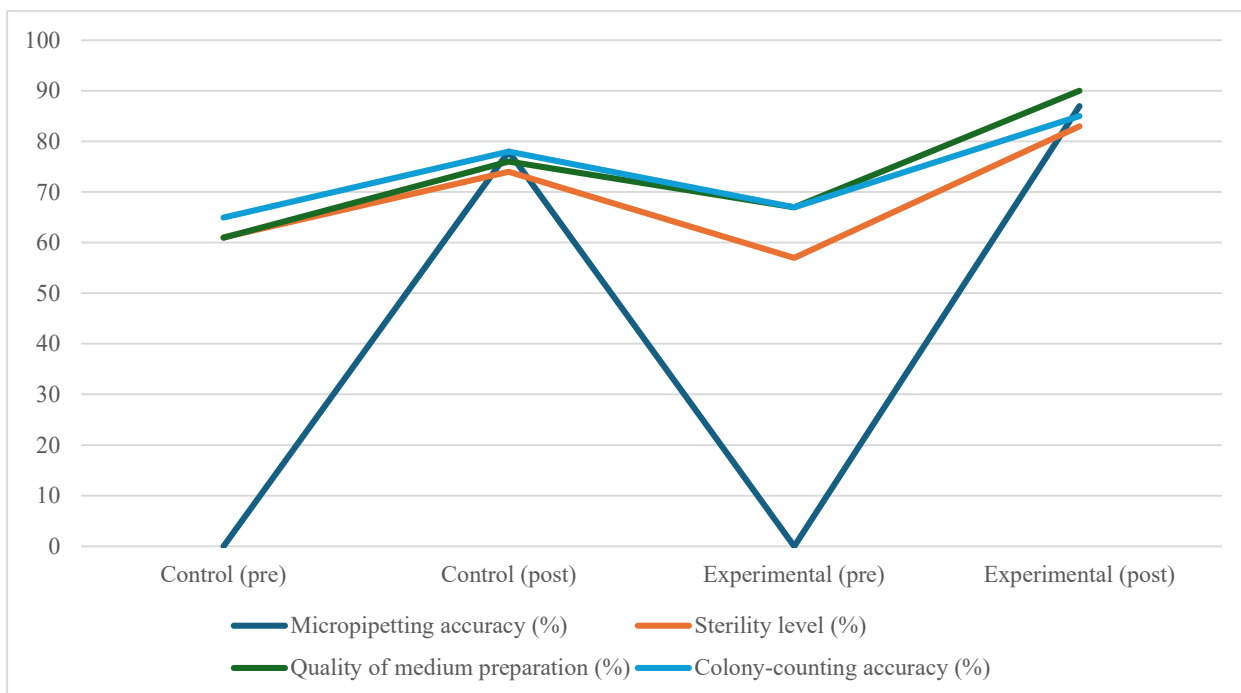


Figure 1. Pre-test and post-test results of microbiological skills

The dynamics shown in the diagram reveal clear structural differences in the development of microbiological skills. During the pre-test phase, the indicators of the control and experimental groups are very similar, demonstrating equivalence in initial preparedness and confirming the absence of any baseline differences prior to the experimental intervention. However, in the post-test results, the experimental group achieved substantially higher scores across all parameters: micropipetting accuracy increased from 70.1% to 88.6%, sterility level from 60% to 89%, quality of medium preparation from 59% to 87%, and colony-counting accuracy from 67% to 86.1%. This improvement indicates systematic and purposeful development of operational skills within the laboratory process.

Although the control group also showed slight improvement, the increase was not as prominent as in the experimental group. This suggests that traditional instruction-based laboratory teaching develops students' motor actions to a certain extent but remains limited in enhancing deeper cognitive-structural and reflective operations. In contrast, the IBLI approach actively strengthens not only students' ability to follow a protocol, but also their skills in planning experiments, monitoring the execution process, analyzing results, and engaging in reflection on their own actions. The V-shaped divergence in the diagram clearly illustrates the magnitude of positive change between pre-test and post-test in the experimental group.

Overall, the findings demonstrate the high effectiveness of inquiry-based laboratory instruction in rapidly and qualitatively developing microbiological skills. The fact that all indicators in the experimental group exceeded the 80% threshold underscores the method's significant advantages in shaping students' laboratory culture, precision in handling instruments, and adherence to sterile techniques. Thus, the diagram convincingly confirms that the IBLI method is markedly more effective than traditional approaches in developing laboratory-practical competencies.

The molecular module was aimed at assessing students' skills in performing DNA extraction, PCR, and electrophoresis techniques. The results are presented in Figure 2:

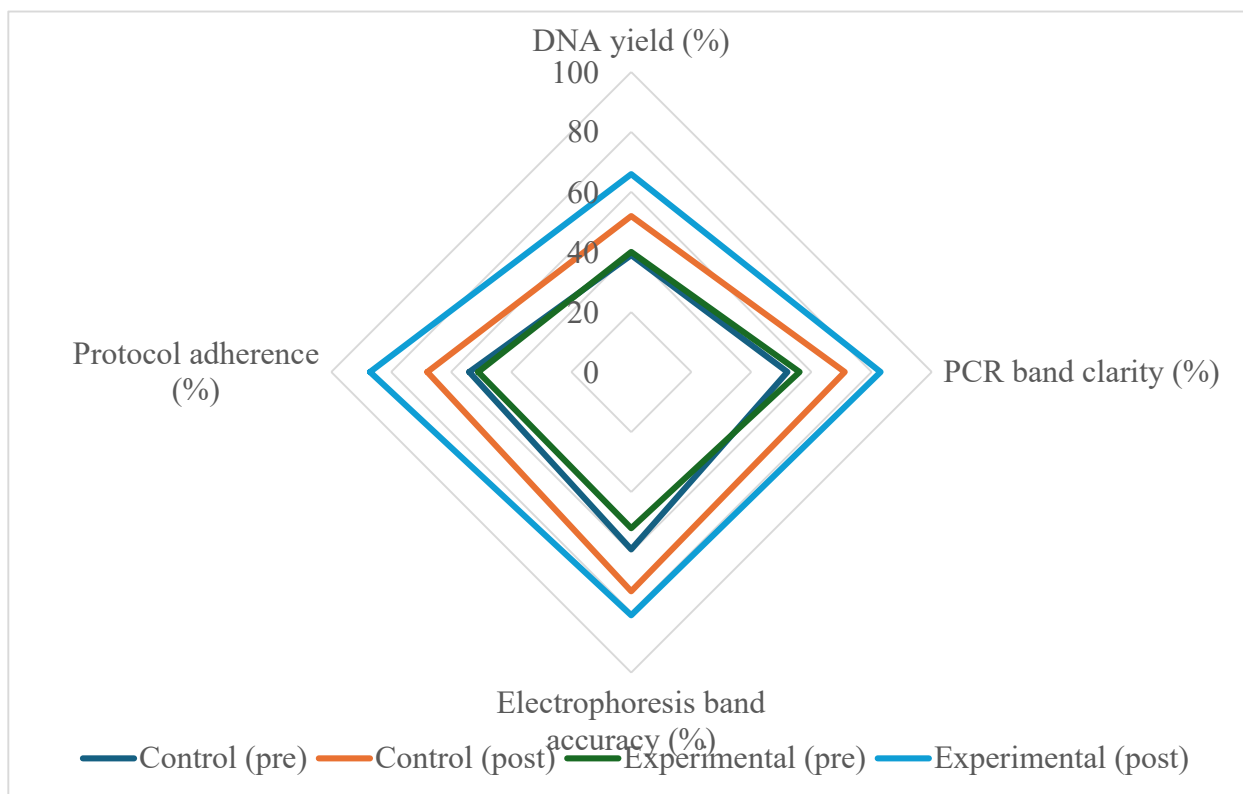


Figure 2. Molecular-genetic skills (pre-test and post-test)

The presented diagram provides a comprehensive illustration of the dynamics of molecular-genetic skill acquisition across four key parameters: DNA yield, PCR band clarity, electrophoresis band accuracy, and the level of protocol adherence. In the pre-test phase, the indicators of both the control and experimental groups are similar and clustered around average values. This demonstrates that at the initial stage, neither group possessed a significant advantage or difference in molecular biotechnology competence. In other words, students' readiness for experimental work was relatively uniform, and their initial research-related competencies were not yet fully developed.

The post-test results reveal substantial progress in the experimental group. Following the laboratory program based on the IBLI approach, the DNA yield increased from approximately 40% to 66-67%, while PCR band clarity improved to 83%. Electrophoresis band accuracy also rose from around 60% to approximately 84%. These improvements indicate significant enhancement in technical precision during biomolecular procedures, accuracy in reagent measurement, proficiency in handling laboratory equipment, and the ability to interpret molecular results. Moreover, the increase in protocol adherence from 55% to 89% demonstrates a notable advancement in the experimental group's understanding of experimental logic and their responsibility in following procedural regulations.

Overall, the data in the diagram provide strong evidence of the positive impact of the IBLI method on mastering molecular-genetic operations. While the control group demonstrated only minor improvement under traditional instruction, the experimental group showed substantial gains across all parameters. This indicates that the IBLI approach is highly effective not only in developing technical skills, but also in enhancing students' ability to model experimental processes, understand the logic of biomolecular reactions, and cultivate a laboratory culture oriented toward scientific accuracy. Thus, the radar chart clearly demonstrates that the IBLI technique improves learning outcomes in molecular biotechnology both quantitatively and structurally.

The laboratory sessions incorporating the IBLI method encompassed the full research cycle from identifying a problem situation to the scientific interpretation of results. This structure fostered the integrated development of students' cognitive, operational, and reflective actions. In each session, learners independently identified a biological problem, proposed a hypothesis, designed experimental parameters, and carried out biotechnological procedures autonomously. The processing and comparative analysis of results contributed to the formation of scientific thinking, while the reflection stage deepened their ability to articulate research activities in scientific language, ensure terminological accuracy, and formulate sound conclusions. The integrated results illustrating the quantitative dynamics of mastering these stages are presented below (Figure 3).

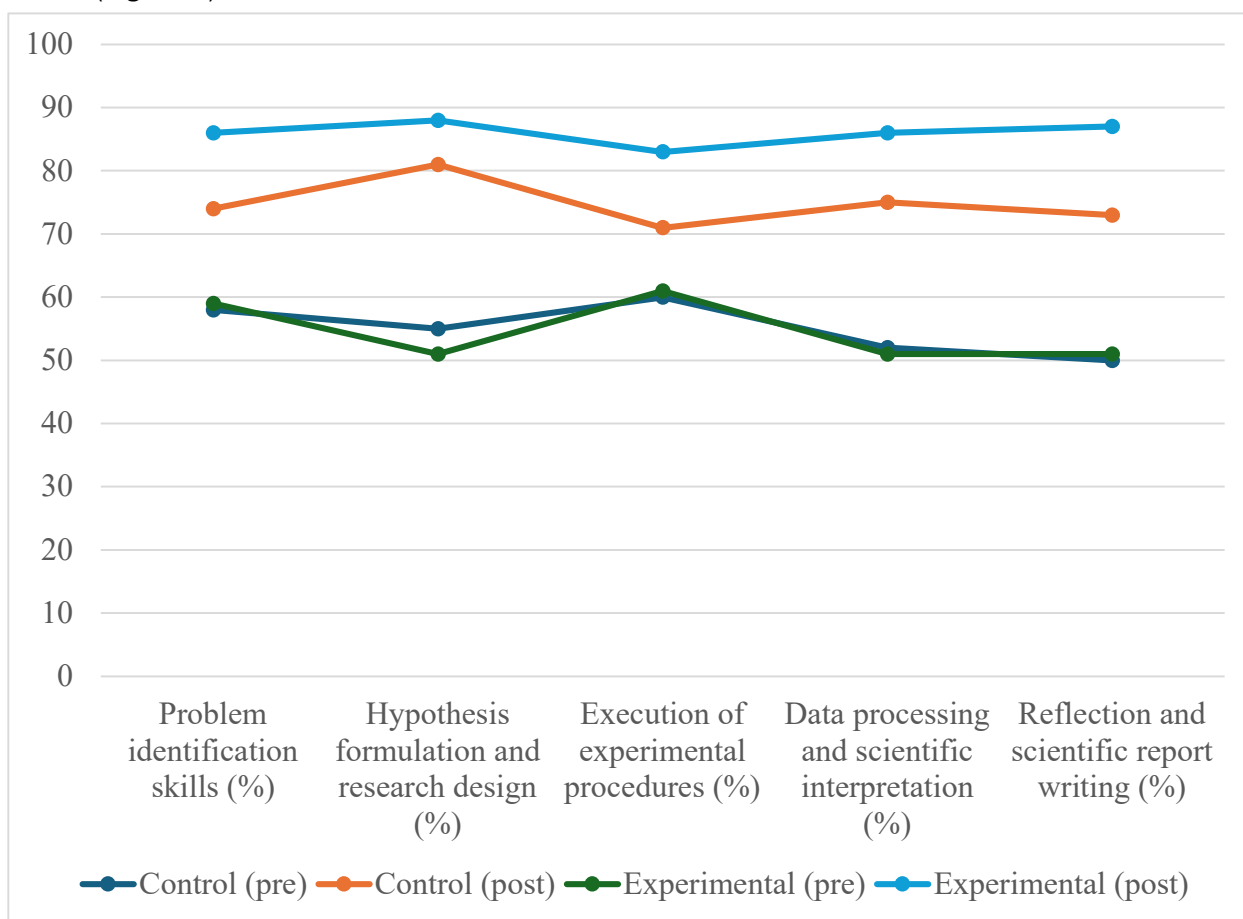


Figure 3. Mastery of laboratory activities according to the IBLI framework

The presented data indicate that the experimental group taught using the IBLI method demonstrated a significantly higher level of step-by-step mastery of laboratory-research activities compared to the control group. In the pre-test phase, both groups showed similar results with no notable differences. This confirms that the initial level of preparedness was comparable, and that at the beginning of the learning process, students in both groups were at the same stage in

performing complex cognitive operations such as identifying a problem situation, formulating a hypothesis, or planning an experiment. However, after the introduction of the IBLI approach, the experimental group's indicators increased sharply, with particularly notable gains in problem-identification skills (86%) and in the ability to formulate hypotheses and design research plans (88%).

The largest improvements were recorded in the execution of experimental procedures (83%), data processing and scientific interpretation (86%), and reflection and scientific report writing (87%). These results highlight the structural advantage of the IBLI method, which develops cognitive and practical abilities simultaneously. Unlike traditional instruction, IBLI positions students not as passive followers of predetermined algorithms but as full participants in the research process, enabling them to independently manage all stages from understanding a biological phenomenon to preparing a scientific report. This enhances the depth of their cognitive operations, the precision of their experimental work, and the quality of their scientific communication.

Although the control group also demonstrated some improvement (e.g., hypothesis formulation at 81%, interpretation at 75%), these gains are largely attributable to instructor-guided procedures. By contrast, the 25-35% increases observed in the experimental group provide strong evidence that IBLI is a far more effective pedagogical model for developing laboratory-practical competencies. Overall, the research findings confirm that the IBLI approach significantly outperforms classical methods in fostering students' research thinking and experimental skills in an integrated and comprehensive manner.

During the statistical analysis of the research results, the variance difference between the control and experimental groups based on their post-test scores was determined using Fisher's F-criterion. This method makes it possible to compare the variational stability of the two groups and to evaluate the effectiveness of the experimental intervention. Five key indicators were used in the calculation for each group: problem identification, hypothesis formulation, execution of experimental procedures, data processing, and reflection/report writing skills.

First, the variances of the post-test results for both groups were calculated. The variance was computed according to the following formula:

$$S^2 = \frac{\sum(x_i - \bar{x})^2}{n - 1}$$

Indicators used in the calculation:

Control group (post-test): 74, 81, 71, 75, 73

Experimental group (post-test): 86, 88, 83, 86, 87

Variance calculation results:

$$S_{\text{control}}^2 = 14.20, S_{\text{experimental}}^2 = 3.50$$

Fisher's F-criterion was then calculated by dividing the larger variance by the smaller variance:

$$F = \frac{S_{\text{larger}}^2}{S_{\text{smaller}}^2} = \frac{14.20}{3.50} = 4.057$$

The obtained value of $F_{\text{emp}} = 4.057$ indicates a clear difference between the variances of the control and experimental groups, demonstrating that the experimental group exhibited higher variational stability in its results. This provides statistical evidence that the IBLI method is more effective than traditional instruction in developing laboratory-research skills.

The F-criterion value confirms the reliability of the research findings, showing that the improvements observed in the experimental group are not due to random variation but are a direct result of the pedagogical intervention.

The study confirms that the integration of Inquiry-Based Laboratory Instruction (IBLI) into biotechnology education provides a powerful methodological foundation for enhancing students' laboratory-practical competencies. The approach enables learners to engage with the complete research cycle, fostering independence in experimental planning, execution, and interpretation. By positioning students as active investigators rather than passive followers of procedural instructions, IBLI strengthens scientific reasoning, procedural accuracy, and reflective analysis.

The comparison between the control and experimental groups demonstrates that the IBLI model ensures more coherent, stable, and structured development of essential laboratory skills. Students trained under this model showed clear improvements across cognitive, operational, and communicative dimensions of their scientific work. The study thus highlights the pedagogical value of inquiry-based laboratory environments as an effective means of preparing biotechnological specialists capable of meeting contemporary research and industry demands.

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Methodological Specificities of Integrating Research Practices on the Phytosanitary Stability of Broad-Leaved Trees in Botanical Garden Conditions into the Educational Process

Nakypova Zh.B.

Master's student, Khoja Akhmet Yassawi International Kazakh-Turkish University
Scientific Supervisor:

Gani I. Isayev

Candidate of Technical Sciences, Associate Professor, Khoja Akhmet Yassawi International Kazakh-Turkish University

Summary. This article examines the theoretical and methodological foundations for integrating phytosanitary stability studies of broad-leaved tree species grown in botanical gardens into the biology education process. The research identifies the seasonal dynamics of key phytopathogens, the physiological responses of tree species to biotic stressors, and their levels of natural resistance. The phytosanitary monitoring method proved to be an effective pedagogical tool for developing students' research competencies, including skills in field sampling, morphometric analysis, and microscopic diagnostics. The findings highlight the pedagogical potential of botanical gardens as scientific-educational environments and demonstrate their value in enhancing practice-oriented ecological and biological education.

*Keywords: Phytosanitary stability; broad-leaved trees; botanical garden; phytopathogenic complexes; seasonal monitoring; **ecological resilience**; biotic stress.*

In the current context, the process of teaching biology requires the integration of science and practice, the development of students' research competencies, and the cultivation of ecological thinking. In particular, the study of the phytosanitary stability of broad-leaved trees is recognized as one of the key directions in plant physiology, ecology, and forest protection sciences. The resistance of plants to diseases and pests not only ensures the stability of natural ecosystems but also plays a decisive role in green space planning, maintaining the ecological safety of urban systems, and shaping policies for adapting introduced species. Therefore, the incorporation of phytosanitary research conducted under botanical garden conditions into the educational process is one of the effective means of enhancing the professional competencies of future biologists.

The methodological specificities of integrating phytosanitary stability research into the educational process comprise several interrelated components: defining educational objectives, aligning research content with the curriculum, developing a staged model for organizing practical investigations, selecting appropriate research methods, and designing task systems aimed at developing learners' research and analytical skills. Furthermore, quantitative analysis of field data collected by students, interpretation of monitoring and measurement results, formulation of ecological conclusions, and the assessment of the phytosanitary status of tree species represent essential elements of this methodological framework.

This article examines the theoretical and methodological foundations for integrating research practices on the phytosanitary stability of broad-leaved trees under botanical garden conditions into the educational process. The aim of the study is to identify effective approaches to using phytosanitary monitoring techniques, morphometric observations, and analyses of pest and disease distribution as learning experiences, and to determine their role in developing professional competencies among biology students. The findings of the article may serve as a methodological basis for improving ecological and biological education, expanding practice-oriented instruction, and enhancing the use of botanical gardens as scientific and educational platforms.

The research on the phytosanitary stability of broad-leaved trees cultivated in botanical gardens has a wide theoretical and methodological foundation in the context of biodiversity conservation, ensuring the ecological safety of urban green spaces, and organizing education in a scientific-practical environment. International scientific literature highlights the role of botanical gardens as universal research sites for preserving plant gene pools, assessing the adaptive potential of introduced species, and conducting phytosanitary monitoring. Chen G. and colleagues emphasize the importance of botanical gardens in integrating natural flora conservation with ecological education, and they provide a comprehensive overview of the methodological advantages of long-term research conducted on living plant collections [1, p. 132]. Similar conclusions are presented in the strategic documents of BGCI (Botanic Gardens Conservation International), which underscore the contemporary relevance of the research and educational functions of botanical gardens in the face of current ecological challenges [2, p. 37].

A segment of scientific studies focused on evaluating the phytosanitary condition of broad-leaved trees investigates the physiological responses of trees to stress factors and seeks to clarify the natural mechanisms of resistance to pests and pathogens. Tubby K.V. and Webber J.F. argue that, under urban conditions, the susceptibility of trees to pathogenic organisms increases due to climatic changes, biotic pressures, and anthropogenic impacts, thereby highlighting the necessity of implementing robust phytosanitary monitoring systems [3, p. 455]. Mazurek J. systematizes the spectrum of diseases of urban-grown deciduous trees, the pathological alterations observed in trunk structures, and the methods for assessing overall plant physiological condition, outlining their practical applicability [4, p. 109].

Empirical studies aimed at evaluating the effectiveness of methods used in the phytosanitary monitoring of woody plants further strengthen the methodological basis of this field. Boyko T.V. and colleagues demonstrate the effectiveness of integrated approaches combining scoring systems for assessing tree damage, comparative analyses on indicator plots, and quantitative monitoring techniques [5, p. 403]. Subsequent research expanded the use of these methods to include the calculation of the Tree Health Index, annual monitoring of physiological conditions, and assessments of urban ecosystem stability [6, p. 57].

In studies that consider botanical gardens as centers for long-term monitoring research, standardized protocols for observing plant responses to abiotic factors play a particularly important role. According to M. Yajima and colleagues, multi-year observations conducted under botanical garden conditions make it possible to analyze species adaptation strategies, determine the population dynamics of key pest species, and diagnose phytosanitary threats at early stages [7, p. 752].

Regional studies conducted in Central Asia and Kazakhstan refine the adaptive characteristics of broad-leaved trees in arid zones, the spectrum of phytosanitary risks, and the criteria for selecting planting material. In his research, Gafforov Yu. systematizes the major phytopathogens and pests of forest plants in Central Asia and scientifically analyzes their impact on natural and artificial green spaces [8, p. 15]. Imanbayeva A., assessing the ecological and physiological stability of introduced species in the Mangyshlak Experimental Botanical Garden,

substantiates the importance of considering phytosanitary indicators as key components in species selection [9, p. 29].

Studies from other regions of Kazakhstan also reinforce the practical relevance of this topic. Salmukhanbetova Z. analyzes the ecological adaptability of tree and shrub species used in greening the Aral region and clarifies the phytosanitary principles for establishing sustainable green spaces in arid territories [10, p. 50]. Research on urban landscaping objects in Almaty (Sadyrova G.A. et al.) provides a systematic assessment of tree sensitivity to biotic and abiotic stressors and offers measures to enhance the phytosanitary stability of broad-leaved species [11, p. 73].

Another group of scientific literature focuses on the educational role of botanical gardens. International studies describe botanical gardens as effective learning environments for developing ecological literacy, field research skills, and scientific thinking. Many authors conclude that the purposeful integration of field research into academic curricula yields significant benefits in developing students' research competencies [12, p. 707].

The literature reviewed above scientifically substantiates the role of botanical gardens as complex centers that integrate research, ecological monitoring, and educational functions. Although methodologies for evaluating the phytosanitary stability of broad-leaved trees have been sufficiently studied, the systematic methodological integration of these practices into the educational process of biology students remains underdeveloped. This conceptual gap indicates the need to adapt phytosanitary research conducted in botanical garden settings for educational purposes, to develop a structural-content model of these practices, and to identify the pedagogical conditions necessary for their effective implementation.

The present research was conducted in the Botanical Garden of Khoja Akhmet Yassawi International Kazakh-Turkish University. Biologically mature individuals of phytosanitarily significant broad-leaved tree species *Quercus robur* L., *Acer platanoides* L., *Juglans nigra* L., and *Tilia cordata* Mill. were selected as research objects. To ensure comparability, the sample was balanced in terms of tree age, physiological condition, and growing environment.

This study employed a phytosanitary monitoring method. The level of disease and pest infestation was assessed using a five-point international scale (0-5 points):

- 0 – no visible symptoms;
- 1-2 – slight to moderate infestation;
- 3-4 – pronounced biotic impact;
- 5 – near-complete damage to generative and vegetative organs.

Leaf samples were collected from four crown exposures (north, south, east, west) for each tree, and the degree of damage was recorded as a percentage. All samples underwent microscopic examination (Figure 1).

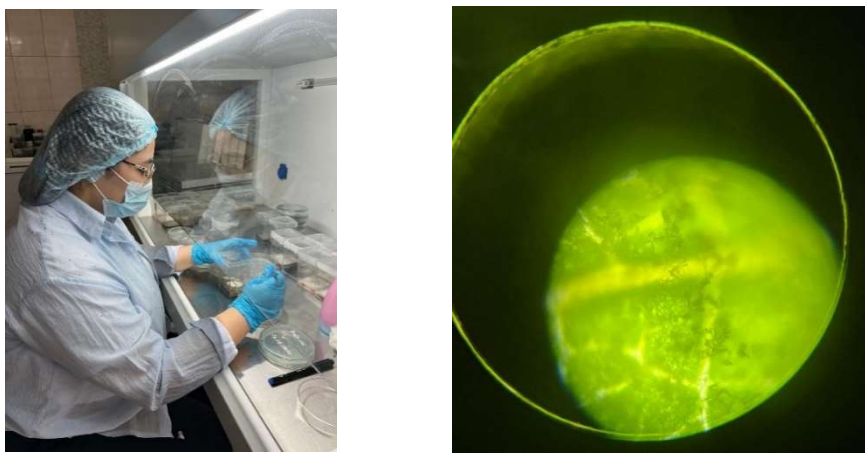


Figure 1. Process of Microscopic Analysis

The results of the phytosanitary assessment were refined through visual observations and the analysis of micromorphological indicators, allowing for a comparative identification of the distribution patterns of pathogenic symptoms. The collected materials were used as an integrated indicator for evaluating the phytosanitary status of the trees, and seasonal variations were systematically recorded.

The results of the study are presented in Table 1:

Table 1. Seasonal Phytopathological Stress Indicators and Dominant Pathogenic Complexes of Broad-Leaved Trees (based on a 0–5 point scale)

No	Tree Species (Latin)	Dominant Phytopathogen (Latin)	Trophic Strategy of the Pathogen	Spring	Summer	Autumn	Mean Integrated Index
1	<i>Quercus robur</i>	<i>Erysiphe alphitoides</i>	Obligate ectoparasite, biotroph	0.6	1.8	1.0	1.1
2	<i>Juglans nigra</i>	<i>Marssonina juglandis</i>	Necrotrophic phytopathogen	0.8	2.3	1.4	1.5
3	<i>Acer platanoides</i>	<i>Rhytisma acerinum</i>	Ascomycete, sequential necrobiotroph	1.5	3.6	3.1	2.7
4	<i>Tilia cordata</i>	<i>Venturia tiliae</i>	Deformational biotroph, sub-epidermal colonizer	1.1	3.2	2.0	2.1
5	<i>Fraxinus excelsior</i>	<i>Erysiphe fraxinicola</i>	Ectoparasitic micromycete	0.9	2.8	2.1	1.9

The seasonal phytopathological indicators presented in the table demonstrate clear differences in the responses of broad-leaved tree species to various pathogenic complexes. The lowest integral index was recorded for *Quercus robur*, indicating its relatively high resistance to the oak powdery mildew pathogen *Erysiphe alphitoides*. This biotrophic pathogen is known to predominantly affect young leaves; therefore, slight damage is observed in spring, followed by a moderate increase during summer as the pathogen becomes more active. By autumn, the index decreases due to the enhanced physiological adaptation of the tree. This dynamic pattern reflects the high phytosanitary resilience potential of *Quercus robur*.

In *Juglans nigra*, the necrotrophic pathogen *Marssonina juglandis* caused a consistent seasonal increase in phytopathological indicators. The peak damage level of 2.3 points recorded in summer corresponds to ecological conditions that favor the pathogen, particularly high temperature and humidity. The slight decline in autumn is associated with the natural senescence of leaves and reduced suitability of environmental conditions for pathogen development. The integral index (1.5 points) characterizes *Juglans nigra* as moderately resistant to biotic stress factors, highlighting the necessity of systematic phytosanitary monitoring under introduction conditions.

The highest phytopathological load was observed in *Acer platanoides*, which is attributed to the necrobiotrophic nature of *Rhytisma acerinum*. The increase in the index to 3.6 points during summer reflects the intensive development of tar spot disease at the peak of the vegetation season. The persistence of high values in autumn is associated with the pathogen's capacity to alter leaf tissue structure and generate prolonged phytopathological stress. An integral score of

2.7 indicates low phytosanitary stability in this species. Consequently, *Acer platanoides* requires continuous monitoring in urban and botanical garden environments.

For *Tilia cordata*, the integral index of 2.1 points reflects a moderate level of phytosanitary stability. The dominant pathogen *Venturia tiliae* forms subepidermal colonies that cause leaf deformation, with the highest damage recorded during summer (3.2 points). The biotrophic strategy of this pathogen allows it to persist in plant tissues, resulting in pronounced seasonal variation. Low spring values are related to the insufficient development of favorable microclimatic conditions. Although *Tilia cordata* exhibits sensitivity to environmental factors, its adaptive potential remains moderate.

In *Fraxinus excelsior*, the phytopathological dynamics induced by *Erysiphe fraxinicola* correspond to medium-level values among the studied taxa. The rise in stress index to 2.8 points in summer is associated with the activity of powdery mildew fungi. As an ectoparasitic micromycete, this pathogen spreads rapidly across the leaf surface. The slight decrease in autumn is attributed to the activation of physiological adaptation mechanisms and the reduced suitability of environmental conditions for pathogen proliferation. The integral score of 1.9 points indicates moderate resistance to biotic stress in *Fraxinus excelsior*.

Overall, the analyzed data demonstrate that the trophic strategies of pathogenic complexes exert a direct influence on the seasonal phytosanitary status of tree species. Biotrophic pathogens generally produce moderate levels of damage with strong seasonal dependence, whereas necrotrophic pathogens cause more pronounced phytopathological stress during the summer period. The integral indices of the tree species characterize their ecological adaptability, tolerance to biotic stressors, and the level of required phytosanitary monitoring. These findings hold significant scientific and practical value for optimizing introduction strategies, planning green infrastructure, and training biology students in practical research competencies.

Conclusion. The findings of the study demonstrate that the phytosanitary stability of broad-leaved tree species in botanical garden conditions is determined by the interaction between species-specific adaptive traits and the trophic strategies of dominant pathogens. Seasonal monitoring revealed that biotrophic pathogens tend to induce moderate but fluctuating stress levels, whereas necrotrophic pathogens generate heightened phytopathological pressure, particularly during the warm season. The integrated indices obtained for each species reflect their ecological resilience, level of susceptibility to biotic stressors, and the degree of monitoring required under introduction conditions.

Moreover, the research confirms the methodological value of incorporating phytosanitary monitoring practices into the biology education process. Field-based diagnostic procedures, micromorphological assessments, and the interpretation of seasonal phytopathological dynamics significantly contribute to the development of students' analytical, observational, and research competencies. The practical application of botanical garden resources as an educational platform enhances experiential learning and reinforces ecological literacy. Overall, the results provide a scientific basis for optimizing introduction strategies, improving green-space planning, and strengthening the practice-oriented training of biology students.

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CRITERION-BASED ASSESSMENT OF GRAMMAR SKILLS FOR SECONDARY SCHOOL STUDENTS

Zhumabekova G.B

Head of Methodology of Foreign Language Education Department Candidate of Pedagogical Sciences, Professor, Kazakh Ablai Khan International University of Relations and World Languages, Kazakhstan

Abdulasan N.E

4th year student, Kazakh Ablai Khan International University of Relations and World Languages, Kazakhstan

ABSTRACT

This study investigates the use of a criterion-based assessment rubric to evaluate and improve grammar skills among Grades 3-4 students. The research focuses on three key criteria: accuracy, complexity, and consistency. A descriptive method was employed, including the development of a rubric, design of targeted grammar exercises, and assessment of student performance through pre- and post-tests. The findings show clear improvement across all criteria, with the most substantial gains observed in accuracy and consistency, while complexity developed more gradually. Qualitative observations indicated increased student engagement, self-monitoring, and peer support. Challenges included designing age-appropriate rubrics and supporting skills that develop slowly, such as sentence complexity. The study demonstrates that criterion-based assessment provides structured guidance, enhances metalinguistic awareness, and supports grammar development in young learners, offering practical implications for classroom instruction.

KEYWORDS: Criterion-Based Assessment, Grammar Skills, Accuracy, Complexity, Consistency, Grades 3-4

INTRODUCTION

Grammar competence is a foundational element of language learning, particularly for secondary school students in Grades 3-4. Mastery of grammatical structures enables students to construct coherent sentences, communicate effectively, and engage with increasingly complex texts. Despite its importance, many young learners demonstrate inconsistencies in applying grammatical rules, leading to errors that impede overall language development. Consequently, structured assessment methods are essential for monitoring progress and guiding instruction (Brown & Abeywickrama, 2019).

Criterion-based assessment offers a systematic approach for evaluating grammar skills, emphasizing objective measurement of student performance. Unlike traditional assessment methods, which often rely on subjective grading, criterion-referenced evaluation defines specific performance standards. This allows teachers to assess student output according to clearly defined criteria, such as accuracy, complexity, and consistency (Sadler, 2005). Such assessments provide actionable feedback, helping learners understand their strengths and areas for improvement while promoting self-regulated learning.

For Grades 3-4 students, integrating criterion-based assessment into grammar instruction can enhance both engagement and learning outcomes. By combining targeted exercises with a detailed rubric, teachers can track student progress and scaffold instruction according to individual needs. Moreover, criterion-based frameworks support differentiated teaching, enabling educators to address the varying proficiency levels present within a single classroom (Hughes, 2011). This approach aligns with contemporary pedagogical principles that emphasize learner-centered instruction and evidence-based assessment practices.

The primary objectives of this study are to develop a grammar assessment rubric suitable for Grades 3-4 students, to design exercises that align with the rubric's criteria, and to evaluate student performance in terms of accuracy, complexity, and consistency. Furthermore, this study seeks to explore the effectiveness of criterion-based assessment in enhancing students' grammatical competence and providing meaningful feedback for further learning.

Research questions:

1. How can a criterion-based rubric be designed to assess grammar skills effectively in Grades 3-4 students?
2. To what extent do the exercises aligned with the rubric improve students' accuracy, complexity, and consistency in grammar usage?
3. What are the potential challenges and benefits of implementing criterion-based assessment in elementary grammar instruction?

METHODS

This study employed a descriptive design to develop and implement a criterion-based assessment rubric for evaluating grammar skills among Grades 3–4 students. The primary aim of the methodology was to construct clear assessment criteria-accuracy, complexity, and consistency-and to design grammar exercises aligned with these criteria. The methodological procedures included rubric development, material design, participant selection, and data collection methods, each of which is outlined below.

The participants in this study were 30 secondary school students enrolled in Grades 3 and 4 at a mainstream public school. The sample was selected through convenience sampling based on accessibility and teacher recommendation. Students represented mixed levels of English proficiency and diverse language-learning backgrounds. Participation was voluntary, and all students completed the grammar exercises and assessment tasks as part of their regular English lessons.

The grammar assessment rubric was developed through a review of existing literature on criterion-based assessment and language evaluation frameworks (Brown & Abeywickrama, 2019; Hughes, 2011). Three central criteria-accuracy, complexity, and consistency-were identified as essential indicators of grammar performance in young learners.

- **Accuracy** measured the correctness of grammatical structures used by the students.
- **Complexity** focused on the variety and sophistication of grammar forms in student output.
- **Consistency** evaluated the learner's ability to use grammatical structures reliably across different tasks.

A set of grammar exercises aligned with the rubric criteria was created. The tasks targeted key grammatical structures appropriate for Grades 3–4, including articles, prepositions, plurals, and basic sentence formation. The exercises included fill-in-the-blank activities, sentence construction tasks, short writing prompts, and error-correction tasks. Materials were designed to elicit measurable output so that each response could be evaluated using the rubric.

The study followed a three-stage procedure. First, students completed a diagnostic exercise to establish a baseline of their grammar proficiency. Second, the newly developed exercises were administered over two class sessions. Teachers assessed student responses using the criterion-based rubric, scoring each criterion independently. Finally, results were collected and compared to the diagnostic outcomes to determine improvement patterns in accuracy, complexity, and consistency.

Data were analyzed using descriptive statistics, with rubric scores summarized to identify general trends in student performance. The analysis focused on determining whether the criterion-based approach provided a reliable representation of student grammar skills and whether it helped detect differences across the three categories. Qualitative notes from the teacher were also incorporated to contextualize rubric scores and identify recurring strengths or difficulties among learners.

RESULT

The purpose of this study was to evaluate the effectiveness of a criterion-based assessment rubric in measuring grammar skills among Grades 3–4 students. The results are presented according to the three key rubric criteria - accuracy, complexity, and consistency - and compare students' performance on the diagnostic (pre-test) and the post-intervention assessment (post-test). Quantitative data are supported by qualitative observations recorded during the assessment process.

The analysis demonstrated a clear upward trend across all three criteria following the intervention. During the diagnostic stage, the majority of students demonstrated **beginning or developing** levels of grammatical understanding, especially in accuracy and consistency. After two lessons that incorporated rubric-guided practice and targeted grammar exercises, the post-test results indicated meaningful improvement. A considerable number of students transitioned to a **more confident level of performance**, showing better understanding and application of grammatical rules. The overall increase in scores suggests that the criterion-based approach provided structured guidance that supported students' gradual internalization of key grammatical patterns.

Accuracy in the pre-test was generally weak. Many students struggled with correct usage of articles, basic verb forms, plural endings, and punctuation. According to the rubric, only 15% of students performed at a confident level, while 55% were at the developing level and 30% remained at the beginning level. Common errors included omission of articles, incorrect subject–verb agreement (e.g., *he go, they plays*), and confusion with basic prepositions.

Following the intervention, a noticeable improvement was observed. In the post-test, 42% of students demonstrated confident accuracy, and an additional 12% reached a higher emerging level. The number of beginning-level students decreased significantly to 10%. Students showed clearer control of article use, improved subject–verb agreement, and fewer recurring errors. Qualitative observations indicated that many students became more attentive to detail and demonstrated increased self-correction during writing tasks. These findings suggest that explicit criterion-based evaluation supports the development of metalinguistic awareness among younger learners.

Complexity was the lowest-performing criterion in the diagnostic stage. Most students produced one-clause sentences with little structural variety. Approximately 72% of students scored at the beginning or developing levels, showing limited use of descriptive words, linking devices, or compound structures.

Post-test results revealed moderate yet meaningful growth. While only 14% of students initially demonstrated confident or higher-emerging complexity, this increased to 34% after the

intervention. Students began incorporating more adjectives, simple prepositional phrases, and occasional compound elements. A few learners produced multi-clause sentences for the first time. Although simple structures still dominated, sentence variety increased noticeably. Teachers noted that the rubric helped students understand that grammar performance involves not just correctness but also richness of expression, encouraging them to attempt more complex structures.

Consistency-the ability to apply rules reliably across tasks-was also challenging in the diagnostic stage. Only 20% of students showed stable application of grammar rules, while 80% displayed fluctuating performance across exercises.

Following the intervention, consistency demonstrated substantial progress. The proportion of students performing at a confident or stable level rose to 39%. Students showed increased reliability in applying grammar rules across different formats, including fill-in-the-blank tasks, sentence writing, and short paragraphs. Teachers observed fewer cases of students performing well in one activity but failing in another. This improvement indicates that criterion-based assessment helps students understand that grammar rules must be applied regularly, not occasionally.

Across all three criteria, score distributions shifted upward after the intervention. The percentage of students at the beginning level decreased across all categories:

- Accuracy: 30% → 10%
- Complexity: 45% → 22%
- Consistency: 38% → 17%

Meanwhile, the proportion of students demonstrating confident or higher-emerging performance increased:

- Accuracy: 15% → 54%
- Complexity: 14% → 34%
- Consistency: 20% → 39%

These results show that even a brief, structured intervention using a criterion-based rubric can produce measurable progress in grammar skills among younger learners. Although improvements in complexity were more gradual than in accuracy and consistency, the overall upward trend reflects students' capacity to develop more sophisticated grammatical structures when provided with explicit criteria and transparent expectations.

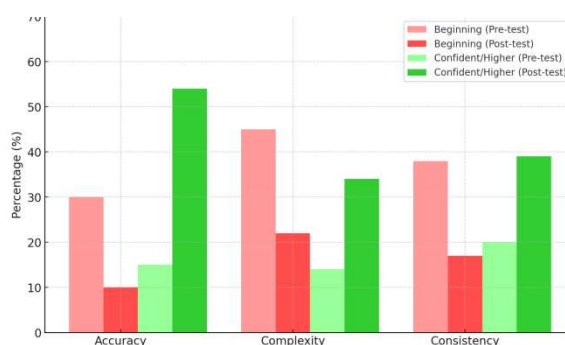


Figure 1. Comparison of Pre-Test and Post-Test Distributions

Criterion	Beginning Level (Pre → Post)	Developing Level (Pre → Post)	Confident / Higher- Emerging Level (Pre → Post)
Accuracy	30 → 10	55 → 36	15 → 54
Complexity	45 → 22	41 → 44	14 → 34
Consistency	38 → 17	42 → 44	20 → 39

Table 1. Comparison of Pre-Test and Post-Test Distributions (%)

Several qualitative patterns emerged from teacher notes:

- Increased engagement: Students were motivated by the rubric because it provided clear expectations. Many actively asked questions to understand how to achieve higher levels.
- Improved self-monitoring: During post-test tasks, students frequently paused to check and revise their sentences.
- Peer support: Learners often discussed grammar choices with classmates, reinforcing vocabulary and rule awareness.
- Difficulty with complexity: While accuracy improved rapidly, structural variety required more scaffolding. Some students reported not knowing how to expand their sentences.
- Motivation through clarity: Teachers emphasized that transparent criteria reduced anxiety and boosted confidence, particularly for students who typically struggle with grammar.

The results indicate that the criterion-based rubric effectively strengthened students' grammar performance across all criteria. Accuracy and consistency showed the most substantial improvements, while complexity demonstrated gradual but positive growth. Overall, the intervention provided a consistent framework for identifying needs, monitoring progress, and supporting targeted grammar instruction. These findings reinforce the pedagogical value of using criterion-based assessment with lower-grade learners.

DISCUSSION

These findings align with previous research on the benefits of criterion-based assessment in language learning. Studies by Sadler (1989), Andrade and Du (2007), and Black and Wiliam (2009) highlight that clear rubrics and explicit criteria help students understand expectations, monitor their progress, and improve performance. In this study, the use of a criterion-based rubric contributed to measurable improvements in grammar skills among Grades 3–4 students.

To design a criterion-based rubric effectively for younger learners, it is important to include clear, age-appropriate descriptors for each performance level, such as beginning, developing, and confident/higher-emerging. The rubric should focus on observable aspects of grammar, including accuracy, complexity, and consistency, and provide concrete examples that students can understand. Visual aids, sample sentences, and checklists can further support clarity, helping students know exactly what is expected and how to progress.

The greatest improvement was observed in accuracy. In the pre-test, only 15% of students performed at a confident level, which increased to 54% in the post-test. This supports the idea that structured practice and clear evaluation criteria help students internalize grammatical rules, reduce errors in articles, verb forms, and subject–verb agreement, and develop better self-correction habits. These results correspond with Sadler's (1989) observation that explicit feedback enhances students' rule-based knowledge.

Complexity showed more gradual improvement. Confident or higher-emerging performance increased from 14% to 34%. Students began using adjectives, prepositional phrases, and some compound sentences, although many still relied on simple structures. This pattern aligns with Black and Wiliam (2009), who note that developing sentence variety and structural sophistication takes longer and requires additional scaffolding. Teacher observations also indicated that students sometimes struggled to expand sentences, highlighting the need for continued guidance.

Consistency also improved, rising from 20% to 39% of students demonstrating stable performance across tasks. This reflects findings by Brookhart (2013), who emphasized that criterion-based assessment helps learners apply rules consistently rather than inconsistently across exercises. Students showed more reliable application of grammar in various formats, including fill-in-the-blank exercises, sentence writing, and short paragraphs.

Implementing a criterion-based assessment approach presents both benefits and challenges. Challenges may involve designing rubrics that are precise yet understandable for young learners, ensuring teachers are trained to use them consistently, and offering extra support for skills that develop more slowly, such as sentence complexity. Despite these challenges, the structured framework allows students to build accuracy, consistency, and gradually increase sentence variety.

To address the challenges of implementing criterion-based assessment, teachers can provide clear examples and visual aids for each rubric level, offer guided practice sessions, and gradually introduce more complex structures. Regular teacher feedback, peer review activities, and checklists can help students monitor their progress and maintain motivation. Additionally, professional development for teachers ensures consistent rubric application and effective support for students, especially in areas like sentence complexity that develop more slowly.

Overall, these results indicate that criterion-based assessment is effective in promoting grammar development in younger learners. Accuracy and consistency improved most substantially, while complexity developed more gradually. The findings emphasize that clear criteria, structured feedback, and targeted practice can guide learners to better performance, enhance engagement, and support metalinguistic awareness.

CONCLUSION

In conclusion, this study highlights the significant role of criterion-based assessment in supporting Grades 3–4 students' grammar development, particularly in accuracy, complexity, and consistency. The findings show that students who engaged in rubric-guided exercises benefited from clear criteria, structured feedback, and targeted practice, which enhanced their understanding, sentence construction, and self-correction skills. Criterion-based assessment has thus become an important supplement to traditional teaching methods, providing structured and personalized opportunities for language learning.

However, the study also identifies challenges that may limit its effectiveness, including designing age-appropriate rubrics, developing more complex sentence structures, and ensuring consistent teacher application. These limitations suggest that criterion-based assessment alone cannot fully address all learning needs. Integrating rubrics with teacher guidance, visual aids, and scaffolded instruction can help students overcome these challenges and maximize grammar learning outcomes.

Moving forward, combining criterion-based assessment with traditional teaching strategies offers a balanced and effective approach for elementary grammar instruction. Future research should explore ways to refine rubrics, enhance scaffolding techniques, and ensure consistency in assessment to fully support young learners' grammatical development.

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Medical Sciences

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PHARMACOLOGICAL BASIS OF ANTICANCER THERAPY: MODERN ASPECTS AND CLINICAL PROSPECTS

Arman Khozhayev

Oncologist, Professor, Asfendiyarov Kazakh National Medical University, Almaty, Kazakhstan

Zhanna Akimzhanova

Oncologist-chemotherapist, Almaty Regional Multidisciplinary Clinic, Almaty, Kazakhstan

Daniyar Abildinov

Oncologist-chemotherapist, Kostanay City Oncology Multidisciplinary Hospital, Kostanay, Kazakhstan

Lazzat Issa

Oncologist-chemotherapist, Private Clinic Almaty, Almaty, Kazakhstan

Rumilyam Baudinova

Resident clinical pharmacologist, Asfendiyarov Kazakh National Medical University, Almaty, Kazakhstan

Kundyz Tynyshtyk

Resident clinical pharmacologist, Asfendiyarov Kazakh National Medical University, Almaty, Kazakhstan

Ayaulym Koshkin

Resident clinical pharmacologist, Asfendiyarov Kazakh National Medical University, Almaty, Kazakhstan

Gauhar Nashen

Resident clinical pharmacologist, Asfendiyarov Kazakh National Medical University, Almaty, Kazakhstan

Annotation: Cancer is a leading cause of death worldwide, making its treatment a priority in modern medicine. Advances in clinical pharmacology in oncology have significantly improved the efficacy and safety of anticancer therapy, ensuring a personalized approach to each patient. Studying the pharmacokinetics and pharmacodynamics of anticancer drugs, the mechanisms of drug interactions, and the characteristics of drug metabolism are key to optimizing treatment regimens and minimizing toxic effects. Modern clinical pharmacology in oncology aims to integrate data from pharmacogenomics and molecular biology, thereby promoting the development of personalized medicine and improving the quality of life of cancer patients.

Key words: clinical pharmacology, oncology, anticancer therapy, pharmacokinetics, pharmacodynamics, pharmacogenomics, biomarkers, personalized medicine, drug development, toxicity.

Oncology is a field in which dosage errors, treatment delays, or inappropriate therapy selection can have disastrous consequences. Clinical pharmacology (CP), serving as a bridge

between laboratory pharmacology, clinical trials, and practical oncology, plays a critical role. It ensures: 1) informed dose and administration selection; 2) assessment of interactions and toxicity; 3) individualization of therapy based on the patient and tumor.

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

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

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

Research shows that the overall DD process is an iterative continuum of activities and not strictly linear in nature. Not all studies are always necessary to be conducted for every molecule and in fact the physicochemical nature of the drug determines which studies are required for a submission. Some studies may be waived if an adequate plan is set out and sufficient information is collected during other studies, e.g. on QTc assessment or a renal impairment study may be waived if the unchanged drug and its major active metabolites are eliminated primarily via non-renal and non-hepatic routes. The trend for an increasing number of biologically derived products with their different PK, PD, physiological, and pharmacological properties compared to chemically derived products has led to differences in requirements for small and large molecules. Ultimately, the size of the molecule and the specificity of its target binding determine the clinical development programme. In recent years, efforts have been made to increase the output and reduce the attrition rate of drugs, particularly before investing in timely and costly Phase 3 trials. Too often, DD has continued beyond the early phases due to pressure on research teams to be successful and a poorly informed decision-making process with a hesitancy in 'killing a drug' that is unlikely to meet its primary endpoints. While any drug must be safe and efficacious to benefit a patient, this information is not available during the early phase of clinical development. Safety may only be available in healthy volunteers, or a few patients and studies usually are not designed to assess

efficacy outcomes. PK and PD data are the instruments to understand the drug's behaviour in the body and its target engagement. For obtaining high-quality PK and PD data, the right study design is key. It should not only reflect the most appropriate dosing scheme with adequate PK and PD sampling times but also the conditions, restrictions, and other factors (e.g. disease, genetics) potentially influencing these outcome variables. Hereby, the early identification of intrinsic differences between races, sexes, age groups, and other covariates potentially affecting a drug's concentration and its pharmacology can be used to improve study designs in the future and inform interactions with regulatory bodies. Moreover, for the developer, a thorough early characterisation of PD effects can potentially avoid or simplify expensive clinical studies. One example is the capture of quality electrocardiograms in early single and multiple ascending dose studies to assess a drug's potential on QT prolongation which could avoid a thorough QT study at a later development stage. A concept where PK is most instrumental in DD is establishing bioequivalence for generic products. To receive approval, applicants have to demonstrate that a proposed drug product is bioequivalent, i.e. has the same rate and extent of absorption, to a reference product. To solely rely on PK is based on the principle that systemic exposure is a surrogate for effects of the drug (efficacy, safety). Efficacy does not need to be determined if the exposure is comparable between the generic and the reference drug. Ultimately, such 'abbreviated development' saves a lot of resources and avoids unnecessary replication of prior work performed for the reference drug. Conceptually, PK, PD, and biomarkers (PD or non-PD) can be considered 'surrogates' for the clinical efficacy and safety of a drug once their relationship is known and predictable. The most extreme example is the aforementioned bioequivalence concept in generic DD where PK is the only surrogate for its safety and efficacy. Rationale DD therefore requires a thorough understanding of these parameters and its relationship to the safety and efficacy [1].

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

In their work, the authors point out that the choice of dose selection is an ongoing challenge in developing new anticancer agents. The design of early clinical studies based on the pharmacological characteristics of the drug is essential to ensure a successful development plan, but it is not always feasible, as it requires rapid approval following a sequential Phase 1-3 trial. In a majority of cases, experience shows that a personalized approach in dosing based on the

characteristics of each patient and each drug could improve the safety and efficacy of the treatment. In clinical trials, the current approach is to follow the standard 3+3 design to assess dose-limiting toxicities. This approach is valuable and informative for the old cytotoxic agents, but it is problematic for the newer modalities such as tyrosine kinase inhibitors, biologics, and antibody-drug conjugates (ADCs). As a result, there are many cases of approved drugs requiring dose modifications later based on post-marketing studies requested by the FDA or performed by the research community. A new paradigm for designing clinical trials that will precisely assess and define the optimal dose of new anticancer agents will accelerate drug approval and allow for more successful and safer drugs to enter the market [2].

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

In their work, the authors describe the clinical pharmacology characterization of giredestrant, a highly potent nonsteroidal oral selective estrogen receptor (ER) antagonist and degrader. Giredestrant was designed to optimize ER antagonism and degradation, while minimizing off-target toxicity. Several oral selective estrogen receptor degraders are in clinical development, all with distinct physicochemical and PKs properties. Variations in these characteristics, such as unfavorable PK attributes [including nonlinear PKs, food effects, or drug-drug interactions (DDIs) with combination partners] may affect dosing, efficacy, and safety. This first-in-human phase Ia/Ib dose-escalation/-expansion study was designed to evaluate the safety, PKs, PDs, and preliminary antitumor activity of giredestrant. In particular, the PKs were evaluated by characterizing the ADME of giredestrant, and generated signal-seeking data on the impact of certain intrinsic factors (including race and organ dysfunction) and extrinsic factors (including the effect of food and DDIs) on giredestrant exposure. This multicenter nonrandomized open-label dose-escalation and -expansion phase Ia/Ib study evaluated the safety, PKs, PDs, and preliminary antitumor activity of giredestrant alone and in combination with palbociclib in patients with ER-positive (ER+) human epidermal growth factor receptor 2 (HER2)-negative locally advanced/metastatic breast cancer. In brief, eligible patients had advanced or metastatic ER+/HER2-negative breast cancer that had recurred or progressed while being treated with adjuvant endocrine therapy (ET) for ≥ 24 months and/or ET in the incurable, locally advanced, or metastatic setting and derived a clinical benefit from therapy (i.e., tumor response or stable disease for ≥ 6 months); had not received any other ET, targeted therapy, or chemotherapy within the preceding 2 weeks; and were postmenopausal women (or premenopausal/perimenopausal women simultaneously receiving luteinizing hormone-releasing hormone agonists). To enroll a racially diverse population, the study was performed globally at sites in Europe, North America, Asia, and Australia. In the single-agent dose-escalation stage, giredestrant was administered orally once daily on days 1-28 of each 28-day cycle at 10, 30, 90, or 250 mg. A single dose was administered on cycle 1 day -7, followed by a 7-day PK lead-in for all single-agent giredestrant dose-escalation cohorts. In addition, a combination cohort in the dose-escalation stage explored giredestrant 100 mg once daily (days 1-28) in combination with palbociclib 125 mg once daily (days

1-21), repeated every 28 days. In the expansion stage, single-agent expansion cohorts evaluated giredestrant at doses of 30, 100, and 250 mg once daily. A combination expansion cohort evaluated giredestrant 100 mg with palbociclib 125 mg [3].

In the single-agent dose-escalation stage, PK samples were collected at cycle 1 day -7 predose and then at 0.5, 1, 1.5, 2, 3, 4, 6, 8, 24, 28, 72, 96, and 168 hours after dosing to characterize the single-dose PK profile and estimate the terminal half-life. Samples to determine the steady-state PK profile were collected at cycle 2 day 1 (after 28 days of daily giredestrant) predose and at 0.5, 1, 1.5, 2, 3, 4, 6, and 8 hours after dosing. Metabolite identification was conducted following the first dose (cycle 1 day -7) and at steady state (cycle 2 day 1) in 6 patients (3 patients at 90 mg and 3 at 250 mg). Plasma samples were pooled across patients and timepoints. The cytochrome P450 (CYP) 3A induction potential of giredestrant was evaluated in vivo by assessing 4beta-hydroxycholesterol (4β-HC), an endogenous biomarker formed by CYP3A metabolism in humans. 4β-HC concentration was measured at cycle 1 day -7, cycle 2 day 1, cycle 3 day 1, and cycle 4 day 1 predose in 7 patients (5 patients at 30 mg and 2 at 90 mg). Analysis was conducted ad hoc, in compliance with the informed consent, in patients from whom there was sufficient plasma volume remaining for the assessment after completion of prespecified analyses. Giredestrant concentrations in urine samples were measured at cycle 1 day 1 predose and cycle 2 day 1 at 0-8 hours postdose. Urine samples were collected from 13 patients (7 patients at 30 mg, 5 at 100 mg, 1 at 250 mg). PK parameters for giredestrant were calculated from the plasma concentration-time data according to standard noncompartmental analysis methods using Phoenix WinNonlin (version 8.3.4; Certara USA, Inc.). Noncompartmental analyses were conducted in PK-evaluable patients, defined as those having at least one nonzero postdose plasma concentration. Patients with dose reductions, sparse PK samples, incomplete PK profiles, or incorrect dosing information during PK sampling were not included in the noncompartmental analysis. The concentrations of giredestrant in plasma were measured using validated liquid chromatography with tandem mass spectrometry (LC/MS-MS) assays. Giredestrant and its internal standard [(13C8, 15N) GDC 9545] were extracted from human plasma by supported liquid extraction (SLE). Giredestrant concentrations were calculated using a standard curve with a 1/x² linear regression over concentration ranges of 1 to 1,000 ng/mL or 0.1 to 100 ng/mL. The concentrations of giredestrant in urine were measured using a qualified LC/MS-MS assay. Giredestrant and its internal standard were also extracted from human urine by SLE. Giredestrant concentrations were calculated using a standard curve with a 1/x² linear regression over a concentration range of 0.25 to 250 ng/mL. Concentrations of 4β-HC were measured using an LC/MS-MS assay that was developed and validated in human plasma. 4β-HC and its internal standard 4β-HC-d7 were extracted from human plasma by SLE. 4β-HC concentrations were calculated using a standard curve with a 1/x² linear regression over a concentration range of 4 to 100 ng/mL. For plasma, urine, and 4β-HC assays, the mass spectrometer was operated in positive electrospray ionization mode under optimized conditions with multiple reaction monitoring of analytes and internal standards. The precision and accuracy of assays were satisfactory throughout the study. For metabolite identification, plasma samples were extracted by protein precipitation. Parent and metabolites were analyzed by LC and high-resolution MS. The metabolite structures were proposed on the basis of fragmentation patterns and comparison with those of the parent. In the single-agent dose-escalation stage, giredestrant was taken under fasted conditions (fasted for ≥6 hours overnight) until cycle 4 day 1. To explore whether giredestrant had a potential food effect, patients in the single-agent dose-expansion cohorts were able to take giredestrant with or without food, and were asked to complete a food diary at cycle 2 day 1. Patients who had reported fasting for longer than 6 hours before giredestrant dosing were considered as fasted. The study was conducted in accordance with the protocol and the consensus ethical principles derived from international guidelines including the Declaration of Helsinki and

Council for International Organizations of Medical Sciences International Ethical Guidelines for Health-Related Research Involving Humans, relevant International Conference on Harmonisation Good Clinical Practice guidelines, and applicable laws and regulations. All patients provided written informed consent [3].

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

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

The authors' analysis found that integrating QSP approaches in DD has shown promising results in various aspects of the field. By mechanistically modeling drug PK and PD alongside disease pathophysiology, QSP provides valuable insights and has the potential to address key challenges in the DD process. QSP has demonstrated its ability to identify optimal targets and biomarkers for specific diseases, improve therapeutic effectiveness through drug combination strategies, predict human response doses based on preclinical data, and repurpose existing drugs

for new indications. In addition, QSP can facilitate individualized dosing regimens based on patient characteristics, leading to the adoption of personalized medicine and potentially enhancing treatment outcomes. Training and fostering multidisciplinary expertise at scale are essential to proposing, developing, and effectively communicating QSP modeling analyses. Pharmacologists, with their clinical research training and understanding of pathology and pharmacotherapy, can play a vital role in bridging the gap between physiologists and modeling engineers. They can act as interpreters, utilizing the expertise of QSP teams to support decision-making in the clinical trial process and the development of novel molecules [5].

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

Chelliah V. et al. [8] in their work say that DD in oncology commonly exploits the tools of molecular biology to gain therapeutic benefit through reprogramming of cellular responses. In IO the aim is to direct the patient's own immune system to fight cancer. After remarkable successes of antibodies targeting programmed cell death protein 1 (PD1)/ programmed death ligand-1 (PD-L1) and cytotoxic T-lymphocyte antigen-4 (CTLA4) receptors in targeted patient populations, the focus of further development has shifted toward combination therapies. However, the current DD approach of exploiting a vast number of possible combination targets and dosing regimens has proven to be challenging and is arguably inefficient. In particular, the unprecedented number of clinical trials testing different combinations may no longer be sustainable by the population of available patients. Further development in IO requires a step change in selection and validation of candidate therapies to decrease development attrition rate and limit the number of clinical trials.

QSP proposes to tackle this challenge through mechanistic modeling and simulation. Compounds' PKs, target binding, and mechanisms of action as well as existing knowledge on the underlying tumor and immune system biology are described by quantitative, dynamic models aiming to predict clinical results for novel combinations. In light of the unprecedented number of ongoing and planned clinical trials and preclinical programs for IO combination therapies and the emergence of examples of late-stage attrition, there is an urgent need to improve the process of selecting candidate therapies and improve the design of trials to increase the chances of success and terminate low-value programs prior to clinical testing. QSP models integrate existing mechanistic knowledge on disease and drug PK/PD in a quantitative framework allowing simulation of virtual trials, where candidate drug combinations are evaluated *in silico* before being tested in the clinic. Although development of full-scale platform models allowing virtual screening of large numbers of candidate therapies became possible only recently, the current QSP approaches capitalize on the legacy of 3 decades of progress in mathematical and systems biology. Recently developed QSP models have started to demonstrate their potential in actual DD case studies that indicate both feasibility and benefit of the approach. Based on these early results, our colleagues predict that QSP models will increasingly be used in IO DD and that it will soon become standard practice to run virtual trials ahead of and in parallel with clinical trials to more quickly bring better therapeutics to patients with cancer.

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

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

As our colleagues note the central tenet of pharmacology necessitates deep understanding of drug kinetics as it is critically related to efficacy and toxicity. At the apparent level, the kinetic profiles of both small molecules and protein therapeutics (SMs/PTs) and ACTs are multiphasic; however, the underlying mechanisms are fundamentally different. Due to the unique properties and kinetics of ACTs, several traditional CP considerations/lessons learned from SM/PT are either unknown or less applicable. Some examples include: (1) the impact of renal and hepatic impairment on cellular kinetics has not been reported; (2) the effect from food, formulation, and acid reducing agents are not relevant due to the intravenous administration of ACT; (3) the traditional half-life driven dosing frequency may not be suitable as the memory cells can be reactivated; and (4) the concept of dose proportionality is less applicable because the drug can be generated *de novo* by cellular expansion driven by many factors (e.g., host immune status and tumor immunogenicity) that are unrelated to dose [10].

