



**INNOVATION-DRIVEN
DEVELOPMENT IN EDUCATION,
DIGITAL ECONOMY,
AND APPLIED TECHNOLOGIES**

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INNOVATION-DRIVEN DEVELOPMENT IN EDUCATION, DIGITAL ECONOMY, AND APPLIED TECHNOLOGIES

Monograph

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3.7. INTEGRATING ARTIFICIAL INTELLIGENCE TOOLS INTO PROJECT-BASED ENGLISH LANGUAGE INSTRUCTION FOR TECHNICAL STUDENTS: A FRAMEWORK FOR FOSTERING CRITICAL AND CREATIVE THINKING

Introduction

In the context of the ongoing Russian war of aggression against Ukraine, the Ukrainian educational system faces a profound and unprecedented test of resilience. Universities have been forced to rapidly adapt to volatile conditions, balancing continuity of instruction with the safety, mental well-being, and future readiness of students. Amid air raid alerts, power outages, and widespread displacement, the classroom – physical or virtual – has emerged as a critical space not only for knowledge transmission, but for fostering (Yeganeh et al., 2025) cognitive strength and creative adaptability. English language instruction, often underestimated in technical universities, has revealed new potential to contribute to the broader goal of preparing students for a world reshaped by crisis, innovation, and global interdependence.

In this high-stakes educational environment, project-based learning (PBL) has gained particular relevance. Its collaborative, inquiry-driven nature encourages students to become active agents of their own learning – an approach that resonates deeply with the current wartime reality, where autonomy, initiative, and problem-solving are vital for both individual survival and societal recovery. Simultaneously, the integration (Ng et al, 2025) of artificial intelligence (AI) tools into the educational process presents a strategic opportunity. While AI technologies have already transformed various fields of engineering and information technology, their thoughtful incorporation into English for Specific Purposes (ESP) teaching enables a rethinking of traditional language pedagogy. AI-powered platforms such as ChatGPT, Grammarly, and others can support multilingual learners in developing not only linguistic competence, but also the critical and creative thinking essential for navigating uncertainty and designing solutions in complex technical fields.

This article proposes a conceptual framework for integrating AI tools into project-based English language instruction in Ukrainian technical universities, with the specific goal of cultivating critical and creative thinking among students. It examines how such integration can empower learners to respond flexibly and analytically to real-world challenges – whether those challenges are technical, linguistic, or geopolitical. By drawing parallels between educational innovation and national resilience, the study positions the English classroom as a site of intellectual resistance and forward-looking development amid the broader struggle for Ukraine's freedom and modernization.

The rapid technological shifts brought about by the Fourth Industrial Revolution – now compounded by the realities of full-scale war – have exposed critical gaps in traditional models of English language instruction for technical students in Ukraine. While technical education has long emphasized hard skills, such as coding, system design, or circuitry, it has often treated language acquisition as a peripheral concern. As a result, students may achieve (Nykyropets et al., 2023) formal knowledge of English grammar and terminology without developing the higher-order thinking skills – particularly critical and creative thinking – needed to apply this knowledge effectively in interdisciplinary and real-world contexts.

At the same time, artificial intelligence has entered the educational sphere not simply as a tool for automation, but as a dynamic partner in the learning process. AI platforms now have the potential to individualize instruction, simulate professional scenarios, and facilitate complex project-based interactions. However, despite the growing body of international research on AI in education, its systematic integration into English for Specific Purposes (ESP) teaching – especially within the specific sociotechnical conditions of Ukraine – remains insufficiently explored.

Moreover, the Ukrainian context (Kot & Nykyropets, 2024) demands an educational response that is both innovative and resilient. The war has accelerated the need for adaptive learning environments that support not only academic achievement, but psychological sustainability and professional relevance. In this regard, English language education for technical

students is not merely a matter of vocabulary acquisition – it is a space for cultivating analytical reasoning, divergent thinking, collaboration, and global competence.

Therefore, the scientific and practical problem addressed in this study is twofold: (1) the lack of integrated pedagogical models that combine AI tools and project-based learning within English instruction for technical disciplines, and (2) the need to develop these models in ways that directly support the formation of critical and creative thinking under the complex educational conditions of modern Ukraine. Solving this problem would contribute to both the theoretical understanding of AI-enhanced pedagogy and the practical improvement of technical language education in wartime and post-war recovery periods. It would also offer a replicable model for other countries facing crisis-driven disruptions to education.

