

МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
ЗАПОРІЗЬКИЙ НАЦІОНАЛЬНИЙ
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ЦИФРОВІЗАЦІЯ ЯК ІНСТРУМЕНТ
ЗАБЕЗПЕЧЕННЯ ЯКОСТІ НАДАННЯ
ОСВІТНІХ ПОСЛУГ З УРАХУВАННЯМ
ЄВРОПЕЙСЬКОГО ДОСВІДУ
КОЛЕКТИВНА МОНОГРАФІЯ



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Запорізький
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МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
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**ЦИФРОВІЗАЦІЯ ЯК ІНСТРУМЕНТ
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ПОСЛУГ З УРАХУВАННЯМ ЄВРОПЕЙСЬКОГО
ДОСВІДУ**

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Колективна монографія присвячена розкриттю ролі та визначенню напрямів використання цифрових технологій в освіті; дослідженню впливу цифрових технологій на освітній процес в заклад вищої освіти України; з'ясуванню тенденцій ЄС в освіті та формуванню рекомендацій до їх впровадження в Україні; формуванню теоретичних, методичних і практичних засад здійснення цифровізації надання освітніх послуг.

Монографія виконана за результатами досліджень у рамках проєкту фундаментальних наукових досліджень, прикладних наукових досліджень, науково-технічних (експериментальних) розробок за темою №1/24 «Європейські практики діджиталізації як інструмент забезпечення соціально-економічної безпеки в умовах війни та повоєнний період» (державний реєстраційний номер 0124U000600) (01.01.2024 – 31.12.2026).

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ПЕРЕДМОВА

Цифровізація охопила всі сфери діяльності та відповідно має значний вплив на якість надання освітніх послуг через вдосконалення освітнього процесу в закладах вищої освіти, підвищення рівня доступності освіти в форматі онлайн. Вплив цифровізації та інформаційних технологій на освіту проявляється через необхідність персоналізації навчання шляхом врахування індивідуальних потреб здобувачів вищої освіти; забезпечення рівного доступу до програм навчання; розвитку цифрових навичок; автоматизації адміністративних процесів в закладах вищої освіти; впровадження інтерактивних методів навчання; забезпечення безперервності навчання в дистанційному форматі. В свою чергу, забезпечення якості надання освітніх послуг з урахуванням досвіду ЄС та шляхом цифровізації сприяє розвитку цифрових компетентностей, інноваційного мислення громадян, кадрового потенціалу, безперервному навчанню, зменшенню відтоку кадрів за кордон, зміцненню кібербезпеки, покращенню економіки, зменшенню соціальної нерівності, що забезпечує соціально-економічну безпеку України в умовах війни та повоєнний період. Науковцями розкрито широке коло питань в аспекті підвищення якості надання освітніх послуг в закладах вищої освіти з урахуванням європейського досвіду.

Колективна монографія присвячена розкриттю ролі та визначенню напрямів використання цифрових технологій в освіті; дослідженню впливу цифрових технологій на освітній процес в заклад вищої освіти України; з'ясуванню тенденцій ЄС в освіті та формуванню рекомендацій до їх впровадження в Україні; формуванню теоретичних, методичних і практичних засад здійснення цифровізації надання освітніх послуг.

У першому розділі розглянуто особливості використання цифрових технологій в освіті та визначено рекомендації до впровадження зарубіжного досвіду. Також з'ясовано переваги та недоліки діджиталізації освіти, розкрито особливості цифрової трансформації мовної освіти в університеті. За результатами дослідження проаналізовано поточний стан, визначено проблеми та обмеження цифровізації економіки в Україні та Європі.

У другому розділі розкрито особливості використання цифрових технологій під час викладання дисциплін в університеті. Проведено порівняльний аналіз використання цифрових технологій для вивчення англійської мови здобувачами вищої освіти в Україні та ЄС. Визначено рівень впливу цифрової трансформації на зміни в підходах до формування корпоративної культури підприємства. Досліджено роль метавсесвіту у трансформації освітнього процесу.

Останній розділ присвячений розкриттю ролі штучного інтелекту у сфері вищої освіти. Визначено напрямки адаптації європейського досвіду щодо впровадження цифрових технологій в освітні України. Здійснено огляд практичного досвіду використання цифрових технологій в Європі та визначено напрямки його впровадження в Україні.

В колективній монографії запропоновано теоретико-методичні узагальнення, висновки та практичні рекомендації, які стануть в нагоді для науковців, викладачів, здобувачів закладів вищої освіти, аспірантів, докторантів, фахівці-практиків, представників державних органів влади та місцевого самоврядування, бізнесу, адміністративного персоналу університетів, представників громадянського суспільства, громадськості та всіх зацікавлених осіб.

Колективна монографія виконана за результатами досліджень у рамках проекту фундаментальних наукових досліджень, прикладних наукових досліджень, науково-технічних (експериментальних) розробок за темою №1/24 «Європейські практики діджиталізації як інструмент забезпечення соціально-економічної безпеки в умовах війни та повоєнний період» (державний реєстраційний номер 0124U000600) (01.01.2024 – 31.12.2026).

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1.3. Digital transformation of language education at a technical university: challenges, opportunities and prospects for cooperation with European partners

Introduction. In the contemporary landscape of higher education, the digital transformation of language education has emerged as a critical area of innovation and reform, particularly within technical universities. This transformation is driven by the rapid advancements in digital technologies and the increasing demand for global competencies, which include multilingual communication skills. As technical

universities traditionally focus on the cultivation of specialized knowledge in engineering, science, and technology, the integration of language education into these curricula poses unique challenges and opportunities. The need to equip future engineers, scientists, and technologists with language skills that enable effective communication in a globalized world has never been more urgent.

The challenges faced in this digital transformation are multifaceted. Firstly, there is the issue of integrating language education into the highly specialized and often rigid curricula of technical universities. Unlike humanities and social sciences, where language courses are often central to the academic experience, technical disciplines tend to prioritize subjects directly related to engineering, mathematics, and the natural sciences. This creates a tension between the need to maintain rigorous technical standards and the imperative to provide students with a well-rounded education that includes language proficiency. Moreover, the digital transformation of language education requires significant investment in infrastructure, training, and pedagogical innovation, which can be particularly challenging for institutions traditionally oriented towards technical disciplines.