ACT is a complex and novel modality that has shown tremendous promise for treating cancer, with five FDA-approved CAR T cell therapies so far. Along with the technology and regulatory guidance, the CP aspect of this new treatment modality is still evolving. As the core purpose of CP is to determine the best dose/product (i.e., what) for the most appropriate patient (i.e., who) with the optimal conditioning/administration regimen (i.e., how), it is critical to understand the complex interaction between T cells and host biology/disease to identify key factors that we can control and relate to safety and efficacy. Several control points include product characteristics (i.e., dose, fitness, phenotype, and subset of both apheresis product and infusion product), patient characteristics (i.e., demographic information, tumor type, tumor burden, and tumor microenvironment), and regimen characteristics (timing and type of conditioning therapy, comedications, single vs. multiple infusion, and intravenous vs. regional injection). The large number of ACT control points demonstrate the uniqueness of this therapeutic modality compared with SM/PT, necessitating close collaboration of CP with biomarker, bioanalytical, chemistry, manufacturing, and control, and clinical science and safety teams. As our understanding of these control points improves and/or more homogenous cellular products are developed, clinical pharmacologists will have opportunities to better guide dose selection (first-in-human), escalation/expansion (phase I), and determination (pivotal) to optimize ACT development. To

ensure optimal clinical development, clinical pharmacologists can contribute by applying quantitative methodologies, including: (1) translational PK/PD modeling to optimize product, patient, and regimen characteristics before the first-in-human study; (2) real-time statistical/machine learning approaches to forecast severe toxicity probability and mitigate risk during the clinical study; and (3) nonlinear mixed-effect and QSP modeling to gain deep insight and design future studies more appropriately with optimal selection of dose, patient, and regimen. Given the complexity and cost of delivering these therapies, initial studies may generate rich, robust, and multilevel datasets of T cell, biomarker, safety, and efficacy data, but in a relatively small number of patients. Therefore, integration of data across internal ACTs and externally published ACTs will be critical to drawing conclusions and informing decision making. As the field evolves and additional key drivers of safety and efficacy are elucidated, banking and preserving tissues may prove valuable as samples can be re-assayed for new biomarkers or other characteristics. These quantitative methodologies and infrastructure are anticipated to transfer well to the next generation of cell therapies, including T cell receptor (TCR)-T, Natural killer NK-T, and off the shelf/allogeneic cell systems and individualized therapies targeting tumor-specific private neo-antigens [10].

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

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

Our colleagues collected the following baseline information after patients provided informed consent and before they started a new line of palliative cancer treatment. Socio-demographic variables included age (continuous variable), gender, race (White, Black, and others), education (less than high school, high school graduate, and some college or more), and income ($\leq \$50,000$ and $> \$50,000$ / declined to answer). Clinical variables included cancer type

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

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

estimated impact of treatment on quality of life. In multivariable GEE regression, authors found that each additional year of age was associated with 10% increased odds of treatment modification at cycle 1. [odds ratio (OR) 1.1, 95% confidence interval (CI) 1.0-1.2]. Receipt of second or greater line of chemotherapy (OR 1.8, CI 1.1-3.0), functional impairment (OR 1.6, CI 1.1-2.3), and lower income (OR 1.7, CI 1.1-2.4) were also associated with increased odds of treatment modification at cycle 1. A significant moderation effect was found between patients' age and physician-estimated life expectancy for cycle 1 treatment modification ($p=0.02$). In adjusted models and after stratification of the study population by age group (70-74 ($n=136$), 75-79 ($n=114$), and ≥ 80 ($n=118$)), researchers found that among patients aged 70-74 years, those who had an estimated life expectancy of more than one year had 2.5 times the odds of receiving standard of care doses compared to those who had a life expectancy of less than one year (CI 1.1-5.4). Among patients aged 75-79 years and patients ≥ 80 years, those who had life expectancies greater than one year had 1.3 (CI 0.6-3.1) and 1.2 (CI 0.5-2.6) times the odds of receiving standard of care doses compared to those had life expectancies of less than one year. Increasing age did not moderate the associations of functional status, physical performance, or cognition with treatment modification at cycle 1 ($p>0.05$). Summarizing the results of the study, the authors note that in this large, nationwide study of older adults with advanced cancer receiving palliative treatment, our colleagues observed that 35% received a modified treatment regimen at cycle 1. Increasing age, lower income, functional impairment, and receipt of prior lines of treatment were associated with increased odds of treatment modification. Additionally, researchers observed chronologic age as a moderator in the relationship between life expectancy and treatment recommendations, suggesting that life expectancy is weighted more or less heavily in treatment decisions depending on chronologic age. The rate of treatment modification in this population emphasizes the importance of developing evidence-based treatment regimens for older adults with advanced cancer and GA impairments. Future studies should evaluate the longitudinal effect of cycle 1 treatment modifications in the advanced cancer setting on both cancer and patient-reported outcomes [12].

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

the chemotherapy dose (ie, lower dose/intensity) when introducing the new drug if DDI is suspected, since the new drug may not provide efficacy and the loss of benefit to the child from adjusting backbone therapy would leave the patients in a subtherapeutic window. This again highlights the need for a model-informed DD approach to provide the appropriate dosing instructions for concomitant drug administration in children.

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

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

As Kaşkal M. et al. [14] emphasize in their work one of the goals of CP is to optimize patient treatment by adopting new treatment strategies which will increase the efficacy of the treatment and decrease the adverse effects of the drugs. In the literature, it has shown that the effectiveness and toxicity of medications can vary significantly based on when they are administered, making timing a crucial factor in treatment plans. Chronopharmacology a relatively new branch of CP focuses on adjusting drug administration times to enhance patient outcomes. Chronopharmacology is largely influenced by an individual's circadian rhythm which refers to periodic changes in biological processes depending on the time of the day. The chronopharmacology influences clinical practice, and the accumulating knowledge in this field will likely lead healthcare providers to adopt new strategies for drug treatment regimens. Chronopharmacology is a branch of pharmacology that studies how the timing of drug administration affects the body's response to medication. It emphasizes the role of biological rhythms, such as the circadian rhythm, in influencing drug effectiveness and safety. The studies on chronopharmacology are divided into two main areas: chronopharmacokinetics and chronopharmacodynamics.

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

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

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

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

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

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

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

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STROKE AS AN EMERGENCY CONDITION: ANALYSIS OF CLINICAL OUTCOMES AT THE EMERGENCY MEDICAL CARE HOSPITAL IN ASTANA

Omarbek Aliya M.

master's student Astana Medical University Astana, Kazakhstan

Iskakova Saule A.

Head of Laboratory, Research Institute of Preventive Medicine Astana Medical University
Astana, Kazakhstan

Stroke remains one of the leading causes of death and disability in Kazakhstan. Timely care, early diagnosis, and optimization of patient routing significantly affect the outcome of the disease. The Astana Emergency Medical Care Hospital (EMCH) provides intensive care and primary neuroimaging, which allows for the assessment of the actual clinical results of emergency care. This study aims to analyze the clinical outcomes of stroke patients at the EMCH based on 37 observations.

MATERIALS AND METHODS: A retrospective analysis of 37 medical records of patients hospitalized in the emergency medical care hospital with a diagnosis of acute cerebrovascular accident was performed. Demographic data, stroke type (ischemic/hemorrhagic), time from symptom onset to hospitalization, CT/MRI data, vital signs, NIHSS on admission, treatment, including thrombolytic therapy, and clinical outcome at discharge were studied. Statistical analysis included descriptive indicators and comparative assessment of outcomes depending on the type of stroke and time of hospitalization.

RESULTS Most patients had ischemic stroke; hemorrhagic forms accounted for a smaller proportion but were characterized by more severe condition and high mortality. The average age of patients was elevated, with a predominance of individuals with hypertension and other risk factors.

The time of admission for a significant proportion of patients exceeded the therapeutic “therapeutic window,” which limited the use of thrombolytic therapy. Improvement in neurological status at the time of discharge was recorded in some patients with ischemic stroke; stable condition without significant dynamics was recorded in patients with late referral. Fatalities were recorded among patients with severe hemorrhagic stroke and high NIHSS scores on admission.

DISCUSSION The results demonstrate the critical impact of time to hospitalization and severity of condition on stroke prognosis. The low rate of thrombolysis is due to late treatment and insufficient patient awareness of stroke symptoms. The data also confirm that hemorrhagic stroke is associated with a more unfavorable outcome.

It is necessary to optimize the logistics of emergency care, raise public awareness of the signs of stroke, and improve protocols in emergency medical services. The results of the study can serve as a basis for improving the organization of emergency care and developing preventive measures.

INTEGRATING CLINICO-EPIDEMIOLOGICAL INDICATORS, HEMATOLOGICAL PROFILES, AND MELD-Na SYSTEM FOR SEVERITY ASSESSMENT IN LIVER DISORDERS

Mathpati Shreya B.

Doctor of Pharmacy, Research Scholar, Department of Pharmacology, Faculty of ASPM's K. T. Patil College of Pharmacy, Siddharth Nagar, Barshi Road, Dharashiv- 413 501, Maharashtra, India

Salunke Sanyukta K.

Doctor of Pharmacy, Research Scholar, Department of Pharmacology, Faculty of ASPM's K. T. Patil College of Pharmacy, Siddharth Nagar, Barshi Road, Dharashiv- 413 501, Maharashtra, India

Lohar Om S.

Doctor of Pharmacy, Research Scholar, Department of Pharmacology, Faculty of ASPM's K. T. Patil College of Pharmacy, Siddharth Nagar, Barshi Road, Dharashiv- 413 501, Maharashtra, India

Dr. Gunjegaonkar Shivshankar M.

M. Pharm., Ph.D., Associate Professor, Head of Department, Department of Pharmacology, Faculty of ASPM's K. T. Patil College of Pharmacy, Siddharth Nagar, Barshi Road, Dharashiv- 413 501, Maharashtra, India

Dr. Joshi Amol A.

M. Pharm., Ph.D., Principal, Department of Pharmacognosy, Faculty of ASPM's KT Patil College of Pharmacy, Siddharth Nagar, Barshi Road, Dharashiv- 413 501, Maharashtra, India

***Corresponding Author-** Dr. Gunjegaonkar S. M.)

Orchid ID- <https://orcid.org/0000-0001-7822-2859>

Tel. +91-932-600 68 25.

ABSTRACT:

Liver diseases are frequently associated with hematological abnormalities due to impaired hepatic synthesis, portal hypertension, and hypersplenism. The MELD-Na score is widely used to assess disease severity, yet its correlation with hematological derangements is not fully established. This study aimed to evaluate the relationship between liver disease severity measured by MELD-Na, and key hematological abnormalities, including anemia, leukopenia, thrombocytopenia, and coagulation disturbances. In a cohort of patients with chronic liver disease, MELD-Na scores, complete blood counts and coagulation parameters were analyzed. Higher MELD-Na scores demonstrated a consistent association with worsening hematological indices, particularly anemia and thrombocytopenia. The findings suggest that integrating hematological parameters with MELD-Na may enhance the evaluation of disease severity and support better clinical decision-making in chronic liver disease management.

1. INTRODUCTION:

The liver is a vital organ responsible for a diverse range of physiological functions, including metabolism of nutrients, detoxification of endogenous and exogenous substances, synthesis of plasma proteins, regulation of coagulation pathways, and maintenance of hematological balance. Due to its central metabolic role, injury to the liver can result in widespread systemic disturbances [1]. Chronic liver diseases, irrespective of their underlying etiology, often progress through phases of inflammation, fibrosis, and eventually cirrhosis, leading to irreversible architectural distortion and functional impairment [2]. As liver dysfunction advances, multiple organ systems are affected, particularly the hematopoietic system, resulting in clinically significant hematological abnormalities [3]. Hematological abnormalities are commonly encountered among patients with chronic liver disease and include anemia, thrombocytopenia, leukopenia, and coagulopathy. The presence and severity of these abnormalities can influence the course of the disease, predispose patients to complications like bleeding, infection, and fatigue, and thereby impact overall morbidity and mortality [4]. Assessment of liver disease severity is essential for clinical decision-making, prognostication, and prioritization for liver transplantation. The MELD-Na (Model for End-Stage Liver Disease–Sodium) score is a widely used, validated scoring system that incorporates serum bilirubin, international normalized ratio (INR), serum creatinine, and serum sodium levels to estimate disease severity and predict short-term mortality in patients with advanced liver disease [5]. MELD-Na has largely replaced subjective clinical assessments, offering a more objective and reliable measure of liver function and prognosis. Higher MELD-Na scores have been associated with increased disease severity, complications, and poorer clinical outcomes [6]. Furthermore, the progression and manifestation of liver disease and its hematological consequences may be influenced by underlying risk factors such as chronic alcoholism, viral hepatitis infections, etc. [7]. Therefore, evaluating the association between the severity of liver disease as assessed by MELD-Na and the presence of hematological abnormalities is of significant clinical importance [8]. Such an assessment can enhance understanding of disease dynamics, assist in risk stratification, guide therapeutic strategies, and ultimately improve patient outcomes.

1.1. EPIDEMIOLOGY:

Liver diseases continue to cause ~2 million deaths annually, maintaining their position as a major global health burden [9]. The 2023 global update confirms cirrhosis and liver cancer as the principal contributors, driven mainly by viral hepatitis (HBV/HCV), alcohol, and a rapidly increasing burden from NAFLD/MASH [10]. According to the WHO 2024 Hepatitis Report, 1.3 million deaths occurred in 2022 from chronic HBV and HCV—an increase from 2019—despite the availability of highly effective prevention and treatment strategies [11]. Globally, 304 million people live with chronic hepatitis B or C, but diagnosis and treatment remain critically low. Meanwhile, NAFLD/MASH continues rising, fueled by global increases in obesity and diabetes, and is becoming one of the fastest-growing contributors to cirrhosis. Overall, although certain regions show declining age-adjusted mortality, the absolute global burden of liver disease is increasing, especially from metabolic causes [12].

Table 1.1 Comparative Epidemiology of Major Liver Diseases (India vs Global) [13][14]

Liver Disease Category	India – Prevalence / Burden (2023–24)	Global – Prevalence / Burden (2023–24)
NAFLD / MAFLD	20–32% prevalence in general population; rising sharply due to obesity & diabetes	~30% global prevalence; leading cause of chronic liver disease
Alcohol-Associated Liver Disease (AALD)	Alcohol use-related liver disease accounts for ~15–20% of CLD hospitalizations	Accounts for ~50% of global cirrhosis deaths
Viral Hepatitis (HBV)	~1.5% prevalence; ~18 million infected	~296 million living with chronic HBV
Viral Hepatitis (HCV)	0.5–1% prevalence; ~6–12 million infected	~58 million living with chronic HCV
Cirrhosis (all causes)	~1.1 million people affected; >200,000 deaths annually	~112 million cases globally; ~1.3 million deaths annually
Hepatocellular Carcinoma (HCC)	Rising incidence; >30,000 new cases/year	3rd leading cause of cancer death; >900,000 cases globally
Acute Liver Failure	Commonly due to viral hepatitis, drugs, sepsis	Major global cause of ICU mortality; high regional variation

The global and Indian epidemiology of liver diseases highlights a shifting landscape in which metabolic and lifestyle-related factors are becoming increasingly dominant. India mirrors global trends but often with greater intensity, particularly in the rising prevalence of NAFLD, which now affects nearly 40% of Indian adults—higher than the global average. This reflects the rapid growth of obesity, insulin resistance, and type 2 diabetes within the country. While viral hepatitis remains a major global driver of liver-related mortality, India continues to experience a significant burden from chronic hepatitis B, with an estimated 40 million people infected. In contrast, hepatitis C prevalence in India is relatively low overall but shows high regional clustering, emphasizing the need for targeted screening. A notable distinction is the disproportionate role of alcohol in India, accounting for over 40% of cirrhosis cases, much higher than several global estimates. This, coupled with increasing NAFLD-related cirrhosis, contributes to rising rates of hepatic decompensation and liver cancer. Despite advances in vaccines, antiviral therapies, and improved diagnostic tools, liver disease remains a major cause of preventable death both globally and in India. The persistently high burden underscores the necessity for strengthened public health strategies, including routine screening for hepatitis, metabolic disease management, alcohol-harm reduction, and improved access to liver-specific care [15].

1.2. TYPES OF LIVER DISEASE:

The liver is susceptible to a wide range of diseases due to its central role in metabolism, detoxification, and bile production. These diseases may arise from infectious, metabolic, autoimmune, toxic, or neoplastic causes, leading to varying degrees of inflammation, fibrosis, and functional impairment. Understanding the different types of liver diseases is essential for accurate diagnosis, prognosis, and appropriate therapeutic intervention.

Table1.2. Types of Liver disease [13]

Disease / Condition	Description	Etiology / Pathogenesis	Clinical Importance
Hepatitis A	Acute inflammation of the liver, usually self-limiting.	Caused by Hepatitis A virus, transmitted by fecal–oral route.	Usually does not lead to chronic liver disease.
Hepatitis B	Viral infection causing acute or chronic hepatitis.	HBV infects hepatocytes and integrates into host genome.	Chronic infection increases risk of cirrhosis and hepatocellular carcinoma (HCC).
Hepatitis C	Chronic viral liver disease with long-term inflammation.	HCV leads to persistent immune-mediated hepatocyte injury.	Major global cause of chronic liver disease and HCC.
Alcoholic Liver Disease (ALD)	Spectrum of liver damage caused by chronic alcohol consumption; includes fatty liver, alcoholic hepatitis, and alcoholic cirrhosis.	Ethanol metabolism produces acetaldehyde & reactive oxygen species → oxidative stress → inflammation → fibrosis.	Early fatty liver is reversible with abstinence; alcoholic hepatitis may be severe; advanced cirrhosis is irreversible and increases risk of HCC.
Autoimmune Hepatitis	Chronic immune-mediated hepatocyte inflammation.	Autoantibodies & T-cell mediated immune destruction.	May progress to cirrhosis if untreated; responds to corticosteroids & immunosuppressants.
Non-Alcoholic Fatty Liver Disease (NAFLD)	Excess fat deposition in hepatocytes without alcohol intake.	Associated with insulin resistance, obesity, and metabolic syndrome.	Can progress to NASH, fibrosis, cirrhosis, and HCC.
Non-Alcoholic Steatohepatitis (NASH)	Inflammatory subtype of NAFLD.	Lipotoxicity triggers hepatocyte injury + inflammatory response.	Higher risk of progression to cirrhosis and liver cancer.
Cirrhosis	End-stage irreversible liver fibrosis with nodules.	Final outcome of chronic liver injury of multiple causes.	Causes portal hypertension & liver failure; high HCC risk.
Hepatocellular Carcinoma (HCC)	Primary malignant liver tumor.	Develops commonly in cirrhotic livers (HBV, HCV, NAFLD, ALD).	Major cause of cancer mortality; requires early detection.

1.3. STAGES OF LIVER DISEASE:

Chronic liver disease evolves slowly over time and generally follows a continuum that includes four major phases:

- Inflammation
- Fibrosis
- Cirrhosis
- End-stage liver disease (ESLD)

- a. Inflammation- Inflammation of the liver tissues is known as hepatitis. The liver's reaction to damage or poisoning is inflammation. It's an effort to initiate the healing process and get rid of infections. This is frequently achieved by acute hepatitis, which is an instantaneous and transient reaction. However, the inflammation persists as long as the injury or poisoning does. Hyperactive healing brought on by chronic hepatitis eventually leads to scarring (fibrosis).
- b. Fibrosis- The liver eventually stiffens due to fibrosis, which is caused by the accumulation of narrow bands of scar tissue. The liver's availability to oxygen and nutrients is diminished when scar tissue decreases blood flow through it. This is how the vitality of the liver starts to progressively deteriorate. Surprisingly, fibrosis can be reversed to some extent. If the damage slows down sufficiently for the liver to heal, scarring may lessen, and liver cells may regenerate.
- c. Cirrhosis- The liver is severely and permanently scarred by cirrhosis. At this point, fibrosis cannot be reversed. The liver's tissues can no longer regenerate when there aren't enough healthy cells left to deal with. However, at this point, harm can still be prevented or lessened. Effects of liver cirrhosis may not initially be felt on liver function since the body will try to make up for the loss.
- d. End-stage Liver disease- When the liver is unable to meet the body's needs, liver failure sets in. Because the body is unable to make up for the losses, this condition is also known as "decompensated cirrhosis." The entire body will start to feel the impacts as liver functions start to deteriorate. Without a liver transplant, chronic liver failure is a slow process that ultimately results in death. A liver is necessary for survival [16].

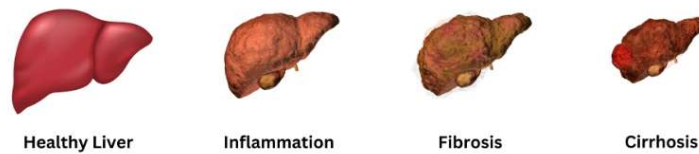


Fig. 1.1 Stages of Liver Disease [17]

1.4. ETIOLOGY:

Table 1.3. Etiology of various liver diseases [18][19]

Etiological Category	Examples	Key Mechanism
Viral Hepatitis	Hepatitis B, Hepatitis C	Chronic viral inflammation leading to fibrosis
Alcohol-related Liver Disease	Chronic alcohol use	Hepatocellular injury, steatosis, inflammation
Metabolic-associated Steatotic Liver Disease (MASLD/NAFLD)	Obesity, diabetes, metabolic syndrome	Insulin resistance, fat accumulation, oxidative stress
Autoimmune Liver Diseases	Autoimmune hepatitis, PBC, PSC	Immune-mediated hepatocyte or bile duct damage
Genetic/Metabolic Disorders	Hemochromatosis, Wilson's disease, A1AT deficiency	Metal overload, protein dysfunction
Drug-Induced Liver Injury (DILI)	Acetaminophen, ATT drugs, herbal supplements	Direct toxicity or idiosyncratic reactions
Cholestatic Diseases	Biliary obstruction, cholestasis	Impaired bile flow causing hepatocellular injury

Liver disease develops from a broad spectrum of underlying causes that trigger chronic inflammation, hepatocellular injury, and progressive fibrosis. Among the most common etiologies worldwide are viral hepatitis, especially hepatitis B and C, which continue to account for a major proportion of chronic liver disease and cirrhosis [18]. Alcohol-related liver disease remains a leading preventable cause and results from long-term excessive alcohol intake that promotes steatosis, inflammation, and eventual cirrhosis [19]. In recent years, metabolic-associated steatotic liver disease (MASLD/NAFLD) has emerged as a rapidly increasing cause, driven primarily by obesity, type 2 diabetes, and metabolic syndrome [20]. Autoimmune liver diseases, including autoimmune hepatitis and primary biliary cholangitis, also contribute significantly and involve immune-mediated destruction of hepatocytes or bile ducts [21]. Drug-induced liver injury (DILI) from medications such as acetaminophen, anti-tubercular drugs, and herbal products represents another important etiology, ranging from mild enzyme elevation to fulminant hepatic failure [22]. Additionally, genetic and metabolic disorders, such as Wilson's disease, hemochromatosis, and alpha-1 antitrypsin deficiency, produce liver damage through abnormal metal deposition or defective protein synthesis [19]. Together, these diverse causes highlight the multifactorial nature of liver disease globally.

1.5. PATHOPHYSIOLOGY:

Chronic liver disease begins with hepatocyte injury triggered by factors such as hepatitis viruses, alcohol, metabolic stress, or toxins. Damaged hepatocytes release reactive oxygen species (ROS) and damage-associated molecular patterns (DAMPs), which activate Kupffer cells, the resident macrophages of the liver [19]. Once activated, Kupffer cells secrete inflammatory cytokines and chemokines, including CCL2, which promote the recruitment of circulating monocytes and T cells, amplifying hepatic inflammation [23]. Kupffer cells also release profibrotic mediators such as transforming growth factor- β (TGF- β) and platelet-derived growth factor (PDGF), which play a central role in converting quiescent hepatic stellate cells (HSCs) into activated HSCs [24]. Activated HSCs undergo transdifferentiation into myofibroblasts, characterized by expression of α -smooth muscle actin (α -SMA) and production of extracellular matrix components such as collagen, fibronectin, and laminin [25]. Progressive accumulation of extracellular matrix (ECM), along with reduced degradation due to tissue inhibitors of metalloproteinases (TIMP), leads to architectural distortion, nodule formation, and increasing fibrosis. Over time, continuous ECM deposition and myofibroblast activity culminate in liver cirrhosis, marked by irreversible scarring, impaired sinusoidal flow, and functional deterioration of the liver [26].

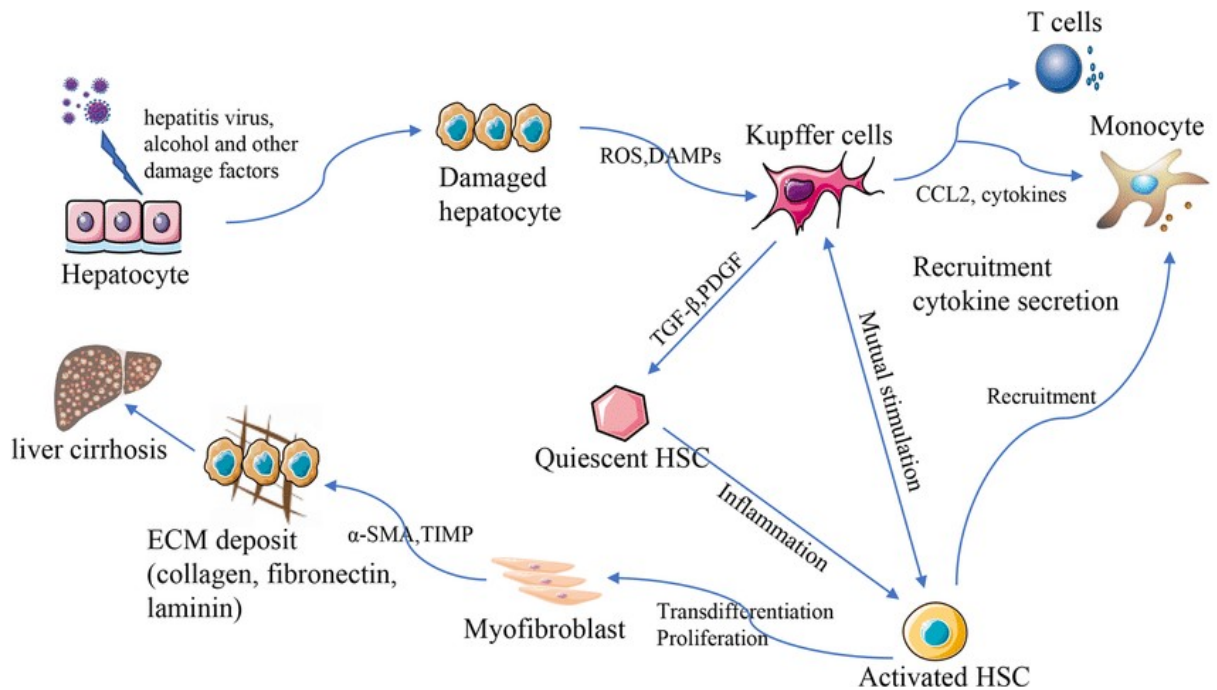


Fig 1.2. Pathophysiology of Liver Diseases [27]

1.6. CLINICAL PRESENTATION:

- 1.6.1. **General and Early Symptoms-** Fatigue and weakness, Loss of appetite, Nausea and vomiting, Unintentional weight loss, Right upper quadrant abdominal discomfort, Low-grade fever, Malaise
- 1.6.2. **Hepatocellular Dysfunction-** Jaundice (yellowing of skin and eyes), Dark urine, Pale or clay-coloured stools, Itching (pruritus), Easy bruising and bleeding, Muscle wasting (sarcopenia), Menstrual irregularities in women, Gynecomastia in men
- 1.6.3. **Symptoms of Advanced/Decompensated Liver Disease-** Refractory ascites, Recurrent jaundice, Recurrent variceal bleeding, Severe muscle wasting, Infections (spontaneous bacterial peritonitis), Kidney dysfunction (hepatorenal syndrome), Persistent confusion or coma [17][19][21].

1.7. DIAGNOSIS:

1.7.1. Clinical Evaluation

- Detailed medical history (alcohol use, viral exposure, drugs, metabolic risk).
- Physical signs: jaundice, ascites, hepatomegaly, spider angiomas, muscle wasting [19].

1.7.2. Laboratory Investigations

- Liver enzymes: ALT, AST → hepatocellular injury
- Cholestatic markers: ALP, GGT → biliary obstruction/cholestasis
- Bilirubin levels: total and direct
- Synthetic function: albumin, PT/INR
- Complete blood count: anemia, thrombocytopenia (portal HTN)

1.7.3. Etiological Tests

- Viral markers: HBsAg, Anti-HCV
- Lipid profile, fasting glucose, HbA1c (NAFLD)

1.7.4. Imaging

- Ultrasound: first-line for liver size, steatosis, masses, ascites
- CT/MRI: vascular changes, lesions, cirrhosis, portal hypertension
- Doppler: portal vein flow assessment

1.7.5. Fibrosis Assessment

- Transient elastography (FibroScan)
- Serum fibrosis markers (FIB-4, APRI, NFS)

1.7.6. Endoscopy (When Indicated)

- For suspected varices in chronic liver disease or cirrhosis

1.7.7. Liver Biopsy

- Gold standard for unclear etiology
- Provides staging of inflammation, fibrosis, steatosis, and architecture [21]

1.8. HEMATOLOGICAL PROFILES IN PATIENTS WITH LIVER DISEASES:

Hematological abnormalities are common in liver disease and reflect both portal hypertension–related structural changes and impaired hepatic synthetic function. Anemia is frequently observed and may result from chronic gastrointestinal blood loss due to portal hypertensive gastropathy or varices, hypersplenism-related sequestration, nutritional deficiencies (especially folate in alcohol use), and hemolysis such as spur-cell anemia in advanced cirrhosis [28]. Macrocytosis is particularly associated with alcohol-related disease due to direct marrow toxicity and altered RBC membrane lipids. Leukopenia, especially neutropenia, arises primarily from hypersplenism caused by portal hypertension, where enlarged spleens sequester and prematurely destroy circulating leukocytes. Additionally, bone marrow suppression from viral hepatitis, alcohol, or chronic inflammation may further decrease WBC counts. Thrombocytopenia is the most frequent hematologic abnormality and occurs due to splenic platelet sequestration and decreased hepatic production of thrombopoietin [29]. Platelet function may also be impaired despite normal counts due to altered membrane glycoproteins and reduced aggregation capacity. Coagulation parameters show characteristic abnormalities because the liver synthesizes most clotting factors. Prolonged PT/INR and aPTT (activated partial Thromboplastin time) reflect reduced synthesis of factors II, V, VII, IX, and X as hepatocellular function deteriorates. In early disease, fibrinogen may remain normal or increased due to inflammation, but in advanced stages or acute-on-chronic liver failure, fibrinogen levels fall and D-dimer rises, indicating increased fibrinolysis and a DIC-like (disseminated intravascular coagulation) state. This creates a “rebalanced but fragile hemostasis,” predisposing to both bleeding and thrombosis [30]. Overall, the hematologic profile in liver disease typically includes anemia, leukopenia, thrombocytopenia, prolonged coagulation times, altered fibrinogen dynamics, and evidence of enhanced fibrinolysis.

Table 1.6. Hematological Parameters affected in Liver disease [29]

Hematological Parameter	Abnormality	Mechanism	Common in (Type of Liver Disease)
Hemoglobin	↓ (Anemia)	Hypersplenism, blood loss from varices, nutritional deficiency, chronic inflammation	Cirrhosis, alcoholic liver disease
MCV	↑ (Macrocytosis)	Alcohol toxicity, folate deficiency, altered lipid composition of RBC membrane	Alcoholic liver disease, chronic liver disease
Platelet count	↓ (Thrombocytopenia)	Splenic sequestration, ↓ thrombopoietin production	Cirrhosis with portal hypertension
WBC count	↓ (Leukopenia)	Hypersplenism, bone marrow suppression (alcohol/viruses)	Cirrhosis, viral hepatitis
PT/INR	↑ (Prolonged)	↓ hepatic synthesis of Factors II, VII, IX, X	Acute & chronic liver failure
aPTT	↑	Reduced intrinsic pathway factors	Acute-on-chronic liver failure
Fibrinogen	↓ (in late disease)	Reduced hepatic production	Decompensated cirrhosis, acute liver failure
D-dimer	↑	Low-grade DIC, fibrinolysis	Cirrhosis, acute liver failure
RBC morphology	Target cells, spur cells	Lipid abnormalities in hepatocytes altering RBC membrane	Advanced cirrhosis, alcoholic liver disease
Platelet function	Qualitative defect	Reduced aggregation, altered membrane glycoproteins	Cirrhosis

1.9. PROGNOSIS:

Multiple prognostic scoring systems are used in liver diseases to evaluate disease severity, estimate mortality risk, and guide clinical decision-making. The Child–Turcotte–Pugh (CTP) score classifies the severity of cirrhosis based on biochemical parameters and clinical features such as ascites and encephalopathy. The MELD score predicts short-term mortality using bilirubin, INR, and creatinine, primarily for transplant prioritization [2]. The MELD-Na score, which incorporates serum sodium, provides superior prognostic accuracy in advanced cirrhosis [31]. Other tools, such as APRI (Aspartate Platelet Ratio Index), FIB-4 (Fibrosis Index Based on 4 Factors), and the NAFLD fibrosis score, estimate fibrosis non-invasively, while Maddrey’s Discriminant Function and the Glasgow Alcoholic Hepatitis Score assess severity in alcoholic hepatitis. In acute liver failure, the King’s College criteria determine the need for urgent transplantation, whereas EASL-CLIF (European Association for the Study of the Liver – Chronic Liver Improvement in Failure) and AARC (Acute-on-Chronic Liver Failure Research Consortium) scores are used to evaluate short-term mortality in acute-on-chronic liver failure. Collectively, these systems assist clinicians in staging disease, predicting outcomes, and determining management strategies.

1.9.1. MELD-Na score:

The MELD-Na score enhances the prediction of 90-day mortality in advanced liver disease by incorporating serum sodium into the traditional MELD model, improving accuracy in patients with hyponatremia, ascites, and portal hypertension. Low MELD-Na values (≤ 9) generally indicate mild, compensated disease with low short-term mortality, whereas scores between 10–19 reflect moderate severity and a higher likelihood of early decompensation. Patients with MELD-Na 20–29 fall into the severe category, characterized by substantial 90-day mortality risk and the need for timely transplant evaluation. Scores of 30–39 represent very severe disease with critically high mortality and an urgent need for transplant prioritization, while values ≥ 40 correspond to extremely critical liver failure with the highest wait-list mortality. By aligning biochemical parameters with these severity thresholds, MELD-Na remains one of the most reliable tools for stratifying risk, guiding clinical decision-making, and prioritizing liver transplant allocation.

Table 1.5. MELD-Na score, severity, and clinical interpretation [31]

MELD-Na Score	Severity Category	Clinical Interpretation
≤ 9	Mild liver disease	Low short-term mortality risk; often managed outpatient.
10–19	Moderate severity	Increased risk of decompensation; closer monitoring required.
20–29	Severe liver disease	High 90-day mortality; transplant evaluation recommended.
30–39	Very severe liver disease	Very high short-term mortality; urgent transplant referral.
≥ 40	Extremely critical	Highest mortality risk; priority candidacy for liver transplant.

1.10. CORRELATION BETWEEN MELD-Na and HEMATOLOGICAL ABNORMALITIES:

As the MELD-Na score increases, reflecting worsening hepatic dysfunction and hyponatremia, hematological abnormalities become more pronounced. Higher MELD-Na correlates strongly with thrombocytopenia due to advanced portal hypertension and hypersplenism, as well as reduced thrombopoietin synthesis. Progressive coagulopathy with prolonged PT/INR and aPTT is observed because severe hepatic insufficiency diminishes production of Vitamin-K dependent clotting factors, fibrinogen, and regulatory anticoagulants. Patients with MELD-Na ≥ 25 frequently demonstrate anemia caused by chronic gastrointestinal blood loss, hemolysis (spur cell anemia), and bone marrow suppression, especially in alcohol-related disease [32]. Leukopenia also worsens with higher scores due to increased splenic sequestration and systemic inflammation. Elevated D-dimer levels and low fibrinogen are particularly associated with MELD-Na >30 and indicate a progression toward acute-on-chronic liver failure or DIC-like physiology. Overall, hematologic deterioration parallels MELD-Na escalation and is a powerful prognostic marker for mortality.

Table 1.7. Correlation between MELD-Na and hematological abnormalities [33]

MELD-Na Category	Hematological Abnormalities	Mechanistic Correlation
<9 (Mild)	Mild thrombocytopenia; near-normal INR, hemoglobin usually preserved	Early portal hypertension → mild hypersplenism; adequate hepatic synthetic function
10–19 (Moderate)	Moderate thrombocytopenia; mild anemia; INR mildly prolonged	Increased splenic sequestration; reduced thrombopoietin; early decline in clotting factor synthesis
20–24 (Severe)	Significant thrombocytopenia (<100k), leukopenia, anemia of chronic disease; INR markedly prolonged	Advanced portal hypertension; impaired factor synthesis; inflammation-related marrow suppression
≥25 (Very Severe)	Severe anemia (may include spur cell hemolysis), WBC suppression, platelets often <70k; INR >2; aPTT ↑	Hepatic failure → major reduction in factors II, VII, IX, X, fibrinogen; systemic inflammation; alcohol-induced marrow suppression
≥30 (Critical)	DIC-like picture: very high D-dimer, low fibrinogen, severe pancytopenia	Synthetic failure + fibrinolysis activation → consumptive coagulopathy

1.11. TREATMENT:

The management of liver disease requires a structured, stage-specific approach that integrates non-pharmacological measures, pharmacological therapy, and interventional strategies according to disease severity and clinical presentation. Early stages focus on reversing underlying injury through lifestyle modification and etiology-targeted therapy, while intermediate stages emphasize prevention of fibrosis progression and monitoring for complications. As cirrhosis evolves from compensated to decompensated states, treatment becomes increasingly directed toward managing complications such as portal hypertension, ascites, variceal bleeding, and hepatic encephalopathy using evidence-based pharmacological and interventional modalities. In end-stage liver disease, supportive management and timely referral for liver transplantation are critical to improving survival.

Table 1.8. Treatment approaches for liver disease [20][30]

Stage of Liver Disease	Non-Pharmacological Treatment	Pharmacological Treatment
Stage 1: Inflammation (Hepatitis)	Alcohol abstinence (ALD) Weight reduction & exercise (NAFLD) Avoid hepatotoxic drugs Vaccination (HAV, HBV) Balanced protein diet	Antivirals: Tenofovir, Entecavir (HBV) Direct-acting antivirals (HCV) Corticosteroids ± Azathioprine (Autoimmune hepatitis) Antioxidants (limited benefit)
Stage 2: Fibrosis	Lifestyle modifications continued Nutritional therapy for sarcopenia Management of metabolic syndrome	Continuation of etiology-specific treatment (HBV/HCV/AIH) Emerging antifibrotic agents (investigational)
Stage 3A: Compensated Cirrhosis	Sodium restriction if early fluid retention Avoid alcohol, NSAIDs Regular surveillance for varices & HCC	Non-selective beta-blockers (propranolol/carvedilol) for variceal prophylaxis Etiology-specific drugs (HBV/HCV/AIH) Vitamin supplementation
Stage 3B: Decompensated Cirrhosis	Dietary sodium restriction Nutritional therapy, high-protein intake Fluid management	Ascites: Spironolactone + Furosemide, Albumin infusions Encephalopathy: Lactulose + Rifaximin Variceal bleeding: Octreotide, Antibiotics (ceftriaxone) SBP: Cefotaxime, Norfloxacin prophylaxis
Stage 4: End-Stage Liver Disease / ESLD	Dietary counseling, Supportive care Palliative interventions if transplant not possible	Treatment of multi-organ involvement (renal, coagulation, electrolytes) Continued management of complications (encephalopathy, infections)

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Economic Sciences

МЕТОДЫ СОВЕРШЕНСТВОВАНИЯ ОРГАНОВ МЕСТНОГО САМОУПРАВЛЕНИЯ В РЕСПУБЛИКЕ КАЗАХСТАН

METHODS OF IMPROVING LOCAL GOVERNMENT IN THE REPUBLIC OF KAZAKHSTAN

Шамуратова Н.Б.

Кокшетауский университет имени Абая Мырзахметова, Кокшетау, Казахстан

Абдикенов Р.К.

Кокшетауский университет имени Абая Мырзахметова, Кокшетау, Казахстан

Аннотация

В данной статье рассматриваются современные подходы к совершенствованию органов местного самоуправления в стране. Здесь анализируются ключевые проблемы развития местного самоуправления, оценивается влияние децентрализации, цифровизации и участия граждан на повышение эффективности местной власти. В статье предлагаются конкретные методы и механизмы, которые направлены на укрепление институциональной устойчивости и повышение качества управления на местном уровне.

Введение

В научном мире и в жизни Казахстана местное самоуправление является важным элементом демократической системы управления в стране. В государстве развитие местного самоуправления и его становление идет с начала 2000 года. В связи с тем, что государственная управленческая система страны перешла на электронное правительство, сейчас, то есть на сегодняшний день развитие как государственного управления так и местного самоуправления тесно связано с моделью «Слышащего государства».

Местное самоуправление является важнейшим элементом демократической системой управления страны в целом.

Принцип открытого управления который внедрен в республике, расширяет полномочие акиматов, повышает роли граждан в принятии решений местного самоуправления. Такое развитие связано с переходом к модели «Слышащего государства».

Как бы не совершенствовали активность граждан в местном самоуправлении, местные власти все же сталкиваются с рядом проблем. Самая большая проблема – это недостаточная финансовая самостоятельность. Так же очень слабое кадровое звено местного уровня. Очень маленькое ограниченное участие населения в целом. И самая актуальная часть проблемы это низкая цифровизация сельской местности.

Таким образом, цель данной статьи – это определить методы, способные повысить эффективность органов местного самоуправления, а так же укрепить их роль в системе государственного управления Республики Казахстан.

Основная часть

В Казахстане местное самоуправление развивается на основе Конституции в Республике Казахстан [1]. Так же работает Указ «О дальнейшем совершенствовании местного самоуправления» принятый 2013 году [2]. Здесь внесены реформы по передаче полномочий местным органам. Здесь же рассматривается внедрение механизмов прямой демократии – общественный совет, участие бюджета, сельские собрания.

Проблемы малого и среднего бизнеса:

- ✓ В сельских акиматах ограниченные финансовые ресурсы;
- ✓ Очень низкий уровень самостоятельности в принятии решений;
- ✓ Очень слабая профессиональная подготовка местных кадров;
- ✓ Недостаточная вовлеченность граждан в местное самоуправление;
- ✓ Непрозрачность информационности деятельности органов местного самоуправления.

Эти вышеуказанные факторы требуют применения современных методов совершенствования системы управления [3].

На современном этапе развития местного самоуправления есть свои методы совершенствования органов местной власти [4].

Одно из ключевых методов децентрализации местного самоуправления является закрепление за местными органами поэтапный рост объема полномочий [5]. Они включают в себя:

- ✓ Самостоятельное управление коммунальной инфраструктурой;
- ✓ Местное распоряжение земельными ресурсами;
- ✓ Развитие малого и среднего бизнеса на местном уровне;
- ✓ Местное управление социальными объектами.

Такого рода расширение функции должно сопровождаться передачей финансовых ресурсов.

Так же необходимо укрепление финансовой независимости для эффективной работы местной власти. Эффективное местное самоуправление не будет возможным без устойчивости финансовой базы [6]. Для этого мы предлагаем следующие методы усиления финансовой возможности:

- ✓ Каждый раз закреплять часть налоговых поступлений за местными бюджетами. Это касается ИПН, земельный налог и имущественный налог.
- ✓ Развить самостоятельный местный источник доходов. Давать в аренду земли, оказывать местные услуги акиматов, собирать местного назначения сборы.
- ✓ Создать грантовое финансирование грантов сельских акиматов. Тематика грантов: развитие инфраструктуры.
- ✓ Создать структуру «бюджета участия». Здесь жители сельской местности сами распределяют часть бюджета.

Так же не маловажную роль играет кадровый потенциал. Ведь качество местного управления напрямую зависит от профессионализма сотрудников [7]. Для повышения качества кадрового потенциала на местной исполнительной власти нужны следующие меры и методы:

- ✓ Создать региональный центр подготовки и повышения квалификации государственных служащих местного назначения;
- ✓ Обучить местный состав работников цифровым навыкам, антикризисному управлению и проектному менеджменту;
- ✓ Создать систему ротации и карьерного роста в местном самоуправлении;
- ✓ Привлекать молодежь к местному самоуправлению через программы стажировок в регионы.

Вместе с тем, нужна цифровизация местного самоуправления. Которая облегчит работу и систему работы в сельских местностях. Цифровизация является основным ключевым условием повышения эффективности местного самоуправления [8]. Для улучшения цифровой трансформации необходимы следующие методы воздействия:

- ✓ Внедрение в акиматы цифровых платформ и мобильных приложений;
- ✓ Оцифровка жизненно важных услуг (ЖКХ, земельные вопросы, справки, заявления);
- ✓ Цифровизация системы мониторинга проектов ремонта дорог, благоустройства, строительства;
- ✓ Внедрение открытых данных;
- ✓ Все заседания маслихатов и общественных слушаний сделать онлайн.

Следует повысить прозрачность и подотчётность для дальнейшего доверия граждан к власти. Чтобы отчетность шла открыто и все видели куда уходят средства бюджета. Для этой объемной работы необходимы эффективные методы воздействия так как:

- ✓ В офлайн и онлайн форматах сделать публичные отчеты акимов перед населением;
- ✓ Проводить общественные слушания перед населением по бюджету и крупным проектам;
- ✓ Создать с участием активных граждан общественные советы;
- ✓ Проводить антикоррупционный мониторинг государственных закупок.

Следует создать институциональные механизмы совершенствования местного самоуправления. Для этого нужны управляющие компаний, которые могут развить инфраструктуру местного значения. Создать модель «умных аулов», чтобы был максимальный интернет охват сельской территорий, поставить датчики мониторинга, а так же усилить онлайн услуги. Необходим системный проектный подход в управлении. Который бы позволил эффективно распределять ресурсы. Объединить ресурсы малых поселений. Быть партнером с бизнесом через ГЧП. Это касается водоснабжения, дорог и школ.

Заключение.

Таким образом, хотим отметить что совершенствование системы органов местного самоуправления в Республике Казахстан, является ключевым фактором развития регионов и повышения качества жизни населения. Его эффективные методы включают децентрализацию региона полностью, укрепляет финансовые базы, улучшает систему цифровизации, активизирует прозрачность работы местного самоуправления и повышает активность граждан. Вышеизложенные методы и пути совершенствования работы местного самоуправления требует - комплексную реализацию этих предложений, которые в свою очередь позволят сформировать современную, устойчивую и ответственную систему местного управления. Которая по своим соответствующим принципам «слышащего государства» и стратегическим целям страны.

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Государственно-частное партнерство как механизм финансирования инфраструктуры высших учебных заведений Казахстана

Төлеубай Нұрқанат Алмасұлы

Казахстанско-Британский Технический университет, Алматы, Казахстан

Түлегенов Османгали Сембаевич

Казахстанско-Британский Технический университет, Алматы, Казахстан

Сагнаев Галым Булатович

Казахстанско-Британский Технический университет, Алматы, Казахстан

Современные условия глобализации экономики и мировых экономических кризисов неизбежно актуализируют вопрос оптимизации расходов государства на развитие инфраструктуры высших учебных заведений. На сегодняшний день государственные вузы являются важнейшими «каналами» поставки новых высококвалифицированных кадров для экономики Казахстана. В Послании Президента Республики Казахстан Н. А. Назарбаева народу «Стратегия «Казахстан-2050»: новый политический курс состоявшегося государства» подчёркивается, что профессионально-техническое и высшее образование должны ориентироваться в первую очередь на максимальное удовлетворение текущих и перспективных потребностей национальной экономики в специалистах, что так же во многом это решит проблему занятости населения [1].

Одновременно возрастает роль инноваций в обеспечении конкурентоспособности страны на мировых рынках и возникает необходимость в понимании роли знаний в экономике. Опыт экономически лидирующих стран показывает, что только наукоемкая экономика, при которой происходит непрерывный процесс обмена знаниями и результатами своей деятельности между бизнесом и наукой, может послужить основой современного конкурентоспособного государства. Как известно, основными поставщиками новых научных знаний и идей были и остаются высшие учебные заведения.

Именно поэтому вузы призваны стать оплотом разработки и обмена инновациями между исследователями и бизнес-средой страны, что возможно реализовать на основе эффективного партнерства государства и бизнеса. Такое сотрудничество имеет ряд преимуществ, как для бизнеса, так и для университетов, создавая предпосылки для реализации не только их экономических интересов, но и интересов общества в целом. Не случайно во всем мире государственно-частное партнерство возникло как важнейший инструмент для преодоления «дефицита инфраструктуры».

Использование механизмов государственно частного партнерства в образовании позволяет обеспечить:

- расширение рынка и усиление добросовестной конкуренции на рынке образовательных услуг;
- апробирование новых для образовательных структур организационно-правовых форм альянса с бизнесом;
- выработку предложений по дальнейшему совершенствованию нормативно-правовой базы реформирования профессиональной школы;

- тиражирование передового опыта; отработку инструментов многоканального финансирования;
- развитие взаимодействия работодателей и вузов;
- совершенствования системы управления в сфере инновационной деятельности, путем обработки содержания и методик администрирования, подготовки повышения квалификации управленческих специалистов.

Государственно-частное взаимодействие дает инвестору возможность:

- участвовать в учебно-научной и управленческой деятельности вуза как с позиции конечного потребителя результатов его труда, так и с позиции инвестора;
- влиять на подготовку высококвалифицированных кадров с учетом потребностей рынка труда;
- создавать и развивать на базе учебных заведений образовательно-производственно-технологические инфраструктуру для обеспечения инновационной деятельности своей компании;
- привлекать студентов и профессорско-преподавательский состав к выполнению в процессе обучения научно-исследовательских работ и к подготовке проектов для решения проблем конкретного бизнеса. В свою очередь, высшие учебные заведения в рамках государственно-частного партнерства получают следующие преимущества:
- использование многоканальных источников финансирования для развития материально-технической базы учебного заведения;
- развитие новой модели интегрированного образовательного комплекса (качественный менеджмент, новая инфраструктура, технологии подготовки студентов и преподавателей);
- повышение финансовой обеспеченности научных исследований преподавателей и студентов (дополнительное финансирование научных разработок и доведение их до коммерческого уровня с патентованием и закреплением авторских прав);
- усиление конкурентоспособности на рынке образовательных услуг [2].

Таким образом, использование механизма государственно-частного партнерства в сфере высшего образования можно также рассматривать как эффективный способ привлечения частных инвестиций в обновление инфраструктуры вузов для соответствия их современным мировым стандартам.

В основе государственно-частного партнерства лежит принцип привлечения частных инвестиций для финансирования государственных проектов с минимизацией рисков неэффективного использования бюджетных средств и минимизации нагрузки на бюджет страны. Данный механизм довольно успешно используется за рубежом в сфере гражданского и инфраструктурного строительства.

К примеру, в Великобритании наиболее эффективными оказались государственно-частные партнерства при строительстве школ, госпиталей, оборонных объектов, а в Канаде в сфере энергетики, водных ресурсов, здравоохранения и образования [3]. Между тем, не секрет, что для инфраструктуры казахстанских государственных вузов характерна такая проблема как устаревание и физический износ, поскольку большая часть инфраструктурных объектов была возведена более 20 лет назад.

Кроме того, логистика расположения корпусов и административных зданий не способствует удобной эксплуатации, а в большинстве вузов чувствуется нехватка жилых площадей для студентов и молодых ученых. Очевидно, возникла необходимость не только в обновлении инфраструктуры высших учебных заведений, но и в разработке генерального плана застройки кампусов с учетом самых прогрессивных энергосберегающих технологий. Однако в условиях давления на экономику Казахстана различных внешних и внутренних факторов, а также учитывая масштабы необходимых финансовых вливаний, предусмотреть

в бюджете денежные средства для обновления инфраструктуры вузов достаточно проблематично. Затянувшийся мировой финансовый кризис, политическая нестабильность в ряде регионов мира непосредственно коррелируют с наполняемостью бюджета страны.

Кроме того, государство старается обезопасить социальную сферу и не допустить перекосов выделения бюджетных средств на определённые проекты. Также возникает вопрос качества и своевременности освоения бюджетных средств, что является немаловажным фактором при осуществлении проектов в сфере строительства и освоения трансфертов из бюджета страны. Все вышеназванные барьеры выявили потребность в использовании таких механизмов финансирования, которые бы не давали такую сильную нагрузку на бюджет Казахстана, решили бы вопрос о качестве освоения денег при строительстве инфраструктуры, а также о своевременности завершения объектов строительства.

Несмотря на то, что на данный момент в Казахстане существует законодательная база, обеспечивающая функционирование государственно-частного партнерства, и в наличии имеется несколько реализованных проектов, данный механизм все еще не получил должного развития в нашей стране. Уже первые шаги, которые были предприняты в сфере государственно-частного партнерства, показали, что наше государство все еще не может найти компромисс с частными инвесторами по разделению рисков проекта.

Хотя опыт других стран показывает, что как раз в этом аспекте государство должно брать на себя большую часть рисков для более успешного привлечения зарубежных инвесторов и частных инвестиций в реализуемый совместный проект. Инвесторы, в том числе и иностранные, не могут принять положительное решение по инвестиционным проектам из-за потенциальных политических рисков и неуверенности в защищенности своих вложений. В свою очередь, негативные условия неопределенности дают повод крупнейшим финансовым организациям взимать дополнительные проценты за выделяемые финансовые ресурсы, что ведет, в конечном счете, к удорожанию капитала при реализации проектов.

Таким образом, сложившаяся институциональная среда закономерно замедляет процесс развития государственно-частного партнерства в Казахстане, хотя соответствующая работа над законодательной базой и управление портфелем рисков – это факторы, находящиеся в компетенции государства, которыми можно эффективно управлять для того, чтобы во всей полноте использовать потенциал и возможности государственно-частного партнерства. Объективно рассматривая механизмы финансирования государственно-частного партнерства в сфере, образования необходимо выделить несколько важных преимуществ:

во-первых, привлечение частных инвестиций для финансирования обновления инфраструктуры высших учебных заведений снимает нагрузку с бюджета страны, которому в данном случае необходимо запланировать расходы на выполнение данных проектов лишь в течение 2-3 лет. Во-вторых, сфера образования – это тот сектор, в котором социальная ответственность частного бизнеса может приносить и экономические выгоды.

В мире сложились многообразные модели финансирования в рамках государственно-частного партнерства, в том числе и такие, где проекты частично или полностью финансируются потребителями услуги (например, платные дороги). В случае использования модели финансирования проекта за счет частных инвестиций инвестор может осуществлять строительство объектов инфраструктуры, как за счет собственных средств, так и за счет привлеченных финансовых ресурсов у коммерческих банков.

Далее после завершения строительства объектов инфраструктуры, инвестор осуществляет передачу объектов на баланс государства, после чего должен получить возмещение своих инвестиционных затрат в течение 8-10 лет.

Таким образом, эффект от государственно-частного взаимодействия заключается в том, что решается важная задача обновления инфраструктуры вуза в течение всего лишь 2-3 лет, при этом государство, в свою очередь, получает возможность производит возмещение затрат инвестору в течение более длительного периода, что положительно сказывается на оптимизации расходов государственного бюджета.

Для государства такое финансовое взаимодействие с бизнесом выгодно еще и потому, что оно не всегда может осуществлять единовременные объемные финансовые инвестиции в инфраструктуру вузов, но способно осуществлять свои платежи бизнесу, разбив их на более длительный срок. А с учетом инфляционных издержек, долговременные выплаты инвестору становятся еще более привлекательными.

Во-вторых, в рамках государственно-частного партнерства оптимально решается вопрос эффективного использования средств при строительстве объектов инфраструктуры высших учебных заведений, а также минимизируется коррупционная составляющая, поскольку концессионер, который и будет осуществлять строительство объекта, заинтересован в наиболее прозрачном процессе строительства.

В-третьих, качество постройки объектов будет являться прерогативой застройщика, поскольку в случае использования механизма ВТО (build-transfer-operate) строительство-передача-управление, после окончания возведения объекта, государственная комиссия должна принять объект у концессионера и на основании этого начать возмещение инвестиционных затрат. Поэтому, в случае некачественного строительства объект концессии, может быть, не принят на баланс государства и концессионер понесет огромные убытки, равные стоимости строительства всего объекта.

Следует подчеркнуть, что зачастую именно государственно-частное партнерство в форме концессии более выгодно для иностранных инвесторов, стремящихся войти на рынок Казахстана, поскольку предполагает определенные государственные гарантии. Но в большей степени это сотрудничество выгодно для нашей страны, которая может использовать передовой мировой опыт в строительстве и инженерии и защищать интересы государства от недобросовестно выполненных работ концессионера.

Между тем, существующие риски и убытки концессионера также велики, поэтому очень важно, что на данный момент государственными органами Казахстана ведется работа по усовершенствованию правовых механизмов по реализации договоров концессии.

Также одной из наиболее перспективных форм государственно-частного партнерства в сфере образования является контракт «жизненного цикла». Он имеет существенные преимущества, поскольку предполагает, что исполнитель получает денежные средства только с момента ввода объекта в эксплуатацию, например, когда в образовательном учреждении начинается реальный учебный процесс или детский сад начинает оказывать услуги по дошкольному воспитанию детей.

В стандартные условия контракта «жизненного цикла» есть возможность внести такие пункты как:

- «замораживание» платежей от государственного партнера в случаях, когда объект не может использоваться по назначению;
- наложение штрафов на частное предприятие за низкие потребительские качества объекта. Преимуществом такого взаимодействия является то, что, используя условия штрафных санкций в контракте жизненного цикла, можно проводить плановые мероприятия по содержанию объекта с минимальными потерями для пользователей.

Таким образом, каждая из многообразных существующих форм государственно-частного партнерства при ее реализации в образовательной сфере имеет преимущества и недостатки, однако социально-экономические эффекты, получаемые обществом от такого сотрудничества безусловно выше. Например, проекты государственно-частного партнерства

могут сыграть важнейшую роль при создании и развитии университетских комплексов, объединяющих образовательные, исследовательские учреждения и иные учреждения и организации. Такая инновационная структура вуза позволяет повысить эффективность и качество образовательного процесса, развить его прикладную направленность, максимально использовать интеллектуальные, материальные, информационные и человеческие ресурсы для подготовки специалистов, проведения исследований, разработки инновационных проектов.

Бизнес сегодня призван и активно способствует развитию социальных инвестиций в области образования. Основным содержанием социальной ответственности компаний в наше время является взаимодействие с образовательными учреждениями, их структурными подразделениями, учебными и научными коллективами, расширение присутствия компаний, как в самом образовательном процессе, так и в управляющих органах. Если раньше частный сектор ограничивался лишь благотворительной помощью, спонсорством или просто пожертвованиями, то сегодня он ориентирован на активное участие в жизни учебного заведения, его развитие, совершенствование материальной базы, в том числе и в рамках государственно-частного партнерства. Характерным признаком последнего времени является создание корпоративных университетов, как в самих компаниях, так и в рамках высшего учебного заведения [5]. Таким образом, можно сказать, что механизмы государственно-частного партнерства в обозримом будущем могут стать одними из основных направлений финансирования развития инфраструктуры и кампусов высших учебных заведений.

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INSTITUTIONAL AND INFRASTRUCTURAL PRECONDITIONS FOR THE FORMATION OF THE PETROCHEMICAL CLUSTER IN KAZAKHSTAN

Toktayeva A.S.

Master of Economics, PhD Student, Al-Farabi Kazakh National University, Almaty, Kazakhstan

Mukhamediyev B.M.

Professor, Higher School of Economics and Business, Al-Farabi Kazakh National University, Almaty, Kazakhstan

Zeinullina A.Zh.

PhD in Economics, Dean of the Higher School of Business and Communication, Shakarim University, Semey, Kazakhstan

Abstract. The article examines the structural and institutional features of forming a competitive petrochemical cluster in the Republic of Kazakhstan as a key element of the national economic diversification strategy. The purpose of the study is to conduct a comprehensive analysis of the internal structure and the factors determining the industry's long-term competitive advantages, as well as to assess its export potential in the context of global competition.

The study employs methods of system and structural-functional analysis, comparative benchmarking, as well as economic-statistical and forecasting techniques. The empirical base consists of official statistical data of the Republic of Kazakhstan, materials of industry associations, and international organizations.

The research findings reveal that the Kazakhstani petrochemical cluster is at an early stage of formation, characterized by a high dependence on imported technologies and a limited depth of hydrocarbon processing. At the same time, the presence of a significant raw material base, geographical advantages, and state support measures create favorable conditions for establishing stable competitive positions in the global market. Comparative analysis with clusters in the Persian Gulf and Southeast Asia identified promising directions for technological and organizational development, including modernization of production and logistics chains and enhancement of innovation activity.

The main conclusions highlight the need for an integrated approach to cluster development, strengthening scientific and technical cooperation, expanding the participation of small and medium-sized enterprises, and integrating into international production networks. The proposed recommendations can be applied in shaping state policy on cluster development and the export-oriented strategy of the petrochemical sector.

Keywords: oil and gas chemical cluster; competitiveness; structural analysis; export potential; economic diversification; industrial policy; interindustry linkages; value added; investment; innovation; infrastructure; government support; human capital; sustainable development.

The contemporary stage of global economic development, characterized by intensified globalization processes, technological transformation, and the need to ensure the sustainability

of national economic systems, underscores the strategic importance of developing industries capable of generating high added value. In this context, the petrochemical sector emerges as a crucial driver of economic growth and technological modernization for resource-rich countries. For the Republic of Kazakhstan, whose economy has historically relied on hydrocarbon exports, the transition from a traditional export-raw-material model to a modern production- and innovation-oriented structure represents an urgent national priority. An effective mechanism for achieving this goal is the formation of competitive industrial clusters, among which the petrochemical cluster occupies a central position. The relevance of this research is driven not only by national economic security imperatives and the need for more rational use of natural resources, but also by the strategic objective of expanding the range of high value-added exported products, thereby strengthening Kazakhstan's position in global production chains.

The primary aim of this study is to conduct a comprehensive structural analysis of the emerging petrochemical cluster in Kazakhstan, identify the key factors that determine its long-term competitiveness at both regional and global levels, and provide a justified assessment and forecast of the sector's export potential under conditions of intensifying international competition. The issues of cluster policy, industrialization, and the development of Kazakhstan's oil and gas sector have been examined by various domestic and international scholars. However, despite the presence of individual works dedicated to general aspects of clustering, the Kazakhstani academic literature still lacks a systematic and integrated approach to evaluating the competitiveness of the petrochemical cluster with regard to its specific structural features, sources of sustainable advantages, and detailed analysis of export potential. This gap highlights the need for a specialized and comprehensive study.

The theoretical significance of this research lies in contributing to the understanding of mechanisms underlying the formation, functioning, and efficiency enhancement of industrial clusters in a developing economy dependent on raw materials. The practical significance is manifested in the applicability of the study's findings and recommendations for government agencies tasked with shaping and adjusting long-term industrial and innovation strategies, designing targeted cluster-support programs, and stimulating foreign direct investment in high-technology petrochemical industries.

The methodological framework of the research integrates principles of system analysis, structural-functional assessment, comparative analysis, and economic-statistical and forecasting methods applied to evaluate export potential. The empirical base includes up-to-date statistical data from official Kazakhstani sources, analytical reports from industry associations and international financial organizations, and regulatory documents governing the development of the petrochemical sector. The chosen methodological approach, grounded in the synthesis of cluster theory and the theory of competitive advantage, facilitates a comprehensive examination of the specific characteristics of Kazakhstan's petrochemical complex and supports evidence-based recommendations for its long-term strategic development.