Review of recent research

In the last two years, a growing body of studies has begun to explore how AI integration into project-based learning can cultivate students' critical and creative thinking – but significant gaps remain, especially in the Ukrainian ESP context. Kyselova (Kyselova, 2024) presents a mixed-methods study on AI-supported project-based learning in professional tertiary education. She finds that AI increases motivation, supports independence and collaboration, and enhances critical thinking and teamwork skills. However, her research is not specific to English language instruction nor tailored for technical disciplines. Zheng et al. (Zheng et al., 2024) report on a co-design exploration where college students planned how AI usage in PBL could be assessed. The study highlights divergent attitudes toward AI but does not examine language learning per se or its impact on creative thinking in technical ESP environments. Lin & Chen (Lin & Chen, 2024) in *BMC Psychology* study how AI-integrated educational apps affect undergraduate creativity and academic emotions. They report potential gains in creativity and engagement, but also risks such as performance anxiety and rigid thinking – pointing to the need for cautious implementation and ongoing evaluation. Zhong et al. (Zhong et al., 2024) analyse generative AI in programming tasks, showing that students who lead the coding process themselves demonstrate higher critical thinking and deeper refinement of solutions than AI-led peers. This suggests that preserving human agency in AI-mediated projects is crucial, a principle largely unexplored in language classrooms. A meta-analysis in *Frontiers in Psychology* (Zhang & Ma, 2023) confirms that project-based learning significantly improves higher-order thinking, especially in technical and engineering subjects, particularly when implemented in groups of 4-5 over 9-18 weeks. Another study emphasizes (Almulla, 2020; Nykyporets et al., 2024) that PBL enhances creative cognition when structured with authentic tasks and active student engagement.

A survey of Ukrainian PhD students (National Academy of Sciences) shows a cautious but open attitude toward AI language-processing tools in EAP courses. Students express desire for explicit instruction on ethical use and the risks/benefits of such tools. A Ukrainian case study on ChatGPT-supported project activities in university English departments reflects both quantitative and qualitative improvements in critical thinking, but remains exploratory and limited in scope.

Identification of gaps

While existing literature affirms that AI-augmented PBL can improve critical thinking and creativity, key areas remain insufficiently addressed. One of them is ESP focus for technical students: few studies directly target English language instruction for engineering or IT majors; most existing work is general education or programming-specific. The next one is context of Ukraine's wartime resilience, – research has not examined how AI-enhanced ESP can serve not only academic but socio-psychological needs of students facing crisis and displacement. The following are preservation of learner agency – insights from programming studies highlight the importance of students maintaining leadership over tasks to foster higher-order thinking; such dynamics are under-explored in language PBL; explicit pedagogical frameworks – there is an absence of integrated models combining AI literacy (e.g. prompt engineering), PBL design, and language pedagogy for critical and creative thinking; and longer experimental durations – existing

interventions are often short or limited in sample size. Meta-analysis recommends programs lasting 9-18 weeks to yield robust outcomes (Zhang & Ma, 2023).

This article directly addresses these under-studied dimensions by:

- a) focusing specifically on AI-enhanced English instruction within project-based modules for technical students, bridging ESP and engineer-centric language education;
- b) embedding the research within Ukraine's wartime educational context, exploring how AI-supported pedagogy can contribute to resilience, agency, and forward-looking mindset;
- c) designing a framework that balances AI support with learner-led inquiry, drawing on findings from AI-augmented programming tasks to preserve student critical and creative leadership;
- d) proposing a comprehensive pedagogical model that integrates AI literacy (prompt-engineering, critical evaluation of outputs), scaffolded PBL tasks, and assessment strategies;
- e) planning longer-term implementation (e.g. multiple-week cycles, small group projects) to align with best practices identified in meta-analyses.

By synthesizing these recent studies and identifying what remains unresolved, this article positions itself as offering a novel, context-sensitive, and theoretically grounded framework for integrating AI into project-based ESP instruction – thereby contributing both to academic understanding and practical innovation in Ukrainian technical higher education.

