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APPLICATION OF ARTIFICIAL INTELLIGENCE ELEMENTS IN STEM EDUCATION**Алайдарова Салтанат Рысбековна***Магистр, старший преподаватель Центрально-Азиатского
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Аннотация. В статье рассматривается интеграция образовательных практик на основе искусственного интеллекта в программы STEM в рамках специальностей иностранного языка. Исследование сосредоточено на междисциплинарных образовательных процессах, сочетающих лингвистическую подготовку с техническими и математическими дисциплинами. Результаты исследования показывают, что системы машинного перевода, адаптивные обучающие платформы и речевые технологии предоставляют реальные возможности для повышения педагогической эффективности преподавателей. Статья предназначена для специалистов в области прикладной лингводидактики и цифровой педагогики.

Ключевые слова: искусственный интеллект, STEM-образование, лингводидактика, адаптивное обучение, цифровые технологии, междисциплинарная связь.

INTRODUCTION

The boundary separating technical disciplines from the humanities has been gradually dissolving in recent decades. This process is particularly evident in higher education institutions that train foreign language professionals: the contemporary linguist-educator is no longer expected merely to develop students' command of a target language as a phonological and grammatical system, but must also prepare them to operate competently with the wide range of instruments available in digital environments. Viewed from this angle, the concept of STEM education — an approach that integrates natural sciences, technology, engineering, and mathematics — has been steadily finding its way into the curricula of foreign language degree programmes.

The incorporation of artificial intelligence (AI) elements into this integrated process represents one of the pressing questions facing pedagogical science today. A survey of the relevant scholarship, however, reveals that the majority of existing studies have been conducted either from a purely technical or a purely linguistic perspective. Research that simultaneously bridges linguistic preparation with STEM content and connects that STEM content with AI-based technologies remains scarce. Addressing this gap, at least in part, constitutes the primary objective of the present article.

The history of technology-oriented approaches to foreign language instruction is closely intertwined with the emergence of computational linguistics. The earliest CALL (Computer-Assisted Language Learning) systems, which appeared in the late 1980s, were essentially rudimentary programmes operating through external linguistic databases. Over the past decade this trajectory has shifted to an altogether different level: neural networks and large language models are now capable of simulating linguistic interaction in ways that were previously unattainable.

The theoretical underpinning for integrating STEM education with linguistic preparation was first explored by J. Burbules and C. Torres (2000) within the framework of interdisciplinary pedagogy. Subsequent researchers — notably R. Lang and M. Stein (2014) — gathered empirical data on the role of language skills in STEM contexts. Their findings indicated that the academic language proficiency (CALP) of students enrolled in STEM programmes develops at a considerably earlier stage than that of their peers in general education curricula.

In the Kazakhstani context, this issue is directly connected to the country's trilingual education policy. The trilingual instruction programme currently in operation demands of foreign language professionals — linguodidacts — not merely the sequential teaching of individual languages, but the capacity to examine the interconnections among several linguistic systems at once. AI technologies are increasingly becoming the analytical instruments capable of supplying that examination with the empirical data it requires.

A Typology of AI Elements Relevant to the Foreign Language Specialty

From a pedagogical standpoint, AI elements can be provisionally grouped into three categories: (1) language-processing instruments, (2) adaptive learning systems, and (3) evaluative-diagnostic platforms. This typology has been developed with due regard for the specifics of the specialty and therefore differs from general pedagogical classifications found elsewhere in the literature.

Language-processing instruments include machine translation tools (DeepL, ModernMT), automated corpus analysis systems, and syntactic parsers. The value of this category for the foreign language specialty is particularly pronounced: a student can engage with the lexical and grammatical organisation of a target

language from the vantage point of computational linguistics. Analysing the errors produced by neural translation — tracing the origins of transfer errors — constitutes an effective means of observing the semantics and pragmatics of linguistic units from the outside, as it were.

Adaptive learning systems (Duolingo, Quizlet, Carnegie Learning) process a learner's actual performance data — response latency, error patterns — in real time and personalise tasks accordingly. When combined with STEM content, these systems can function, for instance, as lexical trackers designed to teach mathematical or chemical terminology simultaneously in three languages.