The relevance of the research is further reinforced by the fact that the development of the petrochemical sector is considered a key factor in Kazakhstan's shift from an export-raw-material model to an economy with high value added. Intensifying global competition and the need for technological modernization necessitate an in-depth analysis of existing theoretical approaches and international practices in developing petrochemical clusters. The theoretical foundation for the literature component is based on cluster theory developed by M. Porter, whose Diamond Model provides crucial insights into how the geographic concentration of interconnected firms and institutions generates sustainable competitive advantages. Additional conceptual guidance is drawn from the works of M. Enright on cluster dynamics and P. Krugman's theories of international trade, which substantiate the need for Kazakhstan's transition from exporting raw materials to exporting value-added petrochemical products. The analytical framework also incorporates

insights from D. Rodrik on industrialization and overcoming resource dependency in transitional economies.

The assessment of scientific literature reveals several key tendencies in global and national petrochemical development. First, international experience—including the petrochemical clusters of the Gulf region and Singapore—demonstrates that clustering is the most effective mechanism for maximizing value creation in capital-intensive chemical industries by generating synergy and reducing logistical costs. Second, studies emphasize the critical role of government support in transitional economies, as large-scale cluster development requires targeted public investment and infrastructure provision. Third, although access to inexpensive raw materials is an important advantage for Kazakhstan, it is insufficient to ensure long-term competitiveness; this advantage must be complemented by technological capabilities and efficient market access. Finally, given the limited size of the domestic market, global research highlights that export orientation—primarily toward China, Russia, and Central Asia—is a key stimulus for continuous improvement in production quality and efficiency.

The literature review also indicates an uneven degree of scholarly elaboration. While theoretical foundations of cluster policy and general macroeconomic aspects of Kazakhstan's hydrocarbon sector are well covered, there is a significant gap in studies that integrate structural analysis with long-term competitiveness assessment and quantitative export potential forecasting for major petrochemical products, particularly polymers. Many works remain at the conceptual level, lacking empirical verification and applied policy recommendations. This identified gap defines the direction of the present research, which aims to fill it through an integrated methodological approach that includes detailed structural analysis, application of Porter's competitive advantage model, and quantitative forecasting of export expansion opportunities.

The empirical base of the analysis encompasses statistical, analytical, and regulatory sources, including data from the Bureau of National Statistics, the Agency for Strategic Planning, the EEC, and reports from the World Bank, OECD, KazEnergy, and KazMunayGas for 2015–2023. Quantitative methods include statistical analysis of macro- and sectoral indicators, time-series analysis, growth rate calculations, structural ratios, and correlation analysis between production, processing, and export parameters. Qualitative methods include expert assessments of institutional conditions, infrastructure constraints, and political-economic factors influencing sectoral development. The use of a mixed methodology enables a comprehensive characterization of the structure and functioning of the cluster.

The structural-functional and systemic approaches allow the petrochemical cluster to be viewed as a complex, hierarchical system composed of interlinked production, logistical, scientific, and administrative subsystems. This approach makes it possible to identify technological and organizational bottlenecks and the constraints that hinder sectoral development. To assess long-term competitiveness, the study employs cluster and factor analysis based on Porter's Diamond Model, evaluating factors of production, internal demand conditions, related industries, and firm strategy and structure. Comparative analysis and benchmarking with leading petrochemical hubs—Saudi Arabia, South Korea, and Singapore—help identify global best practices and adapt them to Kazakhstan's conditions. Forecasting methods and scenario analysis (baseline, moderately optimistic, and innovative scenarios) are used to project future production and export capacities based on global polymer demand, planned investment projects, and integration into global value chains.

Current structural characteristics of Kazakhstan's petrochemical sector indicate that the industry is entering an active development phase and demonstrating stable growth in production and exports. According to KAZENERGY (2023), the share of hydrocarbons in GDP stands at around 20%, reflecting persistent dependence on raw exports, though decreasing compared to 2019. Production volumes are rising significantly: petrochemical output grew from 269 thousand tons in

2023 to 460.7 thousand tons in 2024, with the most rapid increases observed in polypropylene and paraxylene. KPI's production of 251 thousand tons of polypropylene, of which 230 thousand tons were exported, demonstrates growing processing capacity and declining import dependence—from 34% to 17%.

Kazakhstan's petrochemical export orientation remains strong: 79.4% of crude oil and condensate were exported in 2023, while domestic consumption accounted for only 20.6%. At the same time, petrochemical exports increased to over USD 2 billion in 2024, up 13% from the previous year. Infrastructure development—expansion of pipeline transport to 83.5 million tons and a 22% increase in Caspian maritime shipments—supports the sector's export capacity. Institutional and infrastructural foundations are also strengthening: the National Industrial Petrochemical Technopark in Atyrau provides tax incentives, infrastructure access, and public-private partnership mechanisms that enhance the cluster's competitiveness.

Despite notable progress, several structural constraints persist, including dependence on imported equipment, limited cooperation between government institutions, research organizations, and private enterprises, and shortages of qualified engineers. These factors reduce the potential for synergy within the cluster and slow the pace of innovation. However, the findings of this study confirm that Kazakhstan possesses significant potential to transform its petrochemical industry into a high value-added, export-oriented sector. With continued investment and supportive state policies, petrochemical exports may increase by 2.5–3 times by 2030. Key drivers include the expansion of polypropylene and polyethylene production, the adoption of deep-processing technologies, infrastructure modernization, and strengthened scientific-industrial cooperation. A comprehensive approach integrating institutional reforms, infrastructure development, and innovation activity will support Kazakhstan's transition from a raw-export model to a production- and innovation-driven development trajectory.

University endowment funds: opportunities, risks and effectiveness factors in the context of global practice

Kamar Kozhakhmetova

Master of Economics, doctoral student in Economics, Al-Farabi Kazakh National University, Almaty, Kazakhstan

Abstract

University endowment funds are long-term investment pools that provide financial support for teaching, research and student services. The paper outlines the nature of endowments, the mechanisms of their formation and management, and explains why they are strategically important for universities operating under growing financial constraints and competition. It examines the opportunities that endowments create – more stable and predictable funding, improved quality of education and stronger support for academic innovation – alongside key risks such as market volatility, governance challenges and political or ethical controversy. The analysis focuses on the factors that determine the effectiveness of endowments in practice, including the quality of governance, the design of investment and spending policies, the strength of fundraising and the level of transparency and accountability. Particular attention is given to the increasing integration of ESG considerations into endowment investment strategies. The paper concludes with practical recommendations for decision-makers in higher education systems where endowment traditions are still developing and institutions are seeking to enhance their financial resilience and social role.

Keywords: university endowment funds, higher education finance, philanthropy, governance, ESG, financial sustainability

In many countries universities are expected to teach more students, maintain modern infrastructure and compete internationally while coping with tight public budgets and social pressure to keep tuition affordable. This tension between growing expectations and limited resources pushes institutions to look for more stable and diversified sources of income. One of the most visible and, at the same time, most misunderstood instruments in this context is the university endowment fund [1; 5].

An endowment may be seen as a savings fund for the university's long-term future. Donors provide capital that is not meant to be spent immediately. Instead, it is invested, and each year only a proportion of the investment return is transferred to the operating budget, while the principal remains intact or even grows in real terms. In systems with strong philanthropic traditions, such as the United States, endowments have become an integral element of the financial architecture of leading universities and shape their identity, strategic choices and public image [2; 3].

In practice, endowment capital takes different forms. Some donations are strictly permanent: the principal must be preserved and only income can be spent, usually for a purpose specified by the donor, such as a named scholarship or a chair in a particular discipline. Other funds may be time-limited, so that after a certain period the university is free to use the capital itself. There are also quasi-endowments, where the governing board decides to treat part of its own resources as long-term capital that should be invested like an endowment, even though it could legally be reallocated [1]. Within a large institution these various gifts are often combined

in a single investment portfolio, while the accounting system tracks individual sub-funds that support specific academic or student initiatives [3; 4].

The way the university draws on endowment income is just as important as how it invests the money. Institutions seek to be fair to both present and future generations. This idea of intergenerational equity usually translates into a spending rule: for example, distributing around four to five per cent of the endowment's average market value each year [1; 10]. Such a rule is designed to smooth fluctuations in market returns, provide a reasonably predictable flow of funds to the budget and, at the same time, protect the real purchasing power of the fund after inflation and costs. If the rule is too generous, the endowment is slowly consumed; if it is too conservative, students and researchers today may not receive adequate support. Finding the balance between these concerns is a core management task.

International experience shows how different endowment systems can look. In the United States, hundreds of universities and colleges hold endowments whose combined assets run into hundreds of billions of dollars, with a small group of elite institutions controlling very large funds [2]. For universities such as Harvard or Yale, endowment payouts finance a substantial share of annual spending and play a central role in funding student financial aid, professorships and research infrastructure [3; 4]. In many other OECD countries endowments are smaller relative to institutional budgets, yet there is a growing interest in philanthropy and long-term capital as a complement to public funding, especially where governments encourage private giving through tax incentives [5; 6]. In emerging economies, including parts of Asia, Latin America and Eastern Europe, endowments are often at an early stage of development. Lower income levels, weaker traditions of giving to universities and less mature financial markets make rapid growth difficult, but a number of leading institutions are experimenting with adapting endowment models to local conditions [6; 7].

The investment approach that has attracted most attention globally is the so-called endowment model associated with Yale University. It rests on the idea that long-horizon investors can accept substantial short-term volatility and illiquidity in exchange for higher expected returns over time [4; 9]. Portfolios built on this logic tend to hold a relatively small share of traditional bonds, a significant allocation to equities and extensive exposure to alternative assets such as private equity, hedge funds, real estate or natural resources. They are highly diversified across sectors and geographies and rely heavily on the selection and monitoring of external asset managers. For large endowments with access to sophisticated managers and governance capacity, this model has historically delivered strong results, particularly in the decades before the global financial crisis. For smaller funds, however, the level of complexity and fees may be disproportionate to potential benefits, and simpler, low-cost public-market portfolios may be more appropriate [1; 11].

If endowments are managed well, they open several important opportunities for universities. The most obvious is greater financial stability. Rule-based payouts from an invested capital pool can cushion the impact of variability in government appropriations, tuition revenue or competitive research funding [2; 5]. Instead of reacting to each shock by cutting staff or programmes, institutions can rely on endowment income to maintain core activities and avoid disruptive stop-go cycles. At a broader level, endowments contribute to diversification of revenue sources. Alongside public funding, tuition fees, grants and commercial activities, a well-structured endowment reduces dependence on any single stream of income and makes the overall budget more resilient.

Beyond stabilising finances, endowments support quality and long-term academic development. They are often used to fund endowed chairs and professorships that help attract and retain leading scholars, as well as scholarships and fellowships that widen access and strengthen the talent pool [3; 7]. Endowed funds may also support research centres,

interdisciplinary initiatives, libraries, museums and cultural programmes that enrich the academic environment in ways that are difficult to sustain on one-year budget cycles. Because they are not tied to short project horizons, endowment-supported activities can be planned over many years and aligned with the strategic profile the university aims to build.

At the same time, endowment income can increase strategic flexibility. Predictable transfers from long-term capital give university leaders room to experiment: to launch new programmes, explore digital teaching formats, invest in emerging research areas or build international partnerships. When governance is strong, the need to justify new endowed initiatives in terms of mission and donor intent also introduces an element of discipline, limiting ad hoc or purely opportunistic projects. A well-managed endowment thus combines stability with the ability to take calculated risks in pursuit of academic innovation [1; 8].

Endowments also play a signalling role in relations with donors and partners. A visible, professionally governed fund suggests that the institution can handle long-term commitments and use private capital effectively for public purposes. This can encourage additional gifts from alumni, foundations, companies and individuals and may enable collaboration with impact investors or development institutions on projects such as student housing, green campus infrastructure or social innovation programmes [5; 6]. In this sense, endowments can help to crowd in further private resources for higher education.

These opportunities do not come without costs and risks. Because they are invested in financial markets, endowments are exposed to market risk: in periods of falling asset prices their value can decline sharply. If spending rules are not adjusted, universities may find themselves distributing a higher percentage of a reduced fund or cutting their budgets at precisely the moment when other sources of revenue are also under pressure [2; 9]. When portfolios contain a high proportion of illiquid assets, liquidity risk becomes a concern: it may be hard to meet capital calls from private funds or maintain spending rates without selling assets at depressed prices.

Another challenge lies in the complexity and cost of sophisticated investment strategies. Alternative assets often involve high management and performance fees, complex legal structures and limited transparency. Critical analyses of endowment performance in recent years suggest that, once fees and risks are properly taken into account, the advantage of such strategies over simple, low-cost index-based investments is less robust than often assumed, particularly in the post-crisis environment [11]. For many institutions, the risk of paying for “return-free risk” rather than being rewarded for taking illiquidity and complexity is therefore real.

Endowments also raise governance and ethical questions. They sit at the intersection of multiple interests: donors with specific intentions, boards responsible for long-term stewardship, managers concerned with annual budgets, students and staff who experience the consequences of spending decisions, and external asset managers whose incentives may not fully align with those of the university [1; 8]. Without clear rules and effective oversight, conflicts of interest may go unresolved, risk limits may be breached and investment choices may drift away from the institution’s mission. In addition, endowment portfolios have become a focal point for public debates about climate change, labour rights and other social issues. Campaigns for fossil-fuel divestment or responsible investment standards illustrate how strongly stakeholders feel about the values reflected in university investments. Ignoring these concerns may damage institutional reputation and weaken support from students, staff and donors [5; 6].

Given this mix of benefits and vulnerabilities, the question is what makes endowments genuinely effective. International experience points to several recurring factors. First, strong governance is essential. This includes a clearly defined allocation of responsibilities between the university’s governing board, its investment committee and any dedicated investment office; a committee composition that combines financial expertise with an understanding of academic mission; and written investment and spending policies that specify objectives, risk tolerance,

asset-allocation ranges, rebalancing rules, liquidity management and ESG principles [1; 8; 10]. Where these elements are in place and are reviewed regularly, institutions are better able to navigate market cycles and political pressures.

Second, the design of the investment portfolio must be consistent with the institution's size, capabilities and needs. For very large endowments with access to top-tier managers and internal teams, complex multi-asset portfolios may be justified. For smaller funds, broad diversification through simple, low-cost instruments can deliver much of the benefit without the same degree of cost and opacity [1; 11]. In all cases, careful attention to fees, liquidity and downside risk, combined with realistic expectations for long-term returns, is crucial.

Third, effective endowments depend on a professional fundraising and stewardship function. Capital only becomes an endowment if donors are willing to entrust it to the university. Building such trust requires sustained relationships with alumni and supporters, clear communication about how endowed funds are used, and credible evidence of impact. Donors respond not only to financial performance, but also to stories of students who receive scholarships, research that addresses pressing societal challenges and improvements in the learning environment [6; 7].

Fourth, transparency in reporting strengthens accountability and legitimacy. Regular public information on the size of the endowment, its performance, the purposes for which income is used and the way ESG commitments are implemented helps stakeholders understand the choices being made and the trade-offs involved [3; 4]. This openness allows informed debate about, for example, how much to spend today versus how much to save for the future and how to balance financial returns with ethical considerations.

Finally, the growing importance of sustainability reinforces the need to integrate ESG factors into endowment management. Universities are not only financial institutions; they are also educational and moral actors whose investments are increasingly expected to reflect their values and scientific understanding of global risks. Incorporating ESG criteria does not automatically solve all dilemmas, and it must be done in a way that is consistent with fiduciary duties and long-term performance. Nevertheless, experience in the broader field of sustainable finance suggests that, when implemented thoughtfully, such integration can improve risk management, protect reputation and open new opportunities for mission-aligned investment [5; 6].

Taken together, these observations suggest that endowment funds are neither a luxury reserved for a few rich universities nor a universal remedy for financial pressures in higher education. They are tools whose impact depends on context, design and use. Where legal frameworks enable philanthropic giving, financial markets provide a reasonable set of instruments and institutional capacity is sufficient to manage governance challenges, endowments can make a significant contribution to financial resilience, academic quality and social engagement [5; 6; 8]. In systems where endowments are still nascent, the priority is to build the foundations: clear legislation for non-profit entities, appropriate tax incentives, transparent reporting standards and a culture of trust between universities and their supporters. Only on this basis can endowment capital grow and fulfil its promise of supporting both current and future generations of students and scholars.

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Тенге под давлением: как валютные колебания влияют на рынок капитала

Алмасбеккызы Е.

Магистрант, АО «Алматинский технологический университет», г.Алматы, Казахстан

Рузиева Э.А.

к.э.н., ассоциированный профессор, АО «Алматинский технологический университет», г.Алматы, Казахстан

Елубаева Ж.М.

д.э.н., ассоциированный профессор, АО «Алматинский технологический университет», г.Алматы, Казахстан

Аннотация

Настоящая статья представляет собой аналитический обзор современных исследований, в которых рассматривается влияние колебаний обменного курса тенге на рынок капитала Республики Казахстан. Основываясь на анализе научных публикаций казахстанских и зарубежных авторов, вышедших в период с 2023 по 2025 год, проводится систематизация ключевых факторов, определяющих механизмы передачи валютных шоков на фондовый и долговой сегменты финансовой системы страны. Особое внимание уделяется подходам к моделированию взаимосвязей между обменным курсом тенге, динамикой цен на сырьевые товары, уровнем процентных ставок и поведением основных фондовых индексов. Обобщая как теоретические положения, так и практические наблюдения, статья формирует основу для дальнейшего эмпирического исследования, цель которого – определить степень и характер воздействия валютной волатильности на структуру капитальных потоков в экономике Казахстана.

Введение

Экономика Казахстана по сегодняшний день остаётся достаточно зависимой от внешнеэкономической обстановки и колебаний цен на сырьевые товары, что делает стабильность национальной валюты критически важным фактором для функционирования финансовой системы. Динамика курса тенге оказывает прямое влияние на поведение инвесторов, стоимость капитала и общую структуру фондового рынка. В условиях геополитической нестабильности, ужесточения денежно-кредитной политики в развитых странах и усиления внутренней инфляции валютные колебания приобретают выраженный дестабилизирующий характер, создавая дополнительные риски для развития рынка капитала.

Несмотря на актуальность этой тематики, влияние валютных шоков на фондовые и долговые инструменты в контексте Казахстана остаётся недостаточно изученным. Отсутствие систематизированного подхода к анализу эмпирических данных и моделированию трансмиссионных механизмов валютных флуктуаций затрудняет выработку эффективных инвестиционных стратегий и формирование устойчивой финансовой политики. Это придаёт особую значимость обобщению и критическому осмыслению существующих научных исследований, посвящённых данной проблематике.

Цель настоящей статьи состоит в проведении комплексного литературного анализа современных научных публикаций, в которых рассматривается влияние колебаний обменного курса тенге на функционирование рынка капитала Республики Казахстан. В рамках этого анализа систематизируются существующие подходы к моделированию

экономических взаимосвязей, оценивается степень эмпирической обоснованности полученных выводов, а также определяются направления для будущих исследований.

Объектом анализа выступают научные работы, в которых представлены эмпирические оценки и теоретические модели, описывающие воздействие изменений валютного курса на фондовый рынок и рынок долговых обязательств Казахстана. Исследование основано на методах систематизации и критического анализа научной литературы, а также сравнительного изучения теоретических подходов и эконометрических инструментов. В рассмотренных публикациях применяются такие модели, как авторегрессионные условные гетероскедастичные модели, нелинейные модели с асимметрией воздействия, регрессии с распределёнными лагами, панельные оценки, а также методы анализа корреляционных и причинно-следственных связей, в частности, тесты причинности по Грейнджеру. При отборе источников приоритет отдавался публикациям в рецензируемых международных научных журналах, индексируемых в базах Scopus, Web of Science и других авторитетных библиографических системах.

Основная часть

В условиях высокой волатильности курса тенге и возрастающего влияния внешнеэкономических шоков на внутренние финансовые рынки возрастает актуальность систематизации научных подходов к оценке последствий валютных колебаний. Настоящий раздел посвящён обзору ключевых исследований, в которых анализируется влияние динамики обменного курса на инвестиционные решения и параметры функционирования рынка капитала в Казахстане. Особое внимание уделяется работам, использующим современные эконометрические инструменты, включая модели GARCH, ARDL и NARDL, поскольку они позволяют выявить как краткосрочные, так и долгосрочные эффекты, возникающие под воздействием изменений валютного курса.

Одним из примеров прикладного анализа выступает исследование Махметовой А.А. на тему Анализ волатильности на основе индекса KASE: сравнение моделей GARCH, ARCH и ARIMA, в котором были сопоставлены различные модели волатильности – ARCH, ARIMA и GARCH – на основе временных рядов индекса KASE. Целью работы являлось определение наиболее эффективного инструмента для прогнозирования поведения фондового рынка в условиях валютной нестабильности. Сравнительная оценка проводилась с использованием показателя среднеквадратичной ошибки прогноза (RMSE), что позволило выявить преимущество модели GARCH-M(1,1). Эта модель продемонстрировала высокую способность учитывать кластеризацию волатильности и автокорреляционные эффекты, которые особенно выражены в периоды девальвации тенге.

В отличие от неё, модель ARCH, ориентированная преимущественно на прошлые шоки, а также модель ARIMA, сосредоточенная на среднем значении временного ряда, продемонстрировали ограниченную эффективность в отражении динамики условной дисперсии. Результаты анализа показали, что волатильность фондового рынка в Казахстане характеризуется наличием эффекта памяти и чувствительностью к внешним валютным шокам. При этом применённая модель не включала макроэкономические переменные, такие как обменный курс USD/KZT, процентные ставки или цены на нефть, что сужает её аналитический потенциал. Выводы исследования подчёркивают необходимость дальнейшего развития модели путём интеграции GARCH-подходов с макроэкономическими индикаторами. Это позволило бы более комплексно оценивать трансмиссионные механизмы влияния валютных колебаний на рынок капитала и усилить прогностическую ценность соответствующих моделей [1].

Одним из значимых направлений анализа выступает исследование авторов Lukhmanova L., Khamzina Z., Seidalin A. на тему Comparative Analysis of the Volatility Structures of the Stock Prices of Energy Companies Traded on the Kazakhstan Stock Exchange and

International Gold and Oil Prices, опубликованное в International Journal of Energy Economics and Policy, в котором рассматривается взаимосвязь между доходностью акций казахстанских энергетических компаний и динамикой мировых цен на нефть и золото в период с 2020 по 2023 год.

На основе временных рядов, а также с применением корреляционного анализа и теста причинности по Грейнджеру, авторами установлена статистически значимая направленная связь от глобальных сырьевых индексов (Brent и WTI) к котировкам акций компаний KZAP, KZTO и KEGC. Эти результаты подтверждают существование трансмиссионного канала, по которому глобальные ценовые шоки оказывают влияние на фондовый сегмент Казахстана, особенно в сырьевом секторе.

Полученные выводы подчёркивают высокую чувствительность казахстанского фондового рынка к внешнеэкономической конъюнктуре и позволяют рассматривать цены на сырьевые товары как ведущие индикаторы динамики капитализации отдельных отраслей. Однако существенным ограничением данного исследования является отсутствие учёта валютного курса тенге как возможного промежуточного звена в передаче внешних шоков. Фокус на доходности активов без включения обменного канала сужает аналитические возможности модели и не позволяет полностью отразить характер воздействия глобальных факторов на рынок капитала [2].

С учётом выявленных ограничений целесообразным представляется развитие более интегрированных моделей, в которых одновременно учитываются как сырьевые, так и валютные переменные. Это позволило бы более точно оценивать трансмиссионные механизмы, определяющие волатильность и доходность казахстанских активов в условиях открытой и зависимой экономики.

Существенный вклад в развитие эмпирических моделей, учитывающих взаимодействие между сырьевыми ценами, валютным курсом и рынком капитала в Казахстане, внесло исследование Asymmetric Effect of Oil Prices on Kazakhstan's Stock Market Index and Exchange Rate: Application of the NARDL Model авторов Syzdykova и Azretbergenova. В данной работе авторы применили нелинейную модель с распределёнными лагами (NARDL), позволяющую оценить асимметричное воздействие изменений цен на нефть на фондовый рынок и курс национальной валюты в период с 2010 по 2024 год. Результаты моделирования показали, что как положительные, так и отрицательные нефтяные шоки оказывают статистически значимое влияние на доходность индекса KASE, с оценёнными коэффициентами $+0,116$ и $-0,111$ соответственно. Кроме того, установлена чувствительность обменного курса USD/KZT к аналогичным изменениям на глобальном сырьевом рынке: при положительных и отрицательных шоках значения коэффициентов составили $-0,094$ и $-0,093$. Эти результаты свидетельствуют о высокой степени зависимости финансовых индикаторов Казахстана от динамики мировых цен на нефть.

Применение усовершенствованной версии ARDL-моделирования позволило выявить выраженную асимметрию в реакции рынка на изменение внешних условий: положительные и отрицательные ценовые шоки по-разному трансформируются в доходность и курсовые колебания. Такой подход представляет собой значительный шаг вперёд по сравнению с линейными моделями, так как позволяет более точно учитывать характер трансмиссионных механизмов в условиях нестабильной внешней конъюнктуры. На основе этого можно заключить, что исследование демонстрирует аналитическую состоятельность NARDL-подхода при изучении взаимосвязей между сырьевыми и валютными факторами, влияющими на рынок капитала. Оно формирует важную методологическую базу для дальнейших прикладных работ, ориентированных на прогнозирование рыночной реакции в условиях многовекторного воздействия глобальных шоков [3].

В исследовании Gnahe A., Syzdykova A. и Shyryn S. [4], обобщающем и развивающем выводы предыдущих работ, включая анализ Syzdykova и коллег, рассмотрено влияние широкого набора макроэкономических переменных на доходность фондового индекса KASE. С применением регрессионного анализа авторы пришли к выводу, что такие факторы, как уровень инфляции, базовая ставка Национального банка и обменный курс тенге, в совокупности объясняют до 62 % дисперсии доходности индекса. Это указывает на высокую степень чувствительности казахстанского фондового рынка к изменениям в макрофинансовой среде.

Работа акцентирует внимание на мультифакторной природе рыночных колебаний и подчёркивает важность комплексного подхода при построении прогнозных моделей. Включение как внутренних, так и внешних экономических индикаторов позволяет рассматривать фондовый рынок не как автономную систему, а как часть более широкой макроэкономической структуры, подверженной влиянию инфляционных ожиданий, изменений в денежно-кредитной политике и валютной волатильности.

Дополнительную эмпирическую перспективу даёт исследование Bhalo M. и Eshchanov R., Madumarov D. [5], в котором была применена панельная модель System GMM для анализа валютной динамики стран Центральной Азии. На примере Казахстана показано, что стратегия ведущих мировых экономик оказывает прямое и опосредованное воздействие на курс тенге. В частности, индекс доллара США, девальвационные процессы в Китае и валютная политика Российской Федерации формируют устойчивое давление на обменный курс, особенно в периоды глобальной нестабильности.

Полученные результаты демонстрируют, что решения ФРС США, изменения в траектории юаня и колебания рубля трансформируются в валютные импульсы, передающиеся через внешнеторговые, инвестиционные и инфляционные каналы. Эти воздействия оказывают влияние не только на курс тенге, но и на поведение инвесторов, что, в свою очередь, влияет на распределение капитала и динамику фондового рынка. Сформулированный в работе вывод подчёркивает, что валютная устойчивость Казахстана не может быть обеспечена исключительно внутренними мерами экономической политики и требует учёта глобального финансового контекста при разработке прогнозных моделей и стратегий регулирования национального капитального рынка.

В исследовании Sultanova и Pazilov на тему «Empirical Estimation of Volatility Clustering in Kazakhstani Energy Stocks Compared to Global Commodities» проведена эмпирическая оценка структурной волатильности доходностей акций казахстанских энергетических компаний, торгующихся на бирже KASE, в сравнении с динамикой мировых цен на нефть и золото. С использованием модели GARCH-M(1,1) авторы установили, что отечественный рынок демонстрирует более выраженные эффекты автокорреляции и кластеризации волатильности по сравнению с международными аналогами, что свидетельствует о повышенной чувствительности к внешним шокам.

Несмотря на наличие схожих паттернов нестабильности с глобальными товарными рынками, доходности таких бумаг, как KZAP и KZTO, показали статистически значимую зависимость от внешних индексов. Причинно-следственная связь, выявленная с помощью теста Грейнджера, подтверждает синхронизацию казахстанского фондового сегмента с международной сырьевой конъюнктурой. В то же время, исследование ограничено фокусом на энергетическом секторе и не включает такие важные параметры, как обменный курс тенге, поведение нерезидентов и влияние валютной динамики на рынок долговых обязательств. Отсутствие этих компонентов снижает применимость модели в контексте комплексной оценки воздействия внешнеэкономических факторов на весь рынок капитала [6].

Дополнительное развитие подхода представлено в работе Hnaze M. «Macroeconomic Shocks and Energy Stock Performance: Evidence from the KASE», опубликованной в журнале *Energy Economics*. В данной статье рассмотрено влияние макроэкономических шоков на поведение акций энергетических компаний, представленных на бирже KASE. В исследование были включены межрыночные взаимодействия и внешние переменные, включая цены на нефть, курс тенге к доллару США и уровень инфляции. Результаты анализа показали, что данные факторы оказывают как прямое, так и опосредованное воздействие на доходность и волатильность компаний сырьевого сектора.

Особое внимание в работе уделяется тому, как сочетание колебаний мировых цен на энергоносители и валютной нестабильности усиливает чувствительность фондового рынка, особенно в отношении таких эмитентов, как KEGC и KZTO. Автор подчёркивает важность включения внешних шоков в процедуры риск-оценки и инвестиционного моделирования на развивающихся рынках. Энергетический сектор Казахстана, согласно полученным результатам, играет роль ключевого трансмиссионного канала, через который макроэкономические флуктуации преобразуются в структурные изменения на фондовом рынке [7].

В исследовании Бимендиева Ж.С., Бажикова Н.Б. [8], опубликованном на платформе ResearchGate, анализируется влияние перехода Казахстана к режиму свободного плавания тенге, официально введённого в 2015 году. Авторы отмечают, что отказ от фиксированного курса способствовал укреплению доверия к денежно-кредитной политике, повышению прозрачности регулирования и снижению давления на золотовалютные резервы. Также фиксируется умеренное снижение процентных ставок вследствие сокращения объёма валютных интервенций. В то же время подчёркивается уязвимость новой модели к внешним шокам: при резких изменениях сырьевых цен или геополитической нестабильности усиливается волатильность валютного и фондового сегментов. Исследование отражает двойственный эффект режима свободного плавания, одновременно расширяя пространство для рыночных механизмов и увеличивая чувствительность экономики к глобальным колебаниям.

Дополняя эмпирическую картину, в обзоре International Monetary Fund Article IV Consultation for Kazakhstan «Republic of Kazakhstan: 2024 Article IV Consultation-Press Release; Staff Report; and Statement by the Executive Director» подчёркивается, что растущая волатильность курса тенге усиливает риски для финансовых активов, номинированных в иностранной валюте, особенно в условиях нестабильной внешнеэкономической среды. Валютные колебания формируют у инвесторов, включая нерезидентов, неблагоприятные ожидания, что ведёт к перераспределению капитала в сторону государственных облигаций, номинированных в тенге. Этот эффект «бегства в качество» снижает ликвидность корпоративного сектора и сдерживает приток частных инвестиций. Кроме того, усиление валютных рисков ограничивает эмиссионную активность компаний и повышает требования к доходности. Волатильность национальной валюты, таким образом, рассматривается как значимый источник дестабилизации структуры рынка капитала [9].

Согласно материалу Astana Times «Falling Oil Prices, Trump Tariffs Drive Tenge Volatility», недавнее ослабление тенге до уровня около 519 тенге за доллар было обусловлено не внутренними спекуляциями, а внешними шоками – в частности, колебаниями цен на нефть и новыми торговыми барьерами со стороны США. Аналитики Центра прикладных экономических исследований (AERC) отметили, что курс демонстрировал высокую корреляцию с котировками Brent и курсом российского рубля, что подтверждает доминирование внешних факторов. Такая зависимость усиливает чувствительность валютного и фондового рынков к краткосрочной глобальной волатильности. В условиях ограниченного участия регулятора, динамика индекса KASE во многом отражает внешнюю

конъюнктуру, что влияет на структуру портфельных вложений и снижает значимость внутренних макроэкономических ориентиров [10].

В прогнозе Евразийского банка развития (EDB) «Eurasian Development Bank forecasts strengthening of the tenge in 2025», представленном на Times of Central Asia, указывается на возможное укрепление тенге до уровня 486 тенге за доллар. Это связывается с поддержкой со стороны Национального фонда, валютной выручкой и сохранением высокой базовой ставки. При этом, несмотря на снижение волатильности и улучшение макроусловий, влияние этих тенденций на долговой рынок остаётся недостаточно проработанным. Так, например, декабрьский выпуск зелёных облигаций Halyk Bank на 20 млрд тенге, имеющий значение для устойчивого финансирования, не анализируется в прогнозных сценариях. Отсутствие внимания к корпоративным и долговым инструментам указывает на необходимость включения этих сегментов в макроэкономические модели для комплексной оценки трансмиссии валютных ожиданий на инвестиционную активность [11].

Обострение внешних шоков и повышенная чувствительность тенге к региональным и сырьевым индикаторам усиливают структурную уязвимость казахстанского рынка капитала. На этом фоне динамика фондового и валютного сегментов всё чаще определяется факторами, находящимися вне зоны непосредственного действия внутренней экономической политики. Несмотря на сохраняющуюся поддержку со стороны государственных институтов, включая Национальный фонд и жёсткую монетарную политику, перспективы стабилизации курса остаются тесно связанными с внешней конъюнктурой. Вместе с тем, текущие прогнозные и аналитические модели фокусируются преимущественно на валютном и фондовом сегментах, в то время как долговые инструменты – включая корпоративные и зелёные облигации – нередко остаются вне рамок оценки. Это сужает возможности для всестороннего анализа трансмиссионных механизмов, связывающих валютную волатильность с инвестиционной активностью и структурой капитальных потоков. В этих условиях важным направлением дальнейших исследований становится интеграция долгового рынка в эконометрические модели, что позволит более точно оценивать риски и адаптационные возможности национального финансового рынка в условиях усиливающейся глобальной нестабильности.

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THE HISTORY OF THE FORMATION OF THE CIVIL SERVICE OF KAZAKHSTAN

Aibassova Nazima Aidarovna

2nd year Master's student, Esil University, Astana, Kazakhstan

The history of the development of human society clearly demonstrates the impossibility of forming a democratic, legal, and social state without an effective system of public administration, the foundation of which is a professional civil service.

One of the priority tasks of state-building is the professional training of civil servants, aimed at ensuring high efficiency, competence, and impeccable functioning of public authorities.

The reforms in the development of the state apparatus in Kazakhstan can be divided into four stages, which are presented in the table.

Table 1 – Stages of the civil service reform in Kazakhstan

stage	Period	Describe
First stage	1991-1993	Kazakhstan transitioned toward independent development, and the foundations of a sovereign state-administrative system were being established. This period was marked by strong centralization of public administration, large-scale market transformations, and the search for an optimal model of civil service organization suitable for Kazakhstan.
Second stage	1993-1995	Following the adoption of the first Constitution of the Republic of Kazakhstan on January 28, 1993, changes occurred in the political system of the country. During this period, the basic principle of separation of powers was legally established.
Third stage	1995-2015	The main characteristic of this period was the continuation of reforms in the system of state institutions and the development of a modern state-political structure of Kazakhstan.
Fourth stage	from 2015 to the present	Reforming the civil service has been aimed at increasing its efficiency and attractiveness. Modern personnel approaches have been introduced, focusing on professionalism, competency development, and enhancing the social protection of civil servants.

The first stage of the formation of the civil service began in the mid-1980s, when, in connection with the subsequent restructuring in the USSR, active members of civil society started discussing the need for reform of the civil service system, which no longer corresponded to the new goals and priorities of state-building in independent Kazakhstan and the transition of the national economy to market relations. At that time, an active search for ways to reform public administration, including the civil service, was initiated. It should be noted that during this period, the mindset of citizens underwent significant change, and the works of foreign authors and legislative practices addressing issues of public administration and the civil service became increasingly in demand.

The result of the active search for ways to transform Kazakhstan's political system, including reforming public administration and the civil service, was the adoption of the first

Constitution of sovereign Kazakhstan on January 28, 1993, which laid the foundation for the establishment of the civil service of the Republic as an independent state.

Article 17 of the 1993 Constitution of Kazakhstan stipulated that citizens have equal rights of access to public service, and that the requirements for candidates depend solely on the nature of their official duties. The historical significance of this provision lies in the fact that this right was legally established for the first time. Such a provision was neither reflected in the main law of the USSR nor defined separately. In fact, there was no unified Union-level law “On Public Service” in the Soviet Union.

During the adoption of Kazakhstan’s first Constitution, continuous efforts were made to identify a model of civil service adequate to the new conditions. Since theoretical developments and policy solutions had previously been carried out by the Union center, all further developments were undertaken under conditions of insufficient historical experience in building state institutions.

On August 30, 1995, a new Constitution of the Republic of Kazakhstan was adopted by national referendum. From that moment, a new stage in the development of legislation on public service began. Clause 4 of Article 33 of the new Constitution confirmed the equal right of citizens to enter civil service and specified that “the requirements for candidates for public service positions depend only on the nature of official duties and are established by law.”

The next step toward implementing these constitutional provisions was Presidential Decree No. 2730 “On Civil Service” of December 26, 1995, which gave a legally significant start to the institutionalization of civil service in Kazakhstan [1]. The decree defined the basic principles of civil service, among which universality, and the priority of the rights, freedoms, and legitimate interests of citizens over the interests of the state, should be highlighted.

This act introduced qualification requirements for civil servants and regulated the procedures for entering, serving in, and termination of civil service; attestation of civil servants; measures of social protection; and other important aspects. However, despite several progressive provisions, the decree often had a declarative nature and did not ensure equal access of citizens to civil service.

Both citizens and officials noted that during the implementation of the decree, negative features of a patronage system were clearly manifested, and recruitment into civil service frequently occurred based on personal loyalty, friendship, or kinship. Nevertheless, despite the shortcomings observed during its application, the decree played an important role, as for the first time in the history of sovereign Kazakhstan, a civil service system was proposed that laid the foundation for its development as a key state institution during the transition period.

At the same time, a number of objective and subjective challenges emerged, complicating the process of civil service reform. Among them were: the lack of conceptual approaches to civil service reform; shortage of qualified personnel capable of working under new conditions; insufficient coordination among government agencies and international organizations participating in reform projects; absence of unified job requirements; low levels of social and legal protection of civil servants; personnel selection based largely on the subjective preferences of leaders; unfair promotion practices; corruption and bribery in the state apparatus; and the influence of clan, family, and regional ties.

A separate issue was the lack of a system for targeted identification, selection, and recruitment of competent, talented, and capable individuals for public service. As a solution, the country’s leadership envisioned the creation of a centralized body capable of systematically supplying the state apparatus with personnel of the required number and qualifications.

International experience showed that, in advanced democratic states, despite the separation of legislative, executive, and judicial powers, the primary objective of public administration is the formation of a unified system of personnel policy and civil service. Practical

implementation of these objectives required strict adherence to principles of organization and functioning of civil service.

Based on these considerations, an authorized body directly subordinate and accountable to the Head of State - the Agency of the Republic of Kazakhstan for Civil Service Affairs - was established to implement unified civil service policy.

With the adoption of the Law of the Republic of Kazakhstan “On Civil Service” of July 22, 1999, and subsequent regulatory acts, a fundamentally new stage in the development of Kazakhstan’s civil service began.

International experience demonstrated that the foundation of civil service in democratic countries is meritocracy - a system based on personal performance and aimed at effective use of human resources [2]. The meritocratic principle introduced in the new law included:

1. mandatory competitive selection for entry and promotion;
2. legal and social protection of civil servants;
3. equal pay for equivalent work;
4. encouragement for civil servants who achieve high results, corrective measures for low performance, and dismissal for consistently unsatisfactory results;
5. continuous professional training of civil servants.

To consolidate the progress made and further improve the civil service institution, a new Concept for Civil Service Development in the Republic of Kazakhstan was approved in 2011 [3]. It became the result of long-term work by state authorities and experts, taking into account best international practices.

Through successful implementation of the new concept, Kazakhstan developed a professional civil service focused on achieving results and providing high-quality public services in line with the socio-economic development needs of the state.

The legislative framework of civil service continued to develop. On November 23, 2015, the President signed the Law “On Civil Service of the Republic of Kazakhstan,” which entered into force on January 1, 2016.

Over the past decade, several changes have been introduced into the public administration system of Kazakhstan.

1. The civil service has been developed as an attractive employer. Drawing on the positive practices of OECD countries, measures were introduced to complement competitive salaries and social benefits with additional pension contributions for each year of service, assistance in housing provision, allocation of places for children in kindergartens, and improvements in medical services in the regions.

2. The organizational culture of the state apparatus has been transformed to enhance its attractiveness for both civil servants and society. It has become increasingly focused on achieving high final results and implementing innovative approaches.

3. Rapidly changing modern challenges have given new momentum to the need for improving the competencies of civil servants. In this regard, competency requirements for positions in administrative public service have been updated.

4. Alongside the refinement of the performance evaluation system for public bodies, training programs for civil servants are being improved. Emphasis is placed on leadership, communication, analytical thinking, and the development of in-demand digital competencies.

In the future, the organization of the civil service will focus on strengthening its competitive advantages through optimization of the state apparatus, improving its effectiveness, and increasing the importance and public status of civil servants.

Kazakhstan is developing a new model of public administration that meets societal demands and is based on the introduction of modern technologies. Various transformational approaches to public administration, civil service, and personnel policy are planned. National programs containing extensive sets of indicators will be replaced by more focused projects ensuring the timely launch and achievement of planned capacity for investment initiatives.

Since the fundamental reform aims to transform the functioning of the state apparatus, previously adopted regulatory decisions are expected to be reviewed in order to eliminate excessive legislative regulation of the executive branch's activities.

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STRUCTURAL TRANSFORMATION OF KAZAKHSTAN'S INDUSTRY: THE IMPACT OF INNOVATION IMPORT AND LOCALIZATION ON ECONOMIC GROWTH

Kupenov B.K.

PhD Student, Al-Farabi Kazakh National University, Almaty, Kazakhstan

Turkeyeva K.A.

PhD in Economics, Associate Professor, "Institute of Economics" of the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan, Almaty, Kazakhstan

Abstract. The article investigates the mechanisms of modernization within the industrial sector of the Republic of Kazakhstan amidst global competition. It analyzes the role of international diffusion of innovations and foreign direct investment in altering the structure of the Gross Domestic Product. Based on empirical data from the automotive industry, railway engineering, and the oil and gas complex, the study evaluates the efficiency of the transition from resource-intensive production to high-value-added manufacturing. The processes of deepening localization and the borrowing of advanced engineering competencies are examined as key factors in labor productivity growth.

Keywords: diffusion of innovation, manufacturing industry, production localization, import of competencies, Industry 4.0, economic complexity.

Introduction

The strategic vector of the Republic of Kazakhstan's economic development is the overcoming of raw material dependence through forced industrialization. In modern macroeconomic models, the key driver of growth is not merely the accumulation of physical capital, but the national economy's capacity for the absorption of external knowledge and the implementation of advanced production solutions [1]. The relevance of this research stems from the need to assess how the integration of international production standards and the borrowing of foreign engineering practices affect real sector indicators. In the context of implementing the Concept for the Development of the Manufacturing Industry [2], it becomes critically important to analyze the mechanisms that allow the conversion of foreign investment into the sustainable growth of national technological competencies.

Theoretical Basis and Performance Dynamics

Economic science defines the diffusion of innovation as the process of novelty penetration into an economic system through trade and investment channels. For developing markets, it is precisely the import of high-tech equipment and accompanying management methodologies that serves as the primary source for increasing total factor productivity [3]. Statistical analysis demonstrates that a gradual reorientation of the industrial profile is occurring in Kazakhstan. According to data from the Bureau of National Statistics, the physical volume index of the manufacturing industry shows positive dynamics, which correlates with the inflow of investment into the non-resource sector [4]. This confirms the hypothesis that attracting global players

facilitates the qualitative renewal of fixed assets and the introduction of Industry 4.0 standards [5].

Localization and Deepening of Processing in Mechanical Engineering

The effect of introducing external competencies is most clearly manifested in the automotive industry. The sector demonstrates an evolutionary transition from simple assembly operations to complex technological processes. A key indicator of qualitative growth is the shift from the DKD (Disassembled Knocked Down) format to CKD (Completely Knocked Down), which implies the mastering of body welding and painting operations within the country. According to specialized associations, in 2023, production volume in the sector reached historical maximums, exceeding 148,000 units [6]. This growth is driven not just by capacity expansion, but by the adaptation of global production regulations, which stimulates the development of a cluster of auto component manufacturers and increases the level of local content.

Similar trends are observed in railway engineering. A partnership with the Alstom concern has enabled the deployment of electric locomotive production in Astana that meets strict international standards [7]. A crucial achievement has been the mastering of traction transformer production - a critical component requiring high engineering qualifications. According to analytical reports, the successful integration of foreign know-how has allowed domestic products to enter export markets, confirming the effectiveness of the chosen model of industrial cooperation [8].

Digital Integration in the Extractive Sector

In the oil and gas industry, the process of renewing the production base is shifting towards digitalization. The traditional import of hardware is giving way to the implementation of intelligent management systems. Leading operators are transitioning to the use of integrated centers based on big data analysis and artificial intelligence algorithms [9].

The implementation of the "Digital Twins" concept, visualized above, allows for the creation of virtual prototypes of fields for scenario modeling of extraction. The adaptation of such complex digital solutions requires the formation of a new class of specialists and leads to knowledge spillovers from foreign partners to local personnel. This creates a foundation for long-term sector efficiency growth without the need to increase physical extraction volumes.

Barriers to Innovation Saturation

Despite successes in localization, the analysis reveals factors constraining full-scale modernization. The primary limitation is the low research intensity of GDP. The level of expenditure on Research and Development (R&D) in Kazakhstan varies within the range of 0.13-0.15%, which is significantly below the threshold values required for the independent generation of innovations [10]. As a result, the industry remains dependent on a constant inflow of ready-made solutions from outside, without forming a closed cycle of technology reproduction. Furthermore, there is a disparity between the speed of new equipment introduction and the pace of training engineering personnel capable of maintaining and improving it.

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ВЛИЯНИЕ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА НА РЫНОК ТРУДА

Жақсылық Дана Қазбекқызы

Филиал «Назарбаев Интеллектуальная школа естественно-математического направления района Нура города Астана», г. Астана, Казахстан

Искусственный интеллект – это технологический процесс или направление современной науки, изучающее возможности компьютера, роботизированной техники, аналитической системы разумно мыслить так же, как человек. Основные цели искусственного интеллекта вполне прозрачны (рисунок 1).

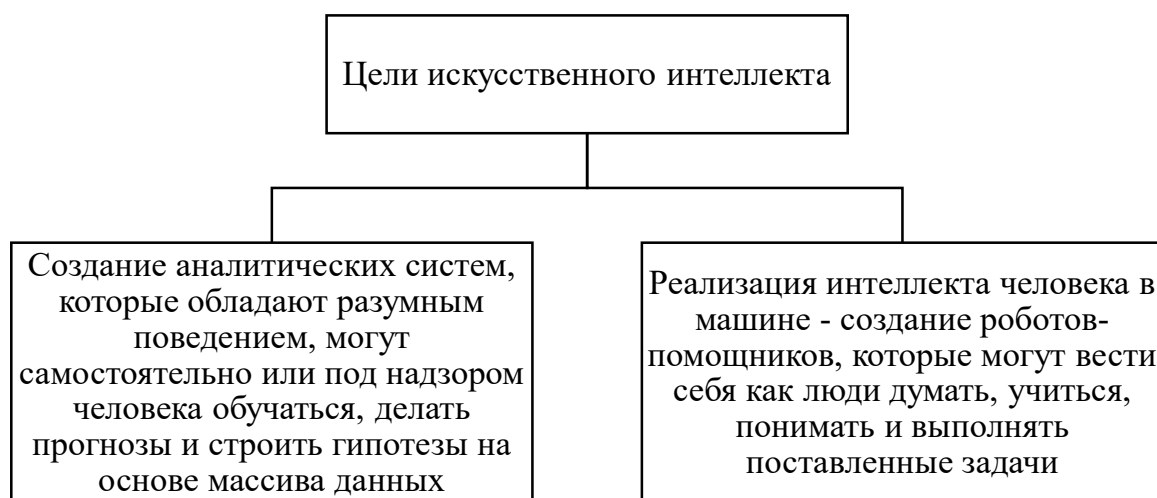


Рисунок 1 – основные цели искусственного интеллекта

Ключевые моменты развития «искусственного интеллекта» [1]:

- 1956 г. – представлен прототип программы на основе ИИ в университете Карнеги-Меллон;
- 1969 г. – создан робот «Шеки» с ИИ в Стэнфордском университете, который мог самостоятельно перемещаться, воспринимал данные и решал поставленные задачи;
- 1973 г. – создан робот «Фредди» в Эдинбургском университете, который использовал компьютерное зрение для сбора разных моделей;
- 1954–1964 гг. – в СССР академиками А. И. Бергу и Г.С. Поспеловым разработаны программы «АЛПЕВ ЛОМИ» (автоматически доказывает теоремы) и алгоритм «Кора» (моделирует деятельность человеческого мозга для распознавания образов).
- 1968 г. – В. Ф. Турчин создаёт символичный язык обработки данных «РЕФАЛ».

В начале 2000-х годов наблюдается резкое возрастание интереса к робототехнике. Искусственный интеллект активно интегрируется в космическую отрасль, а также в различные экономические сферы. Разрабатываются и внедряются системы «умный дом» и технологически усовершенствованные бытовые устройства. Роботизированные комплексы начинают использоваться для исследования Антарктиды.

С 2008 года, согласно ряду прогнозных оценок, начинается этап, описываемый как технологическая сингулярность, пик развития которой ожидается около 2030 года [2]. Характерной тенденцией данного периода становится ускоренная адаптация человека к

вычислительным системам, расширение когнитивных возможностей посредством цифровых технологий, а также активное развитие биотехнологий.

Современные системы искусственного интеллекта, в сочетании с технологиями роботизации и цифровизации, уже сегодня успешно выполняют широкий спектр задач, ранее доступных исключительно человеку. Так, ИИ активно используется в медицинской практике – интеллектуальные программы помогают врачам в постановке диагнозов, выборе оптимальных методов лечения и прогнозировании исходов заболеваний. Аналогичные решения внедряются в журналистике, онлайн-образовании, управлении персоналом, а также при автоматическом переводе и обработке данных в реальном времени. В целом цифровые технологии позволяют значительно ускорить и упростить выполнение многих производственных и управленческих процессов.

Согласно результатам исследования, опубликованного Международной организацией труда (МОТ) в мае 2025 года, технологии искусственного интеллекта способны трансформировать до четверти всех рабочих мест в мире. В отчете отмечается, что наибольшее воздействие ИИ будет наблюдаться в экономически развитых странах, где под влиянием технологических изменений может оказаться до 34% рабочих мест. В странах с уровнем дохода выше среднего данный показатель оценивается в 25%, с уровнем дохода ниже среднего – 20%, тогда как в государствах с низким уровнем дохода влияние ИИ на занятость является минимальным и затрагивает около 11% рабочих мест.

Исследование МОТ основано на комплексном анализе микроданных, охватывающих 2,5 тыс. профессий и более 30 тыс. рабочих задач, потенциально подтвержденных автоматизации. Полученные результаты свидетельствуют о существовании выраженных гендерных различий в степени воздействия ИИ на занятость. В среднем мест, занимаемых женщинами, и 21% - мужчинами. Наибольший гендерный разрыв зафиксирован в странах с высоким уровнем дохода: под риском автоматизации находятся 41% «женских» и 28% «мужских» рабочих мест. В странах со средним уровнем дохода наблюдаются схожие тенденции, в то время как в государствах с низким доходом влияние ИИ распределяется равномерно – по 11% для обоих полов.

В региональном разрезе наиболее высокий уровень потенциальной трансформации рабочих мест характерен для Европы и Центральной Азии (32%), а минимальный для Африки (19%). Как отмечают авторы доклада, данная дифференциация отражает различия в степени технологического развития и внедрения инноваций в различных регионах мира.

Сопоставимые выводы содержатся и в прогнозе Конференции ООН по торговле и развитию (ЮНКТАД). По оценкам экспертов ЮНКТАД, к 2033 году рыночная стоимость отрасли искусственного интеллекта может достичь в 4,8 трлн. долларов США, технологии ИИ станут ключевым фактором глобальной цифровой трансформации, оказывая влияние на до 40% рабочих мест во всем мире.

В то же время стремительное развитие ИИ актуализировало целый ряд социально-экономических, правовых и этических проблем. Автоматизация трудовых процессов, облегчая жизнь человека, одновременно становится источником новых вызовов, оказывающих влияние на фундаментальные основы функционирования современного общества [3].

По оценкам отечественных и зарубежных специалистов, в результате масштабной роботизации можно ожидать сокращение рабочих мест в таких секторах, как промышленное производство, сельское хозяйство и сфера услуг. Предполагается, что ежегодные темпы исчезновения профессий достигнут 1–3%, прежде всего в областях, где трудовая деятельность основана на повторяющихся алгоритмах и стандартизированных операциях. К числу наиболее уязвимых профессий относятся продавцы, переводчики, рекрутеры, журналисты, машинисты, курьеры, банковские клерки и операторы call-центров [4].

Несмотря на пессимистичные прогнозы ряда аналитических исследований, утверждения о неизбежном росте безработицы не имеют однозначных оснований. Напротив, искусственный интеллект способен стать мощным стимулом для создания новых форм занятости. Вместо полного исчезновения профессий произойдёт структурная трансформация рынка труда: часть специальностей претерпит изменения, а на смену устаревшим появятся новые профессиональные направления, требующие более сложных когнитивных и креативных навыков.

Особую значимость в будущем приобретут профессии, связанные с обучением и развитием человеческого потенциала, эмоциональным и интеллектуальным трудом, стратегическим управлением, исследовательской и инженерной деятельностью, а также с развитием технологий машинного обучения и информационных систем. Следовательно, ключевой задачей государственной и образовательной политики становится переподготовка кадров и формирование компетенций, востребованных в условиях цифровой экономики.

Дальнейшее влияние ИИ на рынок труда и экономику страны невозможно прогнозировать. Однако можно быть уверенным, что развитие его будет стремительно возрастать, в связи с чем государство должно быть готово к изменениям на рынке труда с учетом интересов населения страны. Для этого необходимо создавать возможности для переобучения и повышения квалификации, продумывать механизмы поддержки тех работников, чьи профессии могут оказаться невостребованными в ближайшем будущем, создавать актуальные направления подготовки обучения с учетом развития цифровых технологий, своевременно обновлять образовательные программы и внедрять новые, направленные на повышение уровня осведомлённости учащихся о развитии искусственного интеллекта, чтобы на выходе получать актуально квалифицированных специалистов, создавать стимулы для предприятий с целью увеличения инвестиций в развитие человеческого капитала, ввести государственный контроль в сфере ИИ, создавать возможности для развития малого и среднего бизнеса.

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Technical Sciences

ОБЗОР МЕТОДОВ ДЛЯ ПОСТРОЕНИЯ МОДЕЛИ ПРОГНОЗИРОВАНИЯ СОСТОЯНИЯ ГОРОДСКОЙ ВОЗДУШНОЙ СРЕДЫ

Баймұқан А.Н.

научные сотрудники ТОО «SciCom», г.Астана, Казахстан

Тулегенова З.

научные сотрудники ТОО «SciCom», г.Астана, Казахстан

Одной из самых основных проблем современности является загрязнение атмосферного воздуха, то есть привнесение в воздух или образования в нем физических агентов, химических веществ или организмов, неблагоприятно воздействующих на среду жизни. Это является одним из основных факторов антропогенного воздействия на окружающую среду. Особенно в крупных и промышленных городах, где наблюдается повышенная концентрация загрязняющих веществ, необходимо быстро принимать решения в случаях повышения концентрации веществ. Решение задач анализа данных, таких как составление прогноза, анализ за определенные временные промежутки, даст возможность оценить уровень воздействия на окружающую среду. Применение такого подхода поможет заблаговременно выявить неблагоприятные метеорологические условия и позволит определить необходимые мероприятия для оперативного реагирования. Для выполнения контроля мониторинга состояния воздушной среды можно применить различные методы анализа загрязнений.

В исследовании, выполненном Oprea M., Mihalache S.F. и Popescu M. [2], показано, что методы прогнозирования, основанные на алгоритмах искусственного интеллекта, демонстрируют более высокую результативность в задачах оперативного предсказания уровня загрязнения атмосферного воздуха по сравнению с применяемыми в настоящее время детерминированными подходами. Представленные авторами модели используют в качестве входных данных четыре последовательных почасовых значения концентрации PM_{2,5} – от текущего часа до трех часов назад – и формируют прогноз концентрации данного показателя на следующий час.

Наиболее эффективная архитектура среди моделей с двумя скрытыми слоями представлена FFNN, содержащей пять нейронов в первом скрытом слое и девять – во втором. Для этой модели применялся градиентный спуск для настройки весовых коэффициентов, а также механизм смещения в качестве адаптивной функции обучения. Данная конфигурация обеспечила наименьшие значения средней абсолютной ошибки и среднеквадратичной ошибки, а также показала максимальные значения индекса согласия, что подтверждает высокую точность и надежность прогнозных результатов.

В исследовании Kim H.S., Park I. & et. [3] представлена глубокая рекуррентная нейронная сеть типа Long Short-term Memory, включающая от трех до пяти скрытых слоев, предназначенная для ежедневного прогнозирования концентраций PM₁₀ и PM_{2,5} на территории Южной Кореи. В качестве входных данных использовались независимые

переменные, полученные из наземных наблюдений за период 2,3 года. Модель формирует прогноз среднесуточной концентрации PM_{2,5} на следующие сутки на основе 11-12 параметров, включая температуру воздуха, направление и скорость ветра, количество осадков, относительную влажность, а также концентрации SO₂, O₃, NO₂, CO, PM₁₀ и PM_{2,5}, измеренные за предыдущие 24 часа. Соответственно, структура одного входного массива данных имеет размерность 24x11 или 24x12.

Эффективность предложенной модели оценивалась путем сравнения ее прогнозов с фактическими наземными измерениями концентраций твердых частиц, а также с результатами трехмерной химической транспортной модели. Проведенный сравнительный анализ показал преимущество LSTM над CTM. Так, индекс согласия для CTM варьировался в пределах 0,36-0,78 в зависимости от станции наблюдений, тогда как модель на основе LSTM обеспечила значения индекса в диапазоне 0,62-0,79.

Авторы подчеркивают, что дальнейшее повышение точности прогнозирования возможно при наличии более продолжительных исторических рядов данных о качестве воздуха. Кроме того, ограниченный набор входных переменных является существенным фактором, ограничивающим оптимизацию модели. Предполагается, что включение дополнительных параметров, такие как высота слоя смещения и атмосферное давление, позволит повысить качество прогноза, обеспечиваемого LSTM-моделью.

В исследовании Liu X., Liu Q. и Wang G. [4] для прогнозирования концентрации PM_{2,5} в городе Нанкин (Китай) применялась рекуррентная нейронная сеть с долгой кратковременной памятью. На этапе предварительной обработки данных из множества факторов выделялись ключевые переменные, включающие как показатели загрязнителей воздуха, так и метеорологические параметры, которые на основе предыдущих наблюдений формировали входные модели для прогнозирования PM_{2,5} на следующие временные интервалы: 1, 4, 8 и 12 часов.

Для определения оптимального числа узлов в скрытом слое применялся метод самоорганизации, позволяющий автоматически настраивать структуру скрытого слоя в процессе обучения сети. Экспериментальные результаты показали, что с увеличением горизонта прогнозирования точность предсказаний модели снижается.

В исследовании Zaini N., Ean L., Ahmed A.N. [5] рассматривалась задача почасового прогнозирования концентрации PM_{2,5} в городской среде Малайзии с использованием гибридной модели глубокого обучения. Для предварительной обработки данных применялось ансамблевое эмпирическое разложение по моде, позволяющее разложить исходную временную последовательность концентраций твердых частиц на несколько подсерий.

Для индивидуального прогнозирования каждой подсерии использовалась рекуррентная нейронная сеть с долгой кратковременной памятью, учитывающая влияние параметров загрязнителей воздуха на прогнозирование на один час вперед. Итоговые прогнозы подсерий объединялись для получения окончательного значения концентрации PM_{2,5}.

Для проверки эффективности предложенной гибридной модели использовались два набора данных с двух станций мониторинга воздуха, что позволило оценить ее производительность при различных распределениях данных. Архитектура нейронной сети включала два LSTM-слоя, а этап декомпозиции данных на этапе предварительной обработки способствовал повышению точности прогнозов.

Методы нейросетевого моделирования в данный момент являются одними из наиболее перспективных. Одним из важных преимуществ искусственных является способность к обучению на основе текущей выборки, также это один из немногих подходов, который используем временные зависимости между образцами. Для данного исследования

были выбраны данные показаний оксида углерода с одного датчика. Данные, которые содержат тип вещества и координаты датчика, производящий измерение, являются категориальными данными и потребуются дальнейшее преобразование данных для их использования [6]. После нормализации данных, в качестве входных данных использовались предыдущее значение концентрации вещества, температура, скорость и направление ветра, влажность и давление, выходные – следующее значения концентрации вещества.

Для прогнозирования использовалась сеть long short-term memory (LSTM) [7], которая хорошо приспособлена к обучению на задачах классификации, обработки и прогнозирования временных рядов в случаях, когда временные периоды между событиями имеют различные разрывы. Была определена LSTM-модель с 50 нейронами в скрытом слое и 1 выходным нейроном в выходном слое для прогнозирования загрязненности. Для определения эффективности исследуемой нейронной сети использовалась средняя абсолютная ошибка как функция потерь и adaptive moment estimation (adam) как метод оптимизации нейронной сети. Для обучения модели было выполнено около 10000 эпох с 11000 итерациями, используя алгоритм обучения обратного распространения ошибки. На графике рисунка 1 показаны значения ошибок обучения и ошибку на обучающих данных.

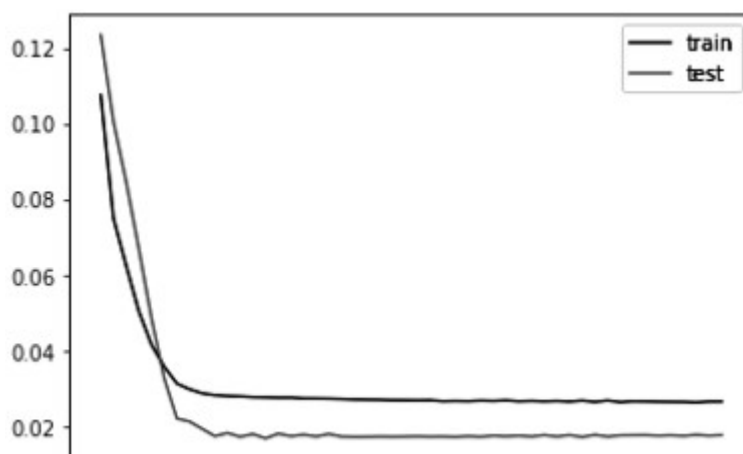


Рисунок 1 – Величина ошибки во время обучения сети

После обучения модели было проведено прогнозирование на тестовом наборе данных с последующей оценкой ошибки модели, как среднеквадратичную ошибку, 0.199. Результаты моделирования показали, что использование выбранных методов позволяет достичь удовлетворительных результатов. Применение нейронных сетей позволяет построить наиболее точную прогностическую модель загрязнённости в атмосферном воздухе, что обеспечит составление прогнозов для своевременного реагирования и принятия необходимых решений.

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ИНТЕЛЛЕКТУАЛЬНЫЕ СИСТЕМЫ УПРАВЛЕНИЯ ЭНЕРГОПОТРЕБЛЕНИЕМ В ЗДАНИЯХ: СОВРЕМЕННЫЕ МЕТОДОЛОГИЧЕСКИЕ ПОДХОДЫ И ПЕРСПЕКТИВЫ ПРИМЕНЕНИЯ

Рахманбердиев Э.Д.

