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STEM-Oriented Foreign Language Teaching: An Experimental Study of Engineering Students in Turkmenistan

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Abstract

The aim of the research is to analyse the role of the STEM approach in the formation of students' foreign language competence and determine its impact on the development of professionally oriented language skills and motivation. The methodology is based on a quasi-experimental design using mixed data collection methods (testing, questionnaires, observation). The participants were 64 business informatic students, divided into control and experimental groups. The experimental programme combined English language learning with STEM components, including project tasks, digital tools, authentic materials, and elements of research. Statistical analysis of the results allowed for an objective assessment of the approach effectiveness and displayed the influence of STEM integration on learning outcomes. The main results showed that students in the experimental group demonstrated a significant increase in lexical competence, communication skills and internal motivation. A positive correlation was found between the increase in language knowledge and motivation, which indicated the interconnection between cognitive and affective factors in learning. The conclusions emphasised that the STEM approach was an effective means of improving the quality of English language teaching for special purpose, promoting the integration of theoretical and practical knowledge, the development of critical thinking, collaboration, digital literacy, and cultivating key competencies for the 21st century in order to ensure modernisation of foreign language teaching in higher education.

Keywords: STEM, English for specific purposes, foreign language competence, project-based learning, digital technologies

1. Introduction

The higher education system is undergoing a profound transformation driven by globalisation, digitalisation and the need to train a new generation of professionals. In the context of rapid technological change and the intensive development of AI, engineering, and information technology, there is a particular need for specialists who can communicate in English in a professional environment (Dooly & Sadler, 2016). Accordingly, traditional approaches to teaching English for specific purposes (hereinafter – ESP) need to be modernised by integrating innovative educational technologies and interdisciplinary teaching methods (Kassymova et al., 2023).

Hence, teachers adopt innovative approaches that combine language teaching with technology and interdisciplinary practices, among which STEM learning is one of the most promising. The STEM approach emerged as an educational response to the needs of the innovative economy and knowledge society (Voogt & Pareja Roblin, 2020). Initially focused on science and mathematics education, it has been gradually transformed into a broader approach that emphasises integrated learning, practical tasks, interdisciplinarity and the application of technology (Bybee, 2013). In modern pedagogy, STEM is used in combination with the humanities, forming variations such as STEAM or STREAM (Yakman & Lee, 2012).

Teaching English to university students requires practice-oriented teaching models. Therefore, the integration of project-based activities and digital technologies increases student motivation and promotes the development of learning autonomy (Babayeva, 2025). Moreover, the STEM approach allows students to view a foreign language as a tool for solving real-world problems in their professional field, which deepens their awareness and increases the effectiveness of language acquisition (Ozturk, 2021).

Despite the growing interest of researchers and practitioners to integrating STEM into language education, most studies

focus on general educational aspects, leaving specific issues of foreign language competence development in engineering students insufficiently explored (Yusupova et al., 2025). There is also a lack of empirical data that would allow for an objective assessment of the effectiveness of the STEM method in teaching English in higher education institutions in Eastern European countries. In addition, a few studies use rigorous quantitative methods of analysis to test the effectiveness of the STEM approach in language teaching.

The aim of the research is to analyse the role of the STEM approach in the formation of students' foreign language competence and determine its impact on the development of professionally oriented language skills and motivation. The research objectives are as follows:

- to analyse the theoretical foundations of the STEM approach and the possibilities for its adaptation to language education;
- to study the impact of project-based learning and digital tools on vocabulary expansion and communication skills development;
- to conduct a quasi-experiment using the ANCOVA statistical model to determine the effectiveness of the STEM approach;
- to identify the pedagogical conditions that ensure the effectiveness of the STEM method in teaching English to engineering students.

In this regard, the research hypothesis is that the use of the STEM method in teaching English to university students facilitates a significant increase in students' foreign language competence compared to traditional approaches by expanding their professionally oriented vocabulary, developing their language skills in interdisciplinary projects, increased motivation to learn English, and the integration of communicative, critical and digital competences.

The article will be useful to researchers and practitioners in the field of language education, as it combines theoretical analysis with empirical data obtained from experimental research. The expected results may serve as a basis for modernising English language teaching programmes for higher education students in Turkmenistan and developing new educational strategies focused on integrating STEM into the humanities.

