

Zh.M. Tentekbayeva^{1*}, A. Mosavi²

¹*Buketov Karaganda National Research University, Karaganda, Kazakhstan*

²*Óbuda University, Budapest, Hungary*

(*Corresponding author e-mail: zh.tentekbaeva@ktu.edu.kz)

¹ORCID: <https://orcid.org/0000-0002-9286-0352>

²ORCID: <https://orcid.org/0000-0003-4842-0613>

¹Scopus ID: 56027539800

²Scopus ID: 57191408081

Integration of AI technologies in teaching English to STEM students

The article focuses on examining the impact of artificial intelligence (AI) technologies on the process of teaching English in higher education and identifying the prospects for their effective integration into educational practice, particularly for students of STEM specialties. The authors consider a range of modern AI tools, including chatbots, automated writing assistants, and digital vocabulary platforms, and analyze their role in enhancing language learning outcomes. The study is based on a combination of theoretical analysis and an empirical investigation using a quasi-experimental design with control and experimental groups. The experimental group engaged in AI-supported learning over an eight-week period, while the control group followed traditional instructional methods. The data collected during the research point to a positive effect of AI-supported instruction on students' English language development. Improvements were observed across all language competencies examined, and the statistical analysis confirmed that these changes were significant. The results also indicate that AI-based tools can enrich the learning process by providing individualized support, increasing student engagement, and creating more opportunities for meaningful language practice. The authors conclude that the successful implementation of AI requires its systematic integration into traditional teaching approaches and adaptation to the individual needs of learners.

Keywords: artificial intelligence, English language teaching, STEM students, AI-based learning, digital education, language acquisition, educational technology, adaptive learning systems, automated feedback.

Introduction

Artificial intelligence (AI) has become an important part of higher education and has influenced teaching and learning practices across many disciplines. In recent years, educational institutions have adopted AI technologies to improve instructional quality, increase student engagement, and support personalized learning. English language education is among the fields that experience substantial changes due to the use of AI-based tools and applications. These technologies provide new opportunities for language instruction through automated feedback, adaptive learning systems, and interactive communication platforms [1]. The integration of AI technologies into English language teaching is particularly important for students in science, technology, engineering, and mathematics (STEM) disciplines. English serves as the dominant language of scientific communication, research publication, and international collaboration. Therefore, STEM students require advanced language skills to access scientific knowledge, communicate technical information, and participate effectively in academic and professional environments. AI technologies can support these requirements by providing personalized learning experiences and facilitating the development of both linguistic and digital competencies [2]. Recent technological advances have introduced various AI tools into language education. These tools include chatbots, voice assistants, automated writing assistants, intelligent assessment systems, and digital vocabulary platforms. Such technologies provide immediate feedback, adaptive content, and opportunities for independent learning. As a result, students can practice language skills beyond the classroom and receive continuous support throughout the learning process [3]; [4]. Chatbots and AI-based conversational systems are widely used to improve speaking and listening skills. These tools simulate authentic communication situations and allow students to practice English in a low-pressure environment. Through repeated interaction, learners can improve pronunciation, fluency, and communication confidence. Studies indicate that AI-supported speaking platforms increase student engagement and encourage auto-

mous language learning [5], [6]. Automated writing assistants represent another important application of AI in English language education. These systems evaluate written texts and provide feedback on grammar, vocabulary, sentence structure, coherence, and style. Such feedback assists students in identifying weaknesses and improving the quality of their written work. Intelligent assessment systems also support more efficient evaluation processes and provide individualized guidance for language development. Research demonstrates that AI-assisted writing tools contribute to improvements in academic writing performance and overall language proficiency [2; 169].

Digital vocabulary platforms also support English language learning through adaptive and personalized instruction. These systems identify learners' needs and provide customized vocabulary exercises that promote effective acquisition and retention of language knowledge. For STEM students, such platforms are especially valuable because they facilitate the learning of technical terminology and discipline-specific vocabulary that are necessary for academic success and professional communication [7], [8]. The educational benefits of AI extend beyond language acquisition. Research indicates that AI-supported learning environments contribute to the development of both linguistic and digital skills. Researchers report significant improvements in language competence and digital literacy among university students who use AI-based learning tools. These findings are particularly relevant for STEM education because digital competence is closely associated with academic achievement and future employability. AI systems also support personalized learning by adapting educational content to individual proficiency levels and learning needs [3; 898]; [4; 1363].