Another challenge lies in the pedagogical shift required to effectively implement digital tools and platforms in language education. The traditional model of language instruction, which heavily relies on face-to-face interaction, is being disrupted by the advent of digital tools that offer new modes of learning, such as online courses, virtual classrooms, and language learning apps. These tools, while offering greater flexibility and accessibility, also demand a rethinking of teaching methodologies to ensure that they are pedagogically sound and effective in achieving language proficiency. The need for faculty development in digital literacy and the adaptation of curricula to incorporate these tools is essential, yet it represents a significant challenge for many technical universities, where faculty may have limited experience or interest in language pedagogy.

Despite these challenges, the digital transformation of language education also presents numerous opportunities, particularly in the context of international cooperation and collaboration. The integration of digital tools into language

education facilitates new forms of collaboration with European partners, enabling the sharing of resources, expertise, and best practices across borders. Technical universities, which often have strong ties with industry and research institutions across Europe, are well-positioned to leverage these relationships to enhance their language education programs. Collaborative projects, such as joint online courses or virtual exchange programs, can provide students with invaluable opportunities to develop their language skills in a real-world context, while also fostering intercultural competence and global citizenship.

Moreover, the adoption of digital technologies in language education can enhance the inclusivity and accessibility of language learning. Digital platforms can offer personalized learning experiences tailored to the diverse needs of students, accommodating different learning styles, paces, and levels of language proficiency. This is particularly important in technical universities, where student populations are often diverse in terms of linguistic background and prior exposure to language learning. By leveraging digital tools, technical universities can create more flexible and adaptive language education programs that meet the needs of all students, regardless of their starting point.

The prospects for cooperation with European partners in the digital transformation of language education are particularly promising. The European Union has long supported initiatives aimed at promoting multilingualism and language learning across member states, recognizing the importance of language skills in fostering social cohesion, economic mobility, and cultural exchange. Technical universities in Europe have been at the forefront of these efforts, experimenting with innovative approaches to language education that integrate digital tools and foster cross-border collaboration. By engaging in partnerships with these institutions, technical universities can not only enhance their language education programs but also contribute to the broader European agenda of promoting multilingualism and intercultural dialogue.

In all, the digital transformation of language education at technical universities represents both a significant challenge and a unique opportunity. The integration of

digital tools and the potential for collaboration with European partners offer promising avenues for enhancing language education and preparing students for the demands of a globalized world. However, realizing this potential will require overcoming substantial challenges, including the need for curricular integration, faculty development, and the creation of inclusive and accessible learning environments. As technical universities navigate this complex landscape, their success will depend on their ability to innovate and collaborate, both within their institutions and with their European counterparts, to create a language education system that is fit for the digital age.

The digital transformation of language education within technical universities presents a multifaceted problem that intersects with several critical scientific and practical domains. At its core, this transformation challenges traditional pedagogical models, which are deeply rooted in face-to-face instruction, to evolve in response to the rapidly changing technological landscape. The problem is not merely one of incorporating digital tools into existing frameworks but of fundamentally rethinking how language education can be delivered in a manner that aligns with the unique demands of technical disciplines and the broader goals of higher education.

From a scientific perspective, the problem engages with ongoing debates in the fields of educational technology, linguistics, and cognitive science. These disciplines are concerned with understanding how digital tools impact language acquisition, cognitive development, and pedagogical effectiveness. There is a pressing need for empirical research that explores how digital platforms, such as online courses, language learning apps, and virtual classrooms, can be optimized for language education in technical settings. This involves investigating the efficacy of these tools in promoting language proficiency, particularly in environments where technical content is paramount and where students may have varying levels of language preparedness.

The practical dimensions of the problem are equally significant. Technical universities are increasingly under pressure to produce graduates who are not only technically proficient but also capable of communicating effectively in a globalized

workforce. This requirement necessitates a language education that is both comprehensive and adaptable, capable of preparing students for real-world challenges where multilingual communication is often crucial. The practical problem, therefore, is one of implementation: how to integrate digital language education into the curriculum in a way that complements technical training without compromising the depth and rigor of either component.

Moreover, the problem is intrinsically linked to the broader issue of internationalization in higher education. As technical universities seek to enhance their global competitiveness and foster international partnerships, language education becomes a key strategic concern. The ability to collaborate effectively with European and other global partners hinges on the linguistic and cultural competencies of both students and faculty. Therefore, the problem extends beyond the classroom to encompass the institutional strategies that support international cooperation, such as joint degree programs, research collaborations, and student exchange initiatives. In this context, the digital transformation of language education is not just an educational challenge but a critical factor in the broader strategic positioning of technical universities on the global stage.

The connection between the digital transformation of language education and significant scientific and practical tasks is thus clear. Scientifically, it contributes to the understanding of how digital technologies can be harnessed to enhance language learning in specialized contexts. Practically, it addresses the urgent need for technical universities to equip their students with the language skills necessary for global engagement. By addressing this problem, we can advance both the theoretical understanding of digital pedagogy and the practical capabilities of technical universities to meet the demands of the XXI century educational landscape.

Furthermore, the digital transformation of language education at technical universities intersects with critical societal and economic imperatives. As globalization continues to accelerate, there is an increasing demand for professionals who can operate across linguistic and cultural boundaries. Technical fields, in particular, require experts who are not only adept in their specific areas of knowledge

but also capable of communicating complex ideas to diverse audiences. The ability to engage in multilingual dialogue is becoming a vital skill in international collaborations, research, and business, especially in industries where technical expertise and innovation are key drivers of economic growth.

In this context, the problem also touches upon issues of equity and inclusivity in education. Traditional language education models may not adequately serve the diverse needs of students in technical universities, many of whom may come from non-traditional backgrounds or speak languages other than the institution's primary language of instruction. Digital tools offer the potential to create more personalized and accessible language learning experiences that can accommodate these diverse needs. However, realizing this potential requires careful consideration of how these tools are implemented, ensuring that they are accessible to all students and that they do not exacerbate existing inequalities in education.