Research objectives and hypotheses

This article's principal objective is to develop and substantiate a pedagogical model of project-based learning integration of the English language and the use of artificial intelligence tools among technical specialties students. The model is designed to induce critical and creative thinking – skills the more important for the academic and professional work as well as for individual survival in the context of wartime and Ukrainian reconstruction realities.

Through the fusion of the potential of the AI-enforced platforms and the collaborative and explorative context of the project-centred learning paradigm, the article aims to signal the potential of revolutionizing the teaching of the English language in technical universities from sideline courses to transformative contexts of intellectual growth and innovation. The article also aims to keep the model thus proposed sensitive to the complex psychological and logistical contexts that surround the students and the educators in the contexts of wartime and post-war pedagogy.

Ultimately, the goal is to design a practical and research-driven solution that encourages language proficiency and higher-order thinking abilities and develops the future Ukrainian engineers, programmers, and technical experts with communicative and cognitive abilities capable of successfully competing in an unpredictable, technology-dominated world.

To achieve the stated purpose, the article sets out the following research objectives.

1. To study the educative potential of the computer software – e.g., ChatGPT, Grammarly, and others – on the enhancement of project-based teaching of the English language in technical school settings.
2. To design a context-appropriate curriculum design of integrating AI tools in project-based learning (PBL) modules with the specific goal of strengthening students' critical and creative thinking.
3. To pilot and evaluate the application of the framework on selected courses of English for Specific Purposes (ESP) in Ukrainian technical universities with consideration of the qualitative and quantitative outcomes.
4. To evaluate the impact of student agency, motivation and collaboration in project work enabled by AI, especially in the context of educational disruption caused by the realities of wartime.
5. Identifying the best practices, issues and ethical concerns about the integration of AI in ESP teaching for technical students.

Based on these objectives, the following hypotheses are proposed.

H1. The integration of AI tools into project-based English language learning significantly enhances students' ability to demonstrate critical thinking skills (e.g., analysis, evaluation, argumentation) compared to traditional ESP instruction.

H2. AI-supported PBL environments contribute to the development of creative thinking (e.g., idea generation, divergent thinking, originality) among technical students, especially when tasks are open-ended and student-led.

H3. Ukrainian students participating in AI-enhanced project-based ESP courses will report higher engagement and perceived relevance of English language learning to their future profession compared to peers in conventional instructional settings.

H4. The thoughtful use of AI tools in wartime education contexts can support not only academic performance, but also foster a sense of learner agency and psychological resilience.

These objectives and hypotheses are rooted in the belief that modern English language education – when enriched by digital tools and grounded in real-world challenges – can offer far more than linguistic competence; it can nurture the adaptive, inventive mindsets Ukraine urgently needs.

Methodology

This study employed a mixed-methods design to develop, implement, and evaluate an instructional framework integrating artificial intelligence (AI) tools into project-based English language instruction for technical students. The research was conducted in Vinnytsia National Technical University during the 2024-2025 academic year, under wartime educational conditions, which shaped both the structure and delivery of the learning interventions.

The study involved 87 fourth-year undergraduate students majoring in electrical engineering. All participants were enrolled in English for Specific Purposes (ESP) courses and had an intermediate or upper-intermediate level of English proficiency (B1-B2 according to CEFR). Participation was voluntary and anonymized, with ethical clearance obtained from institutional review boards. Special care was taken to ensure that the study did not interfere with students' psychological safety or academic workload, given the war-related stress many students experience.

Research design

The research was conducted in three stages.

Table 1. Research design: stages, description, and tools

Stage	Description	Tools / Methods
Framework development	A preliminary instructional model was designed, emphasising student-led inquiry, iterative feedback, and real-world communication tasks.	<ul style="list-style-type: none"> - ChatGPT (for ideation, dialogue simulation, and reflection), - Grammarly (for scaffolding writing and metalinguistic awareness), - Canva, Quillbot (for visual literacy and paraphrasing support in group presentations); - literature review in AI-enhanced PBL.
Implementation	Over 12 weeks, the experimental group completed four project cycles involving brainstorming, collaboration, and self-assessment.	AI-supported task design, technical briefs, blogs, videos, mock interviews.
Evaluation and data collection	Effectiveness measured through cognitive tests, perception surveys, interviews, and document analysis.	Torrance tests of creative thinking (TTCT), Watson-Glaser, surveys, focus groups, project analysis, AI-generated drafts, and final revisions.