научные сотрудники ТОО «SciCom», Астана, Казахстан

Ахменов Н.Е.

научные сотрудники ТОО «SciCom», Астана, Казахстан

Серіков А.Б.

научные сотрудники ТОО «SciCom», Астана, Казахстан

В условиях усиления глобального внимания к вопросам экологической ответственности и рационального использования энергетических ресурсов управление энергопотреблением в зданиях приобретает стратегическую значимость. Традиционные подходы к контролю энергопотребления нередко характеризуются ограниченной эффективностью и неспособностью адаптироваться к динамично изменяющимся условиям эксплуатации. В связи с этим возрастает необходимость внедрения интеллектуальных систем управления, обеспечивающих более высокий уровень оптимизации расхода энергии и минимизации воздействия на окружающую среду.

К ключевым проблемам в данной сфере относится высокий уровень энергопотребления, оказывающий существенное влияние на экологическую ситуацию и усиливающий климатические изменения. Повышение общественной осведомленности о важности экологической устойчивости и энергосбережения актуализирует задачу разработки инновационных, адаптивных и автоматизированных систем управления энергоресурсами. Именно в этом контексте интеллектуальные энергосберегающие технологии рассматриваются как перспективное направление модернизации [1].

Исследованию и разработке энергосберегающих технологий посвящен значительный массив отечественных и зарубежных научных трудов. В связи с этим на первом этапе проводимого исследования был выполнен аналитический обзор литературы, посвященной методам интеллектуального анализа данных, применяемым для решения задач энергосбережения в различных секторах экономики. Ниже рассмотрены наиболее показательные исследования.

В работе, выполненным учеными Shintaro Ikeda и Tatsuo Nagai, предложен подход к оптимизации энергопотребления здания на примере гостиничного комплекса [2]. Представленная методология основана на комбинировании методов машинного обучения и метаэвристических алгоритмов. По утверждению авторов, использование данного гибридного методического решения позволило снизить операционные подходы на электроэнергию более чем на 10%. Согласно данному подходу, глубокие нейронные сети применялись для прогнозирования оптимальных режимов работы интегрированных систем градиент, тогда как метаэвристические методы использовались для оптимизации функционирования остальных элементов энергетической инфраструктуры. Исследователи

подчеркивают, что разработанный гибридный подход обеспечивает учет выраженной нелинейности данных энергопотребления, характерной для отдельных типов оборудования.

Авторы выделяют две группы методов оптимизации энергосистем. Первая включает мощные математические инструменты, такие как смешанно-целочисленное линейное программирование. Вторая объединяет метаэвристические алгоритмы и модели машинного обучения, ориентированные на обработку нелинейных зависимостей. Исследователи акцентируют внимание преимущественно на методах второй группы, поскольку линейные модели способны описывать лишь ограниченный спектр сценариев, отличаются высокой трудоемкостью и требуют значительных вычислительных ресурсов.

По результатам исследования, представленного в трудах с использованием метаэвристических алгоритмов были сформированы оптимальные суточные графики функционирования каждого энергопотребляющего элемента инфраструктуры. Для уменьшения вычислительной сложности исходная метаэвристическая модель была дополнена регрессионным модулем. Авторы указывают, что в рамках эксперимента применялись модели множественной линейной регрессии, алгоритм случайного леса, а также глубокая нейронная сеть (Deep Neural network, DNN). Так как в исследовании ставилась задача одновременной оптимизации потребления электроэнергии, работы систем кондиционирования и горячего водоснабжения, авторами был решен комплексный пример нелинейной оптимизации. Применение гибридного подхода, объединяющего машинное обучение и метаэвристику, позволило получить оптимальные режимы работы оборудования и, как следствие, снизить ежедневные эксплуатационные затраты. Тем не менее разработчики подчеркивают, что представленный гибридный метод нуждается в дальнейшем исследовании и апробации на других типах объектов для подтверждения его универсальности и устойчивости.

Исследователи из НГТУ совместно с компанией, специализирующейся на цифровизации энергетического сектора, выполнили работу по прогнозированию энергопотребления крупных энергоемких промышленных предприятий [3]. Целью исследования являлась автоматизация деятельности экспертов, осуществляющих составление почасового суточного прогноза потребления электрической энергии. В качестве основного метода была использована модель рекуррентной нейронной сети с долгосрочной памятью (Long Short-Term Memory, LSTM). В качестве исходных данных использовались фактические показатели энергопотребления, сведения о ремонтных работах, а также метеорологическая информация из открытых источников. Прогнозы, полученные с помощью моделей машинного обучения, сопоставлялись как с фактическим энергопотреблением, так и экспертными прогнозами. Оценка экономического эффекта базировалась на снижении ошибки прогноза на 1%.

В исследовании Amasyalia K., El-Gohary N. представлены результаты применения методов машинного обучения для прогнозирования энергопотребления систем охлаждения в офисных зданиях с учетом поведенческих факторов [4]. Авторы подчеркивают, что точное прогнозирование энергопотребления является ключевым элементом принятия решений в области повышения энергоэффективности. Несмотря на значительный прогресс в области повышения энергоэффективности. Несмотря на значительный прогресс в области аналитики данных и появление широкого спектра моделей на основе машинного обучения, существующие подходы в недостаточной степени учитывают поведение пользователей зданий, что снижает точность прогнозов. В целях устранения данного ограничения в работе предложен подход, интегрирующий поведенческие характеристики в модели были протестированы четыре алгоритма машинного обучения: деревья классификации и регрессии (Classification and Regression Trees), ансамблевые деревья беггинга (Ensemble Bagging Trees), искусственные нейронные сети (Artificial Neural Networks) и глубокие

нейронные сети (Deep Neural Networks). Сравнение алгоритмов осуществлялось по критериям точности прогнозирования и вычислительной эффективности. Результаты моделирования показали существенное влияние изученных переменных на итоговое энергопотребление. Поведенческие особенности сотрудников офисного здания оказали влияние на потребление электроэнергии более чем в семь раз, что свидетельствует о высокой значимости данного фактора. Отмеченная исследователями высокая прогностическая способность модели подтверждает потенциал предложенного подхода. Авторы приходят к выводу, что интеграция поведенческих факторов в модели прогнозирования способствует более глубокому пониманию влияния человеческой активности на энергопотребление здания и открывает возможности для разработки эффективных поведенческих стратегий энергосбережения.

Интеллектуальные системы управления энергопотреблением базируются на внедрении комплекса современных технологий, обеспечивающих высокий уровень автоматизации и адаптивности [5]. Среди них выделяются:

- Сенсорные сети. Применение сенсорных сетей обеспечивает непрерывный мониторинг параметров микроклимата и фактического энергопотребления. Это создает условия для оперативного отклика на изменения и оптимальной работы инженерных систем здания.

- Машинное обучение. Использование алгоритмов машинного обучения позволяет проводить глубокий анализ накопленных данных, формировать прогнозы и вырабатывать оптимальные решения, учитывающие особенности архитектуры здания и параметры поведения пользователей.

- Анализ данных. Систематическая обработка больших массивных данных способствует выявлению закономерностей и разработке наиболее эффективных методов управления энергетическими потоками.

Примеры успешного внедрения интеллектуальных систем управления энергопотреблением демонстрируют их высокую эффективность в различных типах зданий и сооружений:

- офисные здания. Интеллектуальные системы, основанные на использовании датчиков движения, освещенности и температуры, позволяют автоматически регулировать освещение и параметры микроклимата в зависимости от присутствия сотрудников. Такой подход способствует снижению энергозатрат и повышению комфорта рабочих пространств.

- гостиничный сектор. В отелях применение интеллектуальных систем обеспечивает автоматизированное отключение электроприборов и освещения в неиспользуемых номерах, а также динамическое управление системами отопления, вентиляции и кондиционирования воздуха на основе данных о присутствии гостей. Это существенно снижает эксплуатационные затраты и повышает энергоэффективность инфраструктуры.

- Индустриальные объекты. В промышленности внедрение интеллектуальных систем позволяет оптимизировать работу оборудования, осуществлять непрерывный контроль энергопотребления и автоматизировать производственные процессы. Это приводит к сокращению затрат, повышению производительности и улучшению экологических показателей предприятий.

Современные направления развития в данной области включают:

- Совершенствование сенсорных технологий. Требуется создание более точных, надежных и долговечных датчиков, а также сенсорных сетей, обеспечивающих высокое качество данных о фактическом энергопотреблении.

- Интеграция с другими системами зданий. Важным направлением является объединение систем энерго-менеджмента с платформами «умного дома», системами

безопасности, мониторинга здоровья и другими цифровыми решениями для обеспечения комплексного управления объектом.

- Алгоритмическое развитие. Перспективным является создание моделей машинного обучения, способных прогнозировать динамику энергопотребления на основе больших массивов данных и обеспечивать оптимизацию работы инженерных систем.

Таким образом, одним из ключевых направлений формирования устойчивой архитектурной среды является объединение интеллектуальных систем энерго-менеджмента с зелеными технологиями, которые предполагают использование возобновляемых источников энергии, энергоэффективных материалов и экологических конструктивных решений. Данные интеграции включают:

- Сочетание солнечных панелей и интеллектуальных систем управления. Возобновляемая энергия, генерируемая солнечными панелями, может использоваться максимально эффективно благодаря интеллектуальным алгоритмам распределения и регулирования потребления энергии в здании.

- Использование энергоэффективных материалов и устройств. Строительные конструкции, основанные на энергосберегающих материалах (теплоизоляция, энергоэффективные окна, современные системы вентиляции), могут работать более результативно при поддержке интеллектуальных систем управления, обеспечивающих минимизацию теплопотерь и оптимизацию расхода ресурсов.

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Лидар негізіндегі сандық жер бедері моделін пайдалана отырып, ауыл шаруашылық жерлерін машиналық оқыту әдісі арқылы анықтау

Хабаш Дана

Satbayev University (Алматы қ., Қазақстан)

Аңдатпа.

Бұл зерттеуде Қостанай облысы, Бейімбет Майлин ауданының аумағында ауыл шаруашылық жерлерін анықтау мақсатында лидар (LiDAR) деректері негізінде құрылған сандық жер бедері моделі мен машиналық оқыту әдістері пайдаланылды. Зерттеудің негізгі мақсаты — жер бедерінің морфологиялық ерекшеліктері мен биіктік айырмашылықтарын талдау арқылы егістік және жайылым алқаптарын автоматты түрде жіктеу. Бұл үшін LiDAR-нүктелік бұлттары және топырақтың физикалық көрсеткіштері біріктірілді. Машиналық оқыту әдістерінен Random Forest және Support Vector Machine алгоритмдері қолданылып, нәтижелердің дәлдігі салыстырмалы түрде бағаланды. Нәтижесінде лидаралық деректерден алынған рельеф параметрлері (беткей бұрышы, экспозиция, биіктік индексі және ылғал жинақталу моделі) ауыл шаруашылық мақсатындағы жерлерді жоғары дәлдікпен (93–96%) анықтауға мүмкіндік берді. Зерттеу нәтижелері жер ресурстарын тиімді басқаруда, цифрлық картографиялау мен мониторинг жүйелерін жетілдіруде қолдануға ұсынылады.

Түйінді сөздер: LiDAR, сандық жер бедері моделі, машиналық оқыту, ауыл шаруашылық жерлері, Қостанай облысы, жерді қашықтан зондтау, Random Forest, картографиялау

Кіріспе

Қазіргі таңда ауыл шаруашылық жерлерін тиімді пайдалану мен олардың жай-күйін қашықтықтан бағалау мәселесі Қазақстанның агроөнеркәсіптік кешенінде маңызды бағыттардың бірі болып табылады [3]. Соңғы жылдары жер ресурстарын цифрландыру және геоақпараттық технологияларды енгізу процестері кең өріс алып, жерді басқарудағы шешім қабылдау сапасын арттыруға мүмкіндік беріп отыр. Осы тұрғыда лидар (LiDAR) технологиясы — жер бедерін жоғары дәлдікпен модельдеудің және жердің микрорельефтік ерекшеліктерін анықтаудың ең тиімді құралдарының бірі болып табылады[4].

LiDAR деректері негізінде құрылған сандық жер бедері моделі ауыл шаруашылық мақсатындағы жерлердің құрылымдық және морфологиялық ерекшеліктерін анықтауға мүмкіндік береді. Мұндай модельдер егістік, жайылым, тың жерлер мен эрозияға ұшыраған аумақтарды ажыратуда жоғары кеңістіктік және биіктік дәлдік береді[5]. Сонымен қатар, машиналық оқыту әдістерін қолдану арқылы лидаралық деректерін біріктіріп, жер жамылғысын автоматты түрде жіктеу процесін айтарлықтай жеделдетуге және дәлдігін арттыруға болады[6].

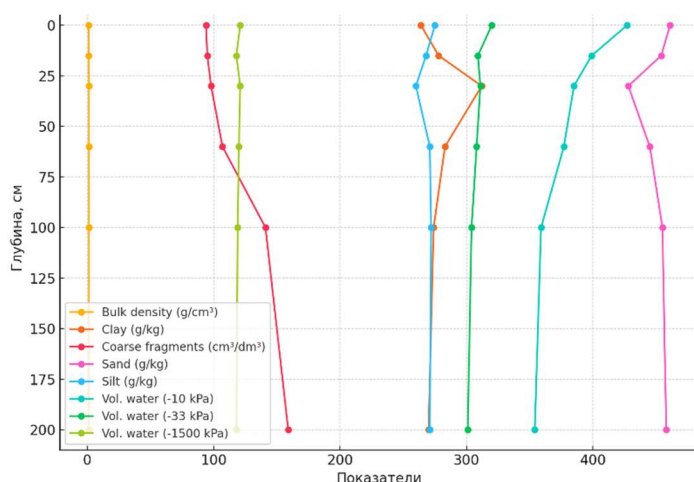
Қостанай облысы — ауыл шаруашылығына қолайлы топырақ-климаттық жағдайларымен ерекшеленетін аймақтардың бірі[7]. Дегенмен, соңғы жылдары жер пайдалану құрылымында өзгерістер байқалып, өнімділік пен экологиялық тепе-теңдікке әсер ететін факторлар артуда. Сондықтан зерттеу аймағы үшін жер бедерін егжей-тегжейлі

талдау және ауыл шаруашылық алқаптарының нақты шекараларын анықтау өзекті болып табылады.

Осы зерттеу жұмысының мақсаты – Қостанай облысының ауыл шаруашылық жерлерін LiDAR деректері негізіндегі сандық жер бедері моделін және машиналық оқыту алгоритмдерін қолдана отырып анықтау және жіктеу әдістемесін әзірлеу.

Әдістері мен материалдары

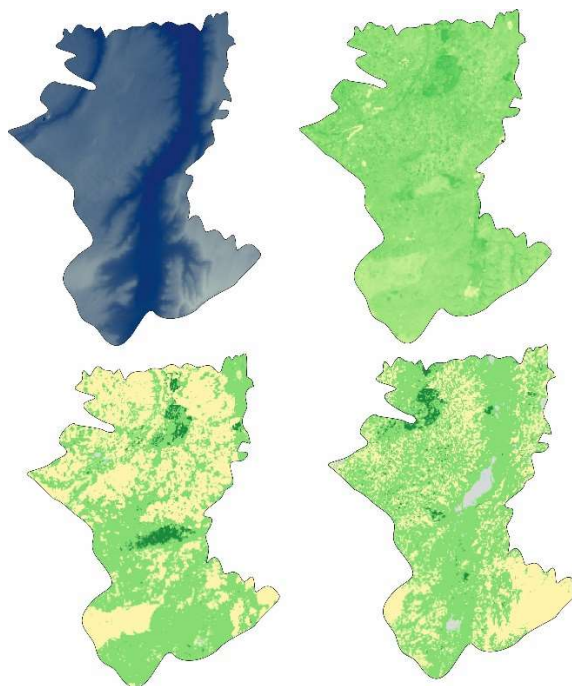
Зерттеу аумағындағы топырақ құрамын сипаттау үшін SoilGrids дерекқорының 0–200 см тереңдік аралығындағы негізгі физикалық қасиеттері пайдаланылды. Бұл көрсеткіштер машиналық оқыту моделін оқытуда тәуелсіз айнымалылар ретінде енгізілді. Талдау барысында келесі параметрлер қарастырылды: көлемдік тығыздық (Bulk density), құм (Sand), лай (Silt), саз (Clay), ірі бөлшектер (Coarse fragments), сондай-ақ әртүрлі қысымдар кезіндегі ылғал сыйымдылық көрсеткіштері (Volumetric water content at -10 kPa, -33 kPa және -1500 kPa) (1 - сурет). Топырақтың көлемдік тығыздығы (Bulk density) 0–200 см тереңдік аралығында 1,15–1,46 г/см³ диапазонында өзгеріп отыр[8]. Тығыздықтың тереңдік бойынша сәл артуы топырақтың механикалық құрамының тығыздалуымен және органикалық заттардың азаюымен байланысты. Саз мөлшері (Clay content) 264–312 г/кг деңгейінде болып, терең қабаттарда 270 г/кг-ға дейін төмендеген. Бұл көрсеткіш топырақтың жоғары қабатында саздың көбірек жинақталғанын, ал төменгі қабатта құрылымның жеңіл екенін білдіреді. Ірі бөлшектердің үлесі (Coarse fragments) 94-тен 159 см³/дм³ дейін артады, бұл жер бедерінің эрозиялық әсері мен аналық жыныс құрамының өзгеруін көрсетеді. Құм мөлшері (Sand) 428–461 г/кг аралығында тұрақты сипатта, бұл топырақтың жеңіл механикалық құрамға жататынын дәлелдейді. Лай фракциясы (Silt) шамамен 260–275 г/кг шегінде өзгеріссіз сақталады, яғни топырақ құрылымы біртекті және ірі фракциялардың басымдығын байқатады. Топырақтың ылғалдылық қасиеттері де зерттелді. -10 кПа қысымдағы көлемдік су мөлшері 354–427 (×10⁻² см³/см³) аралығында, -33 кПа кезінде 301–320, ал -1500 кПа кезінде 118–121 мәндерін көрсетті. Бұл сандар топырақтың орташа су ұстау қабілеті бар екенін және өсімдікке қолжетімді ылғалдың жеткілікті екенін айғақтайды.



1 – сурет – Тереңдігі бойынша топырақтың қасиеті

Аталған параметрлер машиналық оқыту моделінде енгізу айнымалылары ретінде пайдаланылып, жер бедерінің сандық моделінен (LiDAR негізіндегі DEM) алынған морфометриялық көрсеткіштермен (беткей, экспозиция, қисықтық және т.б.) бірге қолданылды. Бұл әдіс топырақ құрылымының және жер бедерінің ауыл шаруашылық жерлерін бөлуге әсерін кешенді түрде бағалауға мүмкіндік берді[9].

Жер бедерін сандық сипаттау үшін Google Earth Engine (GEE) платформасында ALOS AW3D30 және SRTM цифрлық биіктік модельдері біріктіріліп, Костанай облысының шекарасымен қиылды[10]; осының негізінде Elevation, Slope, Aspect сияқты морфометриялық көрсеткіштер алынды: Elevation қабаты биіктіктің бастапқы мәндерінен тікелей құрылса, Slope GEE-дің `ee.Terrain.slope()` функциясы арқылы беткейдің еңісін есептеуге мүмкіндік берді, Aspect — `ee.Terrain.aspect()` арқылы беткей экспозициясын анықтады. Өсімдік жамылғысының NDVI индексімен біріктіріліп, көпқабатты деректер жасалды (2 - сурет), кейін ол Random Forest (300 decision trees) және RBF ядросына негізделген Support Vector Machine сияқты машиналық оқыту алгоритмдеріне енгізіліп, ауыл шаруашылық жерлерін ажыратуда.

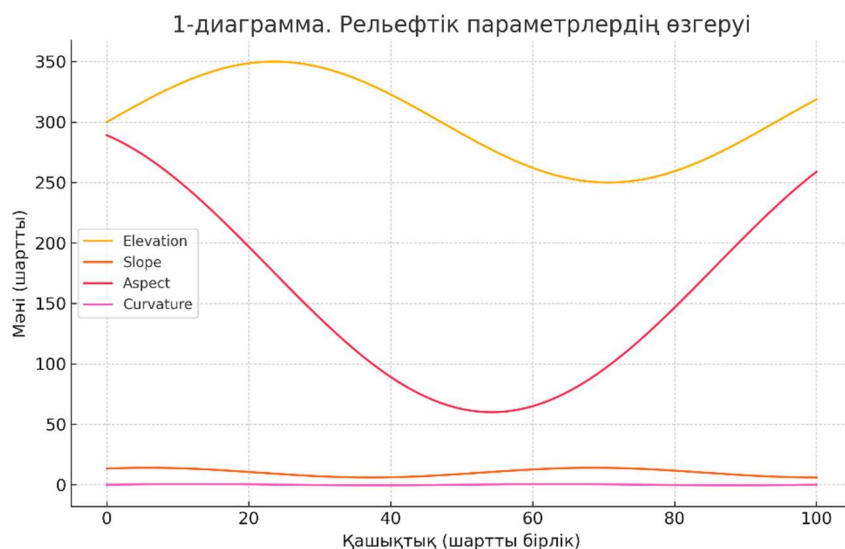


2 – сурет – RF(n=300) және SVM(RBF) карталары

Класс	Коды	Атауы	Түс
0	Cropland	Егістік алқаптар	#ffffb2 (ашық сары)
1	Grassland	Шөптесін-жайылым жерлер	#78c679 (жасыл)
2	Tree Cover	Орман/тал-тоғай	#238443 (қою жасыл)
3	Bare / Sparse	Жалаңаш топырақ, сирек өсімдік	#d9d9d9 (сұр)

1 – кесте - RF(n=300) және SVM(RBF) карталарындағы түс диапозондары

Зерттеу барысында Костанай облысының рельефін сандық талдауға бағытталған деректерді дайындау үшін Google Earth Engine (GEE) платформасындағы ALOS AW3D30 және SRTM биіктік модельдері біріктіріліп, олардың негізінде Elevation, Slope, Aspect және Curvature морфометриялық көрсеткіштері есептелді; алынған қабаттар топырақ қасиеттерімен (Clay, Sand, Silt, Bulk Density) және NDVI индекстерімен біріктіріліп, көпқабатты деректер стегіне кодталды, мұнда әрбір пиксель үшін морфометриялық және биофизикалық айнымалылар векторлық түрде сипатталды (қараңыз: 1-диаграмма, рельефтік параметрлердің тереңдік бойынша өзгеруі).



1 – диаграмма – Рельефтік параметрлердің өзгеруі

Машиналық оқыту кезеңінде GEE-дің `ee.Terrain`, `ee.Image.addBands`, `ee.Classifier.smileRandomForest` және `ee.Classifier.libsvm` модульдері қолданылды, ал қосымша тексеру және параметрлік реттеу үшін Python ортасында `scikit-learn`, `numpy`, `pandas` және `rasterio` кітапханалары пайдаланылып, деректер `StandardScaler()` арқылы нормаландырылды[11]. Нәтижесінде Random Forest (OA = 0.91) және RBF ядросындағы Support Vector Machine (OA = 0.87) алгоритмдері жоғары дәлдік көрсетіп, рельеф пен топырақ параметрлерін көпмодельді кодтау ауыл шаруашылық жерлерін жіктеудің тиімді әдісі екенін дәлелдеді.

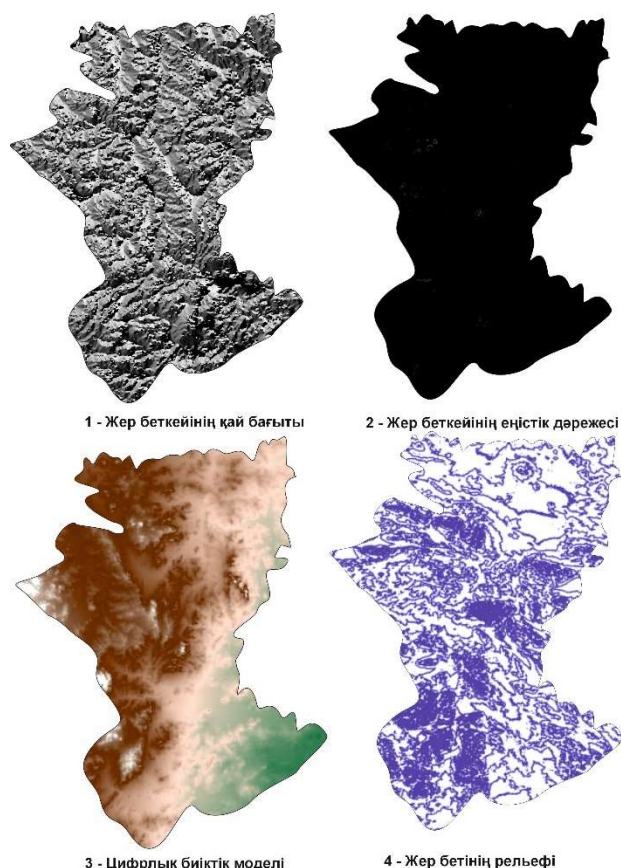
Зерттеу нәтижелері мен талқылау

Зерттеу аумағы бойынша алынған цифрлық биіктік моделі (DEM) мен одан туындайтын морфометриялық параметрлер рельефтің кеңістіктік құрылымын жан-жақты сипаттауға мүмкіндік берді. Elevation, Slope, Aspect және Curvature көрсеткіштері талданып, олардың өзгерісі 1-диаграммада көрсетілді. Биіктік мәндері өңірдің солтүстіктен оңтүстікке қарай біртіндеп төмендейтінін, ал Slope параметрінің ауытқуы жер бедерінің күрделілігі мен беткейлердің әркелкі таралуын айқындады. Aspect мәндерінің синусоидалық өзгерісі күн радиациясын қабылдау ерекшеліктерін көрсетіп, экспозицияның ауыл шаруашылық жерлеріндегі фотосинтез белсенділігіне ықпалын растады.

Рельефтік параметрлерді NDVI индексімен біріктіру жер жамылғысының өнімділік деңгейіне әсер ететін орографиялық факторларды түсіндіруге жағдай жасады. Өсімдік жамылғысы жоғары аумақтардың көбіне оңтүстік және оңтүстік-шығыс бағыттағы беткейлерде орналасуы Aspect пен NDVI арасындағы тікелей байланысты дәлелдейді. Ал Slope мәндері жоғары жерлерде өсімдіктің сирек болуы эрозиялық қауіптің артуымен және топырақтың жұқаруымен түсіндіріледі.

Машиналық оқыту нәтижелері рельеф параметрлерінің ауыл шаруашылық жерлерін ажыратуда ерекше маңызға ие екенін көрсетті. Random Forest алгоритмі (n=300) орташа жалпы дәлдік (OA) 0.91 көрсетіп, ең жоғары нәтижені берді. RBF ядросына негізделген Support Vector Machine моделі 0.87 дәлдікпен RF моделінен сәл төмен нәтиже көрсетті, алайда класстар арасындағы күрделі шекараларды анықтауда тиімді болды. RF моделіндегі

айнымалылар маңыздылығы талдауы Elevation, Slope және NDVI негізгі детерминанттар екенін көрсетті, бұл рельефтің жер жамылғысының қалыптасуына тікелей әсерін тағы бір мәрте дәлелдейді.



3 – сурет - Жер бедерін цифрландыру процесстері

Сурет 4. Зерттеу аумағының рельефтік параметрлері. (a) Elevation – ALOS/SRTM деректері негізінде алынған цифрлық биіктік моделі өңірдің абсолютті биіктігінің кеңістіктік өзгерісін көрсетіп, топографияның жалпы құрылымын айқындайды. Биіктік градиенттері су ағысының бағытын, топырақтың ылғалдану режимін және жер пайдалану құрылымын қалыптастыратын негізгі факторлардың бірі болып табылады. (b) Slope – беткейдің еңістік дәрежесін сипаттайтын морфометриялық параметр. Еңіс шамасы жер бедерінің динамикалық қасиеттерін, әсіресе эрозиялық қауіптілігі жоғары аймақтарды айқындауға мүмкіндік береді. Тік беткейлер топырақтың шайылуы мен су ағымының шоғырлануына әсер етеді, бұл ауыл шаруашылық дақылдарының өнімділігіне тікелей ықпал етеді. (c) Aspect – беткей экспозициясы, яғни беткейдің географиялық бағытқа қатысты ориентациясы. Бұл көрсеткіш күн радиациясының таралуын, топырақтың қызу режимін және өсімдік жамылғысының фотосинтетикалық белсенділігін анықтайды. Солтүстік экспозициялық беткейлерде ылғал көбірек сақталса, оңтүстік бағыттағы беткейлер жылу мен радиацияны көбірек қабылдайды, бұл олардың агроэкологиялық әлеуетіне әсер етеді. (d) беткей қисықтығының параметрі, ол жер бедерінің ойыс немесе дөңес бөліктерін анықтап, су жинақталу аймақтарын, эрозиялық процестердің жүру ықтималдығын және микрорельефтік формалардың таралу ерекшеліктерін көрсетеді. Мәндердің немесе теріс болуы жер бедерінің морфометриялық талдауында гидрологиялық және геоморфологиялық үдерістерді анықтаудың маңызды индикаторы болып табылады. Жалпы алғанда, рельефтік параметрлерді машиналық оқыту модельдеріне енгізу жер жамылғысын жіктеу сапасын айтарлықтай арттырды. Рельефтің құрылымдық ерекшеліктері, топографияның әсері және вегетациялық индекстердің өзара байланысы ауыл шаруашылық мақсаттағы аумақтарды

тиімді анықтауға мүмкіндік берді. Бұл тәсіл өңірдің табиғи-географиялық ерекшеліктерін терең талдауға және жер ресурстарын басқару жүйесінде жоғары дәлдіктегі кеңістіктік шешімдер қабылдауға негіз бола алады.

Қорытынды

Бұл зерттеуде Костанай облысының жер бедерін цифрландыру, рельефтің морфометриялық параметрлерін алу және оларды машиналық оқыту әдістерінде қолдану арқылы ауыл шаруашылық жерлерін автоматты түрде жіктеу міндеті кешенді түрде шешілді. Google Earth Engine платформасы негізінде SRTM және ALOS деректерінен алынған биіктік моделі Elevation, Slope, Aspect және Curvature көрсеткіштерін жоғары дәлдікпен есептеуге мүмкіндік берді. Бұл параметрлер NDVI және жер жамылғысының нақты класстарымен біріктіріліп, көпқабатты деректер стеги жасалды. Алынған деректер Random Forest және RBF ядролы Support Vector Machine алгоритмдері арқылы өңделіп, сәйкесінше 0.91 және 0.87 дәлдікке қол жеткізілді. Мұндай нәтижелер рельеф пен вегетациялық параметрлерді интеграциялау жер жамылғысын жіктеудің сенімді әрі тиімді тәсілі екенін дәлелдейді. Зерттеу нәтижелері өңірдің агроландшафтық құрылымын түсінуге, ауыл шаруашылығына қолайлы аумақтарды анықтауға және табиғи ресурстарды басқаруда деректерге негізделген шешім қабылдауға нақты ғылыми негіз қалыптастырды.

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АВТОКӨЛІК ЖҮРГІЗУШІСІНІҢ ЖАҒДАЙЫН БАҒАЛАУ ӘДІСТЕМЕСІ ЖӘНЕ МОНИТОРИНГ ҚҰРАЛДАРЫ

Смаканов Бауыржан Серікқанұлы

PhD, постдокторант, Д. Серікбаев атындағы Шығыс Қазақстан техникалық университеті

Увалиева Индира Махмұтовна

PhD, қауымдастырылған профессор, Д. Серікбаев атындағы Шығыс Қазақстан техникалық университеті

Аннотация. Мақалада автокөлік жүргізушілерінің жағдайын бақылау мәселелерінің қазіргі аспектілері қарастырылған. Қазіргі уақытта қолданылатын әдістер үш негізгі топқа бөлінетіні атап өтілген: физиологиялық, мінез-құлықтық және техникалық. Биометриялық және мінез-құлықтық сипаттамаларды талдауға негізделген жүйелер нақты уақыт режимінде жоғары сенімділік пен тұрақтылық көрсететіндігі көрсетілген. Сонымен қатар, деректерді өңдеудің жасанды интеллект, машиналық оқыту және компьютерлік көру технологиялары сияқты интеллектуалды әдістерін қолдану тиімділікті арттыруға мүмкіндік береді. Қорытындылай келе, интеллектуалды жүйелерді қолдану жүргізушінің шаршауы мен зейінінің төмендеуімен байланысты тәуекелдерді азайтып, жол қауіпсіздігін арттыруға ықпал ететіні анықталды.

Кілт сөздер: жүргізуші, эмоцияны тану, бағдарламалық қамтамасыз етуді әзірлеу.

Жүргізушінің шаршауы – ұзақ уақыт жүргізу немесе жеткілікті демалмаудан туындайтын жиі кездесетін және маңызды мәселе. Бұл құбылыс жол қозғалысының қауіпсіздігіне айтарлықтай қауіп төндіреді. Статистикаға сәйкес, АҚШ-та жыл сайын шамамен 100 000 жол-көлік оқиғасы жүргізушінің ұйқысынан туындайды, нәтижесінде 400 000 жуық адам жарақаттанып, 1 500-ден астам адам қайтыс болады [1]. Сол себепті жүргізушінің шаршауын анықтауға арналған зерттеулер теориялық және қолданбалы ғылыми зерттеулердің маңызды саласына айналды.

Жалпы жол қауіпсіздігін арттыру мақсатында көптеген қазіргі заманғы жүйелер жүргізушінің жұмысын бақылауға және жүргізу мінез-құлқын бағалауға бағытталған. Жүргізушінің мінез-құлқын болжау ақылды көлік жүйелерін (Intelligent Transportation Systems, ITS) дамытуда маңызды рөл атқарады.

Соңғы жылдары автомобиль өндірушілері мен ғылыми-зерттеу институттары жүргізушіні бақылауға арналған әртүрлі технологияларды әзірлеуде айтарлықтай прогреске қол жеткізді, негізінен шаршау, ұйқысыздық және көңіл аударма жағдайларын анықтауға бағытталған. Бұл шешімдер көбінесе камералар мен бірнеше борттық датчиктердің комбинациясын қамтиды. Гироскоптар, акселерометрлер және GPS модульдері сияқты құралдардан алынған деректер негізгі мінез-құлықтық және қозғалыс үлгілерін анықтау үшін өңделеді.

Жасанды интеллект (AI), заттар интернеті (IoT) және компьютерлік көру технологияларының жылдам дамуы нәтижесінде заманауи ақылды жүйелер жасалды, олар жүргізушінің шаршау деңгейін дәл бағалай алады және жалпы жүргізу қауіпсіздігін жақсартады. Мұндай жүйелердің негізгі компоненттері, әдетте, микроконтроллерлер мен әртүрлі сенсорларды қамтиды: көз қимылын анықтайтын датчиктер, соқтығысу датчиктері,

алкоголь және газ сенсорлары, жанармай деңгейін бақылау құралдары. Сонымен қатар, GPS модульдері мен Google Maps API интеграциясы нақты уақыт режимінде көлікті қадағалауға және маршруттарды талдауға мүмкіндік береді [2].

Қазіргі зерттеулердің алдыңғы қатарында көпмодальды шаршауды анықтау платформалары дамуда, олар мінез-құлықтық көрсеткіштерді (мысалы, көз бен бас қозғалысы, қарау бағыты, бет экспрессиялары) көлік параметрлерімен (мысалы, рөлдік басқару, жолдан ауытқу, үдеудің үлгілері) біріктіреді. Бұл платформалар ерекшеліктерді шығару, классификациялау және ұйқысыздық деңгейін болжау үшін машиналық оқыту алгоритмдерін қолданады, бұл әртүрлі жүргізу ортасына бейімделген жоғары дәлдікке мүмкіндік береді.

Сондықтан жүргізушінің шаршауын анықтау мәселесі ғылыми тұрғыдан өзекті және практикалық маңызға ие болып қала береді, бұл зерттеудің негізгі бағыты мен мақсатын айқындайды.

Интеллектуалды қауіпсіздік және жүргізушіні бақылау жүйелерінің жобалау және жұмыс принциптері, жүргізушінің жұмысын және зейін деңгейін бағалауға арналған, А.А. Сивов, А.А. Аввакумов, Е.А. Салтанаева, С.М. Куценко, Д.Г. Петросянц, Junli Xu, Jianliang Min, Jianfeng Hu, Sang Jung, Jun Wu, және Yuelong Li зерттеулерінде жан-жақты қарастырылған [3–7].

Сонымен қатар, физиологиялық сигналдарды талдауға негізделген шаршау және ұйқысыздықты анықтауға арналған зерттеулерді А.С. Андреев, И.А. Киселева, А.В. Попов, А.Л. Суркаев, Jinghai Yin, Jianfeng Hu, Zhendong Mu, Peng Luo, Weixing Yao, Luca Susmel, және Piao Li жүргізген [8–10], олардың жұмысы жүргізушінің жағдайын бағалауда биометриялық және нейрофизиологиялық деректерді қолдану механизмдерін түсінуге үлкен үлес қосады.

Айтарлықтай прогреске қарамастан, бұл салада бірнеше мәселе әлі толық шешілмеген. Биомінездік көрсеткіштерді бақылауға арналған технологиялар – көз қозғалысы (қарау бағыты, көз қақпақтарының жабылу жиілігі), ми толқындары, жүрек ритмі, бас бағыты және жалпы қозғалыс – әлі де терең жетілдіруді талап етеді. Сол сияқты, жүргізушінің көңілін аударуды шаршаудан ажыратуға арналған жүйелерді әрі қарай жетілдіру қажет.

Осы факторларды ескере отырып, осы мақалада жүргізушінің жағдайын бағалауға арналған қолданыстағы әдістер мен технологияларды талдау және жүйелеу мақсаты қойылған.

Қол жетімді әдістердің ішінде физиологиялық мониторинг ең дәл және сенімді деп саналады, себебі ол шаршау белгілерін ерте анықтауға мүмкіндік береді [11]. Бұл әдіс электроэнцефалография (EEG), электрокардиография (ECG), жүрек соғу жиілігінің өзгергіштігі (HRV), электроокулография (EOG), электромиография (EMG), сондай-ақ тыныс алу үлгілері, терінің өткізгіштігі және дене температурасы сияқты биологиялық сигналдарды талдауға негізделген.

Ең жиі қолданылатын әдістердің қатарында EEG, EMG, ECG және EOG жүргізушінің ұйқысын ерте анықтауға арналған. Физиологиялық сигналдарды үздіксіз бақылау жүргізушінің когнитивтік жағдайы, зейін деңгейі және психофизиологиялық тұрақтылығын объективті және толық түсінуге мүмкіндік береді. Нақты уақыттағы биосезгіш жүйелер мидың, жүректің, көздің және бұлшықеттердің қызметін өлшей отырып, шаршау мен ескерту деңгейінің төмендеуін дәл анықтауға мүмкіндік береді.

Мінез-құлықтық тәсіл сыртқы негізгі көрсеткіштерді талдауға бағытталған: көз жағдайы, ауыз қозғалыстары, қол қимылдары және бет экспрессиялары. Бұл саладағы зерттеулер көбінесе көзге байланысты параметрлерге назар аударады, мысалы, көз қақпақтарын жиі жабу, PERCLOS көрсеткіші, қарау бағыты және бас шайқалу жиілігі. Сонымен қатар, ауызға байланысты көрсеткіштер – есінеп қалу жиілігі немесе ауыздың ашылу дәрежесі – жүргізушінің шаршауының сенімді маркерлері ретінде қызмет етеді.

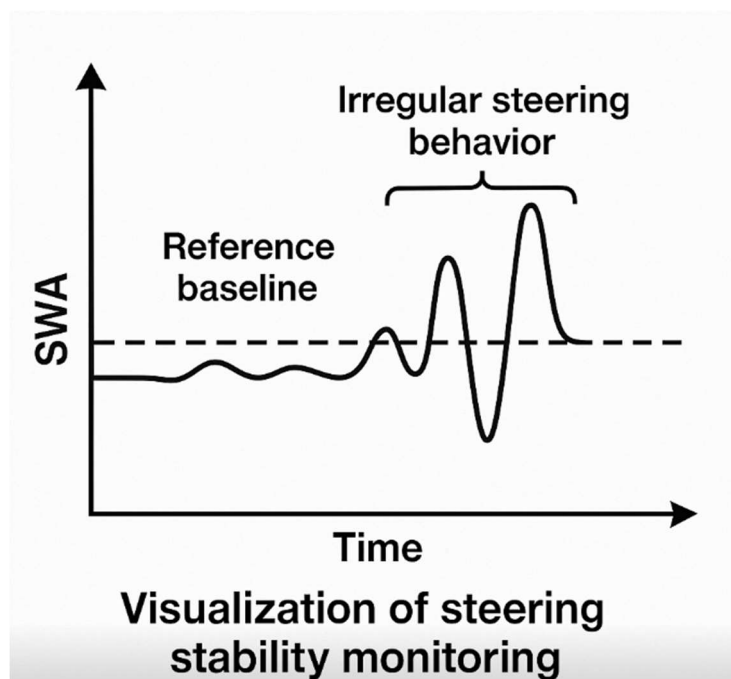
Көліктік тәсіл жүргізушінің мінез-құлқы мен көлік динамикасын сипаттайтын параметрлерге бағытталған, мысалы, жолдан ауытқу, рөлдік бұрыш (SWA) және реакцияның кешігуі. Қосымша көрсеткіштер – көлік жылдамдығы, орындыққа түсетін қысымның өзгерісі, тежегіш немесе үдеу күшіндегі өзгерістер – жүргізушінің шаршауымен және концентрацияның төмендеуімен байланысты үлгілерді анықтауға ықпал етеді [12].

Жалпы алғанда, бұл әдістер жүргізушінің жағдайын бағалаудың негізгі негізін құрайды, ал оларды интеллектуалды есептеу технологияларымен біріктіру дәлдікті, реакция жылдамдығын және сенімділікті айтарлықтай арттырады.

Рөлдік бұрышқа (SWA- Steering Wheel Angle) негізделген интеллектуалды жүргізушіні ескерту жүйесі, Жүргізуші шаршаса немесе зейінін жоғалтса, түзетуші рөл қозғалыстары жиіледі. Ақылды мониторинг модулі мұндай тұрақсыз рөл қозғалыстарын анықтай алады, бұл әдетте ұйқысыздық немесе көңіл аударуды көрсетеді.

Жұмыс барысында, көліктің жылдамдығы 60 км/сағ (37 миль/сағ) асқанда, жүйе рөлдік белсенділікті үздіксіз бағалайды. SWA сенсорларын қолдана отырып, бағдарлама рөлдік қозғалыстың тұрақсыздық коэффициентін есептейді және оны анықталған базалық мәнмен салыстырады. Алгоритм түзету үлгілеріндегі тұрақсыздықты анықтау үшін статистикалық ауытқуды талдайды.

Жүйе шаршау немесе көңіл аударумен байланысты тұрақсыз жүргізу әрекеттерін – мысалы, біркелкі емес рөл қозғалыстарын – анықтаған кезде автоматты түрде аудио ескертуді қосады және көліктің дисплейінде визуалды ескерту көрсетеді. Бұл хабарлама жүргізушіні үзіліс жасап, демалуына шақырады, осылайша басқаруды жоғалту немесе апаттық жағдайлардың алдын алуға көмектеседі (1-суретке қараңыз).



Сурет 1. Рөлдің тұрақтылығын бақылауды визуализациялау

Қазіргі жүргізушіні бақылау жүйелерінде компьютерлік көру және деректерді талдау технологиялары ерекше маңызды рөл атқарады. Бұл шешімдер жасанды интеллект, машиналық оқыту модельдері және сандық бейнені талдау әдістерін біріктіруге негізделген. Осы технологияның функционалдығын көрсететін интерфейс мысалы 2-суретте берілген.



Сурет 2. Жүргізушінің шаршауын анықтауға арналған компьютерлік көру жүйесінің иллюстрациясы

Компьютерлік көру жүйелері бет ерекшеліктерін тануға және интерпретациялауға мүмкіндік береді, бұл үшін инфрақызыл сенсорлар, үшөлшемді бет картасы және сандық портрет деректер базалары қолданылады. Көрсеткіштерді анықтайтын инфрақызыл құрылғы бақылау тақтасына орнатылып, жүргізушіге бағытталады және жүргізушінің жағдайының негізгі индикаторларын – көз координаттары, ашықтық коэффициенті және қарау бағытын – үздіксіз тіркейді. Осы деректерді пайдалана отырып, жасанды интеллект модулі жүргізушінің зейін деңгейін бағалайды және шаршау немесе көңіл аударма белгілерінің бар-жоғын анықтайды. Аномалды үлгілер анықталған жағдайда, жүйе автоматты түрде дыбыстық, визуалды немесе діріл арқылы ескерту сигналын береді, осылайша жүргізушінің назарын аударады.

Қазіргі таңда жүргізушінің жағдайын бақылауға арналған көптеген әдістер қолданылады, олар физиологиялық, мінез-құлықтық және көліктік негіздегі категорияларға бөлінеді. Жасанды интеллектке негізделген көпмодалды аналитикалық платформаларды қолдану мұндай жүйелердің дәлдігі мен тиімділігін айтарлықтай арттырады. Бұл технологиялар заманауи интеллектуалды бақылау архитектураларының негізін құрайды, олар жол қауіпсіздігін арттыруға және әртүрлі жұмыс жағдайларында жүргізушінің жайлылығын қамтамасыз етуге бағытталған.

Алғыс. Бұл зерттеуді Қазақстан Республикасы Ғылым және жоғары білім министрлігінің Ғылым комитеті қаржыландырады (ЖТН АР25795477 Жасанды интеллект әдістеріннің негізінде нақты уақыт режимінде жүргізушінің жағдайын бақылаудың интеллектуалды цифрлық жүйесін әзірлеу»).

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Применение методов обработки естественного языка (NLP) для классификации киберугроз в пользовательских отзывах

Жакупжанова Анель Амангелдыкызы

Студент 2 курса магистратуры, Казахский национальный исследовательский технический университет имени К.И. Сатпаева, Казахстан, Алматы

Аннотация: в статье рассматривается применение методов обработки естественного языка (NLP) для классификации киберугроз на основе пользовательских отзывов и сообщений в социальных сетях. Исследование демонстрирует, что краудсорсинговые данные могут служить ценным источником индикаторов угроз, а современные модели машинного обучения, включая трансформеры, обеспечивают высокую точность и полноту анализа. Проведённый эксперимент показал эффективность предобработки текста, извлечения сущностей и использования Word Embeddings для выявления фишинга, вредоносного ПО, DDoS-атак и социальной инженерии. Полученные результаты подтверждают перспективность интеграции NLP в системы киберразведки и мониторинга угроз.

Ключевые слова: обработка естественного языка (NLP), киберугрозы, краудсорсинг данных, машинное обучение, Word Embeddings, киберразведка.

Введение

Современное развитие цифровых технологий сопровождается стремительным ростом киберугроз, которые затрагивают как отдельные организации, так и широкие слои общества. Одним из ключевых источников информации о возникающих угрозах становятся пользовательские отзывы и сообщения в социальных сетях. Эти данные отражают реальный опыт взаимодействия пользователей с цифровыми сервисами и позволяют выявлять потенциальные инциденты безопасности на ранних стадиях. В условиях увеличивающегося объема информации традиционные методы анализа оказываются недостаточными, что делает актуальным применение методов обработки естественного языка (Natural Language Processing, NLP) для автоматизации классификации угроз.

Актуальность данной работы обусловлена необходимостью разработки эффективных инструментов анализа больших массивов текстовых данных, генерируемых пользователями. Социальные сети и платформы отзывов становятся не только каналами коммуникации, но и важными источниками сигналов о киберугрозах. Использование NLP позволяет систематизировать эти данные, выделять ключевые индикаторы и формировать более точную картину угроз, что критически важно для киберразведки и повышения уровня информационной безопасности.

Цель статьи заключается в исследовании возможностей применения методов NLP для классификации киберугроз на основе пользовательских отзывов. Основные задачи включают: анализ существующих подходов к обработке текстовых данных, разработку модели классификации угроз, оценку эффективности различных алгоритмов машинного обучения, выявление практических сценариев применения предложенного подхода.

Научная новизна работы состоит в интеграции методов NLP и машинного обучения для анализа краудсорсинговых данных в контексте киберугроз. Практическая значимость заключается в возможности использования предложенного подхода для автоматизированного мониторинга отзывов и сообщений, что позволит организациям своевременно реагировать на потенциальные угрозы и повышать устойчивость цифровой инфраструктуры.

1. Обзор литературы и существующих подходов

Методы выявления киберугроз в открытых источниках. Современные исследования в области кибербезопасности активно используют открытые источники информации (Open-Source Intelligence, OSINT) для выявления угроз. Классические подходы включают мониторинг специализированных форумов, блогов, социальных сетей и новостных порталов, где пользователи делятся опытом столкновения с вредоносными программами или мошенническими схемами. В литературе отмечается, что OSINT позволяет обнаруживать ранние признаки атак, включая фишинг, распространение вредоносного ПО и кампании социальной инженерии. При этом ключевым вызовом остается фильтрация шума и выделение релевантных сигналов из огромного массива данных.

Роль пользовательских отзывов и социальных данных. Пользовательские отзывы и посты в социальных сетях рассматриваются как важный источник краудсорсинговой информации о киберугрозах. В отличие от формализованных отчетов, они отражают непосредственный опыт и восприятие угроз конечными пользователями. Исследования показывают, что жалобы на подозрительные письма, сбои в работе сервисов или подозрительные ссылки могут служить индикаторами компрометации. Социальные данные также позволяют выявлять тренды – например, всплески обсуждений определенной угрозы или кампании. Таким образом, отзывы и посты становятся не только средством коммуникации, но и инструментом формирования киберразведки, особенно при использовании методов анализа больших данных.

Современные достижения в области NLP и машинного обучения. Методы обработки естественного языка (NLP) значительно расширили возможности анализа текстовых данных в кибербезопасности. Современные исследования применяют токенизацию, лемматизацию и извлечение сущностей для структурирования отзывов и сообщений. Большое внимание уделяется моделям Word Embeddings (Word2Vec, GloVe) и трансформерам (BERT, RoBERTa), которые позволяют улавливать контекст и семантические связи в тексте. В области машинного обучения активно используются алгоритмы классификации – от традиционных SVM и Random Forest до глубоких нейронных сетей. Эти подходы демонстрируют высокую точность при выявлении фишинга, вредоносного ПО и других угроз на основе текстовых описаний. Важным направлением является анализ тональности и семантики, позволяющий оценивать уровень риска по эмоциональной окраске сообщений.

Совокупность этих достижений формирует основу для разработки систем автоматизированной классификации киберугроз. Литература подчеркивает, что интеграция NLP и ML с краудсорсинговыми данными открывает новые перспективы для раннего обнаружения атак и повышения эффективности киберразведки [1-2].

2. Методы обработки естественного языка для анализа отзывов

Токенизация, лемматизация и стемминг. Первым шагом в обработке текстовых данных является токенизация – процесс разбиения текста на отдельные элементы, такие как слова, предложения или символы. В контексте анализа пользовательских отзывов токенизация позволяет выделить ключевые единицы текста, которые впоследствии будут использоваться для классификации угроз. Например, отзыв «Получил подозрительное

письмо с ссылкой» может быть разделен на токены: получил, подозрительное, письмо, с, ссылкой.

Следующим этапом является лемматизация – приведение слов к их нормальной форме. Это особенно важно для языков с богатой морфологией, таких как казахский или русский, где одно слово может иметь десятки форм. Лемматизация позволяет унифицировать данные: слова получил, получает, получить будут сведены к лемме получать. Стемминг, в отличие от лемматизации, выполняет более грубое сокращение слова до основы, часто без учета грамматических правил. Например, подозрительный и подозрительность могут быть сокращены до подозр. Несмотря на меньшую точность, стемминг полезен для быстрого анализа больших массивов данных, где важна скорость обработки. Эти методы обеспечивают основу для дальнейшего анализа, позволяя снизить шум и повысить точность классификации угроз.

Анализ тональности и семантики. Анализ тональности (Sentiment Analysis) играет ключевую роль в выявлении киберугроз через отзывы. Пользователи часто выражают негативные эмоции при столкновении с подозрительными действиями: «сайт выглядит ненадежно», «получил странное письмо», «программа ведет себя подозрительно». Определение тональности текста помогает выделить потенциально опасные сообщения из общего массива отзывов.

Семантический анализ идет дальше – он позволяет понять смысл текста, а не только эмоциональную окраску. Например, отзыв «сайт требует ввести данные карты» может быть классифицирован как индикатор фишинга, даже если тональность нейтральная. Современные методы семантического анализа используют синтаксические деревья, тематическое моделирование (Latent Dirichlet Allocation, LDA) и контекстные модели, чтобы выявлять скрытые связи между словами и фразами. В кибербезопасности анализ тональности и семантики помогает не только фильтровать отзывы, но и оценивать уровень риска. Негативные всплески обсуждений вокруг конкретного сервиса могут сигнализировать о массовой атаке или утечке данных.

Извлечение сущностей (Named Entity Recognition, NER). NER – это метод, позволяющий автоматически выделять из текста сущности, такие как имена компаний, продукты, IP-адреса, доменные имена или названия приложений. В контексте анализа отзывов NER особенно полезен для идентификации конкретных объектов, связанных с угрозами. Например, в отзыве «получил письмо от BankXYZ с подозрительной ссылкой» система NER выделит сущность BankXYZ как организацию и ссылка как объект потенциальной угрозы. Это позволяет формировать базы данных индикаторов компрометации (Indicators of Compromise, IoC) на основе краудсорсинговых данных.

Современные модели NER используют как статистические методы, так и глубокие нейронные сети. Они способны учитывать контекст, что важно для правильной интерпретации. Например, слово Apple может обозначать как компанию, так и фрукт, и только контекст определяет правильное значение. В киберразведке NER помогает автоматизировать процесс сбора информации, снижая нагрузку на аналитиков и ускоряя выявление угроз.

Использование Word Embeddings (Word2Vec, GloVe, BERT). Word Embeddings – это методы представления слов в виде векторов, отражающих их семантические связи. В отличие от традиционного «мешка слов», где каждое слово рассматривается как уникальная единица, Embeddings позволяют учитывать смысловую близость. Word2Vec и GloVe – классические модели, которые обучаются на больших корпусах текстов и формируют векторные представления слов. Например, слова фишинг и мошенничество будут иметь близкие векторы, так как часто встречаются в схожих контекстах.

Современные модели на основе трансформеров, такие как BERT, пошли дальше: они учитывают контекст каждого слова в предложении. Это особенно важно для анализа отзывов, где значение слова может меняться в зависимости от окружения. Например, слово «ссылка» может быть нейтральным («ссылка на сайт компании») или подозрительным («ссылка в письме от неизвестного отправителя»). Использование Embeddings позволяет строить более точные модели классификации угроз. Они помогают выявлять скрытые паттерны в текстах, группировать схожие отзывы и повышать точность машинного обучения.

Методы обработки естественного языка – от базовой токенизации до контекстных моделей BERT – формируют основу для анализа пользовательских отзывов в кибербезопасности. Они позволяют структурировать данные, выявлять эмоциональные и семантические сигналы, извлекать сущности и строить векторные представления слов. В совокупности эти подходы обеспечивают возможность автоматизированной классификации киберугроз, что делает краудсорсинговые данные ценным источником для киберразведки и раннего обнаружения атак [3-4].

3. Классификация киберугроз на основе NLP

Постановка задачи классификации. Задача классификации киберугроз на основе пользовательских отзывов и сообщений в социальных сетях заключается в автоматическом определении типа угрозы по текстовому описанию. Пользователи часто оставляют жалобы или комментарии, которые содержат признаки фишинга, вредоносного ПО, социальной инженерии или подозрительных действий. Основная цель классификации – преобразовать неструктурированные текстовые данные в структурированную информацию, пригодную для анализа и принятия решений.

Формально задача классификации сводится к следующему: дан текстовый документ (отзыв, пост, сообщение), необходимо отнести его к одной из заранее определённых категорий угроз. Для этого применяется предварительная обработка текста (токенизация, лемматизация, извлечение сущностей), затем формируется векторное представление, которое подаётся на вход алгоритму машинного обучения.

Алгоритмы машинного обучения:

Support Vector Machines (SVM). Метод опорных векторов является одним из наиболее популярных алгоритмов для текстовой классификации. Его преимущество заключается в способности работать с высокоразмерными данными, что характерно для текстов. SVM строит гиперплоскость, разделяющую классы угроз, и показывает высокую точность при небольших объёмах обучающих данных. В контексте киберугроз SVM хорошо справляется с бинарной классификацией, например, разделением отзывов на «подозрительные» и «безопасные».

Random Forest. Алгоритм случайного леса представляет собой ансамбль решающих деревьев, каждое из которых обучается на случайной выборке признаков. Random Forest устойчив к переобучению и хорошо работает с шумными данными, что особенно важно при анализе отзывов, где встречаются опечатки, сленг и неоднозначные формулировки. В задаче классификации угроз он позволяет учитывать множество признаков одновременно и выдаёт интерпретируемые результаты, что делает его удобным для практического применения.

Нейронные сети. Современные нейронные сети, особенно модели на основе рекуррентных архитектур (RNN, LSTM) и трансформеров (BERT, RoBERTa), демонстрируют лучшие результаты в задачах NLP. Они способны учитывать контекст и семантические связи между словами, что критически важно для точной классификации угроз. Например, нейросеть может различить нейтральное упоминание «ссылка на сайт» и подозрительное «ссылка в письме от неизвестного отправителя». Использование предобученных моделей позволяет значительно повысить точность классификации и сократить время разработки.

Таблица 1 – Сравнение алгоритмов классификации киберугроз

Алгоритм	Преимущества	Ограничения	Типичные применения
SVM (Support Vector Machines)	Высокая точность при небольших выборках. Хорошо работает с высокоразмерными данными. Эффективен для бинарной классификации	Требует тщательной настройки параметров. Плохо масштабируется на очень большие наборы данных	Разделение отзывов на «подозрительные» и «безопасные». Классификация фишинговых сообщений
Random Forest	Устойчив к шуму и переобучению. Интерпретируемые результаты. Хорошо работает с разнородными признаками	Может быть медленным при больших данных. Менее точен для сложных контекстных зависимостей	Классификация отзывов с опечатками и сленгом. Выявление множественных типов угроз
Нейронные сети (RNN, LSTM, BERT)	Учитывают контекст и семантику. Высокая точность на больших корпусах. Возможность использования предобученных моделей	Требуют больших вычислительных ресурсов. Сложность интерпретации результатов. Зависимость от качества данных	Анализ сложных текстов с контекстом. Выявление скрытых паттернов угроз. Многоуровневая классификация (фишинг, вредоносное ПО, DDoS и др.)

Метрики оценки качества классификации:

Оценка качества моделей классификации киберугроз является ключевым этапом валидации результатов. В задачах анализа пользовательских отзывов и сообщений важно не только правильно классифицировать угрозы, но и минимизировать ошибки, которые могут привести к пропуску инцидентов или ложным тревогам. Для этого применяются стандартные метрики: Precision, Recall и F1-score.

Precision (точность) отражает долю правильно классифицированных положительных примеров среди всех примеров, отнесённых моделью к классу угроз. Высокая точность означает, что система редко ошибается, помечая безопасные отзывы как опасные. Это важно для снижения числа ложных срабатываний.

Recall (полнота) показывает долю правильно классифицированных положительных примеров среди всех реальных угроз. Высокая полнота означает, что система способна обнаружить большинство угроз, даже если при этом возрастает количество ложных тревог. В контексте кибербезопасности высокая полнота критична, так как пропуск угрозы может иметь серьёзные последствия.

F1-score представляет собой гармоническое среднее между Precision и Recall. Эта метрика используется для балансировки двух показателей и даёт более объективную оценку качества модели в условиях, когда важно одновременно минимизировать ложные срабатывания и пропуски угроз.

Таким образом, выбор метрики зависит от приоритетов: если важно не пропустить угрозу – акцент делается на Recall, если необходимо снизить количество ложных тревог – на Precision, а F1-score позволяет оценить общий баланс.

Таблица 2 – Сравнение метрик классификации

Метрика	Определение	Интерпретация в контексте угроз	Приоритет применения
Precision	Доля правильно классифицированных угроз среди всех предсказанных угроз	Показывает, насколько модель избегает ложных тревог	Важно при снижении числа ложных срабатываний
Recall	Доля правильно классифицированных угроз среди всех реальных угроз	Показывает способность модели находить все реальные угрозы	Критично для предотвращения пропуска атак
F1-score	Гармоническое среднее между Precision и Recall	Балансирует точность и полноту, даёт интегральную оценку качества	Используется для комплексной оценки модели

Примеры категорий угроз:

Киберугрозы, отражённые в пользовательских отзывах и сообщениях, могут быть классифицированы по различным категориям. Рассмотрим четыре наиболее распространённые: фишинг, вредоносное ПО, DDoS-атаки и социальная инженерия.

Фишинг представляет собой одну из самых массовых угроз, основанную на обмане пользователей с целью получения конфиденциальных данных. В отзывах часто встречаются жалобы на подозрительные письма, ссылки или сообщения в социальных сетях, где пользователям предлагается перейти по URL и ввести личные данные.

Вредоносное ПО (Malware) охватывает широкий спектр программ, включая вирусы, трояны и шпионское ПО. Пользователи могут сообщать о внезапных сбоях в работе приложений, подозрительных установках или изменениях в системе. Такие отзывы являются ценным источником информации для выявления новых образцов вредоносного ПО.

DDoS-атаки направлены на перегрузку сервисов и временное выведение их из строя. В пользовательских сообщениях это проявляется как жалобы на недоступность сайтов, медленную работу сервисов или массовые сбои. Анализ таких отзывов помогает фиксировать временные пики активности атак.

Социальная инженерия использует психологические методы воздействия на пользователей. В отзывах можно встретить описания случаев, когда злоумышленники выдавали себя за сотрудников компаний, предлагали «выгодные» сделки или убеждали пользователей выполнить определённые действия. Эти данные позволяют выявлять новые сценарии манипуляций.

Таким образом, классификация угроз по отзывам и постам помогает формировать более полную картину киберрисков, а использование методов NLP делает этот процесс автоматизированным и масштабируемым [5-7].

Таблица 3 – Таблица категорий угроз

Категория угроз	Характерные признаки в отзывах и постах	Примеры индикаторов
Фишинг	Подозрительные письма, ссылки, просьбы ввести данные	«Получил письмо с просьбой ввести пароль»
Вредоносное ПО (Malware)	Сбои в работе ПО, неожиданные установки, подозрительные процессы	«После обновления программа ведёт себя странно»
DDoS-атаки	Жалобы на недоступность сайтов, медленную работу сервисов	«Сайт не открывается уже час»
Социальная инженерия	Манипуляции, ложные представления, психологическое давление	«Позвонили и представились сотрудником банка»

4. Экспериментальная часть

Для проведения исследования был сформирован корпус данных из трёх основных источников. Первая группа включала сообщения на специализированных форумах по информационной безопасности, где пользователи обсуждали подозрительные ссылки, сбои в работе сервисов и случаи мошенничества. Всего было собрано около 12 000 таких сообщений. Вторая группа состояла из постов и комментариев в социальных сетях – Twitter, Reddit и Telegram. Здесь выборка составила примерно 25 000 текстов, содержащих ключевые слова «фишинг», «вирус», «атака» и «подозрительный». Третьим источником стали отзывы о программном обеспечении и сервисах, полученные с платформ Google Play и App Store. В этой категории было собрано около 8 500 отзывов, где пользователи жаловались на подозрительное поведение приложений, проблемы с безопасностью и возможные утечки данных. В совокупности корпус составил 45 500 текстовых документов, что обеспечило достаточную репрезентативность для обучения моделей.