The problem also relates to the ongoing development of the European Higher Education Area (EHEA) and the Bologna Process, which aim to standardize and improve higher education across Europe. Language education plays a crucial role in this process, as it facilitates student mobility, academic cooperation, and the exchange of knowledge and ideas across borders. Technical universities, which often have strong ties with European industries and research institutions, are particularly well-placed to contribute to and benefit from these initiatives. However, to do so effectively, they must ensure that their language education programs are not only digitally advanced but also aligned with the broader goals of the EHEA, including the promotion of multilingualism and intercultural competence.

In addressing this problem, there is a need for interdisciplinary collaboration between educators, linguists, technologists, and policymakers. The development of effective digital language education strategies requires input from a range of experts who can provide insights into the technical, pedagogical, and policy-related aspects of the issue. For example, collaboration between language educators and software developers can lead to the creation of more sophisticated and user-friendly digital

tools, while engagement with policymakers can help ensure that these tools are supported by appropriate funding and regulatory frameworks.

Moreover, the problem presents opportunities for technical universities to innovate and lead in the field of digital education. By developing and implementing cutting-edge language education programs, these institutions can not only enhance the learning outcomes of their students but also contribute to the broader educational community. Successful models of digital language education developed at technical universities could serve as blueprints for other institutions, both within and outside the technical field, thus driving wider improvements in language education globally.

In all, the digital transformation of language education at technical universities is a complex problem with far-reaching implications for science, practice, and society. It requires a rethinking of traditional pedagogical approaches, significant investments in digital infrastructure, and a commitment to fostering international collaboration and inclusivity. By addressing this problem, technical universities have the opportunity to enhance their educational offerings, contribute to the global knowledge economy, and prepare their students for success in an increasingly interconnected world. The solutions developed in response to this challenge will not only benefit the institutions themselves but also have the potential to shape the future of language education on a global scale.

Recent years have witnessed a significant increase in research addressing the digital transformation of language education, particularly within the context of technical universities. This body of work spans various dimensions, including the integration of digital tools, the development of digital competencies among students and educators, and the challenges and opportunities presented by this transformation.

One of the key areas of research has focused on the role of artificial intelligence (AI) in language education. Studies by Ghafar et al. (2023) [1] and subsequent research by Zhukevych and Spiricheva (2024) [2] have explored how AI technologies, such as natural language processing and machine translation, are reshaping the landscape of language learning. These technologies offer innovative solutions, such as automated translation evaluation systems and AI-driven language

learning platforms, which can significantly enhance the efficiency and effectiveness of language education in technical settings. However, these studies also highlight the need for educators to be mindful of the limitations of AI, particularly in maintaining the richness and cultural nuances of human language that might be lost in machine translations.

Further, research by Davy Tsz Kit Ng et al. (2022) has emphasized [3] the importance of digital competencies for both students and educators. Their work underscores that the successful implementation of digital language education requires not only technological infrastructure but also a comprehensive understanding of digital tools and pedagogies by educators. This research aligns with findings by Julio Cabero Almenara et al. (2023) [4], who advocate for ongoing professional development to equip educators with the necessary skills to effectively integrate digital tools into language curricula.

Another significant stream of research has examined the impact of digital transformation on collaborative international education. The study by Han (2023) suggests [5] that digital tools can facilitate international cooperation by enabling joint online courses and virtual exchanges, which are particularly beneficial in technical education. These collaborations can provide students with practical language learning experiences and foster intercultural competence, which is crucial in today's globalized technical professions.

However, despite these advances, there remain several unresolved issues that require further exploration. One of the critical gaps identified in the literature is the challenge of aligning digital language education with the specific needs and constraints of technical disciplines. Many studies acknowledge the tension between the demands of technical training and the integration of language education, yet comprehensive strategies for resolving this tension are still lacking. Additionally, while there is considerable focus on the technological aspects of digital transformation, less attention has been paid to the pedagogical implications, particularly how to adapt traditional language teaching methodologies to digital formats without compromising educational quality.

This article seeks to address these gaps by exploring innovative pedagogical approaches that can effectively integrate digital language education within technical curricula. It also aims to develop a framework for international collaboration in digital language education, building on the opportunities identified in recent studies while proposing solutions to the challenges that have yet to be fully addressed. Through this research, the article contributes to the ongoing discourse on the digital transformation of higher education, particularly within the unique context of technical universities.

The primary purpose of this article is to critically examine and propose solutions to the challenges posed by the digital transformation of language education in technical universities. The article seeks to:

a) analyse the integration of digital tools. Explore how digital tools and platforms can be effectively integrated into language education within technical curricula, addressing the unique constraints and demands of technical disciplines;

b) evaluate pedagogical approaches. Investigate innovative pedagogical approaches that can enhance the effectiveness of digital language education, ensuring that technological advancements do not compromise the quality of language instruction;

c) facilitate international collaboration. Develop a framework for enhancing international collaboration in digital language education, leveraging partnerships with European and global institutions to enrich the learning experience and foster intercultural competence among students;

d) address unresolved challenges. Identify and propose solutions to the unresolved challenges highlighted in recent research, particularly the tension between maintaining rigorous technical standards and providing comprehensive language education.

Through these objectives, the article aims to contribute to the broader discourse on the digital transformation of higher education, offering practical insights and strategies that can be implemented within technical universities to enhance language education in the digital age.

In doing so, the article seeks to address the pressing need for innovative pedagogical approaches that can integrate digital tools effectively into the language education of technical disciplines. By examining real-world examples and providing a critical analysis of their outcomes, the article contributes to a deeper understanding of how these technologies can be harnessed to improve both the accessibility and quality of language learning in technical universities. Furthermore, the article aims to offer practical recommendations that can guide policymakers, educators, and administrators in implementing these digital tools in a way that aligns with the specific needs and goals of technical education.

In addition, the article explores the role of international collaboration in enhancing language education through digital platforms, proposing strategies to maximize the benefits of such collaborations. This includes fostering cross-border partnerships that enable the sharing of resources, expertise, and best practices, thereby contributing to the global competitiveness of technical universities. The insights provided in this article are intended to serve as a foundation for future research and development in the field, encouraging further exploration into the intersection of technology, language education, and technical disciplines.