Furthermore, AI technologies can promote critical thinking, active participation, and academic engagement when they are integrated appropriately into instructional practices. Continuous feedback, self-assessment opportunities, and interactive learning activities encourage students to assume greater responsibility for their learning. Comparative studies indicate that AI-assisted instruction can produce positive learning outcomes and support more effective learning behaviors when combined with appropriate pedagogical guidance [5; 16]; [6; 548]. Despite these advantages, several challenges remain. One concern relates to excessive dependence on AI technologies. Students may rely on automated systems for language production and problem-solving tasks rather than developing independent language abilities. Therefore, AI should serve as a supplementary educational tool rather than a replacement for human instruction and critical thinking [9]. Additional concerns involve ethical, social, and technological issues. Researchers identify challenges related to data privacy, algorithmic bias, transparency, and unequal access to digital technologies. These issues may affect the quality and fairness of educational experiences. Consequently, educational institutions must ensure responsible and ethical implementation of AI technologies within teaching and learning environments [9; 253]. The successful integration of AI into English language education also depends on teachers' readiness and professional competence. Educators play a central role in selecting, implementing, and evaluating AI tools. Research shows that digital literacy, technological confidence, and positive attitudes toward AI influence teachers' willingness to adopt these technologies in educational practice. Therefore, professional development programs and specialized training initiatives are required to support effective AI integration [7; 4]; [9; 254].

Given the growing importance of AI in higher education, further investigation of its role in English language teaching remains necessary. Particular attention should be directed toward STEM students because their academic and professional requirements involve both language proficiency and technological competence. Understanding the opportunities, challenges, and future prospects of AI integration can assist educators and institutions in creating more effective learning environments. Therefore, this article examines the impact of AI technologies on the process of teaching English in higher education and identifies prospects for their effective integration into educational practice, with a particular focus on students of STEM specialties. The study considers major AI tools, including chatbots, automated writing assistants, and digital vocabulary platforms, as well as the benefits and challenges associated with their educational application.

Methods and Materials

The study was conducted during the first academic term and involved 30 first-year STEM students aged 18-19 whose English proficiency ranged from A2 to B1 according to the CEFR scale. To examine the impact of artificial intelligence on language learning, the participants were divided into two equal groups. Fifteen students formed the control group and followed a conventional English for Specific Purposes (ESP) course, whereas the remaining fifteen students participated in AI-enhanced learning activities. The experimental stage of the research lasted eight weeks and was organized in three successive phases. Before the beginning of the course, all participants completed a pre-test to determine their initial level of English proficiency. The

intervention phase followed, during which different instructional approaches were applied in the two groups. At the end of the experiment, students completed a post-test that assessed the same language skills as the initial assessment, namely vocabulary knowledge, writing accuracy, and speaking fluency. Using identical evaluation criteria for both tests made it possible to compare students' progress over the course of the study.

Students in the control group continued learning through conventional classroom instruction based on the ESP curriculum, textbook activities, and teacher feedback. In contrast, the experimental group regularly used AI-supported learning tools as part of their classroom and independent work. Speaking practice was carried out with conversational chatbots, written assignments were revised using automated writing assistants, vocabulary was reinforced through digital applications employing spaced repetition, and pronunciation was practised with speech-recognition software. To complement the test results, students in the experimental group also completed a short questionnaire that explored their learning experience, motivation, and opinions about using AI technologies in English classes.

The effectiveness of the intervention was evaluated using several sources of evidence, including pre-test and post-test scores, questionnaire responses, and classroom observations. The quantitative data were analysed with descriptive statistics, while differences between the control and experimental groups were examined using an independent-samples t-test. Statistical significance was established at $p < 0.05$. The analysis showed that students who learned with AI tools achieved significantly better results than those in the control group ($p < 0.01$). To improve the consistency of the study, both groups completed equivalent tasks and were assessed according to the same scoring criteria. Participation was voluntary, and all information collected during the research remained confidential and was used only for academic purposes.

Results and Discussion

A comparison of the pre-test and post-test scores showed that students made progress in all of the language skills assessed during the experiment, including vocabulary, writing, and speaking. The largest improvement was found in vocabulary knowledge. Before the intervention, the average score was 61 %, whereas after eight weeks of AI-supported instruction it increased to 82 %, representing an overall improvement of 21 percentage points. The statistical analysis confirmed that the difference between the two measurements was significant (paired-samples t-test, $p < 0.01$) (Fig. 1). These results suggest that the observed progress was associated with the integration of AI tools into the learning process rather than with random variation.