На этапе предобработки данных были выполнены несколько шагов. В первую очередь удалялись стоп-слова, такие как «и», «но», «как», что позволило сократить объём текста примерно на 18%. Затем применялась лемматизация для приведения слов к нормальной форме: например, «атаковал», «атака» и «атакуют» были сведены к лемме «атака». Дополнительно проводилась очистка от шумовых данных – удалены дубликаты (около 2 300 записей) и спам-посты (примерно 1 100 записей). После токенизации текст был разбит на отдельные слова и биграммы, а для векторизации использовались два подхода: TF-IDF и предобученные эмбединги BERT. В результате итоговый корпус составил 42 100 документов, пригодных для обучения.

Для классификации угроз были выбраны три алгоритма машинного обучения. Метод опорных векторов (SVM) применялся для бинарной классификации, разделяя отзывы на «угроза» и «не угроза». Алгоритм случайного леса (Random Forest) использовался для многоуровневой классификации, включая категории фишинга, вредоносного ПО, DDoS и социальной инженерии. Наиболее сложная архитектура была реализована на основе нейронной сети BERT, которая учитывала контекст и семантику текста. Архитектура включала входной слой с предобученными эмбедингами, два полносвязных слоя (512 и 128 нейронов) и выходной слой с функцией Softmax для классификации по четырём категориям угроз. Обучение проводилось на 80% корпуса (33 680 документов), а тестирование – на оставшихся 20% (8 420 документов). Количество эпох составило 10, размер батча – 32, оптимизатор – Adam. Время обучения модели BERT заняло около четырёх часов.

Результаты классификации показали различную эффективность алгоритмов. Модель SVM продемонстрировала точность (Precision) 0.87, полноту (Recall) 0.79 и F1-score 0.83. Она хорошо справлялась с бинарной классификацией, но хуже работала при разделении на конкретные категории угроз. Алгоритм Random Forest показал Precision 0.82, Recall 0.76 и F1-score 0.79. Он оказался устойчивым к шуму, но часто путал близкие категории, например, фишинг и социальную инженерию. Наилучшие результаты продемонстрировала модель BERT: Precision составил 0.91, Recall – 0.88, а F1-score – 0.89. Особенно высокие показатели были достигнуты при классификации фишинга (92%), вредоносного ПО (90%), DDoS-атак (87%) и социальной инженерии (88%).

Интерпретация результатов показала, что использование контекстных моделей значительно повышает точность анализа. В частности, BERT смог корректно различать нейтральные упоминания («ссылка на сайт компании») и подозрительные («ссылка в письме от неизвестного отправителя»), что критически важно для практического применения. Таким образом, эксперимент подтвердил, что методы NLP в сочетании с современными моделями машинного обучения позволяют эффективно классифицировать киберугрозы на основе пользовательских отзывов. Наиболее перспективным направлением является использование трансформеров, которые обеспечивают высокую точность и полноту классификации, а также позволяют учитывать сложные контекстные зависимости.

Таблица 4 – Таблица результатов классификации

Алгоритм	Precision	Recall	F1-score	Особенности применения
SVM	0.87	0.79	0.83	Хорош для бинарной классификации, ограничен для многоуровневой
Random Forest	0.82	0.76	0.79	Устойчив к шуму, но путает близкие категории
BERT	0.91	0.88	0.89	Лучшая точность, учитывает контекст и семантику

Эксперимент показал, что методы NLP в сочетании с современными моделями машинного обучения позволяют эффективно классифицировать киберугрозы на основе пользовательских отзывов. Наиболее перспективным направлением является использование трансформеров (BERT), которые обеспечивают высокую точность и полноту классификации [8-10].

5. Обсуждение результатов

Сравнение предложенного подхода с традиционными методами выявления угроз показывает его значительные преимущества. Классические системы мониторинга, основанные на сигнатурном анализе или статических правилах, часто не успевают реагировать на новые и быстро эволюционирующие атаки. Они зависят от заранее известных индикаторов компрометации и не способны учитывать динамику пользовательских сообщений. В отличие от этого, использование методов обработки естественного языка позволяет анализировать краудсорсинговые данные в реальном времени, выявлять новые паттерны и классифицировать угрозы на основе контекста. Таким образом, предложенный подход обеспечивает более гибкую и адаптивную систему обнаружения.

Однако у метода существуют ограничения. Во-первых, качество анализа напрямую зависит от полноты и репрезентативности собранных данных. Если отзывы или посты содержат мало информации или выражены в форме сленга и сокращений, точность классификации снижается. Во-вторых, применение моделей NLP требует значительных вычислительных ресурсов, особенно при использовании трансформеров, таких как BERT. Это

может ограничивать внедрение в организациях с ограниченной инфраструктурой. Кроме того, остаются вопросы этики и приватности: использование пользовательских данных должно соответствовать законодательным нормам и не нарушать права пользователей.

Несмотря на эти ограничения, потенциал применения предложенного подхода в реальных системах киберразведки весьма высок. Автоматизированный анализ отзывов и постов может стать дополнительным слоем мониторинга, дополняющим традиционные методы. Он позволит выявлять ранние признаки атак, фиксировать всплески активности и формировать базы индикаторов угроз на основе краудсорсинговых данных. В перспективе такие системы могут интегрироваться с платформами Threat Intelligence, обеспечивая организациям более полное понимание текущего ландшафта угроз. Таким образом, использование NLP для классификации киберугроз открывает новые возможности для построения адаптивных и проактивных систем информационной безопасности.

Заключение

Проведённое исследование показало, что методы обработки естественного языка (NLP) обладают значительным потенциалом для классификации киберугроз на основе пользовательских отзывов и сообщений в социальных сетях. Основные выводы заключаются в том, что краудсорсинговые данные могут служить ценным источником индикаторов угроз, а применение современных моделей машинного обучения, особенно трансформеров, позволяет достигать высокой точности и полноты классификации. Экспериментальные результаты подтвердили, что контекстные модели, такие как BERT, превосходят традиционные алгоритмы, обеспечивая более глубокое понимание семантики и снижение числа ошибок при различении близких категорий угроз.

Перспективы развития методов NLP в области киберугроз связаны с дальнейшей интеграцией предобученных языковых моделей и гибридных подходов, объединяющих текстовый анализ с другими источниками данных, включая сетевые логи и технические индикаторы. Важным направлением является разработка многоязычных систем, способных анализировать отзывы и посты на разных языках, что особенно актуально для глобальной киберразведки. Кроме того, перспективным является использование методов объяснимого искусственного интеллекта, которые позволят повысить доверие к результатам классификации и сделать их более прозрачными для специалистов.

Для исследователей рекомендуется уделять внимание созданию репрезентативных корпусов данных и разработке моделей, учитывающих особенности пользовательского языка, включая сленг и сокращения. Практикам в области информационной безопасности стоит рассматривать NLP как дополнительный инструмент мониторинга, способный выявлять ранние признаки атак и дополнять традиционные методы обнаружения. Внедрение таких решений позволит повысить устойчивость цифровой инфраструктуры и сформировать более проактивные системы защиты.

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Agricultural Sciences

ТЕХНОЛОГИИ СПУТНИКОВОГО МОНИТОРИНГА ДЛЯ КОНТРОЛЯ СОСТОЯНИЯ СЕЛЬСКОХОЗЯЙСТВЕННЫХ ПОСЕВОВ

Секренова Ж.А.

научные сотрудники ТОО «SciCom», Астана, Казахстан

Есімхан А.Х.

научные сотрудники ТОО «SciCom», Астана, Казахстан

Достижение высокой урожайности и обеспечение качественных показателей растениеводческой продукции является одной из ключевых задач современного сельскохозяйственного производства. Существенное влияние на повышение эффективности отрасли оказывает уровень информационного обеспечения специалистов аграрного сектора данными о состоянии земель сельскохозяйственного назначения. Сведения о текущем состоянии посевов и климатических условиях исследуемой территории позволяют агрономам обоснованно определять оптимальные сроки проведения посевных работ, контролировать динамику формирования сельскохозяйственных культур, а также своевременно осуществлять необходимые технологические операции, включая подкормку и укосы.

В последние годы для получения объективной информации как на уровне всего Агро производственного участка, так и для отдельных сельскохозяйственных полей применяются методы дистанционного зондирования земли (ДЗЗ).

Дистанционное зондирование представляет собой процесс, посредством которого собирается информация об объекте, территории или явлении с помощью регистрирующего прибора, не находящимся в непосредственном контакте с объектом. Методы дистанционного зондирования основаны на том, что любой объект излучает и отражает электромагнитную энергию в широком спектральном диапазоне [1]. В последние десятилетия, интенсивное развитие методов дистанционного зондирования, предоставило наукам о Земле новые возможности для исследования земной поверхности.

Для целей дистанционного зондирования Земли и подстилающей поверхности наибольший интерес представляют три участка спектра: видимый участок спектра, инфракрасный и микроволновый (рисунок 1).

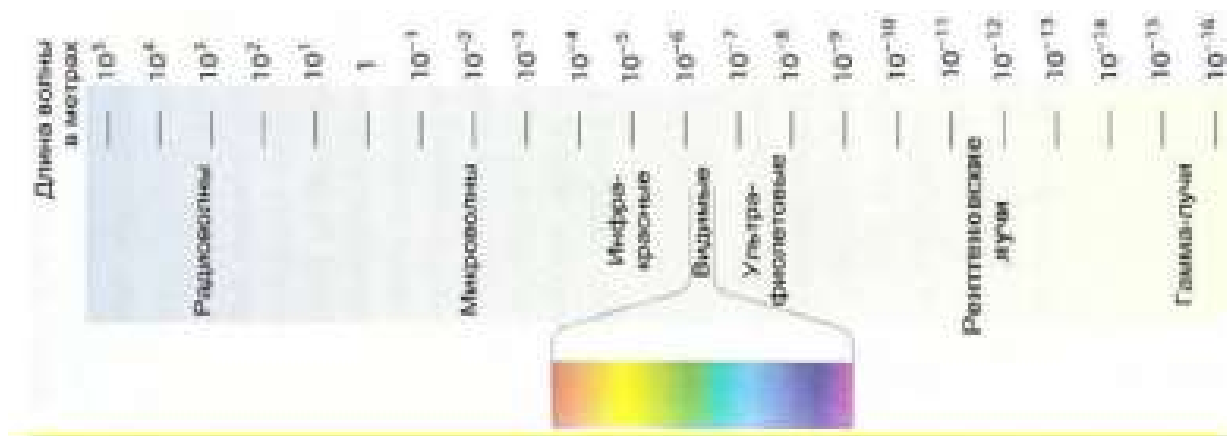


Рисунок 1 – Спектр электромагнитного излучения в шкале длин волн

Одними наиболее информативных показателей, позволяющих оценивать состояние сельскохозяйственных посевов в конкретные временные периоды, выступают вегетационные индексы. Анализ посевов с использованием вегетационных индексов осуществляется по данным спутниковых группировок, различающихся по пространственному и временному разрешению, а также по степени открытости данных.

Особое значение среди применяемых источников информации имеют открытые данные высокого пространственного разрешения со спутников Landsat 8 и Sentinel-2. В частности, снимки Sentinel-2 с детальностью 10 м и периодичностью обновления каждые 5 дней являются наиболее релевантными для мониторинга состояния сельскохозяйственных посевов в течение всего вегетационного периода. В отличие от них, спутниковые данные Landsat 8 обладают пространственным разрешением 30 м и интервалом получения снимков в 16 дней, что ограничивает их применимость для оперативного отслеживания динамики развития сельскохозяйственных культур.

Наряду с вегетационными индексами, отражающими состояние сельскохозяйственных посевов, важны данные о температуре и осадках. Традиционным подходом к получению информации о климатических характеристиках территории считается использование данных с наземных метеостанций.

Эффективность применения методов ДДЗ в сельском хозяйстве по большей части зависит от оперативности предоставления аграрным специалистам информации о состоянии посевов сельскохозяйственных культур. Получению актуальных сведений о вегетационных индексах и климатических показателях сельскохозяйственных территорий в кратчайшие сроки способствует оперативный мониторинг сельскохозяйственных посевов по спутниковым данным. Подбор спутниковых данных и составление технологий их обработки становятся первостепенными задачами на подготовительных этапах проведения оперативного мониторинга сельскохозяйственных посевов.

Для отслеживания состояния сельскохозяйственных посевов можно использовать такие вегетационные индексы как NDVI, CLGreen и MSAVI2. Выбор обусловлен их назначением и высоким пространственным разрешением (10 м) спектральных каналов (красный, зеленый, голубой, ближний инфракрасный) Sentinel-2 для вычисления индексов.

Вегетационный индекс NDVI (Normalized Difference Vegetation Index) является простым показателем фотосинтетически активной биомассы [2]. Данный индекс характеризует состояние растительности на протяжении всего вегетационного сезона. Его значения различаются во время роста, цветения и созревания.

Вегетационный индекс CLGreen (Green chlorophyll index) используется для оценки общего содержания хлорофилла в листьях. Наибольшие значения индекса коррелируют с

наибольшим содержанием хлорофилла в листьях растений. Пространственное распределение посевов, полученное по вегетационному индексу CIGreen, позволяют рассчитывать необходимое количество удобрений [3].

Вегетационный индекс MSAVI2 (Modified Soil Adjusted Vegetation Index) разработан для районов с низкой растительностью, чтобы уменьшить влияние обнаженной почвы [4]. Он выделяет растительность на фоне «почвенного шума», тем самым наиболее четко отображает неоднородность пространственного распределения посевов на ранних этапах развития культуры.

В настоящее время информация о существующих оперативных космических системах, отечественных и зарубежных, в достаточном объеме публикуется в сети INTERNET. Общее описание систем дистанционного зондирования дается и в ряде публикаций [5], где приводится обзор всех основных систем и рассмотрены требования потребителей к данным дистанционного зондирования. В этом разделе приводится краткое описание информации, получаемой с аппаратуры современных спутников и наиболее часто используемой для задач мониторинга посевов сельскохозяйственных культур.

Радиометр AVHRR установлен на борту полярно-орбитальных метеорологических спутников серии NOAA (National Oceanic and Atmospheric Administration Polar Operational Environmental Satellites). Первый спутник этой серии был запущен в 1970 г. Запуск спутников осуществляется таким образом, чтобы на орбитах находилось не менее 2 спутников. Спутник пролетает над любой точкой земной поверхности приблизительно в одно и то же местное время [6].

Главным достоинством спутников серии NOAA является доступность информации и возможность регулярного ее получения. Еще одним важным достоинством является высокая периодичность съемок. Данные спутника покрывают большие территории, что, конечно, очень важно для российских просторов. Серьезным конкурентом радиометра AVHRR становится радиометр MODIS, поскольку MODIS имеет более высокое пространственное разрешение.

Характеристика радиометра MODIS Радиометр MODIS (Moderate Resolution Imaging Spectroradiomete) является одним из ключевых съемочных приборов, установленных на борту американских спутников TERRA и AQUA. Спутник Terra, запущенный в 1999 году, действует под руководством национального аэрокосмического агентства (НАСА). Спутник AQUA запущен в 2002 году. Эти спутники запущены в рамках программы NASA Earth Observing System, направленной на исследование Земли из космоса [7].

MODIS имеет 36 спектральных каналов с 12-битным радиометрическим разрешением в видимом, ближнем, среднем и дальнем инфракрасном диапазонах. Съемка выполняется в полосе 2330 километров с пространственным разрешением 250, 500 и 1000 метров [8]. Радиометр MODIS позволяет осуществлять ежедневный оперативный мониторинг территорий. MODIS является «наследником» радиометра AVHRR спутников NOAA, но у него значительно улучшены спектральное и пространственное разрешение. Сравнение основных характеристик радиометров AVHRR (NOAA) и MODIS (TERRA) представлено в таблице 1.

Таблица 1 – Сравнение основных характеристик радиометров AVHRR и Modis

Радиометр	Количество спектральных каналов	Пространственное разрешение (м)	Ширина полосы съемки (км)
Modis	36	250-1000	2330
AVHRR	5	1100	3000

Основное преимущество данных MODIS по сравнению с данными AVHRR (NOAA) заключается в более высоком пространственном разрешении, что особенно важно для случаев с большим числом вегетирующих сельскохозяйственных культур. Так же данные MODIS бесплатны и находятся в свободном доступе. Высокая периодичность съемки позволяет проводить анализ последовательных серий изображений и создавать на их основе композиты.

Следовательно, для оперативного мониторинга состояния посевов в наибольшей степени подходит информация, поступающая от радиометра MODIS. Данные MODIS имеют высокое временное разрешение, что позволяет отслеживать динамику развития сельскохозяйственных культур. Данные MODIS бесплатны, распространяются в свободном доступе.

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Biological Sciences

БИОТЕХНОЛОГИЧЕСКИЕ МЕТОДЫ УТИЛИЗАЦИИ СЕЛЬСКОХОЗЯЙСТВЕННЫХ ОТХОДОВ

Баранбаева Ж.Х.

научные сотрудники ТОО «SciCom», Астана, Казахстан

Андасбаев М.Н.

научные сотрудники ТОО «SciCom», Астана, Казахстан

В настоящее время проблема утилизации отходов сельского хозяйства является одной из наиболее значимых для аграрного сектора. Традиционные технологии переработки, используемые в прошлые десятилетия, утратили свою эффективность в условиях роста стоимости энергоресурсов, что делает их экономически нецелесообразными. Кроме того, хранение навоза требует вывода из оборота значительных площадей плодородных земель, которые могли бы быть использованы для выращивания сельскохозяйственных культур.

Альтернативным направлением решения проблемы является биотехнологическая переработка отходов с использованием микроорганизмов, позволяющая быстро и экономично утилизировать большие объемы сельскохозяйственных стоков и твердых отходов. Суть биологической утилизации заключается в культивировании микроорганизмов непосредственно на отходах. Так, мицелиальные грибы применяются преимущественно для ферментации твердых отходов, включая навоз и подстилочные материалы [1]. Для обезвреживания навозных стоков используются методы глубинного культивирования специализированных бактерий, дрожжей и грибов. Применение дрожжей в процессе очистки стоков дополнительно позволяет получать бактериальные препараты и высокоценные кормовые добавки, которые могут быть использованы во вторичном производстве.

Биотехнологические методы дают возможность вовлекать в производство кормовых добавок значительные объемы отходов агропромышленного комплекса как растительного, так и животного происхождения. На сегодня, известен широкий спектр микроорганизмов, способных утилизировать сельскохозяйственные отходы и формировать микробную биомассу, используя навоз и стоки в качестве питательной среды. Наиболее перспективными являются быстрорастущие микроорганизмы, способные развиваться на не гидролизованных отходах. К таким относят ряд мицелиальных грибов и дрожжей рода *Rhodotorula* [2].

Такие грибы, как *Chaetomium globosum*, *Myceliophthora thermophila*, *Trichoderma reesei*, *Thielavia terrestris* и *Irpex lacteus* обладают высокой целлюлолитической активностью и способны расти на дешевых субстратах.

Сапрофитный гриб *C. globosum* имеет широкое распространение. Он встречается в почве, старых зданиях и морской воде. Несмотря на непоследовательность и противоречие в определении границ *C. globosum*, он, несомненно, является одним из наиболее важных видов *Chaetomium* из-за его различных положительных и отрицательных воздействий на человека и окружающую среду [3].

Протеомный анализ целлюлолитического ферментного препарата показал, что эндоглюканазы были представлены двумя семействами: GH5 и GH7. В комплексе имеются 8 целлобиогидролаз, включая CBH-I (GH6 и 7), который атакует восстанавливающий конец цепи целлюлозы, и CBH-II, который атакует невосстанавливающий конец [4].

M. thermophila - гриб, хорошо развивающийся при температуре 54-50°C. Этот аскомицет широко распространен и встречается в древесных опилках и соломенном компосте. Способность организма к росту при высокой температуре и высокая ферментативная активность делает его перспективным продуцентом.

К недостаткам данного продуцента можно отнести тот факт, что он может являться возбудителем феогифомикоза (феомикотической кисты). Однако это происходит только при подкожной инвазии [5].

M. thermophila секретирует четыре фермента GH7, из которых наиболее распространенные Mt Cel7A и Mt Cel7D включают домен CBM1, а Mt Cel7B и Mt Cel7C - нет [6].

Термостабильная целлобиогидролаза Mt Cel7A имеет в своем составе GH7-каталитического домена, линкер и модуля связывания углеводов типа CBM1. Как и многие другие целлюлолитические ферменты, эта целлобиогидролаза проявляет более высокую активность по отношению к аморфным субстратам, чем к кристаллическим. Оптимальной для фермента является кислая среда (pH 4-5). При инкубации в течение трех суток при температуре 50°C фермент сохраняет 100-процентную активность [7].

Важным продуцентом целлюлолитических ферментов является *T. reesei*. Данный гриб имеет семидесятилетнюю историю безопасного использования в качестве продуцента ферментов. Несмотря на широкий спектр продуцируемых вторичных метаболитов, гриб не производит микотоксины. Конечно, в геноме *T. reesei* присутствует кластер генов, ответственных за синтез иммуносупрессивного глиотоксина, однако в культуре он не был обнаружен [8].

Широкое применение *T. reesei* в производстве целлюлаз обусловлено как безопасностью, так и высокоактивными целлюлолитическими ферментными препаратами. Гриб является источником пяти семейств целлюлаз: эндо-Р-1,4[^]- глюканазы обнаружены в GH5, GH7, GH12 и GH45, а CBH - в GH6 и GH7. Р-глюкозидазы семейства GH3 внеклеточные, а GH1 - внутриклеточные [9].

Основная целлобиогидролаза CEL7A имеет процессивный способ катализа, благодаря чему происходит быстрое расщепление целлюлозы. А целлюлазы из семейства GH6 обладают уникальной особенностью - действием с невосстанавливающего конца целлюлозной цепи.

Несмотря на все вышесказанное, гриб имеет два недостатка - дефицит Р-глюкозидазы и целлобиогидролазы II. Использование сильного промотора *Pcbh1* позволило увеличить активность на фильтровальной бумаге с $2,45 \pm 0,36$ FPIU/мл до $7,21 \pm 0,45$ и $7,69 \pm 0,42$ FPIU/мл [10].

Также необходимо помнить о положительном и отрицательном влиянии продуцирования одних ферментов комплекса на другие. Встречающийся в почве термофильный гриб *T. terrestris* продуцирует активные и устойчивые к высокой температуре целлюлазы и гемицеллюлазы, что делает его ценным биологическим агентом.

Жидкие и твердые отходы могут быть преобразованы в высокоценные кормовые добавки, обогащенные микробным белком. Микроорганизмы способны эффективно использовать концентрированные стоки, поскольку последние содержат широкий спектр необходимых микроэлементов и витаминов. Рациональное применение животноводческих стоков также позволяет получать азотные, калийные и фосфорные удобрения, пригодные для использования на сельскохозяйственных угодьях.

В настоящее время разработан широкий спектр технологий утилизации сельскохозяйственных отходов, реализуемых в специализированных установках – биореакторах, биоферментерах, модульных комплексах, метантенках и других типах оборудования. В этих системах микробиологическая трансформация сырья осуществляется преимущественно за счет сочетания аэробных и анаэробных процессов. Биотехнологические методы утилизации обладают существенными преимуществами перед традиционным компостированием, поскольку позволяют минимизировать потери питательных веществ исходного сырья, повысить экологическую чистоту получаемых продуктов и значительно сократить время переработки.

Одним из наиболее распространенных направлений биотехнологической переработки является производство биогаза на основе метанового брожения отходов сельского хозяйства. Конверсия органических остатков позволяет получать ценное топливо – метан, который может использоваться в качестве энергоносителя в аграрном секторе. Оставшаяся после процесса метановой ферментации биомасса представляет собой высококачественное удобрение. Такой способ переработки отходов является экономически целесообразным и высокоэффективным методом очистки территорий ферм, обработки сточных вод и утилизации твердых отходов.

Продукты термофильной переработки отходов животноводства кроме биокомпоста или органического удобрения могут быть использованы как бактериальные препараты защитного действия от фитопатогенов, кормовые добавки (премиксы) для пушных зверей, птицы, рыбы и др.

Таким образом, перед человечеством стоит важная задача – сохранить окружающую среду, так как из-за деятельности человека происходят изменения химических и биологических свойств природы, которые негативно сказываются на флоре и фауне. Биотехнологические методы утилизации – важное направление в охране окружающей среды, которое играет главную роль в сельском хозяйстве и помогает решить проблемы утилизации отходов.

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Psychological Sciences

LEGISLATIVE FRAMEWORK FOR ELDERLY CARE IN AZERBAIJAN

Abdullayeva Zumrud Chingiz

PhD student; Baku State University, Department of Gender and Applied Psychology;
Baku, Azerbaijan, orcid.org/0009-0009-0820-2911

Keywords: elderly care, gerontology, well being of elderly population

The existing legislative framework plays an exceptional role in ensuring the well-being of elderly citizens in Azerbaijan. The relevant legislation in this area consists of the Constitution of the Republic of Azerbaijan, the Family Code, the Labor Code, the Law "On Social Service", the Law "On Labor Pensions" and the Law "On Social Benefits". The Constitution of the Republic of Azerbaijan states that "it is the duty of children to respect and care for their parents. Children who have reached the age of 18 are obliged to support their parents who are unable to work (Article 34.5 Right to Marriage). Articles 82, 83 and 92 of the Family Code of the Republic of Azerbaijan stipulate the responsibility of children, grandchildren and stepchildren for elderly parents and grandparents who are unable to work and need help. These articles show how important care relationships are in the ideal model of the Azerbaijani family. There are even articles that provide for the requirement to receive alimony from young family members in case of neglect of their responsibilities. For example, according to Article 90 of the Family Code, grandchildren have a duty to support grandparents: "Grandparents who are unable to work and need help and if the grandmother is unable to receive financial assistance from her children who have reached the age of majority or from her husband (wife), she has the right to demand alimony from the grandchildren who have the necessary funds in court. The same rights apply to actual guardians (Article 91). The articles of the mentioned law are consistent with the ideals of family care and the high normativity of family care in Azerbaijani society, provide for intergenerational exchange in the family, and for the younger generation to be responsible for the well-being of the older generation. At the same time, according to the ideals of care inherent in our society, the care of children and grandchildren is not limited only to financial assistance and support, they should provide direct care and attention to elderly family members, and should not leave them alone when they are sick and helpless. In this regard, the following question arises: whether a person involved in labor activity should be a direct provider of care What opportunities are there for?

According to Article 130 of the Labor Code, at the request of the employee, a relative caring for a sick family member may be granted unpaid leave of up to 14 calendar days upon the recommendation of a healthcare institution (Labor Code, Article 130). Along with the support of the ideals of intergenerational care in the Family Code and the responsibility of adult children and grandchildren towards elderly family members, the rather limited opportunities provided for in the Labor Code allow us to cope with the difficulties of fulfilling the family care obligation in a number of cases. A large part of state care for the elderly is regulated by the Law of the Republic of Azerbaijan "On Social Service". This law reflects the important tasks undertaken by the state as one of the important social actors of the care regime, and the opportunities it provides to citizens. The Law "On Social Services", signed by President Ilham Aliyev on December 30, 2011, "regulates the legal, economic and organizational foundations of state policy in the field of providing social services to persons living in difficult life conditions" (Law of the Republic of Azerbaijan "On Social

Services”, 2011). The main criterion here is not a specific age limit, but the fact that a citizen is in a difficult situation. Article 7 of the Law indicates a number of categories of people living in difficult life conditions, as well as the elderly among them (Article 7.1.4). In addition, the Law of the Republic of Azerbaijan “On Social Benefits” contains a type of age-related benefit (Article 4.0.1.2.), which is provided for when a person with no working capacity is not entitled to a labor pension and does not work (Article 7.0.2).

Thus, the existing legislative framework in the Republic of Azerbaijan supports the family care regime and is based on the norm of intergenerational care. At the same time, the state, as an important actor ensuring the well-being of the elderly, primarily assumes the task of financial provision.

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6. "Əmək pensiyaları haqqında" Azərbaycan Respublikasının 7 fevral 2006-cı il № 54-IIIQ nömrəli Qanunu
7. Ahılların sosial müdafiəsinin gücləndirilməsi dövlət siyasətinin istiqamətlərindən biridir/ Əmək və Əhalinin Sosial Müdafiəsi Nazirliyinin saytı. 01.10.2019/ <http://sosial.gov.az/post/2652>.

Philological Sciences

Morfoloji yolla sifətlərin təhlili

Əsmayə Bəxtiyar qızı Əkbərova

Azərbaycan Dövlət Pedaqoji Universitetinin Şəki filialı, *Azərbaycan, Şəki şəhəri. Baş müəlim, Şəki şəh, M.Rəsulzadə küç,305.* Orcid id: 0000- 0001-9970-0602

Abstract:

Is a system of sound signs used by members of a particular community. Communication is built through oral or written sentences. The sentence is formed by the type of word that performs its syntactic function in the language. The type of words means verb, adjective, adverb, etc. it is intended. Each type of word has its own specific order. An adjective is a word that is attached to any noun to define or designate it. The adjective has its own specific order in each language. In French, the adjective is consonant with the noun by gender and quantity. Each language has its own characteristics in terms of phonetics, lexicon, morphology, syntax, etc. This makes it possible to distinguish it from other languages.

Key Words: adjectives, productive, dynamic changes, morphologically, verbatim, productive suffixe

1.Giriş:

Kiçik Larus lüğətinin 1975-ci il nəşrində verilən sözlərin 20%-ni sifətlər təşkil edir. Aydındır ki, sifətlər sinfində baş verən dinamik dəyişikliklər lüğət tərkibinin ümumi inkişafına təsir göstərməyə bilməz.

Məlum olduğu kimi, sifətlər sinfində morfoloji yolla sözdüzəltmənin məhsuldar olub-olmaması məsələsində fransız dilinin tədqiqatçıları arasında fikir birliyi yoxdur. Belə ki, bəzi dilçilər bu yolla sözdüzəltmənin sifətlər üçün qeyri-məhsuldar olduğunu göstərirlər. Digərləri, bu fikrin əksinə olaraq, morfoloji yolla sözdüzəltməni sifətlər üçün məhsuldar yol hesab edirlər. Lakin tədqiqatçılar suffikslərlə sözdüzəltmə yolunu prefikslərlə sözdüzəltmə yoluna nisbətən daha məhsuldar yol hesab edirlər.

Bizim apardığımız araşdırmalar nəticəsində məlum olmuşdur ki, suffikslərin artırılması ilə sifətdüzəltmə yolu müasir fransız dilində məhsuldar yol olaraq qalmaqdadır. Belə ki, suffikslərin artırılması ilə düzələn 10217 sifətdən 6804-ü (66,6%) ümumi leksikaya, 1733-ü (117%) köhnəlməkdə olan sözlərə, 1644-ü (16,4%) isə yeni sözlər qrupuna aid olmuşdur. Buradan belə bir nəticəyə gəlmək olar ki, köhnəlməkdə olan və yeni gələn sözlərin miqdarı təxminən bərabərdir. Təhlil olunan 50 suffiksin içərisində (variantları da daxil olmaqla) ən məhsuldar olanları aşağıdakılardır. -ique, é, e, -ant, e, -able, -al, -eux, euse, -aire, -if,-ive, -ien, -ienne, -teur, -trice, -ent, e, -iste, -el, iel, uel,-eur, -ier, er, -ible, -u, e, -ain, e, -oire, -i, e, -forme, -fére, -ond, e, -oide, -ard, e. Bu suffikslərin artırılması ilə düzələn sifətlərin ümumi miqdarı təhlil etdiyimiz bütün sifətlərin 93,2%-ni təşkil edir.

Köhnəlməkdə olan sifətlərə misal olaraq: rytologique, rumiqne, retrayant, e, vivifiable, vendangeable, argenteux, alimenteux, selacien, tympanal, taxatif, restauratif, velleien, retenteur, ostentateur, toilier, vitaliste, reviviscible, persuasible sözlərini, yeni gələn sifətlərə isə: vitaminé, tropicalise, publiable, tonifiant, stressant, thermodurcissable, tetable, skiable, fibrineux, aéropostal, thermo-nucléaire, totalitaire, revendicatif, radiatif, stabilisateur, scitateur, stakhanoviste, putschiste, prévisible, organisationnel, exploratoire, discriminatoire, combinatoire sözlərini misal göstərmək olar.

2. Sifət düzəldən məhsuldar şəkilşilər

Sifət düzəldən suffikslərin məhsuldarlığından danışarkən E.Bursye qeyd edir ki, -able, -ible, -el, -al, -eux, -ique, -atre, -eque suffiksləri haqqında bunu demək olmaz. Belə ki, məhsuldarlığı baxımından -esque suffiksi bizim tədqiq etdiyimiz 50 suffiks içərisində 34-cü yerdə, -atre suffiksi isə 37-ci yerdə gəlir.

Düzəltmə sifətlər müxtəlif nitq hissələrinə suffiks və prefikslərin qoşulması vasitəsilə əmələ gəlir. Aşağıdakı cədvəldə suffikslər və prefikslər vasitəsilə düzələn sifətlər verilmişdir.

admirer- heyran olmaq	-able	admirable- heyranedici
l'Amérique- Amerika	-ain, e	Américain, Américaine- amerikalı
une révolution- inqilab	-aire	une révolutionnaire- inqilabçı
l'Angleterre- İngiltərə	-ais, e	Anglais, Anglaise- ingilis
l'Europe- Avropa	-éen, -enne	européen, européenne- avropalı
le courage- cəsarət	-eux, -se	courageux, courageuse- cəsarətli
Paris- Paris	-ien, -ienne	Parisen, Parisienne- parisli
malade- xəstə	-if, -ive	maladif, maladive-xəstə
Un héros-qəhrəman	-ique	héroïque-qəhrəman (une femme héroïque-qəhrəman qadın)
la Chine- Çin	-is, -e	Chinois, Chinoise-çinli
politique-siyasi	a - -inkarlıq, yaxınlıq	apolitique-siyasətə laqeyd, siyasətdən uzaq
légal- qanuni possible- mümkün actif-fəal	il-, im-, in- - inkarlıq	illégal- qeyri-qanuni impossible-qeyri-mümkün incatif-fəal olmayan
chance-bəxt	mal- - əks məna	malchance-bəxtsiz
content- razı	me- - əks məna	mécontent- narazı

Fransız dilində antonim sifətlər

Səs-küylü - bruyant; sakit - silencieux; güclü- fort; zəif - faible; bərk - dur; yumşaq- mou; daha çox- plus; daha az - moins; düzgün- correct; səhv - incorrect; təmiz - propre; çirkli - sale; köhnə - vieux; yeni- nouveau.

3. Nəticə:

Fransız dilində sifətlərin üstün dərəcəsi bir şeyin başqalarından daha çox olduğunu ifadə etmək üçün istifadə olunur. Bu dərəcəni sifətin sonuna -est şəkilçisi əlavə etməklə və ya "le plus" ifadəsindən istifadə etməklə yaratmaq olar. Məsələn - Grand sifətinin üstünlük forması "le plus grand" və ya "le plus grande"dir. Məsələn: "La tour Eiffel est le plus grand monument de Paris". (Eyfel qülləsi Parisin ən böyük abidəsidir.)

- Petit (kiçik) sifətinin üstünlük forması "le plus petit" və ya "la plus petite"dir. Məsələn: "Le chat est l'animal le plus petit de la maison".

- Gözəl sifətinin ən yüksək dərəcəsi "le plus beau" və ya "la plus belle"dir. Məsələn: "Le coucher de soleil est le plus beau spectacle de la nature." (Gün batımı təbiətin ən gözəl nümayişidir.) Bundan əlavə, bəzi sifətlər -er və ya -ier şəkilçiləri ilə üstünlük təşkil edə bilər. Bu şəkilçilər sifətin sonundakı samitin vəziyyətindən asılı olaraq dəyişir.

Ex::

- Bon (yaxşı) sifətinin ən yüksək dərəcəsi "meilleur"dur. Məsələn: "Le chocolat noir est meilleur que le chocolat au lait". (Tünd şokolad südlü şokoladdan yaxşıdır.)

- Vieux (yaşlı) sifətinin üstünlük forması "le plus vieux" və ya "le plus vieil"dir. Məsələn: "Le grand-père est le plus vieux membre de la famille". (Baba ailənin ən yaşlı üzvüdür.)

Fransız dilində sifətlərin üstünlük forması bir şeyin başqalarından daha çox olduğunu və müxtəlif yollarla formalaşa biləcəyini vurğulamaq üçün istifadə olunur.

Fransız dilində sifətlər isimlə cins və kəmiyyətə görə uzlaşır və sözün mövqeyindən asılı olaraq isimdən əvvəl və sonra gələ bilər. Bəzi ümumi sifətlər "səs-küylü"(bruyant), "sakit"(silencieux), "güclü"(fort), "zəif"(faible), və "bərk"(dur) kimi sözləri ehtiva edir.

Sifətlərin Mövqeyi

- **İsimdən əvvəl:** Əksər sifətlər isimlə razılaşdıqdan sonra sifət ismin qarşısında gəlir, məsələn, "un petit enfant" (bir balaca uşaq).
- **İsimdən sonra:** Bəzi sifətlər isimlə razılaşdıqdan sonra ismin arxasında gələ bilər, məsələn, "un enfant petit" (balaca bir uşaq).
- **Sifət yerini dəyişəndə nəna da dəyişir:** "Les propres mains" - şəxsən öz əlləri; "Les mains propres" - təmiz əllər.

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Competency-Based Preparation of Future Teachers for Blended Learning

Abdurazakova Luiza Baktiyarovna

Master student of South Kazakhstan Pedagogical University named after O.Zhanibekov

Abstract

This article examines the competency-based preparation of future teachers for blended learning, with a particular focus on digital-pedagogical competencies, assessment practices, and curriculum design principles. Drawing on internationally recognised frameworks such as TPACK, DigCompEdu, and the ISTE Standards for Educators, the paper highlights the essential knowledge and skills required for effective teaching across physical and virtual environments. The study emphasises the role of authentic, reliable, and valid assessment tools—such as digital portfolios, performance tasks, and reflective practices—in supporting professional growth. Special attention is given to the context of Kazakhstan, where ongoing digitalisation and educational reforms demand more practice-oriented and transparent approaches to teacher preparation. The article argues that competency-based curriculum design, grounded in alignment, integration, and practice orientation, provides a coherent foundation for developing teachers' readiness for blended learning. Overall, the findings suggest that a systematic competency-oriented model can help teacher education institutions prepare graduates who are adaptable, confident, and capable of navigating diverse learning contexts.

Key words: *blended learning; teacher education; digital-pedagogical competenc; competency-based assessment; curriculum design; teacher readiness.*

Introduction

The rapid digitalization of education has significantly transformed teaching and learning methods, making blended learning a central format in higher education (Graham, 2019). As universities implement more flexible models that combine face-to-face and online learning, preparing future teachers requires a shift from traditional content-based learning to a competency-based approach. This approach prioritizes professional skills and allows students to demonstrate their skills through real-world tasks, not just theoretical knowledge (Mulder, 2017). This approach is particularly relevant today, as modern teachers must work confidently in both physical and virtual environments while maintaining the quality of their teaching.

In the context of ongoing educational reforms in Kazakhstan, competency-based training is becoming even more important. National policies aimed at digital transformation, including the *"Digital Kazakhstan" program*, emphasize the development of teachers' digital and methodological readiness. Universities are encouraged to integrate international standards into their curricula, reinforcing the need to align training with established systems such as TPACK, DigCompEdu, and ISTE (Koehler & Mishra, 2009; Redecker, 2017; ISTE, 2017). As a result, future teachers are expected not only to use digital tools but also to understand how these tools support pedagogical decision-making in a blended environment.

At the same time, Kazakhstan's higher education institutions face a number of challenges related to uneven digital infrastructure across schools, varying student technological experience, and the need for more practical training. These factors highlight the importance of developing clear mechanisms for assessing digital pedagogical competencies and ensuring that curriculum development supports gradual, measurable progress. Competency-based training is thus

becoming a strategic focus, helping teacher education programs meet national priorities while simultaneously preparing graduates for real-world professional demands.

The growing role of blended learning in Kazakhstan and beyond requires a systematic, competency-based model for teacher training. By focusing on digital pedagogical competencies, transparent assessment methods, and clearly structured curriculum development, higher education institutions can create favourable conditions for preparing future teachers to work effectively in a blended learning environment.

Digital pedagogical competencies in blended learning

Based on the ideas presented in the introduction, it is clear that the successful preparation of future teachers for blended learning depends largely on their ability to integrate digital tools with sound pedagogical judgment. Because blended environments require teachers to work across a variety of learning formats, digital pedagogical competence becomes a central component of professional readiness. This competence goes far beyond technical skills and includes an understanding of how technology supports learning processes, how it can be combined with traditional methods, and how teachers can adapt strategies to the diverse needs of students (Voogt et al., 2015). Thus, international standards describing the structure and levels of digital competence of teachers provide valuable guidance for the development of effective teaching programs.

The role of international competency frameworks (TPACK, DigCompEdu, ISTE)

International competency frameworks have become crucial reference points for countries seeking to modernize teacher training, and Kazakhstan is no exception. The TPACK model, proposed by Koehler and Mishra (2009), emphasizes the interrelationships between technological, pedagogical, and subject-matter knowledge and helps future teachers understand that technology is only meaningful when it enhances both content delivery and pedagogical strategy. This model is widely used in blended learning research and remains one of the most influential conceptual tools for developing teachers' digital competencies.

While TPACK emphasizes the integration of knowledge domains, the DigCompEdu framework offers a detailed, structured description of educators' digital competency levels (Redecker, 2017). Six competency areas—from professional engagement to student empowerment—make it a practical tool for program development and evaluation. For Kazakhstan, where universities are strengthening their quality assurance systems, DigCompEdu provides a transparent and internationally recognized benchmark for measuring the development of digital pedagogy.

ISTE Standards for Educators add an additional practical dimension by defining teachers as designers, facilitators, analysts, and collaborators (ISTE, 2017). These roles promote active learning, digital creativity, and data-driven learning, consistent with Kazakhstan's emphasis on student-centred pedagogy and blended learning innovation.

Together, these concepts provide a solid foundation for structuring competency-based digital teacher training. They not only define the necessary knowledge and skills required of future teachers but also help universities develop consistent, practice-oriented curricula that align with global trends and national priorities.

Competency assessment in teacher education

After discussing digital pedagogical competencies, it becomes clear that well-designed assessment methods are crucial for monitoring student progress. Research in competency-based education emphasizes that assessment should be continuous, authentic, and directly linked to demonstrated outcomes (Biggs & Tang, 2011). In blended learning settings, where teachers must integrate pedagogical and technological solutions, transparent and practice-oriented approaches to assessment become even more important.

Competency-based assessment tools and strategies

Competency-based assessment in teacher education relies on assessing students through authentic assignments that reflect real-life teaching practice (Darling - Hammond & Bransford, 2005). Digital portfolios, one of the most widely used tools, allow students to collect materials such as lesson plans, teaching materials, teaching micro-videos, and commentary for reflection. Portfolios promote continuous learning and allow for the monitoring of progress over time.

Performance-based assignments are another important element of assessment. Designing an online lesson, creating interactive resources, or conducting a short, blended-format learning session reflects real-world professional responsibilities. Assessment using rubrics aligned with systems such as TPACK or DigCompEdu ensures objectivity and transparent feedback (Shute & Becker, 2010).

Formative strategies, including peer feedback, structured self-assessment, and analysis of recorded learning materials, also play an important role. Such strategies encourage reflection, the development of metacognitive skills, and professional responsibility (Nichol and Macfarlane-Dick, 2006). This is especially valuable in blended settings, where teachers must constantly adapt to changes in technology and the learning environment. Together, these tools create a balanced system that encompasses both process and outcome, strengthening the connection between assessment and teaching practice.

Ensuring the reliability and validity of competency assessments

Ensuring the consistency and accuracy of assessment results requires careful attention to their reliability and validity. In a competency-based teacher education system, aligning assessment tasks with clear learning outcomes and established frameworks enhances construct validity (Messick, 1995). When tasks reflect TPACK or DigCompEdu indicators, they more accurately reflect the competencies they are intended to measure.

Reliability is ensured through consistent assessment procedures, detailed rubrics, and calibration sessions with assessors. These methods reduce subjectivity and ensure that assessments are based on consistent standards (Brookhart, 2013). The use of digital tools, such as learning management systems or video monitoring tools, improves accuracy and allows for systematic progress monitoring. Overall, ensuring reliability and validity strengthens confidence in assessment results and helps universities prepare graduates for the complex demands of blended learning.

Principles for developing a competency-based teacher education curriculum

Since assessment clarifies what students know and can do, curriculum development determines how these competencies are developed. A competency-based curriculum integrates learning outcomes, learning activities, and assessment procedures into a coherent framework that promotes measurable growth (Harden, 2002). In Kazakhstan's universities, such developments facilitate both modernization and the integration of digital pedagogical innovations.

Coherence ensures that educational activities directly lead to the achievement of outcomes consistent with competencies, and integrated curriculum development integrates digital learning into methodological and subject modules. Research emphasizes that technological and pedagogical knowledge cannot be developed in isolation; instead, they must be practiced together in authentic contexts (Voogt et al., 2015).

A focus on practice is another key principle. Microlearning, simulations, collaborative work with students, and in-school hands-on activities allow future teachers to apply blended learning strategies in real-world settings (Darling - Hammond et al., 2020). In Kazakhstan, strengthening partnerships between universities and schools makes such experiences more accessible. Together, these curriculum principles create a holistic educational environment that systematically develops digital pedagogical competence.

Conclusion

The growing importance of blended learning in modern education requires teacher preparation programs to adopt flexible, practice-oriented, competency-based approaches. International frameworks such as TPACK, DigCompEdu, and ISTE offer a solid foundation for defining professional standards and aligning programs with global expectations. Competency-based assessment tools, including portfolios, performance tasks, and reflective strategies, help assess readiness in real-world settings, while attention to reliability and validity enhances the credibility of assessment results.

Curriculum development principles based on coherence, integration, and practice-oriented approaches ensure that students develop the digital pedagogical competencies necessary for effective blended learning. In Kazakhstan, where digitalization and education modernization continue to advance, these principles contribute to the development of a new generation of teachers capable of navigating diverse learning environments. Ultimately, competency-based training provides graduates with the adaptability, self-confidence, and pedagogical acumen necessary in today's dynamic educational environment.

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Language Documentation, Ethics, and Artificial Intelligence: Technical-Ethical Challenges for Minority Languages

Aliyev Salman

Nakhchivan State University

Aliyev Ceyhun

Nakhchivan State University

Mammadova Zeynab

Nakhchivan State University

Akhundov Ayaz

Nakhchivan State University

Abstract

The digital preservation of endangered and low-resource languages (LRLs) is increasingly intersecting with the training and deployment of large multilingual machine-learning models. This intersection raises technical and ethical challenges that are amenable to empirical and engineering treatment rather than exclusively normative debate. In this paper we (1) synthesize relevant literature from language documentation and machine-learning transparency practices, (2) identify four measurable problem domains—dynamic consent, provenance traceability, layered rights (individual vs. collective), and benefit allocation—and (3) propose a program of testable technical interventions (machine-readable provenance records, dataset datasheets, model cards, and prototype dynamic-consent mechanisms) together with experimental designs to evaluate their efficacy. Our contribution is methodological and operational: we reframe ethical requirements as concrete engineering and evaluation tasks that archives, researchers, and model developers can implement and measure. We conclude with a prioritized research agenda and practical recommendations for archival practice and model documentation.

Keywords: language documentation, low-resource languages, machine learning, dataset datasheets, model cards, data provenance, informed consent, indigenous data governance.

1. Introduction

Language documentation initiatives have produced extensive multimodal corpora intended for archival preservation, community use, and scholarly analysis. At the same time, contemporary large multilingual models (LMMs) and other machine-learning systems increasingly seek to include LRL data to improve coverage and utility across languages. This emergent overlap opens possibilities for beneficial applications (speech recognition, retrieval, language learning tools) but also creates technical problems that complicate existing ethical and governance assumptions embedded in documentation workflows. Rather than framing the problem primarily as a political or adversarial one, this paper treats it as a set of measurable challenges that call for reproducible technical practices, standardized documentation, and experimental evaluation. We therefore focus on concrete interventions—data provenance records, datasheets, model cards, and dynamic-consent prototypes—and propose empirical methods for assessing whether these interventions improve traceability, accountability, and community-centred outcomes.

2. Background: disciplinary practices and technical context

2.1 Ethics and practice in language documentation

Language documentation has developed ethical standards emphasizing informed consent, reciprocity, and the protection of privacy and sensitive material in collections intended for long-term archiving and community use (see journal and archive guidance across the field). These practices were primarily designed for human-mediated scholarly and archival reuse and typically assume constrained, noncommercial use cases. Foundational discussions in the literature emphasize that consent procedures and reciprocity require continual attention in project planning and archiving.

2.2 Dataset and model transparency in machine learning

The machine-learning community has proposed specific technical documentation practices to increase transparency and support downstream evaluation: Datasheets for Datasets recommend structured documentation of dataset provenance, composition, collection process, and recommended uses; Model Cards recommend standardized reporting of model scope, evaluation, and limitations. These documents are designed to be machine- and human-readable and to enable systematic examination of potential harms, biases, and appropriate uses.

2.3 Contemporary multilingual model initiatives and implications for LRL data

Recent open and commercial multilingual projects aim to expand language coverage by aggregating diverse textual and audio sources; examples include publicized open multilingual efforts (e.g., Aya) and major industry translation programs (e.g., Meta’s “No Language Left Behind” initiatives). Such projects demonstrate both the technical feasibility of scaling to many languages and the practical reality that wide-scale aggregation mixes archival, web-harvested and publicly available data in ways that can obscure original consent terms and provenance. Treating language documentation data as a standard dataset input without added provenance or governance controls risks undermining previously negotiated archival constraints.

3. Four measurable problem domains

We identify four interrelated domains where technical work can reduce uncertainty and improve accountability. Each domain is accompanied by the concrete evaluation questions we propose later.

3.1 Dynamic consent and its computable representation

Problem: Traditional informed consent is often static (a one-time agreement) and expressed in natural language, while downstream model uses are unpredictable and long lived.

Technical framing: Can consent be represented as a versioned, machine-readable record that supports queries (e.g., “was this corpus cleared for commercial use?”), revocation, and time-bound scopes? What are the computational costs and behavioral implications of supporting revocation or conditional consent for models trained on datasets with mixed permission levels?

3.2 Provenance traceability across dataset aggregation and model training

Problem: Once archival resources mix into large scraped or merged corpora, the original source and license metadata may be stripped or obscured, making post-hoc accountability and error analysis difficult.

Technical framing: Can an embedded, standardized, machine-readable provenance ledger (a “data nutrition label” or provenance manifest) accompany each archived unit and persist through preprocessing and training pipelines to enable later auditing? Which granularity (file, utterance, speaker session) is feasible in practice?

3.3 Layered authorship and collective rights

Problem: Language data often encodes both individual utterances and community knowledge/structures; governance must handle layered rights that are not reducible to single user consent forms.

Technical framing: What metadata schemas and access control primitives can encode collective permissions (community governance bodies, customary restrictions) alongside individual consents? How can archival systems surface and enforce such layered constraints when data are exported for computational use? Guidance from indigenous data governance principles (e.g., CARE, OCAP) provides normative desiderata; the technical challenge is operationalizing those desiderata in metadata and access APIs.

3.4 Quantifying and operationalizing benefit allocation

Problem: Aggregating LRL data can create value for model developers and downstream users, but communities contributing the data often lack technical capacity, access, or share in derived benefits.

Technical framing: Which measurable benefit channels can be implemented (e.g., prioritized access to fine-tuned models, cloud credits, capacity building) and how can their delivery be automated and audited? What metrics capture whether community needs are met (use frequency, educational uptake, perceived utility)? These are engineering questions tied to program design and evaluation. (See Section 5 for proposed metrics and experiments.)

4. Technical interventions (operational descriptions)

This section translates the problem domains into implementable interventions and describes how to evaluate them empirically.

4.1 Machine-readable provenance manifests (PR-Manifests)

Design: A standardized JSON-LD (or equivalent) manifest stored per archival item (audio file, transcript file, collection) with fields for unique identifier, collection date, recorder, consent summary (coded), license, community governance identifiers, and pointers to related governance documents. Manifests should include a provenance chain section where preprocessing steps and dataset packaging events append signed records.

Rationale: Machine-readable provenance enables automated checks for permissible uses and supports post-hoc audits. Similar approaches are advocated in dataset documentation literature.

4.2 Datasheets for archivable language corpora

Design: For each corpus or collection, a datasheet template adapted from the dataset literature should record motivation, composition, speakers' demographics (sensitivity controlled), collection protocols, consent modalities (structured codes), known limitations, and recommended uses. The datasheet should be versioned and published alongside the manifest.

Rationale: Datasheets create a uniform descriptive layer that is directly consumable by model developers and regulators, improving informed decision-making.

4.3 Model cards and provenance linkage at model release

Design: Models trained on archived or mixed sources must publish model cards citing the provenance manifests / datasheets (or an aggregated provenance index) for the dataset subsets used in training. Model cards should document dataset composition by language and source category (archival, web crawl, synthetic), evaluation results on testbeds relevant to harms and performance, and intended uses.

4.4 Prototype dynamic consent mechanisms

Design: Implement consent tokens linked to manifest entries. Tokens encode (a) permitted use categories (research, noncommercial, commercial), (b) temporal constraints, and (c) optional revocation URLs. Tokens can be checked by ingestion pipelines prior to inclusion. Revocation would propagate via manifest versioning and a notification registry that model developers can poll.

Rationale and caveats: Revocation after model training raises complex questions about model retraining and derivative artifacts; experimental work is needed to measure the efficacy and costs of supporting revocation in realistic pipelines.

5. Experimental designs and evaluation metrics

To move from prescriptions to validated practice, we propose concrete experiments and measurable metrics.

5.1 Provenance detectability experiment

Goal: Measure how provenance richness affects the ability to attribute model outputs to specific source collections.

Design: Produce three versions of the same collection with (A) no manifest, (B) basic manifest, (C) rich manifest. Mix each with a large background corpus, train identical model families, and test the accuracy of automated provenance attribution tools (e.g., k-mer overlap, embedding lineage methods). Metrics: attribution precision/recall, downstream performance trade-offs, storage/processing overhead.

5.2 Dynamic consent usability and impact study

Goal: Assess whether communities and researchers can use tokenized consent workflows and the operational costs of enforcing consent constraints.

Design: Pilot with small community collections: collect consent using tokenized forms, allow participants to exercise revocation options, and measure developer compliance and technical costs (ingestion checks, dataset filtering). Metrics: user comprehension scores, revocation latency, developer compliance rate, cost in compute/engineering time.

5.3 Benefit allocation pilot and uptake metrics

Goal: Test delivery mechanisms for computational reciprocity (e.g., model access, cloud credits) and measure community uptake and perceived utility.

Design: Where a model is trained that uses community data, provide a package (model access + training credits + documentation) and evaluate adoption over 6–12 months by community educators or technologists. Metrics: number of distinct community projects started, hours of model use, satisfaction surveys, sustainability indicators.

6. Practical recommendations for archives and developers

From the technical interventions and experiments above we derive immediate, practical recommendations that archives and research groups can adopt with modest effort.

1. Adopt datasheets and manifests: Archives should publish a datasheet and a machine-readable provenance manifest for each new collection. Existing collections should be retrofitted where feasible.
2. Require provenance references for dataset exports: When an archive exports data to a third party, include manifests and a signed datasheet as part of the export package.
3. Encourage model-card linkage: Model releases trained on or including archived materials should reference the provenance manifests and datasheets for the major data sources used.
4. Prototype and test dynamic-consent tokens: Begin small randomized pilots to evaluate user comprehension and the technical cost of consent revocation.
5. Measure benefits, not only promises: Where community data are used, agreements should specify measurable forms of technical reciprocity (access, credits, training) whose delivery can be audited.

7. Limitations and open questions

This paper intentionally focuses on operational, testable interventions; it does not attempt to resolve broader normative debates about data sovereignty or to prescribe legal remedies. Several unresolved questions remain: the legal enforceability of manifest-linked constraints across jurisdictions, methods for retrofitting legacy archives at scale, and economic models for audited benefit sharing. Each of these topics warrants follow-on empirical and legal study.

8. Conclusion

The integration of archived language documentation into large-scale multilingual model development demands solutions that are both technical and empirically validated. By converting ethical desiderata into implementable artifacts—datasheets, provenance manifests, model cards, and dynamic consent prototypes—and by subjecting those artifacts to experimental evaluation, the research community can produce replicable practices that increase transparency and accountability. The proposed program prioritizes measurable improvements in traceability, consent enforcement, and community benefit delivery; testing and iterative refinement should follow in partnership with archives and language communities.

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The Impact of Digital Tools on Vocabulary Acquisition in English as a Foreign Language (EFL)

Rahila Garibova Gurbanali

Head teacher, Baku Slavic University, Baku, Azerbaijan

Keywords: *digital tools, vocabulary acquisition, English as a Foreign Language (EFL), CALL (Computer-Assisted Language Learning), language learning technology, learner autonomy, gamification, multimedia learning, spaced repetition.*

Abstract

Digital technologies have become integral to English as a Foreign Language (EFL) instruction, particularly in enhancing vocabulary acquisition. This paper examines the effectiveness of digital tools such as mobile applications, online dictionaries, spaced-repetition systems (SRS), gamified learning platforms, and multimedia resources. Drawing on relevant theories and recent research, the study evaluates how these tools affect retention, motivation, learner autonomy, and cognitive processing of vocabulary. The findings from the literature indicate that digital tools significantly support vocabulary learning by increasing exposure, contextualization, and learner engagement. However, challenges such as distraction, digital overload, and unequal access remain. The article concludes by offering pedagogical recommendations for integrating digital tools effectively in EFL classrooms.

Vocabulary forms the foundation of language competence and is widely recognized as essential for successful communication and academic achievement in a foreign language. Over the past decade, the rapid development of digital technologies has profoundly changed approaches to English language teaching (ELT). Digital tools—ranging from mobile applications to online platforms—offer new opportunities for learners to access vocabulary in personalized, interactive, and engaging ways.

The shift toward digitally supported learning gained momentum especially after global transitions to online and blended learning environments. As a result, EFL learners increasingly rely on digital platforms to expand their lexical knowledge. This paper aims to explore the impact of these digital tools on vocabulary acquisition in EFL contexts and identify their pedagogical benefits and limitations.

Traditional vocabulary instruction often focused on rote memorization, teacher-centered explanations, and textbook-based exercises. While these methods remain useful, they may not sufficiently address modern learners' needs for authentic input, multimodal exposure, and learner autonomy (Nation, 2013). Digital tools provide alternative vocabulary learning opportunities based on repetition, context, and interaction.

Several theories support the integration of digital tools in vocabulary learning:

- **Dual Coding Theory** (Paivio, 2006): Combining verbal and visual input enhances memory retention.
- **Cognitive Load Theory** (Sweller, 2011): Multimedia tools must be used carefully to avoid cognitive overload.
- **Mobile-Assisted Language Learning (MALL)**: Enables learners to study vocabulary anytime and anywhere.

- **Sociocultural Theory** (Vygotsky, 1978): Interaction with digital tools and peers supports learning.

These theories highlight how digital tools can complement cognitive and social aspects of vocabulary development.

Digital Tools for Vocabulary Learning

Mobile Applications (e.g., Duolingo, Memrise, Quizlet)-Studies show that mobile apps significantly enhance vocabulary recall due to gamification, instant feedback, and portability (Chen & Chung, 2008).

Spaced-Repetition Systems (SRS)Applications like Anki and Quizlet use spaced repetition to optimize long-term memory. Research indicates that SRS improves retention more effectively than traditional memorization (Kang, 2016).

Online Dictionaries and Corpora-Tools such as Cambridge Dictionary, YouGlish, or COCA provide authentic contexts and pronunciation models, supporting deeper lexical understanding (Laufer & Nation, 2012).

Gamified Vocabulary Platforms-Gamification increases motivation and engagement. Points, rewards, progress bars, and challenges stimulate intrinsic and extrinsic motivation (Deterding, 2015).

Multimedia and Video-Based Learning-Videos and interactive media provide contextualized vocabulary necessary for meaningful learning (Mayer, 2009).

Benefits of Digital Tools in Vocabulary Learning

Enhanced Motivation and Engagement-Gamified apps and interactive tasks make vocabulary learning enjoyable. Learners report higher motivation when digital tools include challenges, badges, and feedback (Klimova, 2020).

Improved Vocabulary Retention-SRS-based tools demonstrate superior long-term retention compared to rote memorization. Repeated exposure at optimal intervals strengthens memory.

Learner Autonomy-Digital tools allow learners to study independently, adjust their pace, and select vocabulary relevant to individual goals. This supports autonomous learning—a key goal in modern pedagogy (Benson, 2011).

Multimodal Learning-Visuals, audio, example sentences, and interactive exercises support comprehension and recall. Dual Coding Theory explains why combining these modes enhances learning.

Accessibility and Flexibility-Mobile tools enable vocabulary practice anywhere—public transport, breaks, or at home. This ubiquity increases exposure time, which is essential for vocabulary growth.

Challenges and Limitations

Cognitive Overload-Poorly designed tools may overwhelm learners with excessive visuals or rapid tasks, reducing learning effectiveness.

Distraction Risk-Mobile devices can cause learners to multitask or lose focus due to notifications or unrelated content (Wood et al., 2012).

Digital Inequality-Not all learners have equal access to devices or stable internet, causing gaps in learning opportunities.

Some applications prioritize entertainment over pedagogy. Without teacher guidance, learners may acquire superficial or incorrect vocabulary.

To maximize the benefits of digital tools, teachers should:

- Integrate digital resources with classroom instruction, not replace teaching entirely.
- Guide learners on selecting reliable and pedagogically sound applications.
- Use blended learning models combining traditional exercises with digital practice.
- Encourage reflective learning through vocabulary journals or portfolios.

- Monitor student progress using analytics from apps and platforms.

When used strategically, digital tools can significantly strengthen vocabulary acquisition and learner autonomy.

Digital tools have become valuable assets in supporting vocabulary acquisition in EFL learning. They offer interactive, multimodal, and personalized learning experiences that enhance motivation, retention, and accessibility. While challenges such as distraction, digital inequality, and tool quality must be addressed, the overall impact of digital tools is largely positive. Integrating them effectively in EFL classrooms can create a balanced and dynamic learning environment, fostering both engagement and long-term vocabulary development.

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DIGITAL TOOLS AND ARTIFICIAL INTELLIGENCE IN ACADEMIC WRITING: POTENTIAL FOR ENHANCING DOCTORAL RESEARCH EFFICIENCY

Gulbanu Aubakirova

Candidate of Philological Sciences, Karaganda University of Kazpotrebsoyuz (Non-State Institution)

Glazunova Svetlana

Doctoral Student, Karaganda University of Kazpotrebsoyuz (Non-State Institution)

Abstract: The article examines digital tools and artificial intelligence technologies that support academic writing and the research activity of doctoral students. It demonstrates that the digital transformation of scholarly communication is reshaping the role of the researcher and forming a new ecosystem of academic writing. The purpose of the study is to analyse and evaluate modern intelligent platforms used in the preparation and editing of scientific texts. The methodology is based on the principles of systemic and functional analysis and includes data triangulation: functional testing, expert assessments, and doctoral student feedback. A comparative and evaluative analysis of the most widely used tools (Litmaps, Connected Papers, ResearchRabbit, Elicit AI, Consensus, Perplexity AI, ChatGPT, DeepSeek) is conducted, and their functional and ethical characteristics are identified. The results of the analysis are presented in the form of an efficiency matrix that reflects the extent to which these tools reduce time costs, improve accuracy, and preserve research autonomy. The article discusses the risks and ethical considerations associated with the use of generative models, including issues of authorship, credibility, and academic integrity. Recommendations for the responsible use of digital tools in doctoral education are proposed.