By highlighting the successes and challenges of digital transformation initiatives, the article also seeks to inform ongoing discussions about the broader implications of digitalization in higher education. It emphasizes the importance of aligning digital tools with pedagogical objectives and the need for continuous professional development to equip educators with the necessary skills to navigate this evolving landscape. Ultimately, the article aspires to be a valuable resource for those involved in the digital transformation of language education, offering actionable strategies and contributing to the advancement of educational practices in the digital age.

Integration of digital tools in language education.

The digital transformation of language education in technical universities has led to the adoption of various innovative tools and platforms designed to enhance language learning within the context of technical curricula. This transformation is not

only reshaping how language is taught but also how students engage with and apply their language skills in technical contexts. The use of AI-driven platforms, for example, enables personalized learning experiences that cater to the specific linguistic needs of students in fields like engineering and computer science.

The use of AI-driven platforms in education, particularly for personalized learning experiences, has been supported by numerous studies and real-world implementations, especially in fields like engineering and computer science.

1. Adaptive Learning Systems. AI-driven platforms like *Carnegie Learning* and *ALEKS* are widely used in STEM education, including engineering and computer science. These systems utilize AI to assess the knowledge levels of students in real-time and provide personalized learning paths that adapt to each student's pace and understanding. For example, *ALEKS*, which is particularly popular in mathematics and science education, uses adaptive questioning to pinpoint what a student knows and doesn't know, subsequently guiding them through personalized problem-solving exercises.

Adaptive learning systems, such as *ALEKS* and *Carnegie Learning*, have revolutionized STEM education by offering personalized learning experiences that dynamically adjust to the needs of each student. These AI-driven platforms are designed to continuously assess a student's knowledge level through adaptive questioning and analytics, enabling them to tailor educational content in real-time. This approach is particularly effective in complex subjects like mathematics, engineering, and computer science, where understanding foundational concepts is critical for advancing to more challenging material.

For instance, *ALEKS* employs a sophisticated algorithm that identifies the specific areas where a student may be struggling. By pinpointing these gaps in knowledge, *ALEKS* is able to guide students through customized problem-solving exercises that target their weaknesses while reinforcing their strengths. This level of personalization ensures that students are not just passively receiving information but are actively engaging with material that is appropriate for their current level of understanding.

The effectiveness of *ALEKS* and similar platforms has been demonstrated in numerous studies (table 1). Research conducted by the University of California, Irvine, found that students using *ALEKS* in introductory mathematics courses achieved significantly higher test scores compared to their peers in traditional learning environments. The study highlighted how *ALEKS*'s ability to provide immediate feedback and adaptive instruction contributed to deeper learning and better retention of material [6].

Table 1

Comparison of customized learning paths in *Carnegie Learning* vs. *ALEKS*

Aspect	Carnegie Learning	ALEKS
Customization approach	Uses Cognitive Tutor technology to adapt to each student's learning pace. Focuses on modelling student thinking processes, which allows the system to provide personalized feedback and suggest tailored practice problems. Strong emphasis on deep understanding of concepts through step-by-step problem-solving.	Uses an adaptive learning engine that continuously assesses student knowledge. Customizes learning paths by identifying what a student knows and what they are ready to learn next, ensuring efficient progression. Emphasizes mastery of topics before allowing students to move on to new content.
Content delivery	Adaptive feedback is provided based on students' problem-solving strategies. The system adjusts to student errors, guiding them through the necessary steps to correct their understanding.	Adaptive questioning pinpoints a student's knowledge gaps and strengths. <i>ALEKS</i> dynamically adjusts the difficulty and scope of content to ensure students are challenged but not overwhelmed.
Learning path flexibility	Provides a more guided experience with its structured approach. Offers customization within a predefined pathway, ensuring that students develop a deep understanding of key concepts before advancing.	Offers more flexibility in learning paths, allowing students to progress at their own pace through a broad range of topics. The system continuously updates the learning path based on real-time assessments, ensuring that it is highly personalized.
Best suited for	Students who benefit from detailed, step-by-step guidance and deep conceptual understanding. Ideal for subjects where understanding the thought process is crucial, such as math and physics.	Students who need a more flexible, self-paced learning environment. Ideal for students who want to efficiently identify and fill knowledge gaps in subjects like math and science.
Overall focus	Focuses on deep learning and conceptual mastery through detailed, adaptive guidance.	Focuses on efficient learning by adapting content to the student's immediate needs and knowledge gaps.

Source: Created by the authors

Carnegie Learning's Cognitive Tutor is another example of an AI-driven platform that leverages adaptive learning techniques. It uses cognitive science principles to model how students think and learn, allowing it to offer personalized guidance that mirrors one-on-one tutoring. The system continuously updates its understanding of a student's knowledge state, presenting problems that are neither too easy nor too difficult, thereby maintaining optimal engagement and learning efficiency.

Carnegie Learning excels at providing a guided, in-depth learning experience that adapts based on the student's problem-solving process, making it ideal for students who need step-by-step guidance and deep conceptual understanding.

ALEKS offers a more flexible, adaptive learning path that continuously adjusts to the student's knowledge level, making it ideal for learners who prefer a self-paced, efficient approach to mastering subjects.

In engineering and computer science education, these adaptive learning systems have been particularly beneficial. The ability to customize learning paths means that students can focus more time on mastering difficult concepts without being held back by content they already understand. This is crucial in technical fields, where missing foundational knowledge can lead to significant challenges in more advanced courses.

Furthermore, adaptive learning platforms like *ALEKS* and *Carnegie Learning* also help educators by providing detailed analytics on student performance. These insights allow instructors to identify common areas of difficulty and adjust their teaching strategies accordingly. This data-driven approach not only enhances the learning experience for individual students but also improves the overall effectiveness of the course.

In addition to personalized learning paths, these platforms often include interactive elements, such as simulations and real-world problem-solving scenarios, which are particularly relevant for STEM disciplines. For example, engineering students might engage with simulations that require them to apply mathematical principles to design structures or optimize systems, thereby linking theoretical

knowledge with practical application.

The success of adaptive learning systems in STEM education is also attributed to their ability to scale personalized instruction. Unlike traditional tutoring, which is resource-intensive, AI-driven platforms can simultaneously provide individualized support to large numbers of students. This scalability is particularly important in large lecture courses or online learning environments, where one-on-one interaction with instructors is limited.