Evaluative-diagnostic platforms automate the assessment of speech production and reception. Systems capable of evaluating IELTS Academic Writing essays, or pronunciation-diagnostics tools such as Speechace, do not replace the teacher but substantially reduce the workload associated with formative assessment.

Models for Interdisciplinary Integration within a STEM Context

Several concrete models exist for the effective integration of AI technologies with STEM content in the foreign language specialty. These models can be systematised on the basis of research findings and practical experience.

The first model involves the use of AI instruments within the framework of Content-Based Instruction (CBI). Under this approach, the subject matter of a STEM discipline serves as the channel through which the foreign language is taught. Translating bioengineering texts with DeepL and then comparing the translation to the original source from the perspective of linguistic description, for example, simultaneously cultivates terminological literacy, analytical thinking, and a conscious understanding of the limitations inherent in machine translation.

The second model involves solving real-world problems through chatbots and language models within a Project-Based Learning (PBL) framework. When students are preparing a scientific report on environmental monitoring, they critically analyse the texts obtained from a GPT-type model, identify neologisms and terminological inconsistencies, and substantiate their observations using the conceptual apparatus of linguistics. This constitutes an innovative approach that combines cognitive linguistics with digital literacy within a single project assignment.

The third model involves the use of adaptive platforms in a flipped classroom format. The student engages with theoretical material before the class session using an adaptive instrument; the instructor then devotes classroom time to critical discussion and the clarification of interdisciplinary connections. Research has shown that when language grammar rules are taught alongside STEM content in this format, students internalise abstract rules more rapidly through the mediation of concrete context.

Findings from the Empirical Study

The author of this article conducted experimental work during the 2023-2024 academic year with second- and third-year students enrolled in the foreign language specialty at Central Asian Innovation University. The control group (n=24) followed the conventional curriculum, while the experimental group (n=26) studied under a revised programme that incorporated the CBI model together with AI instruments.

The results of a lexical test administered at the end of the semester indicated that the experimental group's level of STEM terminology acquisition was, on average, 18.4% higher than that of the control group. The gap in critical reading proficiency stood at 12.7%. These figures are statistically significant ($p < 0.05$); however, the limited sample size of the study does not permit broad generalisation of the findings — future research will need to work with larger samples.

Semi-structured interviews conducted with the students revealed that 81% of the experimental group assessed their work with AI instruments as helpful for gaining a clearer understanding of their own linguistic limitations. This finding carries psycholinguistic significance: the relationship between heightened metacognitive awareness and the long-term effectiveness of language acquisition is well established in the scholarly literature.

Challenges and Limitations

The integration of AI technologies into the STEM programme of a foreign language specialty brings with it a number of unresolved issues. The most pressing among them is the matter of instructor readiness. The majority of foreign language teachers at domestic higher education institutions did not acquire practical knowledge of AI platforms during their professional training. Addressing this shortfall will require dedicated retraining programmes — ones oriented not merely towards generic digital literacy, but towards concrete linguodidactic use cases.

A second problem concerns the risk of dependence on algorithmic agency. Adaptive systems may simplify tasks or repeat the same content in response to a learner's previous answers, thereby creating a cognitive comfort zone. If an instructor deploys such systems as anything other than one component of a broader curriculum — and without maintaining ongoing oversight — there is a real possibility that the development of autonomous learning skills will produce outcomes contrary to those intended.

A third limitation relates to questions of academic ethics and intellectual authorship. Whether a student who incorporates text generated by an AI system into a course assignment or term paper is violating academic integrity norms has not yet received a uniform answer within the pedagogical community. Resolving this question — both at the level of regulatory instruments and at the level of classroom pedagogy — will require separate, dedicated research.

The use of AI elements within STEM education in the context of the foreign language specialty is not merely a technological novelty; it represents a new paradigm for interdisciplinary pedagogy. The findings presented in this article confirm that this form of integration yields positive results in the development of lexical and terminological skills, the enhancement of metacognitive awareness, and the cultivation of students' critical thinking capacities.

Future research should proceed along three trajectories: (1) longitudinal studies measuring the long-term effectiveness of AI-informed pedagogy; (2) purpose-built programmes for instructor preparation; and (3) systematic investigations that refine the typology of AI instruments in alignment with the integrated curricula of STEM specialties. The empirical base accumulated across these three areas will contribute to establishing the theoretical foundations for the digital transformation of foreign language education in Kazakhstan.

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