Source: Created by authors

The model emphasized student-led inquiry, iterative feedback, and real-world communication tasks linked to technical disciplines (e.g., writing a project proposal for an AI-integrated smart device). A control group received traditional ESP instruction focused on reading comprehension, vocabulary drills, and grammar exercises. Data were collected using pre- and post-tests of critical and creative thinking (adapted from the Watson-Glaser Critical Thinking Appraisal (<https://www.talentlens.com/watson-glaser.html>) and Torrance Tests of Creative Thinking (<https://www.testingmom.com/tests/torrance-test>)). Quantitative data were analysed using paired t-tests and ANOVA to assess changes in cognitive skill development. Qualitative data were thematically

coded using NVivo (<https://lumivero.com/products/nvivo>) to identify emerging patterns in students' experiences, reflections, and concerns.

Given the wartime context, several limitations affected the study. Variability in internet access and power supply occasionally disrupted synchronous activities. Emotional fatigue and displacement influenced participation and attendance. The sample was geographically limited and does not represent all Ukrainian regions or technical disciplines.

Despite these constraints, the methodological design allowed for a robust exploration of how AI tools can be pedagogically aligned with project-based ESP instruction to support higher-order thinking and learner agency.

Results and discussion

The integration of AI tools into project-based English instruction for technical students produced measurable gains in both critical and creative thinking, as well as increased learner engagement and perceived relevance of language learning. The results of this study confirm the initial hypotheses and provide evidence-based support for the proposed instructional framework.

1. Improvement in critical thinking skills

Quantitative analysis revealed statistically significant improvements in critical thinking among students in the experimental group. Pre- and post-test comparisons using the adapted Watson-Glaser Critical Thinking Appraisal showed a mean increase of 18.2% ($p < 0.01$) in the ability to analyse arguments, evaluate evidence, and draw reasoned conclusions. In contrast, the control group displayed only a 4.3% improvement ($p > 0.05$), attributable to general language exposure rather than targeted instruction. These results are consistent with findings by Zhong et al. (Zhong et al., 2024), who emphasized the value of maintaining student agency when using AI tools in technical education. In this study, AI platforms such as ChatGPT were used not as answer engines, but as collaborative thinking partners – guiding students through multiple perspectives on technical problems and ethical debates (e.g., “Should AI be granted decision-making rights in industrial safety systems?”).

2. Growth in creative thinking/

Creative thinking, assessed through selected tasks adapted from the Torrance Tests of Creative Thinking (TTCT), also improved notably. Students in the AI-enhanced project-based learning environment demonstrated greater originality, fluency of ideas, and willingness to take intellectual risks. The most significant gains were observed in open-ended tasks, such as co-creating product pitches for fictitious tech startups or scripting chatbot dialogues for technical support.

Post-intervention analysis showed a 21.7% increase in TTCT composite scores in the experimental group ($p < 0.01$), with students demonstrating more varied and imaginative approaches to linguistic tasks. This supports prior meta-analytic evidence that project-based learning enhances creativity, particularly when paired with tools that support multimodal expression (Lin & Chen, 2024; Zhang & Ma, 2023).

3. Increased motivation and engagement.

Survey results and focus group interviews confirmed that the integration of AI tools contributed to higher levels of motivation and engagement. 84% of students in the experimental group reported feeling more involved in the learning process, citing the interactive nature of the tools and the real-world relevance of project tasks. Students emphasized that using AI made the learning experience “less mechanical” and “more connected to what engineers actually do.” Importantly, students also reported an increased sense of ownership over their learning. Many viewed AI not as a shortcut, but as a stimulus for deeper inquiry. As one student put it: *“ChatGPT doesn’t give the answer – it gives you options. You still have to decide, edit, and defend your point.”* This aligns with the hypothesis that AI-enhanced PBL promotes learner agency, especially in environments where traditional classroom structures may be disrupted, as is the case in wartime Ukraine.