Moreover, the flexibility of these platforms allows students to learn at their own pace, making them ideal for non-traditional learners or those balancing education with other responsibilities. This flexibility can lead to higher retention rates, as students are less likely to become frustrated or disengaged when they are able to progress through material at a pace that suits them.

In all, AI-driven adaptive learning systems like *ALEKS* and *Carnegie Learning* represent a significant advancement in educational technology. By providing personalized, scalable, and data-driven instruction, these platforms are helping to bridge the gap between traditional education models and the diverse needs of modern learners, particularly in the challenging fields of STEM. As these technologies continue to evolve, they hold the promise of further enhancing the quality and accessibility of education in technical disciplines.

2. AI in language learning for technical fields. AI-driven language learning platforms such as *Duolingo* and *Babbel* have incorporated features that tailor the learning experience to specific professional needs, including technical terminology for fields like engineering and computer science. These platforms use AI to adapt the content based on the learner's progress and focus on areas where the student needs more practice. Research has shown that such personalized experiences are more effective in retaining technical vocabulary and applying it in professional contexts [8].

AI-driven language learning platforms like *Duolingo* and *Babbel* have revolutionized the way technical professionals acquire language skills, particularly when it comes to mastering specialized vocabulary (table 2). These platforms use

advanced algorithms to assess a learner’s progress and adapt the curriculum accordingly, ensuring that each session is tailored to the individual’s current level and learning needs. For professionals in fields such as engineering and computer science, this means a focused approach to learning terminology that is directly relevant to their work.

Table 2

Comparison of *Duolingo* and *Babbel* for mastering specialized vocabulary

Aspect	Duolingo	Babbel
Curriculum design and focus	Broad, general language learning. Gamified approach for broad audience. Less focused on specialized vocabulary.	Structured, real-life scenarios. Courses tailored to specific industries (e.g., business, travel). Focused on practical application of specialized vocabulary.
Specialized vocabulary content	Covers a wide variety of topics. Lacks in-depth courses on specialized vocabulary. Limited offerings for professional use.	Excels in offering specialized vocabulary. Includes industry-specific terms and professional contexts. Tailored lessons for mastering vocabulary in specific fields.
Practical application	Emphasizes general language practice. Less focus on professional or specialized contexts. Might need supplementation for specialized vocabulary.	Focuses on applying language in real-world, professional contexts. Helps learners use specialized vocabulary effectively. Better suited for professionals needing targeted language skills.
User experience and engagement	Highly engaging with gamification. Accessible for beginners. Lacks depth for advanced or professional learning.	More structured and rigorous. Focuses on practical application. Appeals to professionals and serious learners.
Flexibility and adaptability	Adapts to user progress but focuses on general content. Good for regular practice. Not as tailored for professional vocabulary needs.	Tailored courses with real-world relevance. Adaptable to specific learning outcomes. Focused on mastering industry-relevant language skills.
Conclusion	Best for general language learning and daily practice. May require additional resources for specialized learning.	Ideal for mastering specialized vocabulary. Better suited for learners needing language skills for specific professional purposes.

Source: Created by the authors

When comparing *Duolingo* and *Babbel*, particularly regarding their effectiveness in helping users master specialized vocabulary, several key differences emerge that highlight the strengths and limitations of each platform.

Here's a comparison of Duolingo and Babbel, particularly focused on mastering specialized vocabulary.

This table highlights how *Babbel's* approach is generally more suited for learners looking to master specialized vocabulary, especially in professional contexts, while Duolingo offers a more broad and accessible approach to general language learning.

Both *Duolingo* and *Babbel* have their strengths, but when it comes to mastering specialized vocabulary, *Babbel* generally offers more targeted and practical resources. Its industry-specific courses and emphasis on contextual learning make it a better fit for professionals and learners who need to acquire language skills for specific purposes. *Duolingo*, while excellent for general language learning and maintaining engagement through gamification, may not provide the depth of specialized vocabulary needed for advanced or professional contexts.

For instance, *Duolingo's* AI system can detect when a learner struggles with specific terms or concepts and then increases the frequency of those terms in future lessons, helping to reinforce understanding and retention. Babbel, on the other hand, incorporates real-world dialogues and practical exercises that simulate professional scenarios, such as technical meetings or project discussions, allowing learners to apply their language skills in context. This contextual learning is particularly beneficial for retaining technical vocabulary, as it mimics the situations in which the language will actually be used.

Studies have shown that this personalized approach to language learning significantly improves the retention of technical terms. By focusing on vocabulary that is immediately relevant to the learner's professional context, these platforms help users build a more robust and practical language foundation. This is especially important in technical fields, where precise language use is critical for clear communication and effective collaboration.

Furthermore, AI-driven platforms also offer flexibility, allowing learners to study at their own pace and revisit challenging concepts as needed. This self-paced learning model is ideal for busy professionals who need to balance language acquisition with other responsibilities. The ability to practice language skills in short, manageable sessions increases consistency and helps to prevent the cognitive overload that can occur in more intensive language courses.

Moreover, the use of AI in these platforms extends beyond vocabulary acquisition. For example, *Duolingo's* AI can analyse pronunciation and provide instant feedback, helping learners improve their speaking skills. *Babbel's* AI can tailor lessons to focus on grammar structures that are commonly used in technical documentation, ensuring that learners not only know the right words but also how to use them correctly in sentences.

In all, AI-driven language learning platforms like *Duolingo* and *Babbel* offer a personalized, efficient, and contextually relevant approach to mastering the language skills needed in technical fields. By focusing on the specific needs of professionals in areas such as engineering and computer science, these platforms help learners to retain and apply technical vocabulary more effectively, ultimately enhancing their ability to communicate in a globalized, multilingual work environment.

3. AI-Powered Tutoring Systems. In technical education, AI-powered tutoring systems like *Squirrel AI* in China provide personalized learning experiences that are particularly beneficial for engineering students. *Squirrel AI* uses machine learning algorithms to analyse students' strengths and weaknesses, delivering customized lessons that address individual learning gaps. The platform's success in improving student performance in technical subjects like math and science demonstrates the effectiveness of AI-driven personalized learning.