2. Literature Review

In modern education, the STEM approach is considered an innovative model of integrated learning that combines scientific knowledge, technological practice, and the development of critical thinking (Rafiq et al., 2024). Its essence lies in creating a learning environment in which knowledge from different fields is applied in a comprehensive manner, and learning takes place through solving real or simulated problems. According to Kholis and Iryanti (2021), STEM education is aimed at developing the ability to act, analyse, and communicate in the context of interdisciplinary challenges.

Although STEM methodology was originally developed for natural and technical disciplines, over the last decade it has been adapted to the humanities, in particular to foreign language teaching (Aguirre-Muñoz et al., 2024). Therefore, an approach based on constructivism is used, i.e., a theory of learning according to which knowledge cannot simply be transferred from teacher to student as ready-made information. Instead, the student constructs knowledge through their own activities, interactions, observations, and problem solving (Zhao, 2012). Hence, the application of STEM methods in language education involves creating situations in which language becomes a means of solving practical problems, analysing data, and presenting research results.

According Khalid et al. (2024), integrating STEM components into English for special purposes provides opportunities for developing professionally oriented communication. The combination of project-based learning, digital technologies, and interdisciplinary tasks stimulates the use of vocabulary in a professional context and develops skills in reasoning and presenting technical ideas in English. As Voogt and Pareja Roblin (2020) claim, the STEM approach cultivates key 21st-century competencies, such as critical thinking, creativity, communication, and cooperation, which are directly related to communicative competence in language learning.

The use of digital technologies is an important component of STEM education. Interactive online platforms (Google Classroom, Padlet, Quizlet, Kahoot, etc.) provide a space for collaborative content creation, information sharing, and self-assessment (Semenets-Orlova et al., 2022). The digital environment expands the possibilities for authentic interaction and creates conditions for the development of students' digital literacy, which is closely linked to foreign language autonomy (Richards, 2015).

The problem of developing foreign language competence within the STEM approach is also linked to increasing learning motivation. As Ryan and Deci (2000) point out, intrinsic motivation grows when learning has practical significance and provides a sense of autonomy and competence. In the context of foreign language education, applied

STEM tasks reinforce these factors, making the learning process more meaningful and emotionally engaging (Mammadova, 2020).

At the same time, introducing STEM methods into English language teaching for engineering students remains insufficiently researched (Falasca, 2024). Existing studies mostly focus on describing individual pedagogical practices, while empirical evidence of the effectiveness of this approach in developing foreign language competence is scarce (Mynbayeva, 2025). The conditions for the implementation of the STEM model, the relationship between the use of digital tools and student motivation mechanisms, and the criteria for assessing the formation of foreign language and interdisciplinary competences also remain insufficiently studied (Liermann-Zeljak & Ferčec, 2025). This research seeks to address a lack of previous studies by experimentally verifying how effective the STEM methodology is for teaching English to engineering students.

3. Methodological Framework

The study was organised in a quasi-experimental format using mixed data collection methods (testing, observation, questionnaires). This design helped compare the effectiveness of using the STEM method in teaching English to university students with traditional approaches, taking into account quantitative and qualitative parameters of learning outcomes. The STEM approach was aimed at integrating scientific, technological, engineering, and mathematical components into the process of learning English by engineering students. It was based on a combination of interdisciplinary tasks with communication-oriented learning, which allowed students to practise English in professionally relevant situations. The scientific component was implemented through work with authentic English-language sources, such as popular science articles, video explainers, and multimedia materials. Students analysed texts on technical and natural science issues, identified key concepts and terms, created English-language glossaries, and created short posters. This component facilitated the development of academic speech and skills in working with scientific information in a real communicative environment.

Meanwhile, the technological component involved using digital tools to improve the effectiveness of educational activities and develop the digital skills of students. The Google Classroom platform was used to organise educational interaction, which ensured the systematisation of educational materials, communication between participants in the educational process, and monitoring of task completion. Padlet was applied for collaborative work, joint content creation, and discussion of educational topics. Quizlet was used to reinforce specialised terminology, which helped to develop lexical competence in an interactive format. Role-playing games and professional conference simulations were conducted via the Zoom platform. During the training, students created their digital products (video tutorials, multimedia presentations, interactive glossaries), reflecting the practical focus of the educational process. Thus, English language learning was integrated with modern educational technologies, recreating the digital context of the future professional activities of engineering students.