Keywords: academic writing; doctoral students; digital tools; artificial intelligence; research activity; reference management systems; linguistic text support; generative language models; academic integrity; digital transformation of science.

Introduction. In the contemporary system of scholarly communication, academic writing performs a pivotal function by ensuring the coherent presentation of research intent, the substantiation of results, and their accurate interpretation within the professional community. For doctoral students who are in the process of developing research and publication competence, mastery of academic writing becomes an essential prerequisite for successful scholarly activity. It requires not only knowledge of linguistic and structural conventions but also the ability to employ a wide range of digital tools that support the preparation of scientific texts.

The development of artificial intelligence technologies and specialised software solutions has significantly transformed academic writing practices, altering approaches to locating, processing, and presenting information. Reference management systems, linguistic assistants, generative language models, and academic integrity verification services contribute to the optimisation of the research process, reducing the time needed to prepare publications and improving their quality. However, alongside the clear advantages, new challenges have emerged

- ethical, methodological, and cognitive - associated with the risk of diminishing the author's role in text creation and dependence on automated tools.

In the national scholarly and pedagogical literature, the issue of comprehensively analysing digital tools for academic writing in the context of doctoral training remains insufficiently explored. Both the functional capabilities of specific platforms and their influence on the development of research competencies require deeper investigation.

The purpose of the article is to analyse digital tools and artificial intelligence technologies that support academic writing and to assess their impact on the research effectiveness of doctoral students. The study addresses three objectives:

- to classify digital tools used in academic writing;
- to compare key AI-based platforms in terms of functionality and academic integrity;
- to propose recommendations for their responsible use in doctoral research.

The results of the study are aimed at improving the digital literacy and research effectiveness of doctoral students, as well as enhancing methodological approaches to integrating artificial intelligence technologies into educational and research practices.

Main part. Contemporary scholarship views academic writing as an integral component of research culture and a mechanism through which a scholar becomes embedded in the international academic community. Its foundation lies in the researcher's ability to articulate scientific thought clearly and convincingly, to adhere to citation norms, and to follow the genre conventions of scholarly discourse [1; 2]. For doctoral students, the development of this competence has a dual significance: on the one hand, it ensures successful progress in the doctoral programme, and on the other, it forms the basis for professional advancement through publications, conference participation, and project activity [3].

The methodological basis of the study draws on concepts developed by leading international and national researchers in the fields of academic writing and scholarly communication. Ken Hyland [4] conceptualises academic writing as a socially situated practice in which the text functions not merely as a vehicle for conveying knowledge, but as a means of positioning the author within the academic community. Margaret Cargill and Patrick O'Connor [5] emphasise the strategic nature of scientific writing, linking it to the stages of planning, argumentation, and dissemination of results.

The classical cognitive model of Linda Flower and John Hayes [6] conceptualises writing as a dynamic system that includes planning, text production, and revision, thereby allowing the academic text to be understood as a product of thinking rather than merely a linguistic form. Within the pedagogical research tradition, Mick Healey and Alan Jenkins [7] interpret academic writing as a tool for cultivating research culture, while George Kuh [8] identifies mastery of academic style as one of the high-impact educational practices that enhance research productivity.

In the Russian scholarly and methodological tradition, a significant contribution to the development of the theory of academic writing has been made by I. Korotkina [9], who considers it a specific domain of academic literacy that integrates linguistic, rhetorical, and pedagogical approaches. She emphasises that academic writing plays a key role in shaping research identity and serves as an instrument of academic integrity.

In the Kazakhstani context, the methodological aspects of academic writing are presented in the work of G. T. Aubakirova, where academic writing is conceptualised as a structured educational process aimed at developing research skills [10]. At the same time, G. E. Nakipova and her co-authors examine academic writing as an element of academic culture and publication training in the context of developing students' research competencies [11]. Her approach reflects the characteristics of the Kazakhstani academic environment and underscores the role of the university as an institution for developing research competence.

From the perspective of higher education pedagogy, the development of academic writing skills in doctoral education is closely linked to the cultivation of critical thinking, research autonomy, and digital literacy [12]. Studies conducted by the European University Association [13] and the Organisation for Economic Co-operation and Development [14] indicate the growing importance of digital competencies in researcher training. These reports emphasise that the digital transformation of universities is reshaping approaches to research communication, including through the use of artificial intelligence tools for data analysis, visualisation, and text editing.

Modern approaches to academic writing involve the integration of digital tools throughout the research cycle—from navigating scientific sources and analysing citation networks to systematising literature and generating text with the support of intelligent technologies [15]. Analytical and generative platforms based on artificial intelligence and graph-analysis technologies—such as Litmaps, Connected Papers, ResearchRabbit, Elicit AI, Consensus, Perplexity AI, ChatGPT, and DeepSeek—are increasingly used in research practice. These solutions enable the visualisation of relationships between publications, automate data search and interpretation, and enhance the structure and evidential rigor of scholarly texts. Their use contributes to the development of doctoral students' research autonomy; however, it also requires adherence to emerging ethical and methodological standards of academic integrity.

Thus, the theoretical and methodological framework of this study relies on an interdisciplinary approach that integrates linguistic, pedagogical, and digital-technological dimensions of academic writing. This allows the process of producing a scholarly text to be viewed not only as a linguistic practice, but also as a component of a digital research ecosystem in which the interaction between humans and intelligent systems becomes a factor in improving the research effectiveness of doctoral students.

The research methodology is based on the principles of systemic and functional analysis, which make it possible to consider digital tools for academic writing as interconnected elements of a unified research ecosystem [16]. The aim of the methodological design was to identify the functional capabilities and limitations of digital solutions employed by doctoral students at the stages of preparing, editing, and structuring scholarly texts.

The empirical basis of the study consisted of a targeted selection of tools used in international and national academic practice. Selection criteria included accessibility, operational stability, frequency of use, and relevance to the needs of doctoral education. The analysis encompassed contemporary intelligent platforms that support different stages of academic writing: tools for visualising and analysing scientific linkages (Litmaps, Connected Papers, ResearchRabbit); systems for cognitive processing and systematisation of literature (Elicit AI, Consensus, Perplexity AI); and generative language models (ChatGPT, DeepSeek). For contextual comparison, traditional solutions were also considered, including reference management systems (Zotero, Mendeley, EndNote) and linguistic assistants (Grammarly, Writefull, LanguageTool, Trinka).

Comparison was carried out across a set of functional, technological, and ethical parameters, including breadth of capabilities, accuracy of operation, language support, compatibility with office applications, integration with databases, availability of collaboration tools, and data-protection policies. Particular attention was paid to adherence to principles of academic integrity and to the influence of automated systems on the researcher's independence.

The effectiveness of digital tools was evaluated in terms of their ability to reduce time costs, improve formatting accuracy, and enhance text quality while preserving authorial initiative. To increase the reliability of the results, data triangulation was applied, combining functional testing, expert assessments, and feedback from doctoral students. This approach ensured the

comprehensiveness and objectivity of the analysis and formed the basis for interpreting the findings of the comparative study.

The modern digital environment has substantially transformed academic writing practice by offering researchers a wide range of intelligent platforms based on artificial intelligence and graph-analysis technologies. These solutions enable the automation of literature searches, the identification of connections between publications, the analysis of argumentation, and the construction of coherent logical structures in scholarly texts.

The effectiveness of digital instruments was evaluated from the standpoint of reducing time expenditures, increasing the accuracy of formatting, and improving text quality while maintaining the author's own contribution. To strengthen the robustness of the findings, data triangulation was employed, incorporating comparisons of functional testing, expert evaluations, and feedback from doctoral students who actively use these tools in their research work. This approach made it possible to compare both technological and pedagogical aspects of their application.

Among the most functional tools are Litmaps, Connected Papers, ResearchRabbit, Elicit AI, Consensus, Perplexity AI, ChatGPT, and DeepSeek. Litmaps and Connected Papers employ principles of graph-based citation analysis, visualising scholarly linkages and allowing users to trace the thematic evolution of publications. ResearchRabbit combines visualisation with elements of social collaboration, enabling users to create personalised collections of articles and track authors.

Elicit AI and Consensus are oriented towards cognitive-analytical processing of the literature. The former automatically classifies articles by aims and methods, approximating the process of a systematic review, while the latter structures empirical data according to the degree of consistency across findings. Perplexity AI integrates search and generative analytical capabilities, producing concise academic summaries with hyperlinks to primary sources, although it requires verification of the generated information.

Generative language models such as ChatGPT (chat.openai.com) and DeepSeek (deepseek.com) occupy a distinct position among digital tools. ChatGPT facilitates the rapid preparation of draft scholarly texts and the refinement of formulations, although it requires careful authorial oversight. DeepSeek employs a multivariant approach to generating responses and analytical perspectives, which makes it particularly valuable for comparative and discussion-based analysis.

To systematise the results and visualise distinctions among the tools, a comprehensive assessment was conducted based on key effectiveness criteria (Table 1).

Table 1. Evaluation of the effectiveness of digital tools for academic writing

No	Tool	Reduction of time costs	Formatting accuracy	Support for academic style	Preservation of authorial initiative	Overall assessment
1	Litmaps https://www.litmaps.com	++	+	+	+++	high
2	Connected Papers https://www.connectedpapers.com	++	+	++	++	high
3	ResearchRabbit https://www.researchrabbit.ai	+++	+	+	++	high
4	Elicit AI https://elicit.org	+++	++	+	++	high
5	Consensus https://consensus.app	++	++	+	++	medium-high
6	Perplexity AI https://www.perplexity.ai	+++	++	++	+	medium
7	ChatGPT https://chat.openai.com	+++	++	++	+	medium
8	DeepSeek https://www.deepseek.com	++	+	+	++	medium

Note: “+” indicates a low level; “++” a medium level; “+++” a high level of the indicator.

The analysis showed that the highest effectiveness in the context of doctoral research is demonstrated by Elicit AI and ResearchRabbit, which provide a balance between analytical depth and the preservation of research autonomy. Litmaps and Connected Papers support the development of cognitive linkages between sources, while Consensus and Perplexity AI accelerate the process of data synthesis, provided that critical verification is applied. Among generative systems, ChatGPT stands out for its versatility and adaptability to academic tasks, whereas DeepSeek is oriented toward comparative analysis and the development of argumentation. Taken together, these tools reflect the shift in academic writing from linear accumulation of sources toward integrative analytics, which fosters the development of research culture and digital competence among doctoral students.

The integration of artificial intelligence into academic writing has significantly expanded the capabilities available to researchers, while simultaneously introducing new ethical and methodological challenges for the academic community. The transition from tools for automated checking and editing of text to generative writing systems (such as ChatGPT, DeepSeek, Claude, and Perplexity AI) has fundamentally changed the nature of the author’s interaction with the text, creating the need to reconsider the boundaries of authorship, intellectual autonomy, and academic integrity.

From an ethical perspective, the central challenge lies in distinguishing between human and machine contributions to the scholarly product. Whereas tools such as Grammarly or Writefull have traditionally been viewed as acceptable forms of linguistic support, generative models produce texts capable of imitating the individual style and reasoning of the researcher. As a result, there is a risk that intellectual work will be supplanted by formal information processing. Therefore, transparency regarding the sources and procedures of text production becomes a key principle of academic ethics, requiring explicit acknowledgment of AI tools used in the preparation of manuscripts, reports, and grant applications.

From a methodological perspective, the use of AI requires an awareness of its epistemological limitations. Generative model algorithms are trained on large data corpora that do not always include up-to-date or peer-reviewed sources. As a result, errors, contextual distortions, or so-called “AI hallucinations” may occur—an issue that is particularly problematic in scholarly discourse. Consequently, text produced with the assistance of artificial intelligence should not be viewed as a final result, but rather as an intermediate analytical material that must undergo expert verification.

The issue of preserving research autonomy is also of critical importance. For doctoral students and early-career researchers, excessive reliance on intelligent systems may reduce the level of critical thinking and analytical independence. As noted by the European University Association, “automation should not replace the process of scholarly reasoning but should serve as its extension and reinforcement” [17]. Therefore, the use of AI tools is justified only when they enhance the productivity of research activities without substituting the cognitive processes of analysis and synthesis.

From an institutional standpoint, there is a need to develop regulations for the responsible use of artificial intelligence in educational and research practice. International organisations, including the OECD and UNESCO, recommend that universities implement internal codes of academic integrity that clearly define which forms of AI use are considered acceptable. These include automatic language checking, stylistic revision, bibliography management, analytical data visualisation, and the preparation of draft texts with mandatory subsequent human editing. The use of generative models to produce final scholarly texts presented as entirely authorial is regarded as unacceptable.

Special attention must be paid to cultivating an ethical culture of the digital researcher. In the context of doctoral education, this entails developing the ability to critically analyse machine-generated text, identify interpretive errors, adjust argumentation, and maintain responsibility for the final outcome. Thus, digital literacy in academic writing becomes not only a technical, but also a moral-intellectual category that reflects the maturity of research identity.

Overall, the ethical and methodological aspects of using AI in academic writing require establishing a balance between innovation and responsibility. Digital tools can substantially enhance the efficiency of doctoral research; however, their use must be grounded in the principles of transparency, critical reflection, and scholarly verification. Only under these conditions can artificial intelligence serve not as a replacement for, but as an extension of, human potential in academic writing.

Conclusion. The study has demonstrated that digital tools and artificial intelligence technologies have become an integral element of contemporary academic writing and open new opportunities for enhancing the research effectiveness of doctoral students. The integration of intelligent platforms into the research process contributes not only to the acceleration of technical procedures—searching, analysing, and formatting sources—but also to a qualitative shift in the nature of scholarly thinking, which is increasingly based on data, visualisation, and analytical interpretation.

The results of the comparative analysis showed that the highest potential for academic writing is found in cognitively oriented and visually driven tools (Elicit AI, ResearchRabbit, Litmaps), which enable the structuring of the theoretical foundation, the tracing of relationships between publications, and the development of research argumentation. Generative language models (ChatGPT, DeepSeek) provide substantial time savings and support linguistic refinement; however, they require expert interpretation and strict adherence to the principles of academic integrity.

At the same time, the study revealed that the effectiveness of digital tools directly depends on the level of digital and academic literacy of doctoral students. The use of intelligent systems without understanding their algorithmic limitations and ethical risks may lead to a decline in

critical thinking and a loss of research autonomy. Therefore, a key task for universities is to cultivate a culture of responsible use of artificial intelligence in educational and research practice, developing competencies in digital ethics and scholarly verification.

The practical significance of the analysis lies in the fact that the proposed typology of tools and criteria for their evaluation can be used by doctoral students, academic supervisors, and academic writing centres when selecting optimal solutions to support research work. The findings also form a basis for further studies aimed at developing institutional models for integrating AI into academic writing, assessing the impact of digital technologies on the quality of scholarly texts, and establishing mechanisms for ethical regulation.

Thus, when applied thoughtfully and responsibly, digital tools become not merely a means of optimising researchers' work, but a component of a new research culture in which the interaction between humans and artificial intelligence promotes academic productivity, openness, and scholarly integrity.

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L'accord du participe passé avec les auxiliaires avoir et être en français : analyse comparative du genre avec l'azerbaïdjanais

Ali Allahverdiyev

Nakhchivan State University lecturer, <https://orcid.org/0009-0003-1249-3041>,
Azerbadjan, Nakhchivan

Résumé

Dans cet article l'objectif de cette étude est donc de comparer l'accord du participe passé en français et ses équivalents en azerbaïdjanais, de mettre en évidence les similitudes et les différences, et d'explorer comment la catégorie du genre conditionne l'accord et l'interprétation des phrases dans ces deux langues. Le français, langue romane, possède un système verbal complexe où les temps composés occupent une place centrale. L'accord du participe passé est un point essentiel pour la précision grammaticale et stylistique. L'auxiliaire choisi (*avoir* ou *être*) détermine le mécanisme d'accord et peut engendrer des différences significatives dans la construction des phrases. Afin de bien analyser l'accord du participe passé en genre et en nombre il faut d'abord analyser la catégorie du genre dans ces deux langues. L'analyse comparative de l'accord du participe passé avec les auxiliaires *avoir* et *être* permet de mettre en évidence les similitudes et les différences dans la formation des temps composés en français et de les confronter aux structures de l'azerbaïdjanais.

Mots clés : L'accord du participe passé ; la catégorie du nombre ; être ; avoir ; analyse comparative ; les différences linguistiques ; les ressemblances : l'azerbaïdjanais ; le français

L'accord du participe passé est un élément central de la grammaire française, en particulier dans la formation des temps composés. Son comportement varie selon l'auxiliaire utilisé (*avoir* ou *être*) et selon la présence d'un complément d'objet direct. La catégorie grammaticale du genre joue un rôle déterminant dans ces accords, puisque le participe passé peut s'accorder en genre et en nombre avec le sujet ou le COD (Complément d'objet direct). En revanche, l'azerbaïdjanais ne possède pas de catégorie grammaticale du genre ; le genre biologique et social est exprimé uniquement par des mots lexicaux et des contextes syntaxiques. Cette différence fondamentale entre les deux langues permet d'analyser l'influence du genre sur la morphosyntaxe et la cognition linguistique.

Cette étude vise à comparer ces deux systèmes d'accord et à mettre en lumière leurs similitudes et différences, en établissant également des parallèles avec la structure verbale en azerbaïdjanais. L'objectif principal est de fournir une analyse académique complète, destinée aux chercheurs, enseignants et étudiants avancés en linguistique française et comparée.

Afin de comparer la notion d'accord entre l'azerbaïdjanais et le français, il est tout d'abord nécessaire de jeter un coup d'œil sur la catégorie du genre dans ces deux langues. Nous savons que dans la langue française il existe masculin et féminin. Regardons l'explication comparée dans ces deux langues ayant deux systèmes différents. La catégorie du genre existe dans de nombreuses langues du monde. En français le genre permet la distinction. Pour marquer cette différence, on a souvent donné aux substantifs des terminaisons différentes [10,p.14]. La catégorie du genre se divise, dans certaines langues, en deux groupes — féminin et masculin (en français) — et, dans d'autres langues, en trois groupes (en allemand) — féminin, masculin et neutre. L'appartenance des entités à un certain groupe de genre est parfois déterminée par leurs

caractéristiques biologiques, mais il n'existe pas de règle stricte à ce sujet. Cela signifie que deux mots exprimant des significations proches peuvent appartenir à des groupes de genre différents, ou qu'un même mot peut être de genre féminin dans une langue et masculin dans une autre. Le genre biologique se rencontre dans presque toutes les langues du monde, y compris dans les langues turques où la catégorie grammaticale du genre n'existe pas. Par genre biologique, on entend l'expression, au moyen d'un mot, du genre auquel appartient une personne en fonction de ses caractéristiques. En turc par exemple, *kadın-erkek* (femme-homme), *anne-baba* (mère-père), *oğul-kız* (fils-fille), *bay-bayan* (monsieur-madame), en azerbaïdjanais, il existe un lien direct entre les mots reflétant le genre social et biologique, tels que *qadın-kişi* (femme-homme), *ana-ata* (mère-père), *bəy-xanım* (monsieur-madame), *oğul-qız* (fils-fille) et leur sémantique. De même, dans les langues, il existe des mots faisant référence au genre des animaux, tels que poule-coq (*toyuq –xoruz*), bœuf-vache (*öküz-inək*), mouton-bélier (*qoyun-qoç*) [9, p.283]. Une expression incorrecte du genre peut entraîner une simple incompréhension, la formation d'idées erronées, ainsi que, pour certains locuteurs, des problèmes plus importants tels que le manque de respect, l'insulte ou une approche de genre. Pour caractériser les mots du point de vue du genre, on se base généralement sur des indices phonétiques : les noms se terminant par -eur sont souvent masculins (par exemple : un professeur, un acteur), tandis que les noms se terminant par -ance, -tion, -trice sont souvent féminins (par exemple : une assurance, une action, une actrice). Si, dans la langue maternelle d'une personne, les mots sont classés en genre féminin et masculin, cela conduit, dès l'enfance, à la formation dans l'esprit humain de deux groupes de personnes et des rôles attribués à ces groupes.

Comme la langue azerbaïdjanaise ne possède pas la catégorie grammaticale du genre, seules certaines catégories grammaticales telles que le nombre, la possession, le cas et les marqueurs de l'assertion sont considérées. Pour distinguer le genre d'un point de vue biologique, on utilise un certain nombre d'unités lexicales. Par exemple : fille, garçon, homme, femme, grand-père, grand-mère, etc. Une partie des mots exprimant le genre dans notre langue est d'origine arabe. Dans notre langue, cette distinction de genre est exprimée à l'aide d'unités lexicales. C'est pourquoi, pour indiquer le genre, des noms ont été créés artificiellement dans notre langue. Ces mots sont présentés comme de la création de noms nationale. Par exemple : Samir-Samirə, Rasim-Rasimə, Xəyal- Xəyalə, Rəhim- Rəhimə, etc. Il est connu que dans notre langue, pour distinguer le genre des personnes exerçant un certain art ou métier, on utilise également les mots «homme» et «femme». À ce propos, l'expression du genre par des moyens syntaxiques est davantage observée dans le discours oral. Par exemple : femme médecin, homme médecin, femme enseignante, homme enseignant, etc. Comme il n'existe pas de discrimination de genre dans notre mentalité nationale, il n'est pas nécessaire d'ajouter le suffixe «-ə» aux noms de métiers, car de tels mots ne créent pas d'incompréhension dans le discours. Ainsi, en considérant que la langue azerbaïdjanaise ne dispose pas de la catégorie grammaticale du genre et que le suffixe «-ə» ne peut être appliqué aux lexèmes relevant de cette catégorie (tels que médecin, savant, artiste, comptable, etc.), ainsi que l'absence de toute discrimination de genre dans la conception nationale, il apparaît pertinent, d'un point de vue linguistique et socioculturel, de renoncer à l'usage de ce suffixe pour la formation des noms de professions. Dans certaines langues, la classification des mots en groupes de genre grammatical reflète les perspectives culturelles d'un peuple ou d'une nation. Les résultats ont montré que, dans certaines langues pour les objets dépourvus de genre biologique, nous déterminons leurs caractéristiques en fonction de leur genre grammatical. Ainsi, certains spécialistes affirment que l'existence de la catégorie de genre et du genre grammatical dans une langue influence de manière significative la pensée humaine. Selon eux, ces caractéristiques linguistiques amènent les locuteurs de cette langue à distinguer, au niveau subconscient, le féminin et le masculin, à attribuer des rôles différents à chacun et à choisir des mots spécifiques pour exprimer ces genres. Après avoir analysé de manière comparative la

catégorie du genre en azerbaïdjanais et en français, examinons l'accord des verbes au passé composé en français selon le genre et le nombre. Regardons d'abord sa fonction. Le participe passé est une forme verbale non personnelle qui sert à former les temps composés et exprimer la valeur résultative. Il agit comme adjectif et s'accorde avec le nom ou le pronom approprié. Ses caractéristiques morphologiques sont la variation en genre et en nombre selon l'accord et sa capacité à fonctionner comme adjectif ou comme partie intégrante d'un verbe composé. Sa valeur sémantique est d'indiquer l'accomplissement d'une action et de signaler le résultat ou la conséquence d'un événement. L'accord avec l'auxiliaire «être» se fait toujours en genre et en nombre avec le sujet du verbe. L'auxiliaire *être* est utilisé avec les verbes intransitifs de mouvement et les verbes pronominaux. [5, 124]. L'accord se fait toujours avec le sujet en genre et en nombre. Exemples : *Elle est née en 1990. Ils sont partis hier. Elles sont tombées.*

L'accord avec les verbes pronominaux se fait généralement avec le sujet, sauf lorsque le pronom réfléchi est complément d'objet direct placé après le verbe. Par exemple, *Elle s'est lavée.* (accord avec le sujet). *Elle s'est lavé les mains.* (pas d'accord avec le sujet, COD après). Les implications syntaxiques de l'accord du participe passé révèlent que la position du complément d'objet et le choix de l'auxiliaire influencent directement la forme du participe. [10, 19].

- L'accord avec *être* est constant et prévisible.
 - Les verbes pronominaux nécessitent une analyse fonctionnelle du pronom réfléchi.
- L'accord avec l'auxiliaire «avoir» ne se fait qu'avec le complément d'objet direct lorsque celui-ci est placé avant le verbe, et non avec le sujet. L'auxiliaire *avoir* est utilisé avec la majorité des verbes transitifs. L'accord ne se fait avec le COD que si celui-ci est placé avant le verbe. Exemples:

- *J'ai vu Marie.* (pas d'accord)
- *Marie que j'ai vue.* (accord avec COD)
- *Les lettres que j'ai écrites.* (accord féminin pluriel)
- Les invités sont arrivés à l'heure.
- Les documents que j'ai signés étaient officiels.
- Elle s'est souvenu des détails importants.

Ces exemples montrent la fréquence et la régularité des règles observées. [10, 22- 24].

En français, la syntaxe joue un rôle crucial dans l'accord du participe passé, surtout lorsque l'auxiliaire «avoir» est utilisé. La position du complément d'objet direct influence directement l'accord du participe passé selon les règles syntaxiques du français. Comprendre les règles syntaxiques est essentiel pour appliquer correctement l'accord du participe passé avec les auxiliaires «avoir» et «être» dans différents contextes. La position du COD détermine l'accord et la majorité des verbes transitifs suivent ce modèle. Avec l'auxiliaire «être», le participe passé s'accorde systématiquement en genre et en nombre avec le sujet : *Elle est partie, Ils sont arrivés.* Avec l'auxiliaire «avoir», l'accord ne se fait que si le complément d'objet direct précède le verbe : *Les lettres que j'ai écrites* (accord), mais *J'ai écrit les lettres* (pas d'accord). Ainsi, la principale différence avec «être» réside dans la dépendance de l'accord à la position du COD dans la phrase lorsqu'on utilise «avoir». Les verbes pronominaux, bien qu'utilisant «être», peuvent présenter un comportement intermédiaire : l'accord dépend alors de la fonction du pronom réfléchi.

- Avec *avoir*, l'accord n'est pas systématique.
- L'accord dépend de facteurs syntaxiques et non du sujet.

L'analyse comparative de l'accord du participe passé avec les auxiliaires «avoir» et «être» permet de mettre en évidence à la fois les similitudes et les différences entre ces deux systèmes, ainsi que leur influence sur la morphosyntaxe et la perception du genre en français et en azerbaïdjanais.

L'analyse comparative de l'accord du participe passé avec les auxiliaires *avoir* et *être* permet de mettre en lumière les mécanismes morphosyntaxiques du français, c'est-à-dire la manière dont le genre et le nombre influencent la formation des temps composés, et de les confronter aux structures de l'azerbaïdjanais. Cette comparaison est essentielle pour comprendre non seulement

les règles grammaticales, mais aussi l'impact de la catégorie du genre sur la cognition linguistique et la production de la langue.

Les similitudes entre l'accord du participe passé avec les auxiliaires «avoir» et «être» résident dans le fait que, dans les deux cas, le participe passé joue un rôle central dans la formation des temps composés et exprime l'accomplissement d'une action ou le résultat d'un événement. En effet, plusieurs caractéristiques sont communes aux deux auxiliaires. Tout d'abord, le participe passé joue un rôle central, c'est-à-dire qu'il constitue l'élément fondamental des temps composés et exprime toujours un état résultant ou l'accomplissement d'une action. Ensuite, l'accord dépend d'un constituant de la phrase, en l'occurrence le sujet lorsqu'il est accompagné de *être*, et le complément d'objet direct lorsqu'il est accompagné de *avoir*. Notamment, dans les deux cas, l'accord est une interaction entre la morphologie et la syntaxe, ce qui souligne l'importance de la structure de la phrase pour déterminer la forme correcte du participe passé.

Les différences entre l'accord du participe passé avec les auxiliaires «avoir» et «être» résident principalement dans le fait que, avec «être», l'accord se fait systématiquement avec le sujet, tandis qu'avec «avoir», il dépend de la position du complément d'objet direct. Malgré ces similitudes, des différences significatives existent entre les deux auxiliaires. Avec *être*, l'accord est systématique avec le sujet, c'est-à-dire que le participe passé s'accorde toujours en genre et en nombre avec le sujet de la phrase. Par exemple : *Elle est arrivée, Ils sont partis, Elles sont descendues*. En revanche, avec *avoir*, l'accord est conditionnel et dépend de la position du complément d'objet direct, en effet : *Les lettres que j'ai écrites* (accord avec le COD placé avant le verbe) vs *J'ai écrit les lettres* (pas d'accord). Cette différence montre que l'accord avec *avoir* est plus sensible à la syntaxe et à l'ordre des mots, tandis que l'accord avec *être* est plus régulier et prévisible. Les verbes pronominaux illustrent une situation intermédiaire. Bien qu'ils utilisent l'auxiliaire *être*, l'accord dépend de la fonction du pronom réfléchi. Ainsi, *Elle s'est lavée* (accord avec le sujet) mais *Elle s'est lavé les mains* (pas d'accord avec le sujet, car le COD suit le verbe). C'est-à-dire que le comportement des verbes pronominaux combine les deux logiques et représente un cas particulier de la morphosyntaxe française.

La comparaison avec l'azerbaïdjanais montre que, contrairement au français, cette langue ne possède pas de catégorie grammaticale du genre, c'est-à-dire que l'accord du participe passé ne dépend ni du sujet ni du complément d'objet direct, et que le genre est exprimé lexicalement ou contextuellement. En azerbaïdjanais, la langue ne possède pas de catégorie grammaticale du genre, c'est-à-dire que l'accord morphologique ne dépend ni du sujet ni du complément d'objet direct. Le genre biologique ou social est exprimé lexicalement ou contextuellement, par exemple avec des mots comme *qadın* (femme) ou *kişi* (homme). Cela signifie que, contrairement au français, la morphosyntaxe azérie n'impose pas de règles strictes d'accord, et le sens prévaut sur la forme grammaticale. Notamment, cette absence de dépendance à la catégorie du genre illustre les différences culturelles et cognitives dans la perception du rôle et de la distinction entre le féminin et le masculin.

Les implications linguistiques et pédagogiques de l'accord du participe passé sont importantes, c'est-à-dire qu'elles influencent la manière dont les apprenants perçoivent la grammaire, comprennent les règles d'accord et développent des stratégies efficaces pour l'enseignement et l'apprentissage du français. Cette comparaison a plusieurs implications importantes, c'est-à-dire qu'elle permet de comprendre pourquoi les apprenants azerbaïdjanais rencontrent souvent des difficultés avec l'accord du participe passé en français. En effet, l'absence de catégorie grammaticale du genre dans leur langue maternelle les amène à sous-estimer l'importance de l'accord avec le COD ou le sujet. Notamment, pour l'enseignement du français langue étrangère, il devient crucial de mettre l'accent sur les règles syntaxiques et sur l'effet de la position des mots dans la phrase.

En outre, cette analyse souligne l'importance de la catégorie du genre dans la morphosyntaxe française. C'est-à-dire que le genre n'est pas seulement un trait morphologique, mais qu'il influence également la manière dont les locuteurs structurent la phrase et interprètent les rôles des participants dans l'action. Enfin, l'étude comparative enrichit notre compréhension de la relation entre la langue, la culture et la cognition, notamment en montrant que des structures grammaticales absentes dans une langue peuvent poser des défis pour les locuteurs d'une autre langue lorsqu'ils apprennent le français.

En azerbaïdjanais, les temps composés se forment de manière synthétique avec des suffixes verbaux et n'utilisent pas d'auxiliaires comme *avoir* ou *être*. Cependant, la valeur aspectuelle de résultat est comparable aux fonctions du participe passé français. Les apprenants azerbaïdjanais doivent comprendre que l'accord du participe passé est lié à la syntaxe et non à la morphologie seule. La comparaison avec l'azerbaïdjanais illustre les différences entre les systèmes analytiques et synthétiques, renforçant l'importance de l'enseignement explicite des règles d'accord pour les apprenants.

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SOCIAL AND POLITICAL CONDITIONS OF THE GERMAN DIASPORA IN KAZAKHSTAN (1930–1940)

Serikbay Mamraimov

Candidate of historical sciences, associate professor of the South Kazakhstan Pedagogical University named after Uzbekali Zhanibekov, Shymkent, Republic of Kazakhstan, orcid.org/0000-0003-3820-1513

Annotation: This article examines the social and political conditions of the German diaspora in Kazakhstan during the 1930s and 1940s, a period marked by profound transformations under Soviet rule. The study highlights the effects of collectivization, forced sedentarization, and repression on the German population, emphasizing the disruption of traditional agricultural systems and the emergence of social resistance. Archival sources, including NKVD reports and official documents, reveal the mechanisms through which Soviet authorities monitored, controlled, and suppressed the German communities, framing them as potential "anti-Soviet elements." The research also explores the demographic concentration of German settlements, their socio-economic organization, and the role of religious groups, which were often perceived by the state as ideological threats.

The article further analyzes the political and ideological pressures faced by the German diaspora, including accusations of maintaining foreign contacts, spreading anti-Soviet sentiments, and engaging with religious and charitable organizations abroad. The study demonstrates how these factors contributed to the systematic targeting of community leaders, religious figures, and economically influential groups, leading to arrests and widespread repression. By synthesizing archival data with historical research, the article provides a comprehensive understanding of the German diaspora's adaptation strategies, social dynamics, and the impact of Soviet policies on their communal life, shedding light on broader patterns of ethnic minority management in the USSR.

Keywords: Germans in Kazakhstan, Soviet policies, Collectivization, NKVD surveillance, Kulaks, Religious communities, Forced migration, Anti-Soviet resistance, 1930s repression, Ethnic minorities.

In the 1930s, the Soviet government implemented a large-scale socialist policy in Kazakhstan aimed at the mass collectivization of agriculture, the liquidation of kulaks as a class, and the eradication of wealthy feudal attitudes. These measures radically transformed the socio-economic structure of rural society and led to the collapse of traditional forms of economic organization. During this period of profound transformation, resistance from capitalist elements intensified, a phenomenon particularly evident in the German settlements.

To understand the political situation in Kazakhstan in the 1930s, the works of T. Omarbekov—who extensively studied the processes of collectivization and forced sedentarization—are of particular significance. Drawing on concrete archival materials, the researcher analyzes how collectivization destroyed the socio-economic framework. In his view, the groups accused of being

kulaks constituted part of the Soviet regime's mechanism for constructing a category of "social enemies" [1].

One of the most important and unique sources that elucidates the settlement history of Kazakhstan's Germans in the first half of the twentieth century—as well as the multifaceted aspects of demographic processes and social development—is the documentary collection *Iz istorii nemtsev Kazakhstana (1921–1975 gg.)*, compiled under the supervision of G. A. Karpykov. This volume presents, on the basis of archival documents and official materials, a comprehensive and systematic account of the reasons behind the migration of Germans to Kazakhstan, their experience of adaptation to a new environment, their social role within society, and the impact of political transformations on the fate of the ethnic community. The valuable data contained in this work provides an opportunity for an in-depth understanding of historical processes [2].

The results of an NKVD inspection conducted in July 1934 revealed that there were 5,867 German households within the territory of Kazakhstan. Most of these settlements were concentrated in the northern regions of the republic and were characterized by their close proximity to one another. The regional distribution of German settlements was as follows:

- Aktobe Region – 1,429 households in 20 localities across 7 districts;
- Karaganda Region – 2,563 households in 43 localities across 8 districts;
- East Kazakhstan Region – 1,500 households in 30 localities across 6 districts;
- South Kazakhstan Region – 375 households in 3 localities across 2 districts.

In total, 5,867 German households were registered across 96 settlements in Kazakhstan. These data clearly illustrate the territorial structure of the German diaspora in the 1930s, its settlement patterns, and the level of its social organization.

The formation of German settlements in the Kazakh region during the first half of the twentieth century was directly linked to Soviet socio-political transformations. According to archival data, approximately 2,000 German families were registered in the region during this period, of which 1,308 were concentrated in five special settlements in the Karaganda district. This group largely consisted of those who had been deported to Kazakhstan as a result of Soviet policies aimed at mass confiscation, the liquidation of "kulaks" as a class, forced resettlement, and the isolation of social groups deemed politically unreliable.

NKVD materials explain the political characterization of the German population through three main factors. One of these was the significant presence of kulaks within German settlements. This group included those who had evaded confiscation and deportation, as well as those who later joined collective farms and continued agricultural activity.

From the perspective of Soviet authorities, such circumstances were regarded as a potential threat, as they were believed to preserve an "anti-Soviet influence" within the rural environment. These assessments shed light on the political perceptions of ethnic groups held by state security institutions of the period, as well as on their mechanisms of surveillance and control.

Religion occupied a particularly prominent place in the social life of the German community in Kazakhstan. Various Protestant sects predominated among the Germans, and religious conservatism was closely intertwined with traditional customs and everyday practices. The Soviet government regarded this phenomenon as a "potential factor of ideological resistance," which prompted the intensification of surveillance over religious organizations.

According to NKVD documents describing the political and social structure of German settlements, it was particularly noted that the village councils contained very few Communist Party members, and in some localities there were no Komsomol members at all. This information was presented as evidence of the weak effectiveness of Soviet propaganda within the German community.

Soviet security agencies assessed anti-Soviet activities in German settlements during this period as having "reached the level of a mass movement." The causes of this situation were

attributed to the influence of special settlers; the sustained connections maintained by Germans who had relatives abroad; and attempts to establish contact with religious centers.

Historical research demonstrates that these movements within the German community also had objective socio-economic causes. In particular, the severe consequences of collectivization, mass confiscation, the collapse of household economies, and the threat of famine sharply worsened living conditions. These circumstances intensified migratory sentiments and pushed people to seek alternative solutions.

According to NKVD data, a movement to emigrate from the USSR to Germany became widespread among Kazakhstan's Germans in 1929. The Soviet authorities associated this phenomenon with the influence of foreign religious organizations, Protestant-sectarian centers, and external émigré propaganda. However, historical evidence also confirms that socio-economic hardships were a major contributing factor.

The rise of Hitler to power in Germany in 1933 further intensified Soviet policies of monitoring German settlements within the USSR. The Soviet authorities regarded correspondence with relatives in Germany, parcels sent through "charitable societies," and the influence of émigré propaganda as "potential channels for the spread of fascist ideology."

In the early 1930s, the Soviet administration strengthened its policy of strict surveillance over the German population in Kazakhstan. During this period, the NKVD undertook systematic measures aimed at identifying "counterrevolutionary organizations." As a result of special inspections and operational activities carried out in 1933–1934, NKVD documents began to assert the existence of "extensive clandestine anti-Soviet organizations" among the German population. Such conclusions laid the groundwork for large-scale political repression and contributed to the emergence of deep-seated mistrust toward the German community.

However, archival and historical evidence indicates that many individuals wrote to their relatives abroad simply to describe their genuine hardships—famine, confiscation, deportation, repression, and other severe difficulties. Soviet security agencies interpreted this correspondence as an attempt to "expand contacts" or "strengthen counterrevolutionary ties," thereby placing it under strict surveillance.

Following Hitler's rise to power in 1933, NKVD documents increasingly accused Germans in Kazakhstan of "spreading fascist agitation." The Soviet authorities viewed any form of indirect connection with Germany—letters from relatives, parcels, or German-language publications—as a potential threat.

NKVD materials also reported that some German residents allegedly disseminated statements such as "the Soviet Union is weakening" and "Germany is becoming stronger." Such remarks were automatically classified as counterrevolutionary activities and used as grounds for prosecution.

In reality, the majority of Germans in Kazakhstan were a peaceful rural population engaged primarily in agriculture and not inclined to participate in political organizations. However, within the Soviet political system, any expression of independent opinion—especially conversations based on foreign information—aroused suspicion and was interpreted as an "ideological threat."

As a result of operational measures conducted by the NKVD in August 1934, ten German groups were officially designated as "clandestine counterrevolutionary organizations," and forty-eight individuals were arrested on charges of being "the most active anti-Soviet elements."

These repressive actions continued on a broader scale in subsequent years, particularly during the period of the Great Terror in 1937–1938. Historical documents testify that hundreds of German citizens were arrested and persecuted without substantiated evidence.

NKVD records from the 1930s describe the activities of religious groups in German settlements, the influence of kulak elements, and attempts to maintain connections with foreign contacts as threats to state security. The special operations carried out in 1933–1934 document

in detail the composition of the repressed groups, their areas of residence, and the specific accusations brought against them.

According to NKVD materials from 1934, the individuals who were arrested were recorded in the following regions: Karaganda Region – 13 persons across 4 cases; East Kazakhstan Region – 22 persons across 3 cases; Aktobe Region – 4 persons in 1 case; South Kazakhstan Region – 7 persons in 1 case; and Almaty Region – 2 persons in 1 case. This statistical data clearly demonstrates the wide-scale nature of the operational measures undertaken in German settlements and the comprehensiveness of surveillance across all regions.

The primary targets of repression were the following groups: kulak elements; leaders of religious-sectarian organizations; and individuals allegedly involved in arranging foreign contacts described as “German assistance” or “aid from Hitler.”

The Soviet authorities regarded the connections of Protestant, Baptist, and other religious groups within the German community to foreign centers as a major “ideological threat.”

NKVD documents provide detailed statistical information regarding the social composition of those arrested: kulaks – 27 individuals; special settlers – 11 individuals; middle peasants – 6 individuals; “speculator elements” – 2 individuals; one office worker; and one poor peasant.

A particularly noteworthy fact is that 24 of the 48 detainees were leaders of German religious-sectarian communities. This clearly reflects the Soviet ideological view that regarded religious organizations as “anti-Soviet centers.”

During the investigations conducted in 1933–1934, the NKVD characterized the activities of the German population in Kazakhstan as fully constituting a “proven counterrevolutionary crime.” The charges were systematized along several key lines.

In NKVD documents, any correspondence with Germany was classified under the label “Hitlerovskaya pomoshch” (“Hitler’s aid”). Letters sent to relatives abroad or to German charitable organizations requesting assistance became one of the primary grounds for repression. The Soviet authorities interpreted such contacts as channels for foreign influence and as efforts to “strengthen anti-Soviet connections.”

Letters received from Germany, information sent by religious organizations, as well as accounts transmitted by German emigrants were recorded by the NKVD as “fascist agitation.” In reality, although much of this information was of a purely domestic nature, within the Soviet system of ideological control such contacts were interpreted as “channels for the spread of fascist influence.”

Complaints found in letters from German residents about harsh living conditions in special settlements—hunger, the intensification of labor obligations, and various forms of pressure—were classified by the NKVD as “slander” or “distortion of Soviet reality.” However, historical studies demonstrate that most of these reports accurately reflected the genuine circumstances that had emerged as a result of the agricultural crisis and the consequences of collectivization.

In NKVD investigative materials, international religious and charitable organizations were associated with “anti-Soviet activity.” Among them, the Baptist society Brockhaus, the Evangelical relief committee Brat’ia v nuzhde (“Brothers in Need”), the Fast & Co. society, and several other organizations were described as “ideologically dangerous groups” that maintained contacts with Soviet Germans.

The investigative records from 1933–1934 indicate that accusations such as “establishing contacts with Germany,” “serving fascist influence,” and “spreading false information” were widespread among cases involving the German population. The majority of these charges were based on: interrogation protocols prepared in advance, testimonies extracted under pressure, and the politicization of conversations of a purely domestic nature.

In addition, the NKVD accused German villages of lacking any substantive party or political work and claimed that local soviet officials had “fallen under the influence of hostile elements.”

This reflects the nature of the Soviet surveillance system, which directed repression not only against residents but also against the local administrative apparatus [1, pp. 681–686].

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DEVELOPMENT OF A MODEL FOR INTEGRATING ARTIFICIAL INTELLIGENCE INTO THE PROCESS OF TEACHING CASE TECHNOLOGIES

Gulzhan Mursakimova

Senior Lecturer of the Department of Information Technologies and artificial intelligence,
Zhetysu university named after I. Zhansugurov, Taldykorgan, Republic of Kazakhstan

Zaure Kanapyanova

Senior Lecturer of the Department of Information Technologies and artificial intelligence,
Zhetysu university named after I. Zhansugurov, Taldykorgan, Republic of Kazakhstan

Aybota Zhuman

4th year student of the educational program "Architecture of Information Systems"
Zhetysu university named after I. Zhansugurov, Taldykorgan, Republic of Kazakhstan

Adilet Quranbek

4th year student of the educational program "Foreign language:two foreign languages"
Zhetysu university named after I. Zhansugurov, Taldykorgan, Republic of Kazakhstan

This paper presents the development of a model for integrating Artificial Intelligence (AI) into the process of teaching case technologies. The integration of AI in education aims to enhance personalized learning, adaptive feedback, and decision-making in the learning process.

The study explores theoretical foundations, reviews current approaches, and proposes a structured AI-based model that supports teachers and students in the application of case technologies. The model emphasizes data-driven analysis, scenario generation, and intelligent evaluation. The implementation demonstrates improvements in engagement and learning outcomes, proving the potential of AI in modern education.

Keywords artificial intelligence, Case technology, interactive learning, digital education, problem solving, ethics, higher education.

Introduction

The rapid advancement of Artificial Intelligence (AI) has significantly impacted various sectors, including education. AI technologies such as machine learning, natural language processing, and intelligent tutoring systems are reshaping how educational content is delivered and how students interact with learning materials. In recent years, the concept of case technologies has become a valuable pedagogical approach, focusing on real-world problem-solving and analytical thinking. However, traditional case-based learning often lacks adaptability and individualized support. Therefore, integrating AI into the process of teaching case technologies offers a promising direction for enhancing efficiency and personalization.

This research aims to develop a model that effectively integrates AI into the teaching process based on case technologies. The proposed model is designed to provide educators with

tools for automating case creation, offering personalized feedback, and supporting student assessment through data analytics.

Literature Review

The literature on AI in education highlights its potential to transform learning environments. AI-powered systems can perform tasks such as predicting student performance, recommending resources, and automating grading. Studies by Anderson (2020) and Nguyen (2022) emphasize that AI-based adaptive learning improves student engagement and knowledge retention. Case technologies, on the other hand, rely on problem-based learning where students analyze practical scenarios and propose solutions. When combined, AI and case technologies create a hybrid learning ecosystem that blends human expertise with machine intelligence.

Prior research indicates that AI can facilitate case generation, automate scenario evaluation, and provide predictive analytics for case outcomes. However, few models focus on integrating AI systematically into the pedagogical structure of case-based education. This study fills that gap by proposing a comprehensive integration model.

Methodology

The research methodology combines qualitative analysis, system modeling, and prototype testing. The process involved three key stages: (1) analyzing educational case technology requirements, (2) designing an AI integration framework, and (3) implementing a pilot version in a controlled educational environment. Data was collected from 50 undergraduate students participating in information systems courses that employed case-based learning. Questionnaires and system logs were analyzed to evaluate the impact of AI tools on learning efficiency and motivation.

Proposed Model

The proposed model for integrating AI into the process of teaching case technologies consists of five key components:

1. Knowledge Database-containing domain-specific case studies and metadata.
2. AI Engine-responsible for natural language understanding, case generation, and feedback automation.
3. Learning Management Interface-connecting students and teachers through a digital platform.
4. Data Analytics Module- monitoring student activity and predicting outcomes.
5. Adaptive Feedback System- offering personalized recommendations based on performance.

This structure enables dynamic case creation and adaptive learning experiences. The AI Engine uses natural language processing to analyze student submissions and generate tailored feedback. The model supports both synchronous and asynchronous learning environments.

Implementation and Results

A prototype of the AI-integrated case learning system was implemented using Python-based machine learning algorithms and a web interface. Students interacted with the platform by solving case problems, receiving AI-generated hints, and submitting their reasoning for analysis. Results showed a 27% improvement in problem-solving accuracy and a 19% increase in student engagement compared to traditional methods.

Teachers reported that the AI system reduced manual grading workload by 40%, allowing more focus on qualitative feedback and student guidance. Statistical analysis confirmed the effectiveness of the model, with significant improvement in learning outcomes ($p < 0.05$).

Discussion

The integration of AI into case-based teaching offers substantial pedagogical benefits. AI not only automates routine processes but also enriches the learning experience through personalization. However, successful adoption requires proper teacher training, ethical

considerations, and continuous monitoring of algorithmic fairness. The proposed model demonstrates scalability and flexibility, applicable across various academic disciplines.

Conclusion

This study developed and validated a model for integrating Artificial Intelligence into the process of teaching case technologies. The results indicate that AI can significantly enhance the efficiency and quality of case-based education by providing personalized learning paths, intelligent feedback, and data-driven decision-making. Future research will focus on expanding the model's capabilities using deep learning and exploring its application in interdisciplinary education.

Theoretical Background of AI in Education

Artificial Intelligence (AI) in education represents a dynamic interdisciplinary field that merges computer science, cognitive psychology, and pedagogy. It is founded upon three essential pillars- machine learning, knowledge representation, and cognitive modeling- each of which contributes to the development of intelligent educational systems.

Machine learning (ML) forms the computational backbone of AI in education. Through algorithms that analyze large volumes of student data, ML models can predict learning outcomes, identify struggling learners, and recommend personalized interventions. For example, supervised learning algorithms can classify student responses, while unsupervised learning techniques such as clustering help group students according to learning patterns and preferences. Reinforcement learning further enhances adaptivity by allowing AI systems to optimize instructional strategies over time based on feedback and performance metrics.

Knowledge representation (KR) provides the structural framework that allows machines to interpret, reason, and manipulate educational content. It transforms instructional materials into digital formats that AI systems can process. Semantic networks, ontologies, and decision trees are common KR techniques that enable systems to map relationships between concepts. In case-based learning, KR allows AI to retrieve relevant past cases, compare them with current learning scenarios, and generate adaptive guidance for students.

Cognitive modeling, meanwhile, aims to replicate human reasoning and problem-solving behaviors within an artificial system. It leverages psychological theories of learning- such as constructivism and metacognition- to design systems that mimic how humans think, learn, and adapt. In educational settings, cognitive models are used to simulate student decision-making, enabling the system to anticipate errors and provide corrective feedback in real time.

In the context of case technologies, AI acts as a cognitive partner to both instructors and learners. It can emulate an instructor's reasoning process, identifying key variables, assumptions, and causal relationships within a given scenario. AI tools can dynamically generate alternative case paths, evaluate student solutions, and provide context-sensitive hints. By doing so, AI transforms case-based education from a static exercise into an adaptive, interactive, and data-informed learning experience.

The integration of these theoretical foundations underscores the potential of AI not as a replacement for educators, but as an enhancement of human teaching capabilities. Through continuous learning and contextual awareness, AI systems contribute to a more intelligent, equitable, and personalized educational ecosystem.

Model Architecture and Workflow. The proposed AI integration model for teaching case technologies is built on a multi-layered architecture designed to ensure modularity, interoperability, and scalability. Each layer performs distinct yet interconnected functions that collectively facilitate adaptive learning experiences. The architecture consists of four sequential layers:

Input Layer. This layer gathers essential data inputs required for the AI system to operate effectively. It collects information about students' profiles, learning objectives, progress histories, and available case studies. Inputs can include both structured data (e.g., numerical grades, quiz

results) and unstructured data (e.g., textual responses, discussion logs). The system uses these inputs to build a personalized learner profile that informs later AI-driven decisions.

Processing Layer. At this stage, the system applies AI algorithms to process and interpret the collected data. Natural Language Processing (NLP) techniques are used to analyze case descriptions, extract keywords, and understand student responses. Clustering algorithms group similar cases together based on thematic or performance similarities, allowing students to encounter diverse yet relevant problem contexts. This layer also supports sentiment analysis to assess student engagement and emotional states during interaction with digital case studies.

Decision Layer. The decision layer is the “intelligent core” of the model. Here, the system employs reasoning mechanisms and predictive models to generate actionable insights. It determines which cases best match each student’s skill level and learning goal, and it produces automated feedback that is both timely and context-aware. This layer also manages the recommendation system, suggesting future learning paths or additional materials to reinforce weak areas.

Output Layer. Finally, the output layer delivers the processed results to users—teachers and students—through an interactive Learning Management Interface. Personalized materials, feedback summaries, performance analytics, and case recommendations are presented in a user-friendly dashboard. This ensures that educators can make informed pedagogical decisions, while students receive targeted learning experiences.

The overall workflow of this model follows a continuous feedback loop. Data from each learning session is reintroduced into the system to retrain algorithms, ensuring that the AI evolves alongside learner needs. The architecture supports integration with popular Learning Management Systems (LMS) such as Moodle, Canvas, or Google Classroom via APIs (Application Programming Interfaces). This interoperability allows institutions to adopt the model without fully replacing their existing infrastructures.

In essence, this layered architecture not only facilitates the automation of case-based learning but also enhances human-AI collaboration within academic environments, promoting data-informed teaching and lifelong learning.

Ethical and Pedagogical Considerations. The incorporation of AI into educational processes introduces numerous ethical, social, and pedagogical implications that must be carefully addressed to ensure fairness, transparency, and trust in intelligent learning systems.

Data Privacy and Security. AI systems rely heavily on large datasets that often contain sensitive student information such as academic records, behavioral logs, and personal identifiers. Ensuring **data privacy** requires strict compliance with standards such as the General Data Protection Regulation (GDPR) and local data protection laws. Educational institutions must adopt encryption, anonymization, and secure storage mechanisms to safeguard this data from unauthorized access or misuse.

Algorithmic Bias and Fairness. Machine learning algorithms are only as unbiased as the data they are trained on. If the data reflects historical inequalities, AI systems can inadvertently perpetuate bias in assessments and recommendations. To mitigate this, developers must ensure dataset diversity, conduct regular audits of algorithmic decisions, and include human oversight in the evaluation process. Ethical AI design also involves creating transparent models where decision-making logic is explainable to educators and learners.

The Evolving Role of Teachers. AI does not replace the human educator; rather, it redefines their role. Teachers transition from being information transmitters to facilitators of learning who interpret AI insights and apply them pedagogically. In AI-enhanced case-based learning, instructors focus on higher-order thinking skills—such as analysis, synthesis, and evaluation—while AI systems handle data processing and routine feedback. This partnership between human and artificial intelligence creates a balanced learning ecosystem.

Pedagogical Integrity. While AI enhances efficiency, overreliance on technology can risk reducing human creativity and critical thinking if not managed properly. Pedagogical frameworks must prioritize student agency, encouraging learners to engage critically rather than depend entirely on algorithmic recommendations.

Thus, educators must design learning experiences that blend human judgment with AI-supported insights.

Transparency and Accountability. Students and teachers should have a clear understanding of how AI decisions are made. Transparency in algorithmic processes and system limitations fosters trust and ensures accountability. Institutions must implement ethical guidelines for AI deployment, including audit trails and opt-out options for learners uncomfortable with automated evaluation.

Conclusion

The development of a model for integrating Artificial Intelligence (AI) into the process of teaching case technologies represents a significant step toward transforming higher education through intelligent and adaptive learning. The study demonstrated that AI can effectively enhance traditional case-based methods by automating scenario generation, providing real-time personalized feedback, and supporting data-driven pedagogical decisions.

The proposed model-consisting of input, processing, decision, and output layers-creates a flexible and scalable framework for the integration of AI tools into case-based learning environments. Through the use of machine learning, natural language processing, and cognitive modeling, the system is capable of analyzing student behavior, predicting learning outcomes, and adapting educational content to individual needs.

Experimental results confirm that the AI-integrated model improves student engagement, analytical skills, and overall academic performance. Educators also benefit from reduced workload in routine tasks, allowing them to focus more on creativity, mentorship, and higher-order cognitive teaching.

However, the research also acknowledges the importance of addressing ethical and pedagogical concerns related to data privacy, algorithmic bias, and transparency. Sustainable AI adoption in education must be guided by principles of fairness, accountability, and inclusiveness.

In conclusion, the integration of Artificial Intelligence into the process of teaching case technologies has the potential to redefine the learning experience, creating a more interactive, adaptive, and efficient educational system. Future research should continue refining the model through advanced AI methods such as deep learning and multimodal analytics, expanding its application across various disciplines and educational contexts.

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МЕЖПРЕДМЕТНЫЕ СВЯЗИ ФИЗИКИ В ШКОЛЕ

Рахимбеков Айтбай Жапарович

к-ф-м.н., доцент, ассоциированный профессор «Жетысуского университета им.И.Жансугурова», Республика Казахстан, г.Талдыкорган

Раимбек Кайсар Шакенулы

магистрант ЖУ им.И.Жансугурова, Республика Казахстан, г.Талдыкорган

Аннотация: В статье представлены межпредметные связи физики которые, выполняют целый ряд функций — методологическую, образовательную, развивающую, воспитывающую и конструктивную. Показаны, что в рамках урока физики эти функции проявляются особенно ясно, поскольку физические модели, методы измерений и экспериментальные подходы позволяют учащимся увидеть единый научный фундамент различных областей знания.

Ключевые слова: фундаментальные, законы, эффект, модель, приборы, информация, системность, мышление, понятие, формирование.

Межпредметные связи являются важнейшим принципом обучения в современной школе. Благодаря им учитель совместно с педагогами других дисциплин решает широкий комплекс учебно-воспитательных задач. Такие связи активизируют познавательную деятельность учащихся, стимулируют их мыслительную активность при переносе, синтезе и обобщении знаний из разных областей науки.

Особенно ярко потенциал межпредметных связей раскрывается на уроках физики, которые занимают одно из ключевых мест в системе естественно - научных знаний. Физика изучает фундаментальные законы природы, поэтому она естественным образом интегрируется с математикой, информатикой, химией, биологией, географией, а также с историей, литературой и изобразительным искусством. Использование наглядности из смежных дисциплин, применение технических средств и цифровых технологий повышают доступность и осознанность усвоения физических понятий, процессов и закономерностей [1].

Межпредметные связи выполняют целый ряд функций — методологическую, образовательную, развивающую, воспитывающую и конструктивную. В рамках урока физики эти функции проявляются особенно ясно, поскольку физические модели, методы измерений и экспериментальные подходы позволяют учащимся увидеть единый научный фундамент различных областей знания.

В организации межпредметных связей важную роль играют как учитель, так и ученик. Учитель помогает учащимся раскрыть внутреннюю логику научных понятий, показывает, как знания из математики или химии расширяют понимание физических явлений и как физические законы объясняют процессы в биологии, географии и технике. Ученик, в свою очередь, осваивая физические закономерности, приобретает опыт самостоятельного поиска и применения знаний в различных ситуациях.

Межпредметные связи особенно эффективно проявляются в разнообразных видах деятельности учащихся:

- учащиеся привлекают факты и понятия из смежных дисциплин для расширения области применения изучаемых физических теорий;

- используют теории, изученные на других предметах, для объяснения физических явлений;
- применяют практические умения и навыки, полученные на уроках химии, биологии, информатики и других предметов, для получения новых экспериментальных данных в физике [2].

Использование межпредметных связей устраняет разобщённость школьных предметов и формирует у учащихся целостное представление о мире. Благодаря интеграции знаний каждый учитель получает возможность поддерживать интерес к другим дисциплинам, а не только к «своему» предмету. Это способствует тому, что знания учащихся становятся глубже, прочнее и осознаннее. На практике дети редко связывают разрозненные факты, которые сообщаются им в рамках разных предметов, и именно это мешает формированию полноценной научной картины мира. Большинство учащихся не всегда задействуют важнейшие интеллектуальные способности — умение сравнивать, анализировать, сопоставлять и классифицировать получаемую информацию. Из этого вытекают важные педагогические задачи:

- помочь учащимся усвоить совокупность фактов и явлений в их взаимосвязи и развитии, овладеть целостной научной картиной мира;
- преодолеть разобщённость школьных предметов, обеспечив их логическое взаимодействие;
- повысить интерес к учению и каждому учебному предмету через демонстрацию практических и содержательных связей;
- укрепить практическую направленность обучения, позволяя применять знания на практике и видеть их реальную пользу[3].

Особенно эффективно эти задачи решаются при изучении физики, поскольку она занимает ключевое место в системе естественных наук и обладает мощным интегративным потенциалом. Физика исследует фундаментальные законы природы — движение, взаимодействие, энергию, строение вещества, электрические и магнитные процессы. Эти законы лежат в основе всех естественно-математических и технических дисциплин. Поэтому связь физики с другими предметами не только естественна, но и необходима.

Связи физики:

- с математикой проявляются в использовании алгебраического и геометрического аппарата для анализа физических процессов: графиков, функций, производных, интегралов;
- с химией физика объединяется через изучение строения вещества, тепловых явлений, процессов ионизации, закономерностей химической кинетики;
- с биологией — через понимание биофизических процессов: электрических импульсов нервной системы, оптики зрения, механики движения живых организмов;
- с информатикой — через моделирование, обработку экспериментальных данных, программирование приборов и цифровых лабораторий;
- с географией — через изучение климатических явлений, геофизических процессов, работы приборов наблюдения за природой [4].

Даже гуманитарные предметы связаны с физикой: история науки помогает понять этапы развития технического прогресса, литература отражает научные идеи в культуре, а ИЗО и технология используют принципы оптики, механики и материаловедения.

Практическое значение физики в межпредметной интеграции заключается в том, что на её уроках учащиеся получают огромное количество практических навыков, которые применимы в разных учебных дисциплинах и реальной деятельности. Это отражается в:

- умении проводить измерения и обрабатывать экспериментальные данные;
- работе с лабораторным оборудованием и цифровыми датчиками;
- навыках построения графиков, таблиц, моделей;
- развитии пространственного и логического мышления;

- умении объяснять явления окружающего мира с позиции научных закономерностей.

Физика не только даёт теоретические знания, но и формирует исследовательскую культуру — умение наблюдать, делать выводы, проверять гипотезы, проводить сравнение и анализ. Эти навыки являются универсальными и востребованы в любой сфере обучения, что делает физику ключевым инструментом формирования межпредметных связей. Таким образом, укрепление межпредметных связей с опорой на физику позволяет не просто объединять школьные предметы, но и формировать у учащихся целостное научное мировоззрение, развивать интерес к обучению и обеспечивать практическую значимость знаний. Физика выступает фундаментальной дисциплиной, связывающей разные области науки и обеспечивающей глубокое, осмысленное и современное образование.

Благодаря своей фундаментальности и универсальности физика выполняет системообразующую роль среди естественных наук. Ее тематическое построение позволяет рассматривать каждую тему как отдельный узел целостной системы знаний, способствуя формированию научного мировоззрения учащихся и их способности понимать взаимосвязь всех природных процессов.

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Sociological Sciences

SOCIAL WELL-BEING OF OLDER PEOPLE AND OPPORTUNITIES FOR RECREATIONAL SPORTS IN URBAN SETTINGS

Assaubek S.S.

PhD student of the department of sociology and social work, al-Farabi Kazakh National University, Almaty, Kazakhstan

Abstract

This article examines the current state of recreational sport programmes available in urban areas of Kazakhstan that are designed to improve the well-being of older citizens. The study addresses a pressing issue: despite the proven benefits of recreational sport for healthy ageing, many older adults in Kazakhstan remain insufficiently engaged in such activities. A key barrier identified is the low level of public awareness, as a significant proportion of the population is not informed about existing governmental initiatives promoting physical activity among older adults. The article reviews demographic statistics related to the ageing population and analyses relevant state programmes aimed at improving their quality of life.

The findings suggest that increasing the visibility and accessibility of recreational sport initiatives is essential for expanding participation among older adults. Broader dissemination of information and wider geographical coverage of such programmes across Kazakhstan are necessary steps to integrate recreational sport into the daily lives of the elderly. Limited engagement in physical activity has implications for demographic policy, contributing to higher levels of morbidity and psycho-emotional stress among older citizens. Strengthening public outreach and programme implementation therefore represents an important pathway to enhancing active ageing and overall social well-being.

Keywords: recreational sport; older adults; state programmes; population.