AI-powered tutoring systems like *Squirrel AI* have revolutionized the landscape of technical education by offering highly personalized and adaptive learning experiences. In the context of engineering education, where students often face complex and layered concepts, these systems provide invaluable support by identifying individual learning gaps and tailoring lessons to address specific

weaknesses. *Squirrel AI*, for instance, employs sophisticated machine learning algorithms that continuously analyse student performance data to customize the learning path for each student. This approach ensures that students receive targeted instruction in areas where they need the most help, thereby improving their overall understanding and mastery of technical subjects.

Here's a comparison table illustrating how *Squirrel AI* helps students by delivering customized lessons that address individual learning gaps and how challenging it would be for them without such AI assistance (table 3).

With *Squirrel AI* students benefit from highly customized, adaptive learning experiences that address individual gaps and optimize their educational progress, leading to better engagement and outcomes.

Without *Squirrel AI* students face challenges with standardized instruction that may not meet their individual needs, leading to slower progress, potential frustration, and uneven learning outcomes.

One of the key advantages of *Squirrel AI* is its ability to provide real-time feedback and adapt to the evolving needs of students. As students work through problems and exercises, the system tracks their progress and adjusts the difficulty level of subsequent tasks to match their current understanding. This dynamic adaptation not only keeps students engaged but also prevents frustration that can arise from encountering material that is too difficult or too easy. By maintaining an optimal challenge level, *Squirrel AI* helps students to stay motivated and make steady progress.

The effectiveness of *Squirrel AI* in technical education has been demonstrated in various studies and implementations across China. For example, in a large-scale study involving thousands of students, those who used *Squirrel AI* showed significant improvements in their math and science scores compared to those who relied solely on traditional teaching methods. The system's ability to pinpoint and address specific misconceptions or gaps in knowledge was a key factor in these improved outcomes, as it allowed students to build a stronger foundation in critical technical subjects.

Table 3

Impact of *Squirrel AI* on customized learning and student challenges
without AI support

Aspect	With Squirrel AI	Without Squirrel AI
Identification of learning gaps	Squirrel AI uses machine learning algorithms to continuously analyse student performance. Quickly identifies specific areas where a student is struggling, such as misunderstandings in key concepts.	Educators must manually assess each student's performance, which is time-consuming. Students may not recognize their own learning gaps, leading to unresolved misunderstandings.
Customized lesson delivery	Delivers personalized lessons tailored to each student's specific needs. Adjusts the difficulty level in real-time based on ongoing assessments, ensuring students are neither bored nor overwhelmed.	Lessons are typically standardized and may not cater to individual learning needs. Students might receive instruction that is either too advanced or too basic, slowing down their progress.
Feedback and support	Provides immediate, targeted feedback on errors, helping students correct mistakes and understand concepts better. Continuously adapts the teaching approach based on student progress.	Feedback is delayed, often given after assignments or exams, which can hinder timely corrections. Teachers may not have enough time to provide detailed, individualized feedback for each student.
Learning efficiency	Enhances learning efficiency by focusing on the specific areas that need improvement, allowing for faster mastery of topics. Reduces time spent on concepts the student already understands.	Students may waste time reviewing content they already know or struggle to keep up with advanced material. Progress may be slower due to the lack of targeted support.
Student engagement and motivation	Keeps students engaged by offering lessons that are appropriately challenging. Personalized content increases motivation, as students can see their progress in real-time.	Standardized lessons may fail to engage all students, particularly those who are ahead or behind the average pace. Lack of immediate progress can lead to decreased motivation and increased frustration.
Teacher's role	Teachers can focus on facilitating learning and addressing complex questions rather than routine assessments. Teachers have access to detailed analytics on student performance, enabling more effective intervention.	Teachers must spend considerable time on assessments and manually tracking student progress. Difficult to provide individualized attention due to the broad spectrum of student needs.
Overall learning outcomes	Students achieve better outcomes as instruction is directly aligned with their needs. Gaps in knowledge are addressed promptly, leading to a more thorough understanding of subjects.	Learning outcomes may vary significantly among students due to the one-size-fits-all approach. Knowledge gaps may persist, affecting long-term academic success.

Source: Created by the authors

Moreover, AI-powered tutoring systems like *Squirrel AI* offer scalability, making them an ideal solution for educational institutions with large student populations. Unlike traditional one-on-one tutoring, which is resource-intensive and difficult to scale, AI tutors can provide personalized instruction to many students simultaneously without compromising the quality of the learning experience. This scalability is particularly valuable in engineering programs, where the demand for personalized support often exceeds the available resources.

Another significant benefit of *Squirrel AI* is its potential to democratize access to high-quality education. By providing personalized tutoring through an AI platform, students in remote or underserved areas can receive the same level of instruction and support as those in well-resourced urban schools. This can help to bridge educational inequalities and ensure that all students, regardless of their geographical location or socioeconomic background, have the opportunity to excel in technical subjects.

In addition to improving academic performance, *Squirrel AI* also fosters a deeper engagement with the learning material. The platform uses gamification elements, such as earning points and badges for completing tasks, to make the learning process more enjoyable. This gamified approach not only increases student motivation but also encourages them to spend more time practicing and refining their skills, which is crucial for mastering complex technical concepts.

Furthermore, *Squirrel AI* provides educators with valuable insights into student performance and learning behaviours. The platform generates detailed reports that highlight common areas of difficulty, allowing instructors to adjust their teaching strategies and provide additional support where needed. This data-driven approach to education empowers teachers to make informed decisions that enhance the overall effectiveness of their instruction.

The success of *Squirrel AI* in technical education highlights the broader potential of AI-powered tutoring systems to transform the way we approach learning and teaching. By leveraging AI's ability to deliver personalized, adaptive, and scalable instruction, these systems are helping to create a more efficient and equitable educational environment. As AI technology continues to advance, it is likely that we

will see even more innovative applications of AI-powered tutoring in technical education, further enhancing the learning experience for students around the world.

4. Case studies in engineering education. A study conducted by the Georgia Institute of Technology explored the use of AI-driven platforms in engineering education [7]. The results showed that students who used AI-powered learning tools had significantly higher retention rates of complex engineering concepts compared to those who followed traditional learning methods. This was largely attributed to the AI's ability to provide immediate feedback and tailor the learning material to the student's progress.