The engineering component was implemented in tasks related to project- and problem-oriented learning. Students modelled technical solutions and prepared English-language user manuals for imaginary devices. They participated in role-playing games that simulated professional situations, such as presenting engineering solutions to an international customer or a technical project at an exhibition. Completing such tasks developed professionally-oriented communication skills and cultivated teamwork skills in English. In addition, the mathematical component was manifested through working with quantitative data and its linguistic interpretation. Students analysed statistical tables, diagrams and graphs, and learned to describe trends, changes, and correlations in English. The task was to prepare an oral presentation or written description of changes in equipment productivity or energy consumption dynamics. This allowed students to combine mathematical skills with language practices, developing skills in describing data in a professional context.

A quasi-experiment was chosen due to the impossibility of completely random distribution of students into study groups, which is typical for an educational environment. The study was conducted in 2024 at the Turkmen Institute of Finance with the aim of determining the impact of STEM approach on the formation of students' professional competence. The study lasted one semester (16 weeks). Sixty-four full-time business informatics students in their second and third years of study (aged 18 to 21) participated in the study. This choice is conditioned by the fact that at this stage that professional development and the acquisition of key professional disciplines take place.

All participants studied ESP as part of the compulsory programme. To ensure the reliability of the research results, the students were divided into experimental and control groups, allowing for a comparative analysis of the effectiveness of the methods used. The experimental group (n=32) studied a STEM-oriented programme programme that combined English language learning with practical STEM tasks such as creating mini-projects (e.g., developing operating instructions for an engineering device), preparing technical presentations in Google Slides, maintaining a collective online diary on Padlet, modelling professional situations in Zoom, and analysing authentic English-language sources

(video instructions, popular science articles, technical manuals). The control group (n=32) studied a traditional ESP programme focused on translation, grammar exercises, and textbook texts. The study groups were formed to ensure relative homogeneity in terms of academic performance and motivation to learn a foreign language.

The study consisted of three consecutive stages. At the diagnostic stage, initial testing in English was conducted, along with a survey on students' motivation to study the discipline. Preliminary testing of English language proficiency using the Oxford Placement Test showed that all participants in the study had a B1 (intermediate) level, which ensured relative homogeneity of the sample and a more objective assessment of the experiment results. In addition, a questionnaire based on Gardner's Attitude/Motivation Test Battery was used to identify motivational factors.

During the learning stage, the experimental group performed project tasks integrating digital technologies and interdisciplinary aspects, while the control group studied according to the standard ESP programme. Within the STEM approach, training modules were developed that integrated several key components. Firstly, project-based learning was used, during which students worked in small groups on practice-oriented tasks, such as creating presentations of technical products, English-language posters on engineering issues, and preparing video instructions. Secondly, digital tools were applied to organize collaboration and assess knowledge, including Google Classroom, Padlet, Quizlet, and Zoom to provide for effective communication and interaction among students. Thirdly, teaching materials included authentic sources of information: articles from popular science magazines, technical instructions and videos from professional conferences in English, which helped to cultivate professional competence and develop language skills in real contexts.

At the final stage, a final vocabulary test, communication tasks, and a repeat questionnaire were carried out, which allowed for a comprehensive assessment of the dynamics of academic achievement and motivation indicators of the experiment participants. The tasks were focused on the terminology of the relevant technical specialty, as well as oral and written communication tasks that included role-playing games, creating technical descriptions, and group presentations.

Data processing was carried out using mathematical statistics methods. The ANCOVA (analysis of covariance) method was used to test the hypothesis and perform statistical data processing. It helped to assess the differences between groups, taking into account the results of the initial testing, which increased the objectivity of the conclusions. In addition, descriptive statistics (mean values, standard deviations) and the effect size (η^2) were used. All participants gave their informed consent to participate in the study. They were guaranteed anonymity of results and the right to withdraw from participation at any stage. The study complied with the university's ethical standards.

To verify the reliability of the results obtained, Student's t-test and χ^2 criteria were applied, which helped to assess the statistical significance of the differences between the results of the experimental and control groups. The data were analysed from the perspective of educational psychology to interpret the results in the context of students' professional competence development. Thus, the use of combined methods ensured the comprehensiveness of the analysis and the validity of the conclusions.

4. Results

During the 16-week experiment, the impact of STEM approach on the development of foreign language competence among business informatics students was studied. All participants studied the Business and Information Technolog programme and had a B1 (intermediate) level of English according to the Oxford Placement Test results. Before the experiment began, both groups demonstrated relatively similar results in lexical competence testing, which made it possible to conduct a comparative analysis of the effectiveness of educational interventions on an equivalent basis. A modified version of the Oxford Placement Test (Lexical Subtest), adapted to the specifics of engineering, was used to assess the level of professional vocabulary proficiency. The test consisted of 40 closed-ended questions that tested knowledge of terms and phrases from the fields of engineering, information technology, and energy. Each correct answer was scored 1 point, with a maximum possible score of 40 points.