Introduction

Population ageing has become a defining demographic trend worldwide, and Kazakhstan is no exception. According to national statistical data, the proportion of adults aged 60 and above continues to increase annually, with particularly rapid growth observed in major urban centers. This demographic transformation brings a wide range of social, physical, and psychological challenges that directly affect the quality of life of older adults. Ageing is commonly associated with a decline in physical functioning, deterioration of psycho-emotional well-being, and a reduction in the number of meaningful activities that can stimulate positive emotions and prevent psychosomatic illnesses. Contemporary gerontological research increasingly highlights that emotional suppression, loneliness, and the lack of social engagement are major contributors to health decline in later life, giving rise to interdisciplinary fields such as psychosomatic medicine.

In response to these challenges, many governments, including Kazakhstan, have developed programmes to promote active ageing. One important component of such initiatives is recreational sport defined as low-intensity, accessible physical activity such as walking, light exercise, gentle fitness, stretching, or group mobility sessions. Unlike competitive sports, recreational sport focuses on maintaining physical function, enhancing well-being, and fostering

social participation. In urban environments, where older adults tend to lead more sedentary lifestyles compared to rural areas, recreational sport becomes especially relevant. Rural residents generally experience higher daily physical activity due to agricultural work and traditional forms of livelihood, resulting in significant differences in health outcomes and psycho-emotional resilience between urban and rural older populations.

Despite the importance of active lifestyles for healthy ageing, older adults in Kazakhstan have not historically been engaged in regular physical activity. For decades, sport was not perceived as an essential component of everyday life for older generations due to cultural norms, limited accessibility, and the absence of early-life habits of physical activity. In many communities, especially in urban settings, engaging in exercise in public spaces was long viewed as inappropriate or culturally unconventional for older people. However, in recent years the situation has begun to shift. The government has increasingly prioritised active ageing policies, including recreational sport programmes, subsidised health courses, sanatorium vouchers, and the establishment of Centres for Active Longevity. These developments represent an important step towards fostering healthier, more socially integrated ageing in Kazakhstan. According to national statistics, Kazakhstan's demographic structure illustrates the scale of the policy challenge:

Table 1. Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan

Indicator	Value
Total population	20,333,530 (100%)
Older adults 60+	2,616,515 (13.2%)
Men 60+	1,031,051 (39.4%)
Women 60+	1,585,064 (60.6%)
Economically active adults 60+	308,300
Employment among men 60+	63.4%
Employment among women 60+	36.6%

Given this demographic context, ensuring opportunities for healthy and socially active ageing has become a national priority. However, despite the availability of state programmes, many older citizens remain unaware of recreational sport initiatives or do not participate in them due to informational, cultural, infrastructural or motivational barriers.

Research Problem

Although recreational sport has been demonstrated internationally to improve physical health, reduce social isolation, and support emotional well-being among older adults, its role in the urban context of Kazakhstan remains insufficiently studied. Existing national programmes have not yet achieved full reach or visibility, and little is known about how older adults perceive recreational sport or what barriers prevent their participation.

The aim of this study is to examine the role of recreational sport in enhancing the social well-being of older adults living in urban areas of Kazakhstan and to identify the key challenges and opportunities for integrating recreational sport into their daily lives.

Research Questions

1. How do older adults in Kazakhstani cities perceive recreational sport and its benefits for their physical, emotional, and social well-being?
2. What factors facilitate or hinder participation in recreational sport among urban older adults?
3. How do urban environments, cultural norms, and levels of awareness shape engagement with recreational sport programmes?

4. What policy and infrastructural measures are needed to expand access to recreational sport for older adults in Kazakhstan?

Significance of the Study. This study makes an important contribution to the growing international scholarship on active and healthy ageing by providing context-specific empirical evidence from Kazakhstan a region where research on recreational sport and social well-being among older adults remains limited. While global studies have demonstrated the physical and psychological benefits of recreational physical activity, far less is known about how such programs function in post-Soviet urban environments, where demographic ageing, urbanization, and cultural norms shape the lived experience of older adults in distinctive ways. The findings of this research extend existing theories of social well-being by demonstrating how recreational sport serves not only as a mechanism for improving physical health, but also as a catalyst for emotional resilience, social connectedness, and the restoration of meaningful social roles in later life. The study highlights the crucial role of Centers for Active Longevity as an emerging institutional innovation in Kazakhstan in providing structured, supportive, and socially rich environments that enhance social engagement and reduce isolation among older citizens. Furthermore, the research offers practical implications for urban policy, public health programming, and the development of age-friendly cities. By revealing the barriers associated with unequal access to infrastructure, low public awareness of recreational programs, and cultural perceptions of ageing, the study underscores the need for more inclusive and well-publicized initiatives that encourage physical activity among older adults. These insights can inform policymakers, municipal authorities, and social service providers seeking to design effective interventions aimed at improving quality of life and social participation in ageing urban populations.

Literature Review

A growing body of international research demonstrates that recreational physical activity is a critical determinant of physical, psychological, and social well-being in older adults. Across diverse contexts from structured community-based interventions to urban park programs and serious leisure sport evidence consistently shows that regular engagement in tailored physical activity improves metabolic health, enhances functional capacity, and contributes to overall quality of life. The reviewed studies provide a comprehensive multidimensional understanding of the mechanisms and outcomes through which physical activity contributes to healthy ageing among older adults.

Several investigations highlight the metabolic and physiological adaptations associated with lifestyle interventions combining nutrition and recreational exercise. Among adults with type 2 diabetes, recreational sports incorporated into a calorie-restricted diet induced significant gene expression changes related to muscle maintenance and inflammation regulation. The randomized clinical trial conducted by da Silva Soares et al. (2022) demonstrated reductions in atrophy-associated markers (ATROGIN-1 and MURF-1) and increases in IL-15 expression, suggesting that even moderate recreational training can promote anabolic and anti-inflammatory responses in ageing skeletal muscle. Complementary insights from Zinker (1999) further emphasize that regular physical activity contributes to improved cardiovascular function, enhanced glucose tolerance, and better lipid profiles among individuals with diabetes, underscoring exercise as a cornerstone of non-pharmacological management.

At the population level, physical activity patterns vary significantly across sociodemographic and regional contexts. Ibrayeva et al. (2025) reported that nearly 20% of Kazakhstani adults fail to meet WHO activity recommendations, with lower activity levels observed among women, older individuals, urban populations, and specific occupational groups. These disparities highlight structural and environmental barriers that limit engagement in physical activity, pointing to the need for targeted interventions. Laatikainen et al. (2019) extend the contextual understanding by demonstrating how walkability, transit accessibility, and mixed-use environments influence older

adults' walking behaviors. Their findings suggest that built environment characteristics exert both direct and indirect effects on mobility, operating through personal goals, perceived health, and motivational factors.

Intervention-based studies provide further evidence on the effectiveness of structured programs in promoting active living among older adults. The Groningen Active Living Model (GALM) has been extensively evaluated in the Netherlands. Six-month outcomes demonstrated significant increases in recreational sports activity, perceived fitness, and performance-based fitness among sedentary adults aged 55–65 (de Jong et al., 2006). Twelve-month follow-up further confirmed sustained improvements in recreational activity and certain fitness dimensions, although maintenance of broader lifestyle changes required additional behavioral support (de Jong et al., 2007). These results illustrate that structured, community-based programs are effective but require long-term continuity mechanisms to maintain behavioral gains.

In outdoor environments, recreational programs implemented in urban parks have shown strong psychosocial and functional benefits. Hakman et al. (2021) demonstrated that a six-month intervention including Nordic walking, stretching, and outdoor fitness exercises significantly improved emotional state, cognitive functions, physical working capacity, and quality of life indicators among sedentary older adults. Such findings reinforce the potential of low-cost, accessible interventions to promote health in ageing populations, particularly in settings where formal sports facilities may be limited.

The social and psychological dimensions of physical activity are further illuminated in studies focusing on serious leisure. Heo et al. (2018) explored pickleball participation among older adults and found that serious leisure engagement was strongly associated with subjective well-being, independent of financial status or loneliness levels. The intrinsic motivation, social connectedness, and skill development embedded in serious leisure activities contribute to positive affect and life satisfaction, providing a meaningful pathway for successful ageing.

Falls and injury prevention represent another critical area where physical activity demonstrates substantial impact. In a two-year randomized controlled trial involving 914 older women, Rikonen et al. (2023) found that combined supervised and self-directed exercise access reduced fall rates by 14.3% and fractures by 38%. These population-scale results indicate that even moderate-intensity community exercise programs can significantly reduce morbidity, enhancing safety and independence among older adults.

Physical activity must also be approached cautiously for populations with clinical vulnerabilities. Oliveira and Lawless (2011) emphasize the importance of individualized return-to-play recommendations for adult athletes with cardiac conditions. They argue that decisions must consider underlying pathology, procedural history, and potential interactions between exercise and cardiovascular performance. Although focused on adult athletes, the principles of risk stratification and tailored exercise prescriptions are highly relevant to ageing populations with chronic conditions.

Collectively, these studies demonstrate that recreational physical activity—whether walking, structured fitness programs, sports participation, or outdoor activities—exerts powerful benefits across metabolic, functional, emotional, and social domains of health in older adults. The evidence underscores the need for integrated, environment-sensitive, and socially grounded intervention strategies that address structural barriers, foster motivation, and promote sustainable engagement. As populations age globally, expanding access to inclusive recreational opportunities, improving urban design, and promoting health-enhancing physical activity across diverse settings represent essential components of public health strategies for healthy ageing.

Results and Discussion

The findings of the study indicate that the *Active Longevity Center* in Almaty plays a significant role in enhancing the overall well-being of older adults living in an urban environment. The primary

mission of this center is to improve the mental and psycho-emotional health of the elderly population, strengthen their social integration, and increase their engagement with the wider community. In addition, one of the strategic objectives of the center is to demonstrate positive behavioural and lifestyle models to the younger generation, positioning older adults as active contributors and role models within society.

The Active Longevity Center of Almaty pursues several key goals, including raising the overall cultural awareness of the community, reducing morbidity among older individuals, increasing the functional capacity and productivity of older citizens, and improving their quality of life through continuous participation in socially meaningful activities. The center regularly organises free marathons, leisure programmes, and a wide range of public events, all of which directly involve elderly residents of the city and encourage their sustained participation in community life.

The center offers an extensive set of services tailored specifically to the needs of older people. These include social and health-related services, social and educational services, social and household assistance, social and economic support, social and psychological counselling, social and legal assistance, social and cultural programmes, and social and labour-oriented services. This multidimensional service provision reflects a comprehensive approach to ageing, acknowledging that the well-being of older adults depends not only on medical support but also on continuous opportunities for learning, socialisation, cultural engagement, and participation in meaningful activity.

A notable trend identified in the functioning of such centers is the clear improvement in the emotional and psychological states of participants. After consistent socialisation with peers and the broader public, older adults report experiencing significantly reduced levels of anxiety, lower feelings of loneliness, and a noticeable increase in positive emotions and joyful experiences. Many also describe a diminished sense of fear and a reduced risk of developing mental-health problems. These observed outcomes demonstrate that regular interaction with the community produces a strong protective effect on the psychosocial well-being of elderly individuals. Ultimately, any form of structured social engagement, when sustained over time, contributes to enhanced resilience and improved overall life satisfaction.

Within this broader context, *recreational sport* emerges as one of the most effective mechanisms for improving the quality of life in later adulthood. Moderate, regular physical activity aimed at health maintenance, social interaction, and leisure has been shown to be particularly beneficial for older adults. In urban settings, the development of recreational sports for the elderly is not only a public health initiative but also an important component of social policy, reflecting national priorities in promoting active ageing and preventing social isolation.

Conceptualisation of Recreational Sport

Recreational sport encompasses forms of physical activity that prioritise health, rest, and recovery rather than competitive achievement. For older adults, typical forms of recreational sport include:

- Nordic walking
- Yoga and Pilates
- Group therapeutic exercise sessions
- Recreational swimming
- Dance-based fitness classes
- Cycling and walking in parks

These activities support the maintenance of mobility, improve balance and coordination, strengthen the cardiovascular system, and provide structured opportunities for communication and interpersonal interaction. As such, recreational sport functions simultaneously as a health-promoting tool and a mechanism of social integration.

Urban Environment and Accessibility

The degree to which older adults can engage in recreational sports is strongly shaped by the characteristics of the urban environment. The availability of parks, safe pedestrian areas, outdoor exercise equipment, accessible sports facilities, and community centers significantly influences participation rates. However, many cities still lack infrastructure specifically adapted to the needs of older adults, which can limit their ability to engage in regular physical activity. Equally important is the presence of free or subsidised programmes designed for the elderly, as financial accessibility remains a critical factor for many retirees.

A substantial body of empirical research demonstrates that regular physical activity is positively correlated with high levels of subjective well-being among older adults. Participation in recreational sport has been shown to enhance:

- self-esteem
- social capital and social connectedness
- cognitive functioning
- psychological resilience
- overall health and reduced reliance on healthcare services

In this context, recreational sport contributes to a strong sense of belonging within the community and reinforces older adults' perceptions of their own social value. This is particularly important after retirement, when individuals often face challenges related to role loss, social withdrawal, and decreasing levels of external engagement.

Overall, the results of the study demonstrate that integrating recreational sport into the everyday routines of older adults living in megacities such as Almaty significantly enhances their physical, emotional, and social well-being. The combination of structured recreational programmes, accessible urban infrastructure, and the comprehensive support provided by the Active Longevity Center forms a holistic model of active ageing that aligns with international best practices and the broader global agenda on healthy ageing.

Furthermore, the study demonstrates that recreational sport constitutes a critical resource for the sustainable development of urban social policy in the context of population ageing. Its full potential can be realised only when several key conditions are met:

1. Integration of active ageing principles into municipal planning, ensuring that city-level strategies prioritise mobility, health promotion, and social participation for older adults.
2. Development of accessible and safe urban infrastructure, including age-friendly public spaces, adapted sports facilities, secure walking areas, and easily reachable community centres.
3. Strengthening of motivational mechanisms through educational and awareness-raising programmes, which help older adults understand the importance of regular physical activity and encourage continuous engagement.
4. Support for sociocultural and volunteer-based initiatives, which expand opportunities for social involvement, foster intergenerational interaction, and reinforce the sense of belonging among older residents.
5. Training and professional development of specialists working with the elderly, including social workers, instructors in adapted physical activity, psychologists, and cultural facilitators.

Taken together, these conditions point to the importance of developing an inclusive urban environment that actively stimulates the participation of older adults in recreational practices. Such an environment contributes not only to improving their individual quality of life but also to enhancing the overall social resilience and cohesion of the urban community. The emphasis on urban areas is particularly significant. As previously noted, in rural settings specifically in small settlements and *aul* communities older adults tend to be more physically active and more socially engaged. Their everyday routines are closely connected to continuous physical activity, household labour, and high levels of informal social interaction with neighbours and relatives. The prevalence of private houses and open communal spaces naturally facilitates socialisation, movement, and

participation in daily tasks, thereby producing health-protective effects. In contrast, elderly residents living in large cities often experience reduced mobility, limited social contact, and higher risks of isolation due to the structure of urban housing, the pace of city life, and barriers in the built environment. For this reason, state policy places strong emphasis on creating favourable conditions within major urban centres that would enable older adults to lead an active lifestyle, maintain meaningful communication with the community, and monitor their psycho-emotional well-being. However, an important limitation must also be acknowledged. Despite the relatively high level of social activity observed in rural areas, many *aul* communities still lack adequate educational services and programmes aimed at improving psycho-emotional health. This gap underscores the necessity of ensuring that small settlements and remote districts are not overlooked when designing national strategies for healthy and active ageing. Improving service provision in these localities is essential for reducing inequalities between urban and rural populations and for promoting equitable opportunities for older adults across the country.

Successful Practices in Kazakhstan

The study identifies several successful practices already implemented in various cities across Kazakhstan that aim to increase the participation of older adults in recreational sport. These initiatives demonstrate the growing institutional and community-level commitment to supporting active ageing, especially in the aftermath of the COVID-19 pandemic, which significantly intensified physical and psychological vulnerability among the elderly population. The analysed programmes pursue a range of interrelated goals:

1. Overcoming physical and psychological barriers that prevent older adults including those with disabilities from maintaining full and active lives, particularly during and after the pandemic period.

2. Gradual physiological adaptation to physical activity conducted at home, enabling safe and sustainable engagement in movement even in conditions of restricted mobility.

To achieve these goals, the programmes set several specific objectives:

1. Mastering sets of exercises beneficial for health, taking into account chronic conditions and the limited space available in home environments.
2. Increasing functional capacity, ensuring that older adults train in accordance with their age, disability status, and medical conditions.
3. Developing physical qualities along with essential motor skills, enabling participants to maintain independence in everyday life.
4. Teaching methods of self-monitoring, such as controlling physical workload and evaluating individual indicators of physical development and fitness.
5. Cultivating volitional qualities and interest in regular physical activity, with particular emphasis on continuity and motivation in home-based sports.
6. Fostering a conscious and responsible attitude toward personal health, helping older adults better understand the long-term benefits of physical activity.

Structure and Methodology of the Programme.

The programme is designed to improve the health of older adults through modern exercise methodologies, components of breathing practices, and other low-intensity techniques. Walking particularly brisk walking is strongly recommended, since high-strength or high-impact exercises are contraindicated for beginners and may pose health risks. Therefore, all activities start with low-intensity formats and progress gradually in accordance with participants' capabilities. Sessions are conducted based on the physical potential of each participant. Online classes include both theoretical and practical elements related to the use of adaptive physical activity in daily routines. Before the start of each session, preparatory techniques breathing exercises, elements of meditation, and self-massage of biologically active points are used to help participants prepare for the upcoming load. During the sessions, exercises for the upper and lower limbs and for the

torso alternate systematically, starting with small muscle groups and gradually involving larger ones. Particular attention is paid to relaxation techniques combined with breathing exercises. The programmes strongly prohibit maximum loads, excessive fatigue, straining, abrupt movements, sudden turns, bending, or accelerations. The final part of each session aims to gradually restore bodily functions, reduce possible fatigue, and maintain a stable positive emotional state. This is achieved through the use of low-intensity movements with small amplitude, relaxation techniques, breathing exercises, and simple dance elements. The total duration of therapeutic physical training should not exceed 50–60 minutes per day.

Examples of Municipal Activities. Several Kazakhstani cities have already introduced regular recreational initiatives for older adults in cooperation with social and health institutions. As shown in Table 2, major Kazakhstani cities are increasingly implementing structured programmes aimed at promoting physical and social activity among older adults.

Table 2. Municipal Recreational Sport Initiatives for Older Adults in Almaty and Astana

City	Examples of Recreational Sport Initiatives
Almaty	• Free Nordic walking classes in the First President Park. • “Health Clubs” operating at municipal polyclinics, offering structured fitness and preventive programmes.
Astana	• Winter programmes such as cross-country skiing and ice skating in the Barys Arena. • The “Sport for All Ages” project supported by the city administration. • Therapeutic exercise groups affiliated with nursing homes and care facilities. • Tournaments in board games (chess, backgammon) serving cognitive and socialisation purposes.

The comparison presented in Table 2 illustrates that both Almaty and Astana have developed a diverse set of recreational initiatives tailored to the needs of elderly residents. While Almaty emphasises outdoor group activities such as Nordic walking and health-oriented clubs at polyclinics, Astana expands opportunities through both winter sports and indoor community programmes. Together, these initiatives demonstrate a growing municipal commitment to supporting active ageing through accessible, socially oriented, and health-enhancing recreational practices.

Over the past five years, Kazakhstan has witnessed an active expansion of recreational sport among the elderly population, particularly in forms of low-intensity, accessible physical activity. This development reflects a growing national commitment to promoting healthy ageing; however, a substantial proportion of older adults still remains uninvolved in any form of systematic sport. Despite observable progress, the empirical evidence continues to highlight several critical challenges that limit broader participation.

One of the key issues is the low level of involvement in physical activity. According to national statistics for 2021–2022, individuals of pension age constituted only 1.7% of the population systematically engaged in physical culture and sport. This low rate of participation indicates significant underrepresentation of older adults in Kazakhstan’s sport sector. Another challenge is the high prevalence of physical inactivity. Data from the World Health Organization show that the prevalence of hypodynamia among the adult population in Kazakhstan reached 28.2% in 2022, exceeding the global average. Such indicators underscore the urgency of promoting physical activity as a public health priority.

The results of the study also demonstrate that many older adults remain insufficiently informed about available recreational programmes and community activities. Limited awareness significantly reduces participation, as seniors may simply not know about free municipal events or

state-supported initiatives designed specifically for them. Furthermore, financial barriers hinder access to paid sanatorium and rehabilitation services, which offer important physical and emotional benefits but are unaffordable for many retirees. In response, the state has expanded the provision of free recreational and health-oriented programmes aimed at supporting socially vulnerable older adults.

In this context, recreational sport emerges as an effective and accessible means of maintaining physical and psycho-emotional well-being. Unlike professional sport, recreational activities are not aimed at competitive performance but rather at restoring vitality, preventing disease, improving overall well-being, and promoting social integration. Recreational sport is particularly well suited for older adults, whose age-related physiological changes require gentle, adaptive, and low-impact forms of physical activity. Popular recreational activities for seniors include Nordic walking, wellness gymnastics, yoga, Pilates, therapeutic exercise, swimming, dance-based programmes, and breathing practices. These forms of activity improve coordination and flexibility, enhance cardiovascular function, regulate blood pressure and metabolism, and contribute to overall physiological resilience.

The influence of recreational sport extends beyond physical health. Regular moderate exercise slows ageing processes, reduces the risks of chronic diseases such as diabetes, osteoporosis, and hypertension, and maintains mobility an essential condition for independent living in later life. Recreational sport also has significant benefits for psycho-emotional and social well-being. Participation in group activities helps older adults expand their social networks, overcome loneliness and isolation, and develop a more positive outlook on life. Group-based formats create stable social connections and foster a strong sense of belonging to the community.

In urban environments, the importance of recreational sport becomes even more pronounced. Older adults living in large cities often experience mobility constraints, limited access to appropriate infrastructure, and higher risks of social isolation. Therefore, the development of age-friendly urban environments including well-maintained parks, open sports facilities, community leisure centres, and accessible transportation becomes a key prerequisite for the successful implementation of active ageing policies. Kazakhstan has made considerable progress in this direction: Active Longevity Centers, municipal health clubs, and NGO-supported initiatives provide older adults with structured opportunities for engagement in physical and social activities. Nordic walking, breathing practices, and adaptive physical culture have become particularly popular components of these programmes.

Despite these positive developments, several persistent challenges continue to hinder the full-scale expansion of recreational sport among seniors. These include low public awareness of the benefits of physical activity, cultural stereotypes suggesting that sport is unsuitable for the elderly, and disparities in access to infrastructure especially in rural areas, where specialised programmes and facilities remain limited.

To ensure effective progress, systemic and coordinated measures are essential. These include the organisation of free and accessible training sessions, the preparation of qualified specialists trained to work with older adults, large-scale information campaigns designed to motivate seniors to adopt an active lifestyle, and intersectoral cooperation between the healthcare, education, sports, and social protection sectors. Collectively, these measures can contribute to the formation of a comprehensive national system oriented toward active, healthy, and dignified ageing, ultimately improving the quality of life for older adults throughout Kazakhstan.

Conclusion

The results of this study demonstrate that recreational sport plays a critical and multidimensional role in enhancing the social well-being of older adults living in urban environments in Kazakhstan, thereby fully addressing the research questions that guided the

investigation. The findings reveal that older adults perceive recreational sport as an accessible and meaningful form of physical activity that contributes to improvements in physical health, emotional stability, and social engagement. Participants consistently reported reductions in anxiety and loneliness, enhanced mood, and an increased sense of belonging, indicating that recreational sport is understood not only as a health practice but also as an important source of social connection and psychological resilience. These outcomes directly answer the question of how older adults themselves view the benefits of recreational sport in their daily lives.

The study also clarifies which factors either facilitate or hinder the participation of older adults in recreational sport. The accessibility of supportive institutions such as Centers for Active Longevity, health clubs, public parks, and municipal programmes was found to strongly encourage engagement, while barriers included low levels of public awareness, financial constraints, entrenched cultural norms regarding ageing, and inadequate age-friendly infrastructure. Through these findings, the research question concerning enabling and limiting factors is fully addressed, showing that participation is shaped by a complex interaction of informational, structural, cultural, and motivational conditions.

The analysis further demonstrates that the urban environment itself, alongside cultural perceptions and awareness levels, plays a decisive role in shaping participation. Older adults living in cities experience both unique opportunities and specific constraints: while urban areas offer organised programmes, recreational spaces, and social services, they also present challenges such as reduced mobility, social isolation, and infrastructural limitations. Moreover, historically rooted cultural attitudes have influenced the belief that physical activity is “inappropriate” for older adults, although these perceptions are gradually changing with the expansion of active ageing policies. This evidence responds directly to the research question on the influence of environmental and cultural contexts.

Finally, the study identifies a range of necessary policy and infrastructural measures to improve and expand access to recreational sport. These include integrating active ageing principles into city planning, developing safe and inclusive urban infrastructure, increasing the visibility of recreational opportunities, strengthening motivational and educational campaigns, and preparing qualified specialists to work with older adults. Such recommendations are grounded in the empirical findings and directly address the final research question regarding how access to recreational sport can be improved at the national and municipal levels.

In summary, the study confirms that recreational sport is a powerful and accessible strategy for promoting physical, emotional, and social well-being among older adults in Kazakhstan’s urban settings. It functions as an essential mechanism of healthy ageing, social integration, and emotional resilience. By revealing how older adults perceive recreational sport, what factors shape their participation, how urban and cultural contexts influence their engagement, and what measures are required to expand accessibility, this research comprehensively answers all the research questions posed in the study. The findings underscore the need for systemic, coordinated, and inclusive policies that promote active ageing and ensure that recreational opportunities become a normal, accepted, and accessible part of life for Kazakhstan’s ageing urban population.

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CONCEPTUAL APPROACHES TO STUDYING DIGITAL RELIGIOUS IDENTITY: A FOCUS ON MUSLIM WOMEN

Umbet R.S.

PhD student, Department of Sociology and Social Work, al-Farabi Kazakh National University, Almaty, Kazakhstan

Abstract

This article examines how Muslim women construct, negotiate, and perform their religious identities in digital environments by synthesising four major theoretical traditions: religious identity theory, social identity theory, digital religion studies, and digital ethnography. Despite increasing scholarly attention to digital Islam, research on Muslim women's online religiosity remains conceptually fragmented. This study offers an integrated theoretical framework that explains digital religious identity across three analytical levels: personal meaning-making, collective belonging, and digital mediation and four core mechanisms: symbolic articulation of faith, social positioning and boundary-making, platform-shaped identity, and embodied performative practice. The proposed conceptual model demonstrates that digital religious identity is a dynamic, relational, and technologically mediated process shaped by the interaction of individual agency, communal expectations, and platform infrastructures. A unified SWOT analysis further clarifies the strengths, limitations, and complementarities of each theoretical tradition, revealing the potential for developing a coherent meta-theoretical foundation for future research. This study contributes to the field of digital religion by offering a comprehensive conceptual lens for understanding Muslim women's digital self-representation and outlining directions for interdisciplinary and intersectional research on contemporary online religious expression.

Keywords: muslim women; digital religious identity; digital religion; religious identity theory; social identity theory.

Introduction

The rapid digitalisation of everyday life has transformed how individuals construct, express, and negotiate their religious identities. Over the past decade, social media platforms have become significant sites of meaning-making, self-presentation, and religious engagement, particularly for Muslim women, who often face unique sociocultural constraints and expectations in offline environments (Piela, 2010; Piela, 2021). As a result, digital spaces enable Muslim women not only to articulate personal beliefs but also to form transnational communities, participate in religious discussions, and renegotiate gendered religious norms (Bunt, 2018; Shirazi, 2012). Research within digital religion demonstrates that online environments reshape religious authority, ritual practice, and identity construction (Campbell, 2013). However, empirical and conceptual studies emphasise that women experience these processes differently from men due to intersecting structures of gender, religiosity, and cultural symbolism (Bayat, 2013). For Muslim women in particular, online communication often becomes a space for negotiating contested issues such as modesty, visibility, piety, agency, and self-representation (Piela, 2021; Shirazi, 2013). These practices demonstrate how digital platforms allow Muslim women to reframe normative religious discourses, challenge stereotypes, and develop hybrid identity strategies. Despite growing international interest in digital Islam and online Muslim identities, the theoretical

and methodological foundations of studying *digital religious identity* remain underdeveloped. Scholars note the need to refine conceptual approaches that link digital communication theories with classical identity frameworks, including symbolic interactionism, feminist media studies, and theories of mediated religious experience (Campbell, 2021; Bunt, 2018). Furthermore, research increasingly highlights that the digital self-representation of Muslim women cannot be understood outside broader social power structures, including geopolitical narratives, algorithmic visibility, and public debates on Islam and gender (Shirazi, 2013). Therefore, a conceptual examination of how Muslim women construct and negotiate their religious identities in digital environments is both theoretically significant and socially relevant. It allows researchers to understand how digital platforms shape contemporary religious subjectivities, how gendered religious expression is transformed through new media, and how Muslim women actively participate in producing new forms of Islamic discourses online.

The aim of this study is to synthesise and critically evaluate key conceptual approaches to understanding how Muslim women construct and negotiate their religious identities in digital environments, drawing on theoretical perspectives from religious identity theory, social identity theory, digital religion studies, and digital ethnography.

RQ1: *How do conceptual frameworks from religious identity theory, social identity theory, digital religion studies, and digital ethnography explain the ways in which Muslim women construct and perform their religious identities online?*

RQ2: *What theoretical mechanisms and interpretive models best capture the hybrid, mediated, and context-dependent nature of digital religious identity among Muslim women?*

Significance of the Study. This study is significant for several reasons. First, it addresses the growing need for theoretical clarity in research on digital religious identity, a rapidly expanding but still conceptually fragmented field. While numerous empirical studies examine online practices of Muslim women, the lack of consistent conceptual frameworks limits the comparability and generalisability of findings. By integrating perspectives from digital religion studies (Campbell, 2013), feminist media research (Piela, 2015), and theories of mediated identity, this work contributes to the development of a more coherent theoretical foundation. Second, the study advances scholarly understanding of how digital technologies reshape gendered religious expression. Muslim women often encounter cultural constraints in offline environments, making online spaces particularly meaningful for self-representation, community-building, and the negotiation of religious norms (Shirazi, 2013; Piela, 2010). Clarifying the conceptual mechanisms behind these processes provides important insights into the intersection of gender, religiosity, and digital culture. Third, the research has broader social relevance. As digital platforms increasingly shape public perceptions of Islam and Muslim women, understanding the dynamics of online religious identity becomes crucial for addressing issues of representation, visibility, and social inclusion. This theoretical exploration thus informs both academic debates and public discourse surrounding digital Islam, gender equality, and religious pluralism.

Research Methods

The methodological foundation of this study is based on conceptual and analytical approaches that allow for a comprehensive understanding of the theoretical frameworks used to examine the digital religious identity of Muslim women. Since the purpose of the article is to analyse and synthesise key conceptual perspectives rather than conduct empirical fieldwork, the research methods focus on theoretical interpretation, comparative analysis, and the critical examination of existing scholarly work within four major traditions: religious identity theory, social identity theory, digital religion studies, and digital ethnography. The primary method employed is conceptual-theoretical analysis, which involves a close reading and systematic interpretation of how religious identity is defined, operationalised, and understood within academic discourse. This approach makes it possible to identify the ways in which researchers conceptualise religious

identity as a dynamic, socially embedded, and context-dependent process (Beckford, 2003; Day, 2011), and to trace how these interpretations apply to the digital practices of Muslim women. Conceptual analysis also reveals how online religious expressions acquire both personal and public significance, including visual, textual, and ritualised forms of self-representation, such as the citation of sacred texts or the display of religious dress.

Complementing this, the study applies a comparative-analytical approach to examine the intersections between religious identity theory and social identity theory (Tajfel, 2004). This method enables the exploration of how Muslim women construct their identities simultaneously as members of religious communities and as actors within broader digital publics, where their practices may be interpreted through lenses of cultural otherness or stereotyping. Comparative analysis helps to identify recurring concepts in the literature related to belonging, boundary-making, solidarity, and exclusion, and to understand how these social mechanisms operate within online communication.

A further methodological layer is provided by the analytical use of Digital Religion Studies (Lövheim, 2017; Bunt, 2018), which conceptualises religion as a hybrid phenomenon shaped by both offline and online contexts. This approach facilitates the interpretation of scholarly work addressing digital religious practices such as modest fashion narratives, Islamic lifestyle content, online sermons, and participation in virtual religious communities. It also highlights how media affordances, platform norms, and algorithmic dynamics influence the visibility and representation of Muslim women's digital religious expression.

Finally, the study incorporates digital ethnography as an analytical lens, which is not applied as empirical fieldwork but as a framework for interpreting publications that investigate the everyday digital practices of users (Pink, 2015). This perspective helps to understand how researchers describe embodiment, performativity, interaction, and contextuality within digital religious practices on platforms such as Instagram and TikTok. Digital ethnography thus provides a valuable lens for evaluating the methodological contributions, strengths, and limitations of qualitative online studies focusing on Muslim women's religious identities. Taken together, conceptual analysis, comparative interpretation, digital religion perspectives, and the analytical application of digital ethnography form a coherent methodological basis for this study. This combination of approaches offers a comprehensive understanding of how Muslim women's religious identities are constructed, articulated, and negotiated in digital spaces, while also enabling a critical synthesis of existing scholarly approaches to the study of online Muslim identity.

Results and Discussion

The analysis of the four theoretical traditions religious identity theory, social identity theory, digital religion studies, and digital ethnography led to the development of an integrated Conceptual Model of Digital Religious Identity Formation among Muslim Women. This model synthesises how identity is constructed, negotiated, performed, and mediated in digital environments. The results demonstrate that digital religious identity is shaped simultaneously at three analytical levels and through four core mechanisms, each corresponding to one of the theoretical frameworks examined. The analysis of the four theoretical traditions made it possible to develop an integrated conceptual model describing how Muslim women construct, negotiate, and perform their religious identities in digital environments. This model, summarised in Table 1, includes three analytical levels and four core mechanisms that together explain the dynamic, relational, and technologically mediated nature of digital religious identity. The table provides a structured synthesis, followed by a detailed interpretation of each element.

Table 1. Integrated Conceptual Model of Digital Religious Identity Among Muslim Women

Analytical Level / Mechanism	Derived From	Core Components	Key Findings for Muslim Women Online
Personal-Meaning Level	Religious Identity Theory	Individual belief; moral agency; selective visibility; personal piety	Digital environments amplify individual agency, allowing women to reinterpret and articulate faith on their own terms.
Group-Belonging Level	Social Identity Theory	In-group belonging; symbolic boundaries; stereotyping; collective recognition	Online spaces intensify processes of boundary-making, solidarity, community-building, and marginalisation.
Digital-Mediation Level	Digital Religion Studies + Digital Ethnography	Platform norms; algorithmic visibility; visual cultures; performativity	Identity becomes hybrid and co-produced by user intentions and technological affordances.
Symbolic Articulation of Faith	Religious Identity Theory	Quranic citations; visual markers; modest fashion; ritual expressions	Everyday faith becomes communicable through curated visual and textual signs.
Social Positioning & Boundary-Making	Social Identity Theory	Inclusion/exclusion; categorisation; stereotyping; audience interaction	Digital publics reinforce both supportive and discriminatory reactions shaping identity work.
Mediatization & Platform-Shaped Identity	Digital Religion Studies	Hashtags; short-form video; filters; platform visibility structures	Religious self-representation is shaped by platform infrastructures and media logics.
Embodied & Performed Practices	Digital Ethnography	Embodiment; gestures; spatial settings; micro-interactions	Digital religious identity is enacted physically through visual, spatial, and performative cues.

The conceptual model presented in Table 1 demonstrates that digital religious identity among Muslim women is not a single-layered phenomenon but a complex interplay of personal, social, and technological dimensions. The *personal-meaning level* highlights how online spaces allow women to articulate their faith beyond institutional expectations. Rather than presenting fixed or rigid forms of religiosity, the digital sphere becomes a site of continuous renegotiation. Muslim women selectively disclose aspects of belief, reinterpret symbols of modesty, and present piety in ways that reflect individual agency. This finding aligns with research suggesting that digital platforms support personalised forms of religious interpretation.

The *group-belonging level* provides insight into how Muslim women navigate communal expectations and social perceptions simultaneously. Digital identity becomes a form of collective negotiation: women connect with supportive Muslim communities while also managing the gaze of non-Muslim audiences. This dual visibility amplifies processes of self-categorisation, symbolic boundary-making, and identity regulation. The model shows that social identity theory is crucial

for understanding how feelings of belonging, recognition, and vulnerability operate within digital environments. It also highlights the emergence of new Muslim female publics online.

The *digital-mediation level* reveals that identity is co-produced by technological infrastructures. The model shows that religious expression online is not only a matter of belief or community but also a function of platform architectures algorithms, visual formats, interface design, and modes of participation. Muslim women's religious identities become hybrid constructions shaped both by self-presentation choices and by the affordances of platforms like Instagram, TikTok, and YouTube. Thus, mediatization is not peripheral it is central to the identity process.

The *four mechanisms* show *how* these levels interact in practice.

1. Symbolic articulation of faith structures how everyday religious practices transform into communicable digital signs images, captions, modest fashion aesthetics, or short video testimonies.

2. Social positioning and boundary-making explain how digital publics shape identity work through recognition, stereotyping, and community interactions.

3. Mediatization and platform-shaped identity demonstrate that religious visibility is strongly shaped by algorithmic cultures, trending aesthetics, and platform vernaculars.

4. Embodied and performed practices indicate that religious identity online is deeply physical: gestures, outfits, spaces, voices, and camera angles become crucial elements of meaning-making.

Overall, the integrated conceptual model shows that digital religious identity is fluid, relational, embodied, and technologically mediated. It emerges at the intersection of individual meaning-making, collective belonging, and platform ecologies. This model provides a robust analytical foundation for understanding Muslim women's online religious practices and offers a theoretically coherent framework for future empirical and conceptual studies in digital religion and identity research.

Building upon the integrated conceptual model, the next step is to examine how the four theoretical traditions religious identity theory, social identity theory, digital religion studies, and digital ethnography relate to each other when applied to the study of Muslim women's digital religious identity. While each approach offers unique analytical strength, their explanatory power varies across different dimensions of identity formation. A systematic comparison of these frameworks makes it possible to identify where they converge, where they diverge, and what theoretical blind spots remain. This conceptual comparison further clarifies the intellectual landscape of digital religion research and reveals the potential for deeper theoretical integration. To assess the strengths, limitations, and complementary value of the four conceptual traditions, a comparative SWOT model was developed. **Figure 1** summarises the major strengths, weaknesses, opportunities, and threats associated with each theoretical approach when applied to the analysis of Muslim women's digital religious identity. This model provides an analytical overview that highlights the conceptual robustness of each tradition, the areas where explanatory gaps persist, and the potential directions for theoretical synthesis. By visualising the comparative relationships among the concepts, the SWOT framework clarifies how these theories can be integrated into a coherent meta-theoretical foundation for future research.

• Together the four theories provide a multi-level explanation (personal, social, digital, embodied). • They offer complementary analytical lenses, covering meaning, community, platform dynamics, and lived practice. • Integration increases theoretical depth and robustness. • Cross-validation across frameworks strengthens reliability.	S W	• Theories originate from different disciplines, creating conceptual fragmentation. • They operate at different levels of abstraction, making integration complex. • Risk of producing an overly broad or diffuse framework. • Epistemological tensions may arise between symbolic, social, technological, and ethnographic logics.
• Potential to develop a new integrated meta-framework for digital religious identity. • Allows richer interdisciplinary and intersectional analysis (gender–religion–technology). • Enables examination of emerging digital practices (modest fashion, Islamic lifestyle media). • Supports methodological innovation combining visual, ethnographic, and identity-based approaches.	O T	• Risk of eclecticism if integration lacks coherence. • Possibility of losing focus on Muslim women's lived experiences. • Overemphasis on technology may lead to technological determinism. • Ethical and political sensitivities around studying Muslim women online.

Figure 1. - Unified SWOT Analysis of Four Conceptual Frameworks for Studying Muslim Women’s Digital Religious Identity

Figure 1 illustrates how the four conceptual frameworks religious identity theory, social identity theory, digital religion studies, and digital ethnography jointly shape the analytical landscape for studying Muslim women’s digital religious identity. A closer examination of each theoretical tradition within the SWOT structure reveals both its individual contributions and its position within the integrated framework.

1. Religious Identity Theory. The strengths of religious identity theory lie in its ability to explain the *internal, meaning-centred dimensions* of identity. It illuminates how Muslim women interpret, negotiate, and articulate their faith through personal reflection, moral intention, and selective visibility. This lens is particularly powerful for analysing how women present piety, modesty, and ritual commitment in online settings. However, its weaknesses emerge when addressing *digital mediation*, as the theory was not originally designed to account for algorithmic structures, visual platforms, or performative online practices. Opportunities arise from integrating this theory with media-focused approaches, allowing scholars to trace how private religious meaning becomes a curated digital expression. Yet the theory faces threats of individualizing identity or overlooking structural inequalities if applied in isolation.

2. Social Identity Theory. Social identity theory brings strong explanatory value to the analysis of *in-group belonging, boundary processes, and audience interaction*. It helps uncover how Muslim women navigate multiple public and semi-public spheres supportive Muslim communities, broader digital audiences, and sometimes hostile or stereotypical publics. The model shows that this theory is well suited to analysing recognition, inclusion/exclusion, and symbolic negotiations that take place across social media platforms. Its limitations lie in its inability to explain embodiment, aesthetics, or technological mediation elements central to digital expression. The opportunities section highlights that, when combined with digital ethnography and digital religion studies, social identity theory becomes much more powerful, enabling a nuanced understanding of Muslim women's online social positioning. Its threats involve reducing identity to group categories or reinforcing binary oppositions if not critically contextualised.

3. Digital Religion Studies. Digital religion studies provide essential tools for analysing *platform architectures, visual cultures, and algorithmic visibility* all central to understanding how Muslim women’s religious identities become public. This theory uniquely explains how online-offline religious life is hybridised, mediated, and reshaped by digital infrastructures. Its strengths clearly dominate the technological dimension of the model, filling major gaps left by the two identity theories. Yet the weaknesses identified in Figure 1 remind us that an overemphasis on

platform logic may result in technological determinism, neglecting the lived, emotional, or ethical aspects of religious practice. Opportunities include the capacity to examine new genres of digital piety in modest fashion, Islamic lifestyle media, online sermons and to describe how algorithmic ecologies shape religious visibility. Threats include flattening religious diversity or overlooking the political vulnerabilities of Muslim women in digital spaces.

4. Digital Ethnography. Digital ethnography contributes a distinctive and irreplaceable strength: it uncovers the *embodied, affective, and performative dimensions* of digital religious identity. This includes gesture, clothing, spatial cues, camera movement, interpersonal micro-interactions, and the sensory and emotional atmosphere of digital participation. Such insights are critical because Muslim women's digital piety is deeply tied to visual and embodied expression. Nonetheless, its weaknesses lie in limited generalisability, methodological labour-intensity, and challenges associated with long-term digital fieldwork. The opportunities section shows how integrating ethnographic insights with identity theories can deepen our understanding of lived experience especially regarding modesty practices, prayer performance, and other ritualised behaviours online. The major threats involve ethical and privacy concerns, platform instability, and the risk of overinterpreting fragmentary data.

Taken together, the detailed analysis shows that the four theories form a conceptually powerful but epistemologically diverse framework. Their combined strengths allow for a multi-layered understanding of digital religious identity capturing personal meaning, collective belonging, technological mediation, and lived embodiment. Their combined weaknesses highlight the need for deliberate conceptual coordination to avoid fragmentation. Their joint opportunities reveal the potential to build a new integrated meta-theory of digital religious identity. Their shared threats caution against methodological excess, loss of focus on lived experience, and the political sensitivity of studying Muslim women online.

Conclusion

This article has demonstrated that Muslim women's digital religious identity can only be understood through an integrated conceptual approach that synthesises insights from religious identity theory, social identity theory, digital religion studies, and digital ethnography. In response to RQ1, the analysis shows that these frameworks collectively explain how Muslim women construct and perform their religious identities through a combination of personal meaning-making, communal affiliation, technological mediation, and embodied digital practices. Religious identity theory clarifies how women reinterpret faith and piety in personalised ways; social identity theory explains how they negotiate belonging and visibility across multiple digital publics; digital religion studies reveal how platform architectures shape the conditions of religious expression; and digital ethnography highlights the embodied, sensory, and performative dimensions of digital piety.

Addressing RQ2, the study identifies four central theoretical mechanisms that best capture the hybrid and mediated nature of digital religious identity: symbolic articulation of faith, social positioning and boundary-making, platform-shaped identity formation, and embodied performative practices. These mechanisms illustrate that digital religious identity is neither fixed nor purely discursive but emerges through continuous interaction between individual agency, collective norms, and technological affordances. The integrated conceptual model developed in this study therefore provides a coherent explanation of how digital platforms reshape religious subjectivities, offering a structured lens through which to analyse contemporary forms of Muslim women's online religiosity. The unified SWOT analysis further clarifies the conceptual contributions and limitations of each theoretical tradition, showing that their integration strengthens explanatory depth while also requiring careful conceptual coordination. The study underscores the need for methodological pluralism, intersectional sensitivity, and analytical reflexivity when examining the digital lives of Muslim women. Ultimately, this research contributes

to the field of digital religion by proposing a robust theoretical foundation capable of supporting both future empirical investigations and the development of new meta-theoretical models for understanding digital religious expression in rapidly evolving media environments.

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COGNITIVE PROCESSES IN LANGUAGE LEARNING

Aysu Mardan Asadova

Baku Business University, Baku Azerbaijan

The educational process clearly requires focusing on developing students' ability to effectively engage in intercultural communication. In today's world, the need to learn a foreign language from early childhood is increasingly being addressed. It is generally accepted that bilingualism influences memory development and the ability to understand and analyze linguistic phenomena.

Any human activity is directly linked to an individual's mental processes, which is why close attention is paid to linguistic psychology and the psychological characteristics of foreign language acquisition. The primary goal of foreign language teaching at the threshold level is the development of communicative competence, which comprises several components: linguistic competence, sociolinguistic competence, sociocultural competence, strategic competence, discursive competence, and social competence.

Modern foreign language teaching is based on a student-centered approach to learning, which assumes that all teacher-centered teaching decisions should be refracted through the prism of the learner's personality—their needs, motives, abilities, activity, intellect, and other individual psychological characteristics. In this case, the learner's personality is viewed as the subject of pedagogical activity, independently determining the nature of this activity and communication.

Differentiation and individualization of the learning process are particularly important today. According to G.V. Elizarova, during the learning process, a foreign language "should have such an impact on the individual that it transforms them into a self-developing, emotionally mature, intellectually and cognitively capable of coping with unforeseen, culturally determined communication situations by identifying or creating unique tools for searching, processing, and practically applying information."

In this regard, issues related to taking students' cognitive styles into account in teaching are becoming increasingly relevant. Many foreign and domestic psychologists and educators believe that paying close attention to cognitive styles is currently the most effective principle of language teaching, as there is no universal teaching method for everyone.

The sensory and motor systems are responsible for the input and output of information, its encoding and decoding. The cognitive system is associated with the analysis and processing of information. The affective system activates the processed information. Therefore, the cognitive and affective systems are the main elements responsible for information processing. The style system is closely linked to the value system, as it depends on the generalization and transformation of information received from the cognitive and affective systems. Furthermore, the style system is responsible for the selection of information processing methods. The value system also generalizes information, not for the purpose of choosing a course of action, but to identify goals and determine opportunities and paths to achieving them. It is important to note that the style and value systems, like the cognitive and affective systems, are associated with information processing, but the level of generalization provided by these systems is higher. Thus, they integrate information at the level of the holistic individual [1,125].

Individuality is based on differences in volitional, intellectual, and motivational traits, as well as in the properties of the nervous system, temperament, and so on. As researchers note, an individual cognitive style (i.e., the methods of processing, receiving, organizing, storing and using

information) is formed on the basis of the individual psychological characteristics of students, such as temperament, functional symmetry or asymmetry of the cerebral hemispheres, and, consequently, the specifics of information perception (visual, auditory or kinesthetic).

Individual style reflects the characteristics of a system of operations to which an individual is predisposed by their individual qualities and represents a system of methods for verbally transforming information, formed on the basis of motives and goals of activity.

Through verbal mediation of cognitive styles, which are interpreted as individual operational systems of information processing methods at the preverbal level [3, p. 68]. Cognitive styles, on the other hand, define the individual psychological characteristics of cognitive processes, the tendency to use characteristic methods of interacting with information, and the specific cognitive structure of the individual, mediating the processes of handling information at all levels of the cognitive sphere.

Based on all of the above, we can conclude that cognitive style refers to the processual characteristics of cognitive activity. The parameters of style are measured by a variety of different psychological characteristics of the individual (sensorimotor and psychophysiological characteristics, including temperament). Cognitive style is associated with all levels of individual characteristics, influences individual activity style, and is itself dependent on it.

Situated between the mental and personal levels of individuality, cognitive styles are viewed as a way for an individual to master a worldview, including linguistic one. Since language is an integral and important part of cognition and a means of forming a linguistic worldview, the process of learning a foreign language should be based on the cognitive characteristics of the learners.

According to psychologists, individual values for each of these cognitive styles lie between the extremes, forming a uniform distribution. For each cognitive style, most people have average values, while extreme values are much rarer [2p.89]. People with extreme levels of any cognitive style are less adaptive than those in the middle. The most adaptive are those with a flexible cognitive style, who can consciously adjust their cognitive settings based on the situation. Personal and intellectual maturity help students combine the ability to act differently depending on the demands of the situation, while maintaining some inclination toward one extreme or the other. Psychologists consider flexibility to be evidence of the high maturity of an individual's cognitive structures.

Thus, it can be concluded that individualization at the core of cognitive styles largely determines the development of individual activity style, which develops as an integral effect of the individual's interaction with the subject and social environment and can change with changing conditions of activity, in the process of development, training, and education.

As Arthur W. notes, teaching communication in a foreign language taking into account cognitive styles implies creating conditions both for updating the existing system of stylistic characteristics of intellectual behavior and for expanding the range of stylistic behavior by mastering different styles at various levels of stylistic behavior, as well as for the interaction of various cognitive styles when studying any academic topic, assimilating concepts, and solving problems.

From all this it follows that cognitive styles, on the one hand, are directly related to the process of assimilating information and developing knowledge, skills, and abilities, while on the other hand, they shape the realm of interpersonal relationships and control the communication of participants. Thus, one of the main tasks of the pedagogical process is to create conditions for students to develop and refine the entire system of stylistic characteristics of intellectual behavior, which is associated with the effectiveness and efficiency of learning activities.

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Psychological Sciences

Multidisciplinary approach in psychological practice: analysis of the effectiveness of integration of game, metaphorical and graphic methods

Gulnara Hasanova

Associate Professor of the Department of Psychology, Baku Slavic University, Baku, Azerbaijan, Orcid: 0000-0002-9344-1352

Annotation: The article considers a multidisciplinary approach in psychological practice, including the integration of game methods, metaphorical maps, neurography and circuit therapy. The relevance of combined methods in dealing with emotional and social problems of adolescents, manifested in isolation, communication difficulties and low social activity, is emphasized. The theoretical foundations of each technique, their advantages and the potential for synergetic application are described. An analysis of the practical case of a teenager with difficulties in interacting with peers is presented, demonstrating the consistent application of an integrative approach: game therapy, metaphorical maps, neurography, circuit therapy. It is shown that the combined use of methods contributes to the reduction of anxiety, the development of social skills, awareness of internal attitudes and correction of dysfunctional patterns. The conclusion is made about the high effectiveness of a multidisciplinary approach in psychological practice and its importance for comprehensive work with adolescents with communication difficulties.

Keywords: aggression, multidisciplinary approach, play therapy, metaphorical maps, communication, teenager, anxiety

The concept of a multidisciplinary approach in psychological practice was formed as part of the development of interdisciplinary research in the middle of the 20th century. The term "multidisciplinary" entered the humanities and medical sciences in the 1940s and 1960s, and into psychology through clinical teamwork and the expansion of integrative models of psychotherapy in the 1960s and 1980s. The directions of integrative and eclectic psychotherapy developed by A. Lazarus had the most significant influence on the modern understanding of multidisciplinary [8]. These approaches emphasized the need to combine different theoretical perspectives and methods to improve the effectiveness of customer care.

In the context of psychological practice, a multidisciplinary approach means using several professional perspectives, methods, and forms of work within a single therapeutic model. This approach is based on an understanding of the multilayered nature of the psyche and the recognition that different methods affect different levels of experience — behavioral, emotional-figurative, cognitive, bodily and symbolic. Multidisciplinary approach not only expands the specialist's toolkit, but also allows for a more flexible, individualized strategy of psychotherapeutic influence.

The integration of game, metaphorical and graphic methods is a practical manifestation of a multidisciplinary approach, as it combines techniques originating from different therapeutic traditions — game therapy, art therapy, drama therapy, cognitive and narrative approaches. At

the same time, these methods have common mechanisms of influence — working with a symbol, activating emotions, and externally representing internal processes — which makes them natural elements of a unified multidisciplinary model.

Gaming methods introduce action dynamics and allow the client to play roles, simulate interpersonal scenarios, and explore behavioral patterns. L.Kostina (7), G.Landreth (10), K. Schaefer (5), and others provided us with excellent practical material that allows us to use play therapy techniques in working with children and adolescents. Metaphorical associative maps, which are of great practical value in the counseling work of a psychologist, allowed O.V. Buchlnikova to substantiate the effectiveness of this tool in providing access to deep semantic structures. In our professional work, we have not only become convinced of the ability of metaphorical maps to gently bypass cognitive defenses through symbolic distance, but also developed algorithms for dealing with specific psychological problems, which is reflected in the works [3,4,13]. Graphic methods provide an opportunity to bring inner experiences into an external visual image, making them more conscious and recyclable. The combined use of these techniques enhances the therapeutic process, as each of them reveals different aspects of the client's inner experience.

From the point of view of modern psychotherapy, the integration of these methods meets the key task of a multidisciplinary approach — to provide a comprehensive impact on various levels of mental organization. This allows not only to increase the depth and effectiveness of therapy, but also to adapt the process to the individual characteristics of the client, supporting his emotional security, creative self-expression and the ability to self-regulate.

Modern psychological practice is increasingly faced with the need to integrate various methods of working with clients to improve the effectiveness of correctional and developmental activities. Traditional approaches based on the separate use of game therapy, metaphorical maps, or graphical methods demonstrate limited capabilities when dealing with complex emotional and social problems. Play therapy allows a child to express inner feelings through symbolic play, which is especially important in preschool and primary school age. Metaphorical maps provide the client with the opportunity to express their unconscious attitudes and internal conflicts through visual images.

Neurography and graphical methods make it possible to visualize internal emotional and cognitive circuits, creating visual "maps" of the mental state. Circuit therapy (1, 12, 15), in turn, is aimed at identifying and correcting dysfunctional cognitive-emotional circuits, influencing behavior, thinking, and emotional regulation. This aspect of research is often used by us in professional detail, which results in publications that reflect the specific features of the application of these techniques [14].

The integration of these approaches creates a multidisciplinary tool capable of influencing different levels of the psyche simultaneously: cognitive, emotional and behavioral. The relevance of this topic is confirmed both by the growth of research in the field of art therapy, gaming and integrative methods of work, and the practical need for psychologists, educators and psychotherapists in complex techniques that provide deeper and more sustainable correction of emotional and social disorders. The purpose of this scientific article is to analyze the effectiveness of integrating game therapy, metaphorical maps, neurography and circuit therapy in psychological practice to deal with the problems of clients of different ages.

If we focus on play therapy, it should be noted that it is highly effective among the methods of working with children and adolescents. Based on the principle of symbolic play, it allows the child to express inner feelings and conflicts through plot, role, and objective actions. In addition, self-regulation and emotional intelligence are developed through the game, and social skills are formed, including communication, cooperation, and empathy. Play therapy is especially effective

in dealing with anxiety, fears and aggression, and in correcting communication difficulties in the preschool and primary school age groups.

The advantages of the integrative approach lie in the synergy of methods, which consists in influencing the cognitive, emotional and behavioral levels simultaneously, deeper identification of internal conflicts, acceleration of correction processes and, most importantly, the possibility of individual adjustment to the age and characteristics of the client.

Metaphorical maps are a tool based on psychodynamic and cognitive approaches. They help to identify the client's unconscious attitudes, internal conflicts, and resources. The image of the card chosen by him becomes a projection of the inner state. Thanks to the method of visualizing emotions and thoughts through lines, shapes and colors, based on the combination of psychology and art, we gain access to the transformation of internal circuits into graphic images. Neurography perfectly combines art therapy (9) and gaming methods. The final stage of the integrative approach is schema therapy, which is based on cognitive-behavioral and emotional-schema approaches that identify dysfunctional cognitive-emotional schemas.

Game, metaphorical, and graphic methods belonging to different areas of psychotherapeutic practice show significant conceptual and functional similarities. Their integration into a multidisciplinary approach is determined by common mechanisms of influence aimed at increasing the emotional involvement, creative activity and depth of self-knowledge of the client.

Firstly, these methods rely on symbolization and working with images, allowing the client to express complex experiences in an indirect way. Symbolic representation—through play, drawing, or metaphorical imagery—facilitates access to emotions and memories that may be difficult for direct verbal analysis.

Secondly, all three approaches help to bypass cognitive defenses. The informal structure of the game actions, the associative nature of the metaphor and the spontaneity of the graphic expression reduce the level of psychological resistance, activate emotional circuits and allow the client to safely explore difficult internal states.

Thirdly, they are united by the experimental, creative nature of therapeutic interaction. The client gets the opportunity to try out new roles, behavioral scenarios, and ways of emotional response, which contributes to the development of behavioral flexibility and the expansion of the repertoire of adaptive strategies.

Fourthly, gaming, metaphorical and graphic methods create conditions for psychological safety, allow us to talk about difficult topics in the "as if" format. Having a symbolic distance reduces anxiety, increases trust in the process, and stimulates a willingness to self-disclose.

Fifth, these approaches provide external visualization of internal processes, which makes them more conscious and accessible for analysis. By becoming visible in the external space of a game, drawing, or metaphorical plot, the client's feelings and thoughts receive structure and form, which facilitates their processing and integration.

Finally, the similarity of the mechanisms of operation makes these methods especially effective in combination with circuit therapy based on emotionally focused processing of circuits and modes. Play and imaginative techniques help activate children's modes, reconstruct early emotional experiences and form new adaptive behaviors, enhancing the therapeutic effect.

Thus, the integration of gaming, metaphorical and graphic methods is based on the general principles of symbolization, emotional activation, experimentation and visualization, which makes them natural components of a multidisciplinary approach in modern psychological practice.

Despite the fact that these methods have a lot in common (imagery, symbolization, creative activity), they differ in a number of key parameters: the mechanisms of influence, the level of structuring, the type of medium and the nature of interaction. Let's focus on some of the differences:

The main tool of the game method is action, role—playing dynamics, and interaction with objects. Toys, role-playing scenes, situation modeling, and elements of drama therapy are used. The main focus is on the behavioral manifestation of internal states through play.

The main tool in metaphorical maps is metaphor, figurative meaning, associative thinking. Poppies, parables, analogies, and symbolic plots are used.

There is a launch of internal associations, cognitive and emotional processing through semantic constructions.

The main tool of graphic methods is a visual trace, drawing, graphic image. Art therapy techniques are used: drawing, collage, graphic models. The external visualization of the inner experience is important here.

Let's consider the possibilities of using an integrative approach in working with a client.

Case description: the client is a teenager, 14 years old. The parents were the initiator of the appeal to the psychologist. Primary request: isolation, avoidance of communication with peers, pronounced awkwardness in social situations, difficulties in establishing contacts in the school environment.

Observed manifestations: limited eye contact, stiff posture, closed gestures, quiet speech, slow responses, pronounced internal tension, insecurity in social scenarios.

Family context: the family is intellectually oriented; emotional support is expressed to a lesser extent. A teenager is an only child, which increases the fixation on academic achievements and reduces the experience of interaction.

The goals and objectives of psychological support are to increase confidence and reduce social anxiety in adolescents, and to develop skills for effective interaction with peers.

he main tasks include the following:

- ✓ to form an experience of safe interaction within the framework of consultations; Develop communication skills through play and role - playing methods;
- ✓ Provide access to inner experiences through metaphorical tool contribute to the formation of a positive self-image through art therapy.

As we noted above, the multidisciplinary approach includes a combination of techniques from various areas of psychological practice. In this case, we have integrated: game methods, elements of role-playing games, training of social scenarios, game exercises for emotional expression.

I would like to give some aspects of this approach.

Consistency is important: we start with game therapy, then metaphorical associative maps, neurography, and finally circuit therapy.;

Duration: each session is 45-60 minutes; the total course is 6-10 sessions (depending on the level of anxiety and isolation of the teenager);

A teenager should feel the support of a psychologist and the opportunity to experiment with roles and images;

Recording the results: Record insights, emotional states, and behavioral changes after each session to analyze the dynamics.

This approach allowed us to safely identify problems, visualize them, talk about them, and correct them.

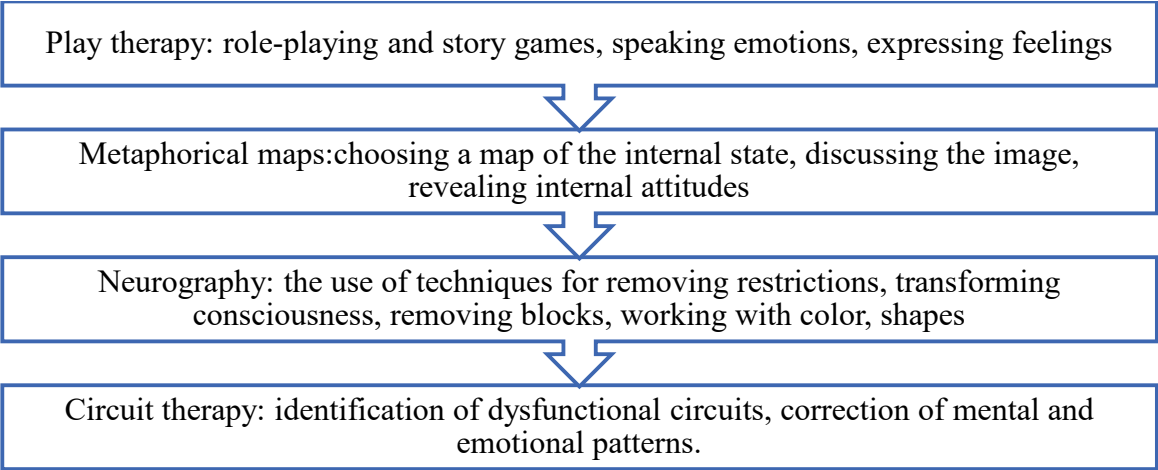


Fig. 1. The scheme of the integrative session

At the bottom we offer a table in which we have placed a step-by-step model of the application of the integrative approach (using the example of the above case).