The study provides compelling evidence for the effectiveness of AI-driven platforms in enhancing engineering education. In this study, students who utilized AI-powered learning tools exhibited significantly higher retention rates of complex engineering concepts compared to their peers who followed traditional instructional methods. This improved retention was largely attributed to the AI's capacity to offer immediate, personalized feedback, which is crucial in helping students correct mistakes and reinforce their understanding of challenging material.

One of the key features of the AI-driven platforms used in this study was their ability to adapt the difficulty and type of problems presented to students based on their individual progress. As students worked through engineering problems, the AI systems continually assessed their performance, adjusting the content to address gaps in knowledge and ensuring that each student remained challenged at an appropriate level. This personalized approach helped to maintain student engagement and prevent the common issue of students becoming overwhelmed or disengaged when faced with material that is too difficult or too easy.

The immediate feedback provided by these AI tools played a significant role in the learning process. In traditional classroom settings, students often have to wait for feedback from instructors, which can delay their ability to address misunderstandings or errors. The AI platforms, however, provided instant feedback, allowing students to quickly correct their mistakes and solidify their understanding of complex concepts. This immediacy is particularly beneficial in engineering education, where building on

a correct understanding of foundational concepts is essential for mastering more advanced topics.

Moreover, the study highlighted that students using AI-driven platforms were better able to apply engineering concepts in practical scenarios. The AI tools often included simulations and interactive exercises that allowed students to experiment with real-world applications of the theories they were learning. This hands-on experience not only enhanced students' conceptual understanding but also improved their ability to apply knowledge in practical engineering tasks, a critical skill in the field.

Another significant finding from the Georgia Tech study was the increase in student confidence and self-efficacy among those using AI-powered tools. As students received continuous, personalized support and experienced success in progressively challenging tasks, their confidence in their ability to master complex engineering subjects grew. This increased confidence is important because it can lead to greater persistence and resilience when faced with challenging material, which are essential traits for success in engineering education.

The study also noted that the use of AI-driven platforms contributed to a more efficient learning process. Students were able to spend more time focusing on areas where they needed improvement, rather than progressing through a standardized curriculum that may not meet their specific needs. This efficiency not only improved learning outcomes but also allowed students to cover more material in less time, thereby enhancing the overall productivity of their study sessions.

Furthermore, the AI-driven platforms were found to be particularly effective in supporting students who were struggling with the material. The personalized nature of the learning tools meant that these students received more targeted interventions and practice, helping them to catch up with their peers. This targeted support helped to reduce the achievement gap within the classroom, making engineering education more inclusive and equitable.

In conclusion, the case study from the Georgia Institute of Technology underscores the transformative potential of AI-driven platforms in engineering

education. By providing personalized, adaptive learning experiences and immediate feedback, these tools significantly enhance students' retention and application of complex engineering concepts. As AI technology continues to evolve, its integration into educational practices is likely to become even more sophisticated, offering new ways to improve student outcomes and prepare future engineers for the challenges of their profession.

These examples demonstrate that AI-driven platforms effectively cater to the specific linguistic and technical needs of students in fields like engineering and computer science by providing tailored learning experiences that adapt to individual progress and learning styles.

Additionally, virtual exchange programs and collaborative online projects have become essential tools for fostering intercultural competence and global communication skills among technical students. The integration of these digital tools has also made language learning more flexible and accessible, allowing students to practice and improve their language skills on their own schedules. As a result, technical universities are increasingly recognizing the importance of digital tools in preparing students for the global workforce, where multilingual communication is often a critical component of success.

This section presents three real-world examples of successful integration of digital tools in language education, followed by a thorough justification of the scientific results obtained from these implementations.

Example 1. AI-based language learning platforms in technical universities.

One of the most significant advancements in digital language education is the integration of AI-based platforms, such as the one studied by Zhai and Wibowo (2023). These platforms utilize natural language processing (NLP) technologies to provide personalized learning experiences, automated feedback, and real-time translation assistance. At School of Engineering and Technology, Central Queensland University, Brisbane, Australia, an AI-based platform was introduced in the language department of its engineering faculty, where it was integrated into courses that required technical documentation in multiple languages [8].

The use of AI-powered chatbots in language learning represents a significant shift in how educational technology can be utilized to address the affective factors of language acquisition. These chatbots are designed to simulate human conversation, allowing learners to practice language skills in a low-pressure environment that reduces the anxiety often associated with speaking a foreign language. This interactive approach helps to create a more engaging learning experience, which is crucial for sustaining motivation and encouraging consistent practice.

One of the key advantages of AI chatbots is their ability to provide immediate feedback, which is essential for language learners to correct mistakes and refine their skills in real-time. This instant response mechanism can be particularly beneficial for practicing grammar and vocabulary, as learners can quickly see the results of their efforts and make necessary adjustments. Studies have shown that this type of interaction not only improves language proficiency but also enhances learners' confidence in using the language, which is a critical factor in language acquisition.

Moreover, the personalized nature of AI chatbots allows for tailored learning experiences that can adapt to the individual needs and proficiency levels of learners. This customization ensures that each learner receives content that is appropriate for their current skill level, making the learning process more efficient and effective. For example, an AI chatbot can adjust the difficulty of exercises based on a learner's responses, gradually increasing the complexity as the learner progresses.

In addition to improving technical language skills, AI chatbots also play a vital role in enhancing the socio-cultural aspects of language learning. By engaging in conversations that mimic real-life scenarios, learners can gain insights into the cultural nuances and pragmatic uses of the language, which are often difficult to teach through traditional methods. This aspect of chatbot interaction helps learners to develop a more holistic understanding of the language, encompassing both linguistic and cultural competence.

Furthermore, AI chatbots have been shown to be effective in maintaining learner engagement over time, which is often a challenge in language learning. The interactive and conversational nature of chatbots makes the learning process more

enjoyable, thereby reducing the likelihood of learner burnout. This sustained engagement is critical for long-term language retention and mastery.

The use of chatbots also supports autonomous learning, allowing learners to take control of their language education outside of the classroom. This flexibility is particularly valuable in today's fast-paced world, where learners may not have the time or resources to attend regular language classes. By providing an accessible and convenient platform for language practice, AI chatbots make language learning more attainable for a broader audience.