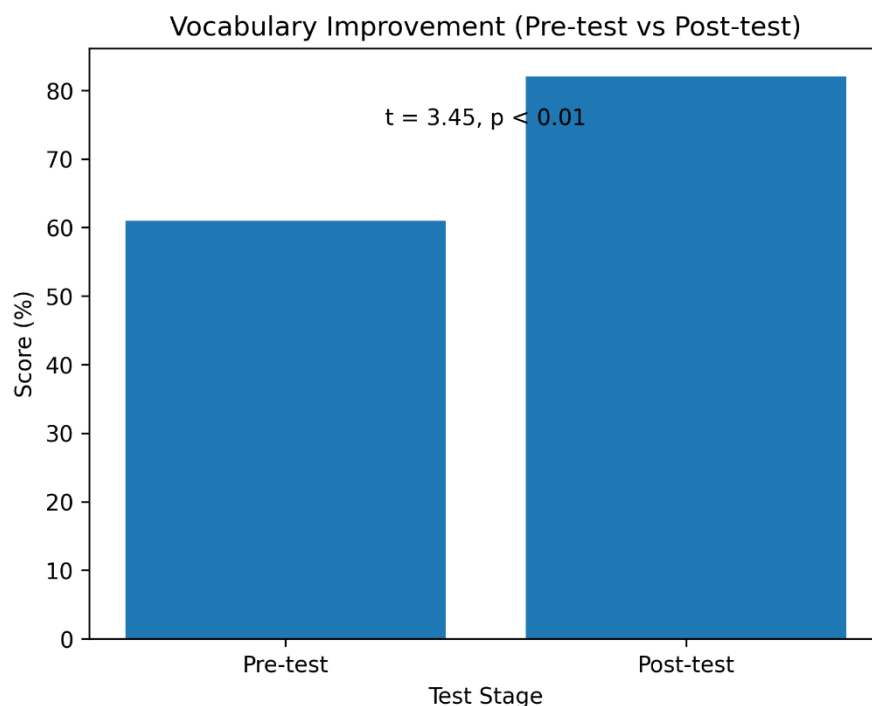


Figure 1. Vocabulary improvement (Pre-test vs Post-test)

The improvement in vocabulary can largely be linked to the regular use of AI-supported learning applications. These platforms enabled students to practise independently, revisit difficult words, and receive exer-

cises adapted to their current level of knowledge. As the experiment progressed, many students showed greater confidence in using newly learned words and were able to apply subject-specific terminology more accurately in different language tasks. This is especially relevant for STEM students, whose future academic and professional activities require a solid command of specialized English vocabulary. Unlike traditional classroom instruction, AI-based applications provide continuous practice and individualized support, making vocabulary learning more efficient and better suited to students' needs.

Improvements were evident not only in vocabulary, but also in students' writing skills. According to the obtained results, grammatical accuracy improved by approximately 28 %, whereas lexical diversity increased by 25 %. One possible explanation for these gains is the use of automated writing assistants, which provided immediate feedback and enabled students to revise their work more effectively. Unlike traditional teacher correction, which is often delayed, AI-based tools offered instant suggestions and encouraged students to reflect on their mistakes. Nevertheless, it should be emphasized that automated feedback cannot fully replace the teacher's role. In our view, excessive dependence on such technologies may reduce students' ability to analyse language independently; therefore, AI tools should be used as a supplement rather than as a substitute for traditional instruction.

Similar trends were identified in the development of speaking skills. The analysis showed a 24 % increase in speaking fluency, while students' confidence in oral communication improved by nearly 30 %. These results can be associated with the use of AI chatbots and speech-recognition technologies, which provided opportunities for regular speaking practice in a stress-free environment. Many students reported that interacting with AI systems reduced their fear of making mistakes and encouraged them to participate more actively in communicative tasks. Immediate feedback on pronunciation and unlimited opportunities for practice also appeared to contribute to the improvement of oral performance (Fig. 2).