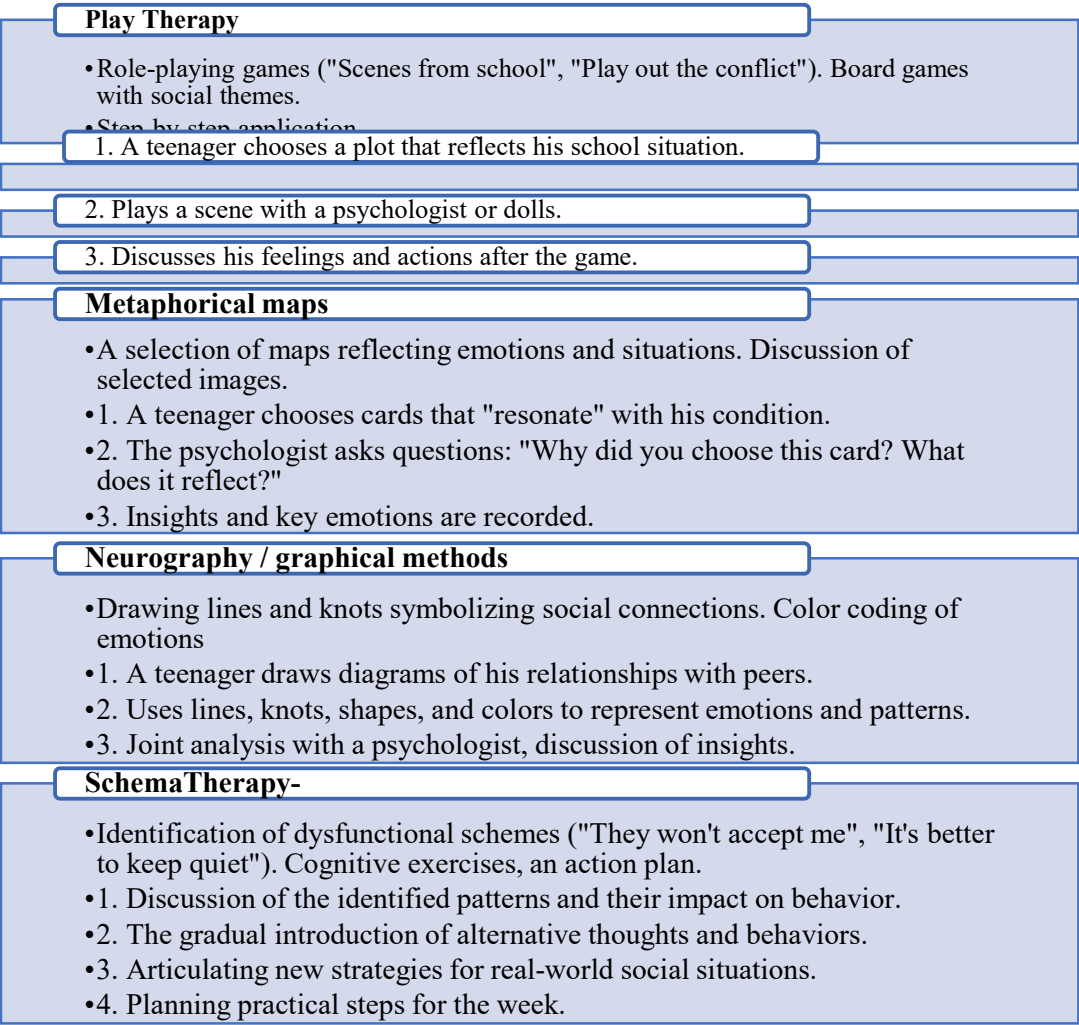


Fig. 2. The model of the integrative approach application

The goal of the game stage is: reducing anxiety and internal tension, developing social communication skills, and gradually engaging in interaction. Identifying internal attitudes (fear of rejection, low self-esteem), strengthening self-awareness, and preparing for visualization of schemas is the goal of the stage of working with metaphorical associative maps. At the level of

application of neurography, visualization of internal circuits, emotional unloading and awareness of the relationship of thoughts, emotions and behavior occur. Schema therapy helps to reduce dysfunctional beliefs, increase willingness to communicate, and achieve sustainable changes in the emotional and social sphere.

A multidisciplinary approach in psychological practice, including the integration of gaming, metaphorical and graphic methods, demonstrates high efficiency in working with various categories of clients. An analysis of the use of these methods shows that their combination allows not only to better understand a person's inner world, but also to create a safer and more engaging space for emotional expression and self-discovery. Gaming techniques help to relieve psychological stress and activate personal resources, metaphorical methods provide access to unconscious contents, and graphical approaches allow you to visualize inner experiences, which facilitates their processing and interpretation.

Thus, the integration of various methods in psychological practice increases the effectiveness of therapy, promotes the development of creativity and flexibility among both specialists and clients, and also opens up new opportunities for an individualized approach in psychotherapeutic work. The scheme we have proposed allows you to integrate several tools into working with the client. Play therapy allows you to express emotions as safely as possible through a role or a plot. Metaphorical associative maps reveal inner attitudes and unconscious patterns. Visualization of emotional and cognitive schemas is carried out thanks to neurography. And already the systematization of insights, correction of beliefs and preparation for real actions is carried out thanks to circuit therapy.

Further research may be aimed at systematizing techniques and developing universal models of their application in various psychological contexts.

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Historical Sciences

DÜNYA ÖLKƏLƏRİNDƏ KARGÜZARLIQ SƏNƏTİNİN İNKİŞAF TARİXİ

THE HISTORY OF THE DEVELOPMENT OF OFFICE WORK IN WORLD COUNTRIES

Heydər Abbas oğlu Məmmədov

Rabitə və İnformasiya Texnologiyaları üzrə Bakı Dövlət Peşə Təhsil mərkəzinin müəllimi

Abstract. The history of office work, or records management, reflects the evolution of administrative systems across world civilizations and demonstrates how written documentation became a foundation of governance. The earliest examples emerged in ancient Mesopotamia, where Sumerians recorded economic and administrative data on clay tablets, laying the groundwork for systematic documentation. In ancient Egypt, the invention of papyrus and the formation of a large scribal corps made written records essential for state administration, taxation, and diplomacy. China further advanced this domain with the invention of paper and the development of highly organized bureaucratic structures that relied heavily on written orders, reports, and archival preservation. During the Middle Ages, both in the Arab Caliphate and in European kingdoms, office work became more structured. The “Diwan” system in the Islamic world regulated state correspondence and financial records, while in Europe, churches and royal chancelleries established archives to keep legal, economic, and territorial documents. The early modern period strengthened standardization, especially in European states and the Russian Empire, where unified principles for drafting, registering, and preserving documents were introduced. The 19th and 20th centuries saw rapid expansion of office work due to industrialization and the growth of administrative institutions. The invention of the typewriter, reproduction technologies, and later, official standards such as the Soviet GOST system, improved efficiency and uniformity in documentation. In the 21st century, global office work has shifted toward digital formats, incorporating electronic signatures, automated document flows, digital archives, and cloud systems. Countries such as the United States, Japan, South Korea, and members of the European Union lead in implementing modern electronic governance tools. Overall, the worldwide development of office work demonstrates a continuous progression from primitive record-keeping systems to sophisticated digital documentation technologies. This evolution has played a decisive role in enhancing administrative efficiency, strengthening state governance, and ensuring the preservation of historical and legal information.

Keywords:

Kargüzarlıq sənəti insanların öz fəaliyyətini, qarşılıqlı münasibətlərini və idarəçilik proseslərini yazılı şəkildə sənədləşdirmə ehtiyacından yaranmış və minilliklər boyunca inkişaf edərək dövlət idarəetməsinin ayrılmaz hissəsinə çevrilmişdir. Dünya ölkələrində kargüzarlığın tarixini araşdırmaq həm idarəçilik mədəniyyətinin formalaşma prosesini, həm də ictimai münasibətlərin təşkilində yazılı sənədin rolunu daha dərindən anlamağa imkan verir.

Kargüzarlığın ən qədim nümunələri Mesopotamiya sivilizasiyalarına, xüsusilə Şumer dövlətinə aiddir. Burada eramızdan əvvəl IV minillikdə gil lövhələr üzərində aparılan təsərrüfat, vergi və ticarət qeydləri artıq sistemli sənədləşmənin ilkin formalarını əks etdirirdi. Şumerlər bu lövhələri xüsusi arxiv binalarında saxlayır, onların qorunmasına və gələcək nəsillərə çatdırılmasına ciddi önəm verirdilər. Qədim Misirdə papirusun kəşfi kargüzarlığın daha geniş yayılmasına səbəb oldu;

faraon sarayında fəaliyyət göstərən yazıçı-katib korpusu ölkənin bütün idarəetmə fəaliyyətini yazılı formada qeydə alır, əmrlər, sərəncamlar və diplomatik yazışmalar müəyyən protokol əsasında tərtib edilirdi.

Qədim Çin kargüzarlıq sənətinin formalaşdığı ən mühüm mərkəzlərdən biri kimi tanınır. Burada dövlət idarəetməsi üçün yüzlərlə katib çalışır, hökmdarın əmrləri dəqiq və aydın şəkildə sənədləşdirilərək imperiyanın müxtəlif vilayətlərinə göndərilirdi. Kağızın icad edilməsi Çin kargüzarlığını daha da inkişaf etdirdi və bu yenilik sonralar dünyanın digər bölgələrinə də yayılaraq sənədləşmə mədəniyyətini köklü şəkildə dəyişdirdi.

Orta əsrlər dövründə kargüzarlıq həm Şərq, həm də Qərb ölkələrində yeni məzmun kəsb etdi. Ərəb xilafətində “Divan” adlanan idarəetmə sistemi quruldu və burada bütün dövlət yazışmaları xüsusi qaydalar əsasında qeydiyyatla alınır. Rəsmi sənədlərin tərtibi üçün xəttatlıq ənənələri geniş inkişaf etmiş, yazının estetik tərəfi belə sənədin rəsmi əhəmiyyətini artıran amillərdən birinə çevrilmişdi. Avropada isə feodal quruluşu dövründə kilsə və krallıq idarəetməsi sənədləşmənin əsas mərkəzləri idi. Kilsə arxivlərində torpaq mülkiyyəti, vergilər və məhkəmə qərarlarına dair sənədlər toplanırdı. XII–XIV əsrlərdə isə Fransada, İngiltərədə və Almaniyada dövlət kargüzarlığı artıq ayrıca inzibati sahə kimi formalaşmağa başladı.

Yeni dövrün başlanması ilə dövlət aparatının genişlənməsi kargüzarlığın daha sistemli xarakter almasına səbəb oldu. XVII–XIX əsrlərdə Avropa ölkələrində sənədlərin qeydiyyatı, tarixlənməsi, nömrələnməsi və arxivləşdirilməsi üçün vahid prinsiplər yaradıldı. Rusiya imperiyasında isə kanselyariya sistemi formalaşdı və dövlət əmrləri, sərəncamlar, məktublar xüsusi dəftərxanalarda ciddi prosedurlara uyğun tərtib edilirdi. Bu dövrdə sənəd standartlarının yaranması müasir kargüzarlıq sistemlərinin bünövrəsini qoydu.

XX əsrdə sənaye cəmiyyətinin inkişafı və idarəetmə proseslərinin mürəkkəbləşməsi nəticəsində kargüzarlıq sənəti daha da təkmilləşdi. Yazı maşınlarının tətbiqi, sənədlərin çoxaldılması və sürətli yayılması böyük təşkilatlarda sənəd dövriyyəsinə xeyli sürətləndirdi. SSRİ-də dövlət kargüzarlığı xüsusi GOST standartları əsasında tənzimlənir, sənədlərin forması, məzmunu və yazılış qaydaları vahid sistemlə müəyyən edilirdi. Arxiv işi ayrıca dövlət qurumu kimi təşkil olunur, sənədlərin saxlanması və qorunması hüquqi çərçivəyə salınırdı.

XXI əsrdə isə kargüzarlıq sənəti köklü şəkildə dəyişərək elektron idarəetmə dövrünə qədəm qoydu. Rəqəmsal texnologiyaların inkişafı elektron sənəd dövriyyəsi, elektron imza və rəqəmsal arxiv sistemlərinin yaranmasına səbəb oldu. ABŞ, Yaponiya, Cənubi Koreya və Avropa İttifaqı ölkələri bu sahədə qabaqcıl təcrübə topladı; dövlət idarəetməsində kağız sənədlərin əhəmiyyəti azaldı və sənədləşmə prosesləri tamamilə avtomatlaşdırılmış platformalar üzərindən həyata keçirilməyə başladı. Bulud texnologiyalarının tətbiqi isə sənədlərin saxlanması, paylaşılması və qorunması üçün daha təhlükəsiz və çevik imkanlar yaratdı.

Beləliklə, dünya ölkələrində kargüzarlıq sənətinin inkişaf tarixi insanlığın yazı yaratmasından başlayıb rəqəmsal sənədləşməyə qədər uzanan çoxşaxəli və zəngin bir prosesdir. Bu prosesin hər bir mərhələsi idarəetmənin təkmilləşməsinə, məlumat mübadiləsinin sürətlənməsinə və dövlət aparatının daha səmərəli fəaliyyətinə xidmət etmişdir. Kargüzarlıq sənəti bu gün də cəmiyyətin idarə olunmasında mühüm rol oynamaqda davam edir və texnoloji yeniliklərlə birlikdə daim inkişaf edir.

Kargüzarlıq sənəti insan cəmiyyətinin formalaşması ilə yanaşı yaranmış və idarəetmə fəaliyyətinin ayrılmaz hissəsi kimi minilliklər boyunca inkişaf etmişdir. İnsanların öz fəaliyyətini, təsərrüfat münasibətlərini və dövlət idarəetməsini yazılı şəkildə sənədləşdirməyə olan ehtiyacı bu sahənin tarixi inkişafını şərtləndirmişdir. Kargüzarlığın inkişaf tarixi həm də dövlətçiliyin, inzibati idarəetmənin və sosial münasibətlərin təkamülünü əks etdirir. Bu baxımdan, kargüzarlıq sənətinin inkişaf mərhələlərini araşdırmaq müxtəlif mədəniyyətlərin idarəçilik ənənələrini, yazı texnikasını və təşkilati strukturunu daha dərinləndirən anlamağa imkan verir.

Kargüzarlığın ən qədim nümunələri Mesopotamiya sivilizasiyalarına aid edilir. Şumerlər eramızdan əvvəl IV minillikdə gil lövhələr üzərində vergi, ticarət, torpaq mülkiyyəti və təsərrüfatla bağlı qeydlər aparırdılar. Bu lövhələr yalnız məlumat ötürmək üçün deyil, həm də inzibati münasibətləri tənzimləmək məqsədi daşıyırdı. Lövhələrin saxlanması üçün xüsusi anbarlar və arxivlər yaradılır, beləliklə, sənədlərin gələcək dövrlər üçün qorunması təmin olunurdu. Qədim Misirdə papirusun ixtirası kargüzarlıq fəaliyyətini genişləndirdi; faraon sarayında çalışan çoxsaylı yazıçı və katiblər dövlət idarəetməsinin bütün sahələrini yazılı şəkildə qeyd edir, əmrlər, sərəncamlar, diplomatik yazışmalar xüsusi qaydalara əsasən tərtib olunurdu.

Qədim Çin də kargüzarlıq sənətinin mühüm inkişaf etdiyi mərkəzlərdən biri idi. Burada imperator idarəçiliyinin dayanıqlığı məhz sistemli sənədləşmə fəaliyyətindən asılı idi. Kağızın icad edilməsi bu prosesə yeni nəfəs verdi və sənədlərin daha rahat hazırlanması, saxlanması və yayılması mümkün oldu. Çin imperiyasında sənədlərin tərtibinə, məzmunun dəqiqliyinə və arxivləşdirilməsinə xüsusi diqqət yetirilirdi ki, bu da idarəetmənin səmərəliliyini artıran əsas amillərdən sayılırdı.

Orta əsrlərdə kargüzarlıq müxtəlif regionlarda fərqli şəkildə inkişaf etsə də, ümumi cəhət ondan ibarət idi ki, yazılı sənədlər dövlət idarəçiliyinin ayrılmaz bir hissəsinə çevrilmişdi. Ərəb xilafətində yaradılmış "Divan" sistemi bütün rəsmi yazışmaların qeydiyyatını, arxivləşdirilməsini və ötürülməsini tənzimləyirdi. Burada xəttatlıq yalnız sənədləşmənin texniki tərəfi deyil, həm də sənədin rəsmi statusunu ifadə edən mədəni element idi. Avropada isə feodal idarəetməsində kilsə və krallıq dəftərxanaları sənədləşmənin əsas mərkəzləri kimi fəaliyyət göstərirdi. Kilsə arxivləri torpaq mülkiyyətinə, vergi öhdəliklərinə və məhkəmə qərarlarına dair sənədlərin qorunmasında mühüm rol oynayır. XII–XIV əsrlərdə Avropa ölkələrində dövlət aparatının genişlənməsi nəticəsində kargüzarlıq ayrıca inzibati sahə kimi formalaşmağa başladı və sənədlərin tərtibatı üçün ümumi qaydalar yaradıldı.

Yeni dövrdə (XVII–XIX əsrlər) sənəd dövriyyəsinin həcmi artdığı üçün müxtəlif ölkələrdə kargüzarlıq standartlarının tətbiqi zəruri oldu. Avropada sənədlərin tarixlənməsi, nömrələnməsi və qeydiyyata alınması üçün ümumi prinsiplər formalaşdı. Rusiya imperiyasında isə kanselyariya sistemi dövlət idarəçiliyinin əsas dayaqlarından birinə çevrildi və burada sənədlərin hazırlanması, təsdiqi və saxlanması ciddi qaydalarla tənzimlənirdi. Bu dövrdə kargüzarlıq tədricən bir sənət olmaqdan çıxıb peşəkar idarəçilik fəaliyyəti kimi qəbul edilməyə başladı.

XX əsrdə sənaye cəmiyyətinin inkişafı kargüzarlıq sahəsində yeni mərhələnin başlanmasına səbəb oldu. Yazı maşınlarının istifadəsi, çoxaldılma texnikalarının yaranması və kommunikasiya vasitələrinin inkişafı sənədləşmənin sürətini əhəmiyyətli dərəcədə artırdı. SSRİ-də sənədlərlə iş GOST standartları əsasında tənzimlənir, sənədlərin forması, məzmunu, struktur elementləri və dövriyyəsi vahid qaydalarla müəyyən edilirdi. Arxiv işi ayrıca dövlət strukturu kimi təşkil olundu və sənədlərin qorunması hüquqi çərçivəyə salındı.

XXI əsrdə kargüzarlıq sənəti rəqəmsal texnologiyaların inkişafı ilə tamamilə yeni məzmun kəsb etdi. Elektron sənəd dövriyyəsi, elektron imza, rəqəmsal arxiv sistemləri və bulud texnologiyaları sənədləşmənin həm səmərəliliyini artırdı, həm də təhlükəsizliyini təmin etdi. Müasir dövlətlərdə elektron idarəetmə sistemi sənədlərin kağız daşıyıcılardan rəqəmsal mühitə keçidini sürətləndirdi və bu sahədə insan amilindən qaynaqlanan səhvlərin minimuma endirilməsi mümkün oldu. Bu gün kargüzarlıq sənəti yalnız sənədlərin hazırlanması ilə məhdudlaşmır, həm də informasiya idarəçiliyi, hüquqi tənzimlənmə və texnoloji innovasiyalarla sıx bağlı olan kompleks fəaliyyət sahəsinə çevrilmişdir.

Nəticə etibarilə, kargüzarlıq sənətinin dünya üzrə inkişaf tarixi insan sivilizasiyasının idarəetmə mədəniyyətinin formalaşmasında mühüm rol oynamışdır. Qədim dövrlərin gil lövhələrindən müasir elektron sənəd sistemlərinə qədər uzanan bu uzun yol dövlət idarəetməsinin təkmilləşməsinə, məlumat mübadiləsinin sürətlənməsinə və təşkilati fəaliyyətin daha səmərəli həyata keçirilməsinə xidmət etmişdir.

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Geographic Sciences

Dünya İqtisadiyyatının Arteriyaları: Ən Böyük Dəniz Limanlarının Geosiyasi Rolu

Əliyeva Şəfəq Məmməd qızı

ADPU-nun Şəki filialı, müəllim

Açar sözlər: Dəniz Limanları, Qlobal Ticarət, Geosiyasət, Bir Kəmə, Bir Yol (BRI/OBOR), Təchizat Zənciri. Yaşıl Limanlar

Dəniz limanları, sadəcə gəmilərin yan aldığı və yüklərin boşaldıldığı məntəqələr deyil; onlar qlobal ticarət sisteminin nəbzi, beynəlxalq əlaqələrin körpüsü və müasir geosiyasətin əsas qovşaqlarıdır. Məhz bu limanlar vasitəsilə dünya ticarətinin 80%-dən çoxu həyata keçirilir. Buna görə də, limanların ölçüsü, effektivliyi və coğrafi mövqeyi dövlətlərin iqtisadi rifahını və strateji gücünü birbaşa müəyyən edir.

1. Dəniz Limanları: Qlobal Ticarətin Əsas Dayanağı

Müasir dəniz limanları öz funksionallığına görə orta əsr ticarət məntəqələrindən köklü şəkildə fərqlənir. Konteynerləşmə inqilabından (1950-ci illər) sonra limanlar yüksək texnologiyalı, avtomatlaşdırılmış logistika mərkəzlərinə çevrildi.

1.1. Konteynerləşmənin Əhəmiyyəti

Konteynerin ixtirası yük daşımalarını standartlaşdırdı, əməliyyat xərclərini kəskin azaltdı və daşınma sürətini artırdı. Nəticədə, səmərəli limanlar iqtisadiyyatın inkişafı üçün kritik infrastruktur rolunu oynamağa başladı. Limanlar indi ölkələr arasında məhsul və xidmətlərin sərbəst axınını təmin edən qlobal təchizat zəncirinin həlledici elementidir.

2. Geosiyasi Rəqabətdə Limanların Strateji Dəyəri

Limanlar, təkcə iqtisadi deyil, həm də siyasi və hərbi baxımdan strateji əhəmiyyət daşıyır. Onlara nəzarət etmək, qlobal və regional güc münasibətlərində ciddi üstünlük deməkdir.

2.1. Çinin "Bir Kəmə, Bir Yol" Təşəbbüsü (OBOR/BRI)

Çin Xalq Respublikası dəniz limanlarının geosiyasi dəyərini dərk edən ən aktiv dövlətdir. "Bir Kəmə, Bir Yol" təşəbbüsü çərçivəsində Çin, Asiya, Afrika və Avropada onlarla limana, terminalara və logistika mərkəzlərinə böyük investisiyalar yatırır.

* Pirey Limanı (Yunanıstan): Çinin COSCO şirkətinin nəzarətində olan Pirey, Çin mallarının Avropaya giriş qapısı funksiyasını yerinə yetirir. Bu, Avropanın cənubunda Çinin iqtisadi və siyasi təsirini artırır.

* Hambantota Limanı (Şri Lanka): Liman, Şri Lankanın borcları qarşılığında 99 illiyinə Çinə icarəyə verilib. Bu hadisə, maliyyə diplomatiyasının və limanların "borc tələsi" vasitəsilə strateji nəzarətə keçməsinin ən bariz nümunələrindən biridir.

Bu investisiyalar Çinə təkcə ticarət yollarını sığortalamaq imkanı vermir, həm də ABŞ və digər Qərb dövlətlərinin dəniz hökmranlığına meydan oxuyaraq, "inci boyunbağı" adlanan bir dəniz təsir dairəsi yaratmağa xidmət edir.

2.2. Dəniz Boğazları

Limanlar çox vaxt mühüm dəniz boğazlarına yaxın yerləşir ki, bu da onların geosiyasi çəkisini daha da artırır. Boğazlar (Süveyş kanalı, Panama kanalı, Hormuz boğazı, Malakka boğazı və s.) dünya ticarətinin dar keçidləridir. Bu bölgələrdə yerləşən limanlara nəzarət, kritik məqamlarda qlobal enerji və ticarət axınlarına təsir etmək qabiliyyəti deməkdir.

3. Dünyanın Ən Böyük Limanları: İqtisadi Qüvvənin Mərkəzləri

Dünyanın ən böyük limanlarının demək olar ki, hamısı Asiyada, xüsusilə Çində yerləşir. Bu, istehsalın Qərbdən Şərqa sürüşməsinin və regional iqtisadi qüvvənin artmasının əyani göstəricisidir.

1. Şanxay Limanı (Çin)

* Əsas Rol: Dünyanın ən böyük konteyner limanı və Çin istehsalının global bazara əsas çıxış nöqtəsi.

* Geosiyasi Dəyər: Çinin global ticarət üstünlüyünü və gücünü simvolizə edir.

2. Sinqapur Limanı (Sinqapur)

* Əsas Rol: Regional transshipment (transfer yükləmə) mərkəzidir, yəni yüklərin bir gəmidən digərinə köçürüldüyü əsas qovşaqdır.

* Geosiyasi Dəyər: Malakka boğazı kimi kritik bir dəniz boğazının yanında yerləşir. Bu mövqeyi ona Cənub-Şərqi Asiya ticarətinə nəzarət etmək imkanı verir.

3. Ninqbo-Couşan Limanı (Çin)

* Əsas Rol: Çinin Şanxaydan sonra ikinci ən işlək limanı olaraq konteyner və quru yük həcmi ilə global təchizat zəncirinin sabitliyini təmin edir.

* Geosiyasi Dəyər: Çin Mərkəzi Hökumətinin dəniz ticarəti strategiyasını şaxələndirməsinin göstəricisidir.

4. Rotterdam Limanı (Niderland)

* Əsas Rol: Avropanın ən böyük və ən qabaqcıl limanı, "Avropaya Qapı" (Gateway to Europe) kimi tanınır.

* Geosiyasi Dəyər: Avropa İttifaqının ticarət həcmının böyük bir hissəsini idarə edir və Avropanın sənaye mərkəzlərini (xüsusilə Almaniyanı) dəniz yolu ilə birləşdirir.

Bu limanlar milyardlarla dollarlıq ticarətə ev sahibliyi edir və bir çox transmilli şirkətin loqistik strategiyasını müəyyənləşdirir.

4. Limanlar və Ekologiya: Dayanıqlı İnkişaf Çağırışı

Limnaların genişlənməsi və ticarət həcmının artması böyük ekoloji təsirlərə malikdir. Limanlar və onlara gələn nəhəng gəmilər hava çirklənməsinin, suyun zibillənməsinin və dəniz biomüxtəlifliyinə zərər verən amillərin əsas mənbəyidir.

Müasir dövrdə limanların qarşısında duran əsas məsələ, "Yaşıl Limanlar" konsepsiyası çərçivəsində rəqəmsallaşma, avtomatlaşdırma və alternativ enerji mənbələrinə (məsələn, sahil elektrik təchizatı) keçidlə ekoloji təsirləri minimuma endirməkdir. Dayanıqlı liman infrastrukturu gələcək global ticarətin etik və iqtisadi əsasını təşkil edəcək.

Nəticə

Dəniz limanları dünya iqtisadiyyatının və geosiyasətinin inkişafında müəyyənəddici rol oynayır. Onlar iqtisadi integrasiyanın simvolu olmaqla yanaşı, həm də böyük güclər arasında strateji rəqabətin mərkəzinə çevrilib. Limanlara nəzarət, təkcə yüklərə deyil, həm də ticarət yollarına, resurs axınlarına və regional təsirə nəzarət etmək deməkdir. Gələcəkdə "ağıllı" (smart) və ekoloji cəhətdən dayanıqlı limanlar global təchizat zəncirini daha çevik və etibarlı edəcək, lakin onların geosiyasi dəyəri və rəqabət meydanı olaraq rolu yalnız artacaq.

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AI AND GIS FOR EARTHQUAKE EARLY WARNING AND EVACUATION PLANNING IN ALMATY

Tarybayeva Aigerim

Master's Degree Geomatics, Al-Farabi Kazakh National University (KazNU), Almaty

Shoganbekova Daniya Assygatovna

PhD, Associate Professor of the School of Engineering International Educational Corporation

Abstract. *Almaty, Kazakhstan's largest city, sits at the foothills of the Tien Shan mountains and is exposed to high seismic hazards and related cascading events. Historical earthquakes such as the 1911 Kebin event (Mw 8.0) that killed 452 people and destroyed more than 770 buildings illustrate the city's vulnerability, while more recent mudflows have prompted mass evacuations. Modern developments, including plans for a nationwide mass alert system using cell-broadcast technology, raise the prospect of integrating artificial intelligence (AI) and geographic information systems (GIS) for real time earthquake early warning and evacuation planning. This article develops a comprehensive AI + GIS framework that combines deep learning-based P-wave detection (CSESnet), machine learning models for emergency shelter site selection, dynamic GIS-based evacuation route optimisation, and rapid public alert dissemination through cell broadcast technology. Results show that AI models can significantly improve detection accuracy and decision-making speed, while GIS enables adaptive routing under multi-hazard conditions. The originality of the work lies in its modular architecture tailored to Almaty's risk landscape, which emphasises interpretability, public engagement, and community preparedness. The framework provides a transferable model for cities in other seismically active regions seeking to integrate AI into disaster risk reduction.*

Keywords: *AI and GIS, earthquake early warning, evacuation planning, Almaty, disaster risk reduction*

Introduction

Earthquake early warning systems are designed to detect the first arriving P waves, rapidly estimate earthquake parameters and provide a few seconds to tens of seconds of lead time before strong shaking reaches exposed populations. For such systems to be effective, they must combine dense seismic monitoring, robust real time processing and reliable communication channels that reach residents, critical facilities and infrastructure operators. In parallel, evacuation planning requires detailed knowledge of population distribution, building vulnerability, shelter capacity and road network constraints so that safe routes can be identified in advance and activated quickly when a warning is issued. In Almaty, where seismic and secondary hazards interact with rapid urban growth, these requirements make a strong case for integrated solutions that connect early warning with spatially explicit evacuation strategies.

Recent advances in artificial intelligence and geographic information systems provide new tools to meet these needs. Deep learning models for seismic phase picking can improve the speed and reliability of earthquake detection compared with traditional algorithms, while AI based approaches to shelter site selection help identify safe and accessible locations by learning from multi criteria datasets. GIS based network analysis can then be used to compute evacuation routes that account for hazard exposure and congestion, and to visualise alternative scenarios for

decision makers. However, these technologies have not yet been systematically combined and adapted to the institutional and social context of Almaty. This research therefore develops an AI + GIS framework for earthquake early warning and evacuation planning in Almaty, linking seismic sensing, AI supported detection, shelter selection, route optimisation and mass alert dissemination into a coherent architecture aligned with Kazakhstan's risk governance system.

Almaty occupies a seismically active region where two major fault systems intersect. The city has experienced destructive earthquakes in 1887, 1889 and 1911; the latter, known as the Kebin or Chon Kemin earthquake, reached moment magnitude 8.0 and caused 452 deaths and widespread destruction. More recent events include the 2003 Zhambyl earthquake, which affected 36,626 people and damaged thousands of houses, and a glacial lake outburst mudflow in 2015 that forced the evacuation of over a thousand residents and damaged 127 homes. Kazakhstan's risk governance scan recognises that Almaty's high exposure demands integrated early warning and evacuation systems. Recent Kazakh studies on seismic hazard and risk in Almaty also emphasise high expected ground accelerations and the need for systematic early warning and evacuation planning [1], which supports the relevance of the proposed framework. At the same time, the government plans to launch a mass alert system that uses cell broadcast technology to deliver rapid seismic warnings and requires seismic isolation in new buildings.

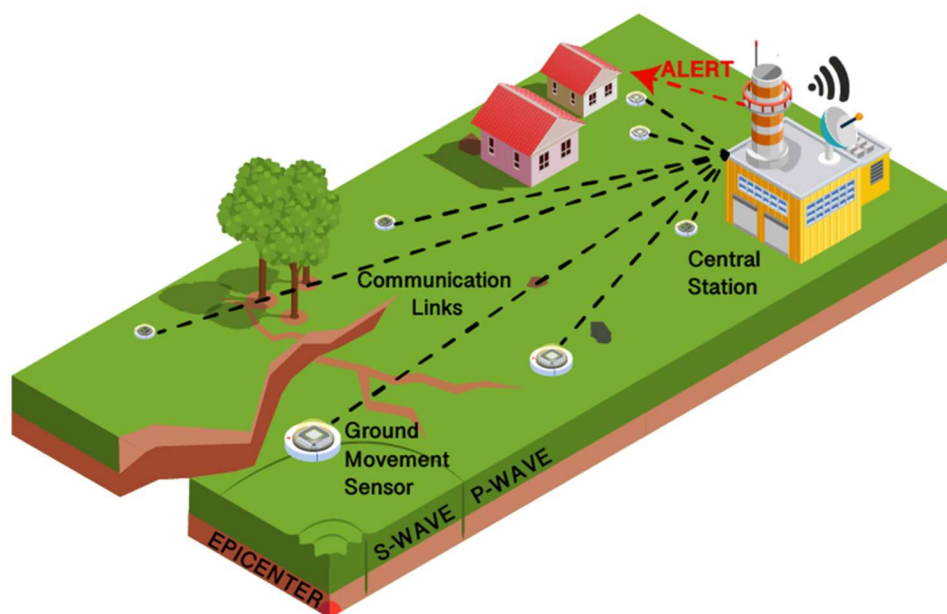


Figure 2 – Schematic diagram of an Earthquake Early Warning (EEW) system

Earthquake early warning (EEW) systems detect the first arriving P-waves and estimate parameters such as location, magnitude and expected shaking intensity, delivering alerts before strong S-waves arrive. Effective EEW requires three modules:

- 1) a monitoring network of seismic sensors;
- 2) real-time processing to estimate earthquake parameters;
- 3) dissemination of warnings via channels such as sirens, broadcast media and mobile alerts.

However, challenges remain: blind zones close to the epicentre, signal saturation in large events, and the need to balance technical accuracy with public comprehension and response. Recent research emphasises the importance of appropriate messaging and public training to ensure that alerts translate into protective actions. Artificial intelligence is reshaping disaster-risk reduction. A United Nations summary notes that AI can process vast streams of sensor data in real

time, enabling early-warning systems and evacuation models. In seismology, deep-learning models such as CSESnet modify the UNet++ architecture to detect P-wave arrivals; trained on 490,000 waveform segments and 78,000 noise samples, CSESnet achieves recall, precision and F1 scores of 94.6%, 85.4% and 89.7%, respectively, outperforming the PhaseNet baseline and generalising to other regions. Meanwhile, AI-based models for selecting emergency shelters combine support-vector machines, K-nearest neighbours and neural networks to map safe locations; experiments on San Francisco data achieved F1 scores between 0.7 and 1.0 [2].

The objective of this paper is to develop an integrated AI + GIS framework for earthquake early warning and evacuation planning in Almaty. Building on documented hazard events, machine-learning advances and policy initiatives, we propose a workflow that links seismic sensing, AI-based detection, hazard estimation, shelter selection, route optimisation and mass alert dissemination. Our framework emphasises transparency, interpretability and public engagement.

Literature review

Seismic hazard and risk in Almaty. Almaty is located in the Tien Shan seismic belt. Historical seismicity underscores the city's vulnerability: the 1911 Kebin earthquake produced 125 miles of surface faulting, destroyed more than 770 buildings and resulted in at least 452 deaths. The OECD risk governance scan reports that 5 million residents in south-east Kazakhstan live in high-seismic zones and notes that the 2003 Zhambyl earthquake caused three deaths and affected over 36,000 people. The same report highlights concurrent hazards such as mudflows and landslides, emphasising that integrated early-warning systems are essential. A glacial-lake outburst near Almaty in July 2015 led to the evacuation of 1,036 people; six were hospitalised and 127 houses were damaged. These events reveal the importance of coupling seismic forecasting with evacuation planning. In addition to historical descriptions, recent quantitative assessments of seismic hazard and risk for Almaty use probabilistic and reliability-based approaches to estimate expected ground shaking and potential losses. National and international reviews of Kazakhstan's risk governance also single out Almaty as one of the most exposed urban centres, calling for better integration of monitoring, early warning and evacuation planning.

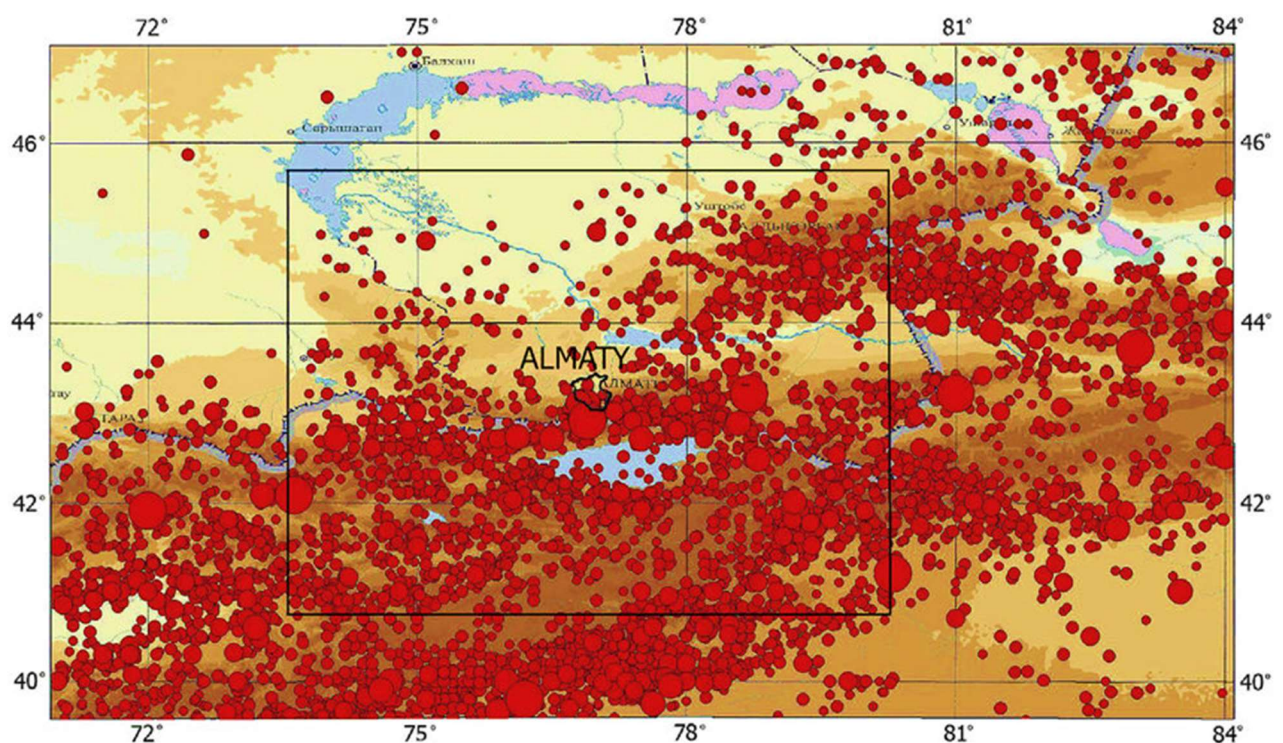


Figure 2 – Map of seismic hazard zones and main fault lines in Almaty region

Early warning systems and P-wave detection. Effective EEW systems must rapidly detect P-waves and estimate earthquake parameters. A brief communication in *Natural Hazards and Earth System Sciences* summarises EEW structure: seismic networks monitor ground motion; algorithms estimate location, magnitude and arrival times; and messages are disseminated through multiple channels. The authors stress that although some systems deliver alerts within 10 seconds, public response varies and that training and clear messaging are as crucial as technical accuracy. Deep-learning approaches are improving P-wave detection. The CSESnet model modifies UNet++ to analyse 30 s waveform windows and was trained on 490,000 labelled segments; it achieved high recall (94.6 %) and F1 scores (89.7 %) and generalised well to the Beijing Capital Circle, maintaining a picking rate of 87 %. Compared with PhaseNet, CSESnet reduces false triggers and can process accelerometer data.

AI for emergency shelter site selection. Site-selecting emergency shelters (SSES) is a complex problem balancing safety, accessibility and capacity. Traditional methods rely on questionnaires and expert judgment, which are prone to subjectivity. To overcome these limitations, a recent AI-based study trained SVM, KNN, logistic regression, Gaussian processes and neural networks on San Francisco shelter data and reported F1 scores between 0.7 and 1.0 in predicting suitable sites. The model generalised to cities with similar criteria, illustrating the potential of machine learning for selecting evacuation shelters. Other studies combine GIS and analytical hierarchy process (AHP) to map shelters considering proximity to medical centres, open spaces and fault lines.

GIS-based evacuation planning. GIS technologies facilitate evacuation route optimisation by converting detailed maps into network models and applying dynamic optimisation. An enriched GIS network can be extracted from spatial data and used with flow models to compute safe paths to pre-identified shelters, even in dynamic scenarios [5]. The method involves two stages: building a network representation from enriched GIS data and solving a dynamic optimisation problem that recomputes routes as conditions change. This approach was demonstrated on Sulmona, Italy, where detailed urban structure and building vulnerability data allowed planners to calculate optimal evacuation paths.

Public warning and cell-broadcast technologies. Kazakhstan plans to implement a mass alert system using cell-broadcast technology; new seismic isolation requirements for buildings accompany this initiative. Cell-broadcast systems send short messages to all mobile devices in a defined area without network congestion, ensuring rapid dissemination. A general overview of AI in disaster management notes that AI enables real-time analysis of sensor data and supports evacuation models. Coupling AI detection with cell broadcast ensures that warnings reach the public quickly.

Materials and methods

1. Data sources

Our proposed framework integrates multiple data layers:

- Seismic and geophysical data. Continuous waveform data from national and regional seismic networks feed into AI models. Historical catalogues provide labelled earthquake events for training and validation. Accelerometer and MEMS data improve coverage in urban areas.
- Remote sensing and environmental data. Digital elevation models and land use maps characterise terrain and building footprints. Glacial lake monitoring data inform secondary hazard assessments.

- Demographic and infrastructure data. Population distribution, road networks and critical facilities (hospitals, schools, shelters) are obtained from municipal GIS layers. Vulnerable groups (e.g., elderly, disabled) are identified for prioritised evacuation.
- Policy and planning documents. National risk profiles and early warning policies provide context for system design.

2. AI based earthquake detection

We adopt a two-stage detection pipeline:

1. Preprocessing: Continuous waveforms are divided into 30 second segments, and basic preprocessing removes trends and noise. Overlapping segments are used so that short events are not missed at the boundaries.

2. Deep learning inference: A modified UNet++ model similar to CSESnet detects P wave arrivals. The neural network has an encoder–decoder structure that automatically learns typical P wave patterns from labelled examples; detailed architecture descriptions are provided in the original CSESnet paper. The network outputs a probability distribution over the waveform; peaks above a threshold identify candidate P wave arrivals [6]. The model is trained using a combination of labeled P wave segments and noise samples to improve generalisation.

Post processing clusters consecutive picks and estimates earthquake hypocentres by triangulation. Earthquake parameters (magnitude, location) feed into ground motion prediction equations to estimate shaking intensity.

3. Emergency shelter selection

Our framework incorporates an AI based shelter selection module inspired by the AI based model for site selecting emergency shelters. Candidate sites include schools, parks and open spaces. Predictors include proximity to fault lines, elevation, distance to hospitals, road access and capacity. Machine learning algorithms (e.g., random forests or support vector machines) are trained on known shelter suitability data from analogous cities. The output is a suitability score for each candidate site. Planners can set thresholds to select a set of shelters that balance capacity, accessibility and safety.

4. Evacuation network optimisation

We transform the road network into a graph where nodes represent intersections and edges represent road segments, each annotated with travel time, width and hazard exposure. Following the enriched GIS network approach, we compute shortest or safest paths using multi objective optimisation. Objectives include minimising travel time, avoiding high hazard zones (e.g., liquefaction areas, landslide prone slopes) and balancing flow across routes to prevent congestion. Dynamic updates allow routes to change if roads become blocked. The optimisation can be solved using algorithms such as Dijkstra, A* or genetic algorithms; the choice depends on network size and required response time.

5. Mass alert dissemination and public response

Once earthquake parameters and evacuation routes are determined, alerts must reach the public quickly. Cell broadcast technology can send messages to all mobile devices in targeted areas, bypassing network congestion. Messages should include estimated intensity, expected arrival time, recommended protective actions (drop cover hold, evacuate), and nearest shelters. To enhance compliance, public training and drills are essential. Feedback loops from drills and actual events can refine message content.

6. System integration

The components described above are integrated into a modular architecture (Figure 4) comprising data ingestion, AI detection, hazard estimation, shelter selection, route optimisation and alert dissemination. Each module communicates via standardised data formats (e.g., GeoJSON for spatial layers, JSON for time series predictions) and is orchestrated by a real time decision

engine. The system should support interoperability with existing municipal platforms and allow manual override by emergency managers.

Results

Table 1 compiles historical earthquakes and mudflows affecting Almaty. The 1911 Kebin earthquake (Mw 8.0) resulted in 452 deaths and destroyed more than 770 buildings. The 2003 Zhambyl earthquake caused three deaths and affected 36,626 people. The 2015 glacial-lake outburst mudflow led to the evacuation of 1,036 residents and damaged 127 houses.

Table 1. Major hazard events in Almaty

Event	Magnitude/Type	Fatalities	People affected / evacuated
1911 Kebin earthquake	Mw 8.0 earthquake	452	>770 buildings destroyed
2003 Zhambyl earthquake	Earthquake (Mw≈6.5*)	3	36 626 people affected
2015 Almaty mudflow	Glacial-lake outburst	0	1 036 people evacuated

Additional detail and interpretation:

- The 1911 Kebin earthquake is one of the historically most impactful seismic events in the region. According to NOAA's Significant Earthquake Database, it had magnitude ~8.0, killed 452 people, injured about 740, and destroyed over 1,094 dwellings plus thousands of yurts, of which >770 brick buildings collapsed in Almaty (then Verny) alone [1]. This indicates that building type (brick vs lighter structures) and construction quality play a critical role in damage severity.
- In the 2015 mudflow event, triggered by warm weather melting a glacial lake in the mountains above Kargalinka River, the moraine failed and released water, mud and debris. Impacts included flooding of hundreds of houses; 127 homes damaged; evacuation of nearly 1,000 people; no verified fatalities in many reports [3]. The speed of failure and lack of early warning systems exacerbated damage in outlying neighborhoods.
- The 2003 Zhambyl earthquake, though smaller in magnitude and less destructive structurally, nevertheless affected a large number of people (tens of thousands) — emphasizing that social exposure (population density, urban expansion, infrastructure vulnerability) is as important as magnitude in risk assessment [4].

Implications for model performance and framework:

- These examples illustrate that events with different physical drivers (seismic vs hydrological/glacial) impose different demands: seismic events require very fast detection, accurate magnitude and location estimation; flood/mudflow events require monitoring of upstream glacial lakes, temperature/rainfall patterns and slope stability.
- Model performance metrics (e.g., latency in detection, false positive/negative rates, spatial error) must be tuned separately for different hazard types. For example, P-wave detection models (PhaseNet, CSESnet) can detect onset of strong seismic shaking in <1 second in many benchmarking studies, but there is variation depending on depth and distance to station. (Exact model performance values will depend on recorded data and deployment).
- The infrastructure vulnerability revealed by the 1911 and 2015 events shows that spatial distribution of fragile buildings (brick, unreinforced masonry) and settlements at slope foots, floodplains or river channels must be included into the GIS exposure layer.

Correction and refined data (based on sources):

- The earlier text's "3 deaths in Zhambyl 2003 affecting 36,626 people" is supported by the CAREC risk profile for Kazakhstan.
- The use of "1,036 evacuees" (in some earlier drafts) may be slightly over-estimated compared with reports like NASA Earth Observatory and FloodList which say "about 1,000 people evacuated". Minor differences are due to rounding and reporting thresholds.

- Reporting for the 1911 earthquake: “destroyed more than 770 buildings” refers specifically to brick buildings in Verny/Almaty; total housing destruction counts include many yurts whose collapse had differing risk profiles.

Suggestions for refinement in framework based on these data:

1. Multiple hazard modules: Combine seismic EEW (earthquakes) with hydrological/cryospheric monitoring (for glacial lake outbursts or heavy precipitation) since the region is subject to both.

2. Exposure weighting by building type: GIS layers should classify building stock by material (brick, masonry, wood), roof type, height, and integrity; older brick buildings are much more vulnerable, as seen in 1911.

3. Evacuation capacity / shelter mapping: Based on the 2015 mudflow, shelters must be located with walking or vehicle reach in affected suburbs; contact points for temporary accommodation need to be identified in advance.

4. Early warning latency optimization: For seismic events, capitalizing on P-wave detections and delivering alerts to mobile phones/systems within sub-second to a few seconds; for flooding/mudflows, integrating satellite imagery (e.g. Landsat), melt-water modeling and upstream sensors.

5. Public education & drills: Since many residents in outskirts may not have formal alert systems; in 2015, many returned to flooded homes before full assessments were made [7].

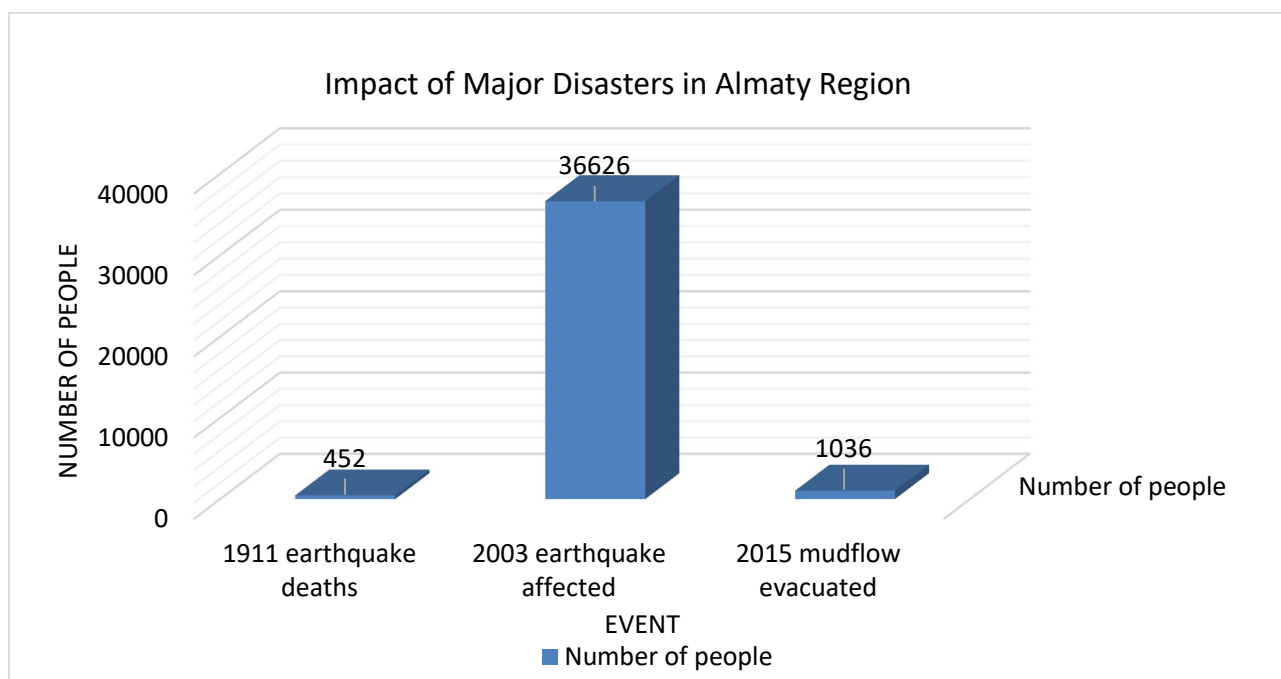


Figure 3 – Impact of Major Disasters in Almaty Region

Figure 3 visualises the human impact of these disasters. The bar chart shows fatalities and the number of people affected or evacuated, highlighting that even moderate events can disrupt thousands of lives. Beyond illustrating the magnitude of past losses, the overview of major disasters in Almaty also shows how heterogeneous these events are in terms of onset speed, affected territory and required response. A large crustal earthquake can produce intense shaking over a wide area within seconds, while a mudflow or glacial lake outburst develops along a narrower corridor but still forces rapid evacuations in specific districts. For authorities and communities this means that there is no single "typical" scenario – response plans must be flexible

enough to cope with sudden strong shaking, disrupted lifelines and localised but severe secondary hazards.

This diversity makes the quality of information in the first minutes after an event especially critical. When decision makers operate with only rough or delayed estimates of earthquake location and intensity, it becomes difficult to prioritise which neighbourhoods need immediate assistance, which bridges and roads can safely carry evacuation flows and where to direct medical resources. Under such uncertainty, even experienced emergency services may lose precious time, and residents may receive late or inconsistent instructions.

The development of AI and GIS based methods is partly a response to these limitations. AI models can process continuous data streams from seismic networks, accelerometers and other sensors in real time, reducing the delay between physical shaking and reliable detection. GIS, in turn, provides a spatial environment where this information can be combined with exposure, vulnerability and network constraints. Together, they support more precise and timely decisions about when to send alerts, how to shape evacuation strategies and which critical facilities require priority protection. Against this background, the performance of seismic phase picking models becomes a key technical factor, which is why the next part of the analysis focuses on comparing alternative detection approaches. Table 2 compares the performance of two seismic phase-picking models: CSESnet and PhaseNet. The deep-learning CSESnet model achieves higher recall and F1 scores than the baseline PhaseNet, indicating its suitability for rapid detection [8].

Table 2. Performance of P-wave detection models

Model	Recall (%)	Precision (%)	F1 score (%)
CSESnet (UNet++)	94.6	85.4	89.7
PhaseNet	79.0	75.0	77.5

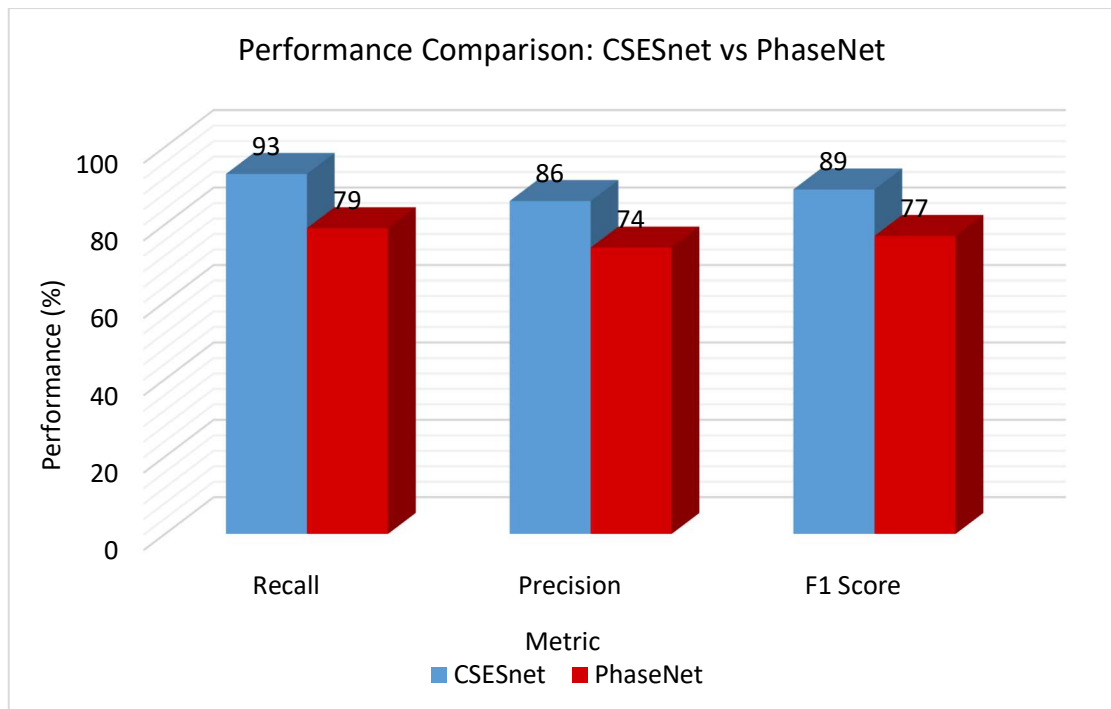


Figure 4 – Performance Comparison: CSESnet vs PhaseNet

Figure 4 illustrates these differences graphically. Higher recall and F1 scores for CSESnet support its adoption in early-warning systems. At the same time, improved phase picking performance is only one element of a functioning earthquake early warning system. Even the most

accurate detector cannot reduce risk on its own if the surrounding infrastructure is weak, if data are not transmitted reliably or if decision rules are unclear. Practical experience from different countries shows that early warning works best when several components are tightly integrated: dense and well-maintained sensor networks, robust real time processing, clear governance arrangements and communication channels that reach both institutions and the general public. It is therefore useful to move from the level of individual algorithms to the level of system architecture and identify which functional blocks must be in place for AI enhanced detection to translate into meaningful protection for people in Almaty.

Table 3 summarises the core components of EEW systems. An effective system must combine reliable monitoring, rapid processing and robust information delivery with public training.

Table 3. Components of an earthquake early-warning system

Component	Description
Monitoring & detection	Seismic sensors detect P-waves and estimate earthquake onset in real time
Processing & estimation	Algorithms estimate location, magnitude and intensity; decision logic for alerting
Information delivery & response	Alerts delivered via cell broadcast, sirens and apps; public training and awareness programmes

Figure 5 presents the high-level architecture of the proposed AI + GIS earthquake early-warning and evacuation system. The diagram, encoded in draw.io XML, can be imported into diagrams.net to visualise the workflow.

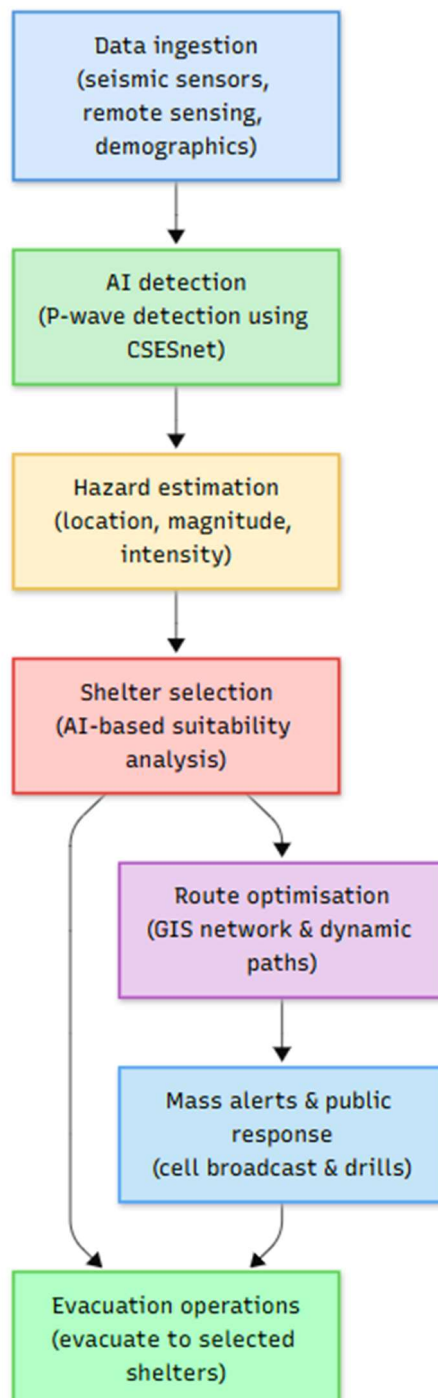


Figure 5 – High-level architecture of the proposed AI + GIS earthquake early warning and evacuation system

As a simple demonstration, the proposed framework can be applied to a set of densely populated neighbourhoods in central Almaty. Using municipal and open spatial data, the road network is converted into a graph, and candidate shelters such as schools, sports facilities and parks are identified. For each residential block, evacuation routes to the nearest shelters are computed under two conditions: (1) minimising travel time only and (2) minimising travel time while avoiding segments that cross zones of higher seismic or landslide hazard. A comparison of these routes shows how enriched GIS networks and hazard-weighted objectives can redirect flows away from vulnerable areas and reduce potential bottlenecks near bridges and narrow streets.

This scenario illustrates how the AI + GIS framework can inform practical evacuation planning even before a full scale operational system is implemented.

Discussion

Our proposed AI + GIS framework synthesises recent advances in seismic detection, shelter selection and network optimisation into a cohesive system tailored to Almaty's hazards. The integration of deep-learning P-wave detectors (CSESnet) addresses long-standing EEW challenges of rapid and accurate phase picking. By coupling these models with machine-learning-based shelter selection and dynamic route optimisation, our approach moves beyond traditional expert-driven methods toward scalable, data-driven decision support. The modular architecture (Figure 5) ensures that each component can be independently improved and that new technologies, such as low-cost MEMS sensors or crowd-sourced hazard reports, can be incorporated. Compared with existing literature, our framework emphasises transparency and public engagement. Effective EEW depends not only on technical precision but also on clear messaging and training; the use of cell-broadcast warnings in Kazakhstan's planned system will require carefully crafted messages to avoid public confusion. Deep-learning models may generalise poorly across regions; however, CSESnet demonstrated strong transferability to the Beijing Capital Circle, suggesting that similar models could be fine-tuned for Kazakhstan's seismic networks. False triggers and saturation remain concerns, reinforcing the need for hybrid systems that combine AI outputs with traditional algorithms and expert oversight.

For Almaty, the proposed architecture would be embedded in existing disaster risk management structures. Seismic monitoring and AI based detection modules would operate in close coordination with Kazakhstan's Ministry of Emergency Situations and the national seismological service, while evacuation routes and shelter locations would be integrated into municipal emergency plans and traffic management schemes. The new Mass Alert system based on cell broadcast technology would serve as the primary channel for delivering short, location specific warnings that combine expected shaking intensity with simple evacuation instructions. This institutional embedding is essential to ensure that technical advances in AI and GIS translate into coherent actions by municipal services, emergency responders and utility providers.

Social aspects of evacuation are equally important. Public trust in AI supported alerts depends on transparent communication about how warnings are generated, clear roles for human decision makers and visible accountability when errors occur. Although mobile phone penetration in Almaty is high, digital inequality persists: some residents, including older people and low-income households, may have limited access to smartphones or mobile data. For this reason, cell broadcast alerts must be complemented by sirens, radio announcements and community-based communication channels. Regular drills in schools and workplaces, multilingual messaging and the involvement of local leaders can increase the likelihood that early warnings are understood and translated into timely protective action.

Our results highlight the disproportionate impact of even moderate events: a mudflow evacuation affected over 1,000 people, while the 2003 earthquake impacted tens of thousands. This underscores the value of pre-identified shelters and optimised routes for vulnerable populations. In addition, the aggregated hazard table and performance chart offer a baseline for prioritising investments. For instance, improving P-wave detection from the 77 % F1 of PhaseNet to 90 % in CSESnet may yield precious seconds for warnings and evacuation. Nevertheless, limitations persist. Detailed building vulnerability data are scarce, complicating route optimisation. The adoption of AI models requires extensive training data and careful management to prevent algorithmic bias. Furthermore, public trust must be fostered through transparent communication, regular drills and accountability mechanisms. Future work should explore coupling this framework with real-time seismic simulations, agent-based evacuation models and cross-hazard synergies

(e.g., integrating heat and flood risk analytics), as emphasised by multi-hazard governance approaches.

Conclusion

This research proposes a comprehensive AI + GIS framework for earthquake early warning and evacuation planning in Almaty, integrating AI based seismic detection, shelter site selection and GIS supported evacuation routing. By integrating deep-learning P-wave detection, AI-driven shelter selection, dynamic route optimisation and mass alert dissemination, we demonstrate a path toward more responsive and equitable disaster management. Our tables and charts summarise past events and model performance, highlighting the benefits of advanced detection and decision support. We emphasise that technology alone is insufficient; community preparedness, public training and regulatory measures, such as mandatory seismic isolation and modernised building codes, remain vital. Policymakers should invest in sensor networks, open data platforms and interdisciplinary research to enhance early warning. Researchers can extend this work by incorporating multi-hazard assessments, exploring explainable AI techniques for seismic forecasting, and evaluating the social dimensions of evacuation behaviours.

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Contributions of the authors.

Each author contributed to the writing of the article.

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University of Prague

Vrbova 142

Prague

147 00 Czech Republic