To ensure the validity and reliability of the assessment, criteria developed on the basis of the Council of Europe (CEFR) recommendations on language proficiency levels were used. The total score of each student was converted into a composite index of lexical competence on a scale from 0 to 100 points. The average score in the control group was 41,2 points, while in the experimental group it was 42,0 points, which corresponds to level B1 (intermediate) according to the CEFR. This relative homogeneity of the sample permitted to interpret further differences between the groups as the result of pedagogical intervention rather than the students' initial knowledge.

After completing the 16-week semester, noticeable changes in lexical competence were observed, which were recorded in the final test results. The same tool was used for assessment as in the initial test, but with new content covering tasks of equivalent complexity and type. The final test included 40 multiple-choice questions that tested knowledge of professionally oriented English vocabulary in the engineering. Each correct answer was scored as one point, and the

results were converted to a scale from 0 to 100 points. To ensure objectivity of assessment, the final test was conducted under standardised conditions with a strictly regulated time limit (40 minutes). The reliability of the test instrument was verified on a pilot group of students (internal consistency coefficient α=0,87), which confirmed its validity. The assessment was carried out by two independent ESP teachers.

According to the test results, the average score in the control group increased from 41,2 to 48,3, which corresponds to an increase of 7,1 points, while in the experimental group this indicator increased from 42,0 to 60,4, i.e. by 18,4 points. This difference indicates a significant positive effect of the STEM approach on the acquisition of professional vocabulary (Table 1).

Table 1. Dynamics of lexical competence test results

Indicator	Control group	Experimental group	Difference in growth rates
Initial testing (M±SD)	41,2 ± 5,3	42,0 ± 5,1	—
Final testing (M±SD)	48,3 ± 6,2	60,4 ± 7,0	+11,3
Absolute growth	+7,1	+18,4	—
F(1,61)	—	—	24,37***
p	—	—	<0,001

Note: p<0,001 indicates a high level of statistical significance; η^2=0,29 indicates a large effect according to Cohen's classification.

These results demonstrated that the integration of project-based learning, authentic materials, and digital tools facilitated the acquisition of a larger volume of terminology and stimulated its use in practical tasks, such as creating technical descriptions, role-playing games, and group presentations.

The results of the analysis of communicative tasks (oral and written) showed a similar trend. In the control group, the average score on a scale of 0-10 increased from 5,8 to 6,7 (+0,9), while in the experimental group it increased from 5,9 to 8,3 (+2,4). The analysis of motivational indicators (using Gardner's AMTB adapted scale) also showed an increase in both groups, although it was more pronounced in the experimental group from 73 to 86 points as compared to 72 to 75 in the control group. The correlation analysis showed a moderate positive relationship between the increase in lexical results and the increase in motivation (r=0,42; p<0,01), indicating the interdependence of cognitive and affective factors in the learning process (Table 2).

Table 2. Dynamics of communicative and motivational indicators

Indicator	Control group	Experimental group
Oral/written communication (before)	5,8	5,9
Oral/written communication (after)	6,7	8,3
Motivation (before)	72	73
Motivation (after)	75	86
Correlation of gains (vocabulary×motivation)	r=0,42	r=0,42

The quantitative results were confirmed by qualitative observations. The analysis of student projects completed during the experiment showed a significant improvement in the quality of language, logical sequence of presentation, and professional relevance of the material. In 78% of the experimental group's work, the adequate use of technical terminology, accuracy, and clarity of language was noted, while in the control group this indicator reached 43%. Students in the experimental group indicated improved confidence in communicating in English, the development of teamwork, and a better connection between theoretical knowledge and practical application. Most participants noted that STEM tasks helped them understand how English was used in a professional context or that working on technical projects forced them to think in English rather than translate from their native language. Moreover, the analysis of the final projects showed an increase in the frequency of use of professional terminology and a more logical structure of argumentation. The work of the experimental group was assessed as more authentic, relevant to professional communication, and rich in content.

Furthermore, the results demonstrated profound positive changes in the linguistic, cognitive, and motivational spheres of students who studied using STEM-oriented methods. Firstly, there was a significant improvement of lexical competence. This is explained by the fact that STEM methods provide constant practical application of professional terminology in interdisciplinary tasks, where knowledge from the natural sciences, technical and linguistic fields is integrated into a single system. Such conditions facilitate not only the mechanical memorisation of terms but also an understanding and automation of their use, which was reflected in an average increase in lexical testing scores of 42,0% compared to the control groups.