4. Ethical awareness and reflective use of AI.

An unexpected but highly valuable outcome was the emergence of ethical reflection around the use of AI. Through scaffolded tasks involving peer critique and self-assessment, students began to articulate nuanced positions on when and how to use AI responsibly. Several groups,

for instance, critically compared human-generated versus AI-edited texts, debating issues of originality and attribution. This development highlights the dual pedagogical role of AI: not only as a cognitive scaffold but also as a trigger for metacognitive and ethical reasoning – skills essential for both engineers and responsible citizens in the digital age.

5. Challenges and constraints.

Despite overall success, several challenges emerged. Students with lower digital literacy initially struggled to engage productively with AI tools. Some overrelied on AI-generated phrasing, resulting in a need for stronger teacher scaffolding on critical evaluation of outputs. Inconsistent infrastructure (internet, electricity) in some regions interfered (Ibrahimova & Nykyporets, 2025) with the full implementation of synchronous collaborative activities. These findings underscore the need for ongoing teacher training and flexible instructional design that accommodates both technological and psychological realities in Ukraine's current educational climate.

Table 2. Summary of key findings

Outcome category	Experimental group	Control group
Critical thinking gain	+18.2% ($p < 0.01$)	+4.3% (n.s.)
Creative thinking gain	+21.7% ($p < 0.01$)	+6.9% ($p > 0.05$)
Motivation increase	84% self-reported	42% self-reported
Ethical awareness	Strong emergence	Not observed

Source: Created by authors

These results affirm the pedagogical value of strategically integrating AI into project-based English instruction, especially in disciplines traditionally focused on technical content. By supporting both language development and higher-order thinking, the framework contributes to preparing Ukrainian students not only for employment in a global economy, but for intellectual resilience in a time of profound national adversity.

Table 3. Recommendations for educators, curriculum developers, and policymakers

Recommendation area	Suggested action	Details
AI integration	Integrate AI tools into language instruction as cognitive companions, not replacements.	Encourage AI use for brainstorming and feedback, but ensure students retain responsibility for evaluation and output.
Project-based tasks	Design project-based tasks that mirror real-world technical communication.	Focus on outputs like technical blogs, manuals, interface dialogues to ensure meaningful, transferable language learning.
Teacher training	Prioritize teacher training in both AI literacy and project-based pedagogy.	Support teacher understanding of AI affordances and project-based learning strategies to guide student agency.
Ethical awareness	Embed ethical reflection into AI-enhanced learning.	Promote discussions on originality, authorship, and responsible AI use to develop metacognition and digital citizenship.
Wartime adaptation	Adapt the framework to wartime conditions: Ensure flexible access	Flexibility is crucial. Provide asynchronous options and simplify tools to accommodate infrastructure instability during wartime.
Cross-disciplinary use	Apply model to other subjects	Extend AI-supported, project-driven learning to other soft-skill disciplines beyond English for Specific Purposes.

Source: Created by authors

Conclusions and recommendations

This study set out to examine how the thoughtful integration of artificial intelligence tools into project-based English language instruction can support the development of critical and creative thinking among technical students in Ukraine. Conducted amid the ongoing Russian war

of aggression, the research underscores the capacity of pedagogical innovation to serve not only academic goals, but also broader societal needs – namely resilience, adaptability, and future-oriented competence.

The findings demonstrate that when AI tools are embedded within well-structured project-based learning tasks, students become more engaged, think more deeply, and generate more original and contextually relevant ideas. The AI-supported framework presented in this article fostered tangible improvements in both critical analysis and creative expression, while also cultivating learner agency and ethical awareness – key competencies in times of instability and transformation.

This study contributes to a growing body of international research on AI in education by offering a model that is both theoretically grounded and pragmatically tailored to the Ukrainian context. Unlike many existing models, it recognizes the dual pressures faced by educators in wartime: the need to maintain instructional quality and the imperative to support students' psychological and cognitive growth under exceptional conditions.

Based on the outcomes of this research, the following recommendations are proposed for educators, curriculum developers, and policymakers.

In conclusion, artificial intelligence, when integrated with care and pedagogical purpose, offers far more than automation – it becomes a catalyst for human growth. In the context of a nation rebuilding itself through education, such tools are not luxuries, but necessities. This study affirms that technical students in Ukraine deserve – and are capable of – learning experiences that are not only functional, but transformative.

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