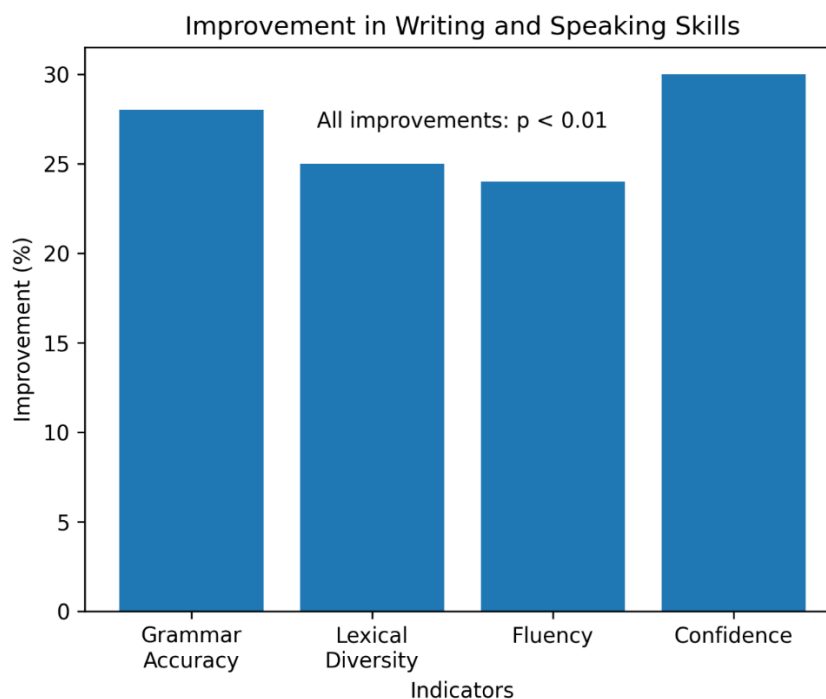


Figure 2. Improvement in writing and speaking skills

The data demonstrate that the use of AI technologies had a positive impact on different aspects of language learning. Significant progress was observed not only in vocabulary acquisition but also in writing and speaking skills, with all differences being statistically significant at $p < 0.01$. These results suggest that AI tools support the development of communicative competence in a comprehensive manner rather than improving isolated language components.

The survey conducted among the participants also shed light on students' perceptions of AI-assisted language learning. Most students expressed favourable opinions regarding the use of AI technologies in English classes. In particular, 91 % of respondents reported higher levels of motivation, while 87 % believed that

AI tools helped them learn more effectively. Moreover, 89 % indicated that they would like such technologies to remain part of the learning process in the future. These responses suggest that AI-based learning environments are perceived positively by students and may contribute to increased engagement.

The findings obtained in this research are generally in line with previous research emphasizing the benefits of artificial intelligence in language education. Our results support the idea that combining several AI tools within one instructional framework can support multiple language skills. The simultaneous use of chatbots, automated writing assistants, vocabulary platforms, and speech-recognition systems appears to create favourable conditions for the development of different language skills.

At the same time, several limitations should be acknowledged. First, AI technologies should not be regarded as a replacement for teachers, whose role remains crucial in organizing the learning process and supporting students. Second, the effectiveness of AI largely depends on the way these tools are integrated into classroom practice. Finally, the present study involved a relatively small number of participants, which limits the generalizability of the findings. Further studies involving larger samples would provide a more comprehensive understanding of the role of AI in language learning.

Despite these limitations, the study highlights the considerable potential of artificial intelligence for teaching English to STEM students. The use of adaptive learning systems, automated feedback, and interactive communication tools makes the learning process more flexible and learner-centred. Therefore, AI technologies may become an important component of modern foreign language education and contribute to improving the quality of language training in higher education institutions.

Conclusions

Taken together, the results suggest that AI technologies can be a valuable addition to English language teaching for STEM students. During the eight-week experiment, students improved their performance in vocabulary, writing, and speaking, with vocabulary showing the greatest progress. The statistical analysis confirmed that these changes were significant. This suggests that combining AI-supported activities with traditional classroom instruction creates more favourable conditions for language learning than relying on conventional methods alone.

An important observation from the research was that the combination of several AI-based applications provided complementary support across different language skills. Each technology addressed a particular aspect of language learning, and together they provided students with varied opportunities to practise vocabulary, writing, speaking, and pronunciation. By providing immediate feedback and opportunities for individualized practice, these technologies helped students become more engaged in the learning process and increased their motivation to study English.

At the same time, the study supports the view that artificial intelligence should be regarded as an additional educational resource rather than a replacement for the teacher. Effective learning still depends on pedagogical guidance, well-designed learning activities, and meaningful interaction between teachers and students. Therefore, the successful implementation of AI technologies requires their thoughtful integration into existing teaching practices.

The findings highlight the considerable potential of artificial intelligence for improving English language instruction in technical universities. As digital technologies continue to develop, AI-based tools may become an important component of modern language education and contribute to preparing STEM students for academic and professional communication in an increasingly globalized world.

CRedit Author Statement

Zh.M. Tentekbayeva: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Data curation, Writing — original draft preparation.

A. Mosavi: Conceptualization, Methodology, Validation, Resources, Supervision, Writing — review and editing.

Both authors approved the final version of the manuscript.

Conflict of Interest Statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Information about the authors

Tentekbayeva Zhuldyz Mukhamedgaliyevna (contact person) — PhD student in Educational Programme 8D01702 — Foreign Language: Two Foreign Languages, Buketov Karaganda National Research University, Karaganda, Kazakhstan; e-mail: zh.tentekbaeva@ktu.edu.kz; ORCID ID: <https://orcid.org/0000-0002-9286-0352>; Scopus ID: 56027539800

Mosavi Amir — PhD, Professor, Óbuda University, Budapest, Hungary; e-mail: amir.mosavi@uni-obuda.hu; ORCID ID: <https://orcid.org/0000-0003-4842-0613>; Scopus ID: 57191408081