Secondly, the results demonstrated a noticeable improvement in students' communication skills. Working with authentic materials, digital platforms, and simulation projects enhanced the development of effective oral and written communication skills in a professionally oriented context. Students participated more enthusiastically in discussions, intergroup consultations, and presentations of their research results in English, which increased their confidence in communication and their ability to express their opinions in a reasoned manner. Thirdly, the motivational effect of the STEM approach was evident. The survey data showed an increase in internal learning motivation: 78% of students noted that thanks to interactive and technology-rich learning, they perceived foreign languages as a practical tool for achieving professional goals. The use of digital laboratories, online projects, and gamified elements stipulated the formation of a positive emotional background for learning.

Apart from that, the results of the experiment confirmed the comprehensive nature of STEM education. It facilitated language development and the cultivation of critical thinking, creativity, collaboration, and digital literacy. Thus, when implementing interdisciplinary projects, students demonstrated an increase in their ability to analyse information, make joint decisions, and use ICT tools to search for, process, and present data. This indicated the gradual formation of professional autonomy and readiness for self-education in a digital environment. Therefore, the study results confirmed the hypothesis that the use of STEM methods in the English language teaching improves the effectiveness of learning and facilitates the development of students' professional, cognitive, and social competences, which is a necessary prerequisite for their successful adaptation to the challenges of modern digital society. Consequently, it can be stated that STEM-oriented methodology creates a productive educational environment that combines cognitive activity, emotional engagement, and practical orientation of learning. The quantitative and qualitative data show that students who learn through interdisciplinary tasks demonstrate more stable language dynamics, higher motivation, and better communication results.

In addition, STEM education illustrate a number of guidelines to be implemented in higher education in Turkmenistan. In this regard, it is important to create integrated learning modules that combine English learning with interdisciplinary STEM tasks (Çelik, 2025). Such integration ensures the natural inclusion of language activities in the context of professional training in order to develop the ability to use English as a tool for describing, analysing, and presenting technical ideas. The use of project-based and research-based work formats increases students' cognitive activity and develops comprehensive cognitive and communicative skills.

The digital educational environment plays a significant role in improving the effectiveness of STEM-oriented learning. The use of online platforms, interactive services, and shared virtual spaces creates conditions for the development of student autonomy, their ability to self-organise and cooperate. Digital tools also cultivate key 21st-century competencies, in particular information literacy, critical thinking and creativity, which are important components of the professional mobility of future specialists. Improving the system for assessing learning outcomes is also important. Therefore, it is advisable to expand the traditional criteria for language proficiency by supplementing them with indicators that reflect students' ability to use English in real or simulated professional situations. This approach allows for the assessment the level of language acquisition and the development of communicative, analytical, and digital skills.

Finally, it is essential to prepare university teachers to work in a STEM-oriented environment. The effective implementation of such methods requires a combination of linguistic, pedagogical, and digital competences, which entails specialised professional development and interdisciplinary interaction between language and technical departments. The development of such cooperation will increase institutional capacity for the sustainable implementation of innovative teaching methods. Overall, the obtained data showed that STEM integration in foreign language teaching was a means of improving students' academic performance and a mechanism for cultivating a comprehensive system of competencies necessary for professional self-realisation in a digital society.

5. Discussion

The results confirmed the effectiveness of the STEM approach in teaching ESP and revealed its potential as a means of integrating linguistic, cognitive, and technological training of students. The data showed that participants who underwent STEM-integrated training demonstrated significantly higher success in vocabulary acquisition, communicative fluency, and motivation to learn compared to those who studied using traditional ESP methods.

In contrast to traditional ESP teaching, where the learning process often consists in mastering professional vocabulary and performing standard exercises, the STEM approach is based on activity-based, research-based, and problem-oriented paradigms. This allows students to get immersed in practical contexts of language use through modelling professional situations, creating digital products, and analysing real-life cases. As a result, language becomes a tool for thinking, research, and communication in engineering. These conclusions correlate with the results of studies by Aguirre-Muñoz et al. (2024) and Khalid et al. (2024), who emphasised that STEM integration in the humanities promoted the development of cognitive flexibility and increased the level of linguistic autonomy.

Moreover, students in the experimental group learned professional terminology more effectively because they encountered it in authentic and functionally relevant contexts. This is consistent with the constructivist principle that knowledge is best acquired through meaningful use and situational practice (Saurbayev et al., 2024). The integration of STEM approach created real linguistic tasks, such as designing prototypes, analysing data or explaining technical processes in English, which transformed vocabulary learning from a memorisation exercise into an active process of knowledge construction. Students' communicative competence also improved significantly. The experimental group demonstrated greater fluency and accuracy in spoken and written English due to their regular participation in collaborative tasks mediated by digital tools. Working in interdisciplinary teams, students practised spontaneous speech, negotiation, and presentation skills, reflecting the communicative authenticity of professional discourse.

It is also possible to claim that the integration of digital technologies as a component of STEM education into language courses provides a variety of information sources and develops students' digital competence, i.e. the ability to work with multimedia data, search for, process, and present information using ICT tools. In this context, language learning becomes a means of developing media literacy and critical perception of digital content. According to the approaches described by Voogt and Pareja Roblin (2020), such integration of the technological component improves the quality of education and adapts it to the needs of the modern labour market, where foreign language and digital skills are complementary competencies. These competencies, which underpinned by the EU framework programme Key Competences for Lifelong Learning (European Commission, 2019), are seen as important outcomes of modern education. Through research-based learning, students practised evaluating evidence, formulating hypotheses, and communicating results that reflect authentic scientific discourse and professional practice. Therefore, STEM integration positions language education as a means of developing the intellectual and social skills needed in a digital and knowledge-based economy.

However, the results point to certain challenges accompanying the introduction of STEM methods into language education. First, teachers should have interdisciplinary knowledge and the ability to organise learning in the form of project-based research activities, which requires additional training. Secondly, ensuring technical conditions (availability of digital resources, stable internet connection, multimedia tools) is a necessary prerequisite for the successful implementation of the approach. Apart from that, it is worth considering the possible cognitive overload of students caused by the high level of integration of learning content, which requires clear structuring of material and pedagogical support (Hasanova & Vokhidova, 2025). Despite these problems, the study results proved that STEM integration in foreign language teaching promoted the transition from reproductive to creative and research-based forms of work. This allows STEM to be considered a pedagogical paradigm that combines learning, research, and technology, presenting perspectives for the development of innovative foreign language education.

Finally, it can be asserted that the STEM approach provides comprehensive development of students' linguistic, cognitive, and social competences, which are decisive for their professional mobility and competitiveness. The results are consistent with the concepts of competence-based and integrative learning and confirm the relevance of the learning by doing model in the digital educational environment. In this regard, prospects for further research lie in the development of models for the phased introduction of STEM methods into language education and the quantitative analysis of their impact on the development of specific components of communicative competence in various academic disciplines.

6. Conclusions

The results of the study confirmed the hypothesis that integrating STEM methods into the process of teaching English was an effective means of developing foreign language competence in business informatics students. The use of interdisciplinary, project-oriented, and digital forms of learning increased the level of professional vocabulary, the development of communication skills, and the motivation to learn and the formation of complex cognitive and social competences.

The obtained data showed that students involved in a STEM-oriented learning environment demonstrate better quantitative results in testing and a qualitatively new level of linguistic and professional activity. They were able to use English more effectively as a tool for analytical thinking, professional communication, and creative problem solving. This indicated a transition from a reproductive to a productive model of knowledge acquisition, which is in line with current trends in competency-based learning.

Apart from that, the STEM approach proved effective in bridging the gap between theoretical knowledge and practical application of the English language. The use of digital tools (Google Classroom, Padlet, Quizlet, Zoom, etc.) contributed to the development of digital literacy, independence, and collaborative interaction among students, while interdisciplinary projects stimulated their cognitive activity and professional reflection.

Thus, STEM integration into language education opens up new opportunities for modernising ESP programmes in

higher education institutions in Turkmenistan. It ensures the development of not only foreign language but also interdisciplinary competence, develops students' ability to think critically, act creatively, and collaborate effectively in a digital environment. Prospects for further research consist in studying the long-term effects of STEM methodology on academic performance, developing adaptive models for its implementation at different levels of language training, and investigating the potential of the STEM approach in distance and blended learning formats.

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Authors contributions

Senior lecturers B.Abdyyeva and A.Yazberdiyeva were responsible for study design and revising, lecturer D.Mudarova was responsible for data collection, lecturer W.Berdiyev drafted the manuscripts and senior lecturer A.Atayeva revised it.

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