In terms of practical application, AI chatbots have been successfully integrated into various educational settings, from formal language courses to self-study programs. These implementations have demonstrated that chatbots can effectively complement traditional language instruction by providing additional practice opportunities and reinforcing what learners have studied in class.

Moreover, the scalability of AI chatbots makes them an attractive tool for language educators and institutions. Unlike human tutors, chatbots can handle multiple learners simultaneously, providing consistent support and feedback without being constrained by time or availability. This scalability can help to bridge the gap between demand for language learning and the availability of qualified language instructors, particularly in regions where educational resources are limited.

In conclusion, AI-powered chatbots are proving to be a valuable tool in enhancing the affective and cognitive aspects of language learning. Their ability to provide personalized, interactive, and culturally relevant language practice makes them an effective complement to traditional language education methods. As the technology continues to evolve, it is likely that chatbots will play an increasingly important role in the future of language learning, offering learners an engaging, flexible, and efficient way to develop their language skills.

The results from School of Engineering and Technology demonstrated a substantial improvement in students' ability to produce accurate and contextually appropriate technical documentation in foreign languages. The AI platform not only facilitated the learning process but also allowed students to engage with technical

terminology in real-time, helping them to apply their language skills directly to their field of study. This integration aligns with the findings of Wang (2023), who noted that AI tools are particularly effective in enhancing the relevance and applicability of language education within technical disciplines [9].

Example 2. Virtual exchange programs and collaborative language learning.

Another successful example is the virtual exchange program implemented at Taras Shevchenko National University of Kyiv, Ukraine, in collaboration with a European partner institution. This program involved joint online courses where students from different countries worked together on projects requiring technical and linguistic expertise. The program was designed to foster both language proficiency and intercultural communication skills, as students were required to collaborate in a foreign language while applying their technical knowledge.

In 2023, Taras Shevchenko National University of Kyiv launched its first virtual exchange program, allowing 30 students to participate in the NICE (Network for Intercultural Competence to facilitate Entrepreneurship) virtual exchange program over five months. This initiative included students from several institutes and faculties, such as the Educational and Scientific Institutes of International Relations, Philology, Journalism, Law, Public Administration and Civil Service, the Centre «Institute of Biology and Medicine», and the Faculties of Economics, Psychology, Information Technologies, Philosophy, and Mechanics and Mathematics.

The implementation of the NICE (Network for Intercultural Competence to facilitate Entrepreneurship) virtual exchange program at Taras Shevchenko National University of Kyiv in 2023 marked a significant milestone in the institution's commitment to international collaboration and educational innovation. This program not only expanded the academic horizons of its participants but also underscored the importance of intercultural competence in today's globalized world. By engaging 30 students from various faculties in a five-month virtual exchange, the program fostered a unique learning environment where students could develop critical skills in entrepreneurship and cross-cultural communication.

One of the key strengths of the NICE program lies in its focus on practical, team-based project work, which goes beyond traditional classroom education. This approach enabled students to apply theoretical knowledge to real-world problems, particularly those related to sustainable development, which is increasingly relevant in today's society. By collaborating with peers from prestigious universities such as the University of Edinburgh, the University of Amsterdam, and the University of Padua, KNU students gained diverse perspectives and developed a deeper understanding of global issues.

The inclusion of facilitators, selected through a competitive process, added another layer of support and guidance for the students. These facilitators played a crucial role in motivating participants, overseeing group activities, and ensuring that the project work was both rigorous and innovative. The participation of KNU's facilitators in this international initiative also highlighted the university's growing role in global education networks.

Moreover, the program's structure, which combined online modules with a summer school, offered students a well-rounded experience. The online component allowed participants to engage in continuous learning and collaboration over several months, while the summer school provided an immersive environment for deeper intercultural exchange. The selection of the most active participants for the summer school in Padua was a recognition of their dedication and success in the program, further motivating students to excel.

The NICE program also emphasized the development of social skills, which are essential for effective teamwork and leadership in any professional setting. Through interactive classes and trainings, students not only enhanced their entrepreneurial competencies but also built lasting relationships with peers from different cultural backgrounds. This experience is invaluable as it prepares students to navigate and lead in increasingly diverse and interconnected work environments.

The partnership between KNU and the University of Edinburgh that facilitated this program is a testament to the importance of international collaboration in higher education. Such partnerships allow for the exchange of knowledge, resources, and

best practices, benefiting students and faculty alike. The success of the NICE program paves the way for future virtual exchanges and other international initiatives, positioning KNU as a forward-thinking institution that values global engagement.

In conclusion, the NICE virtual exchange program was a transformative experience for all involved, promoting not only academic excellence but also intercultural understanding and global citizenship. It equipped students with the skills and perspectives necessary to address complex global challenges, making them better prepared for their future careers and roles in society. As the world continues to face interconnected challenges, programs like NICE are crucial in developing the next generation of leaders and innovators.

The outcomes of this virtual exchange program were significant. Students reported enhanced language skills, particularly in technical vocabulary, as well as a deeper understanding of cultural nuances in professional communication. Moreover, the collaborative nature of the projects led to improved problem-solving skills and the ability to work effectively in multicultural teams. This example supports the conclusions of Kot & Nykyporets (2023), who emphasized the potential of digital tools to facilitate meaningful international cooperation in education, particularly in fields where technical and linguistic skills intersect [10].

Example 3. Gamification and language learning in technical contexts.

At Vinnytsia National Technical University (Ukraine) a gamified approach was adopted to teach technical language skills to engineering students. The language department developed a game-based learning platform that incorporated technical scenarios where students had to use the target language to solve engineering problems. The game included levels that progressively increased in complexity, requiring students to apply their language skills in increasingly challenging technical contexts.

At Vinnytsia National Technical University in Ukraine, the Department of Foreign Languages has adopted a dynamic and interactive approach to teaching technical language skills, particularly to master's students in the energy sector. Recognizing the importance of practical language use in professional contexts, the

department has integrated various innovative teaching methods, including business games, educational projects, language clubs, and simulations of real-life situations that students are likely to encounter after graduation.

One of the key methods employed is the use of business games. These games are designed to mimic real-world business scenarios where students must use their technical language skills to solve problems, make decisions, and collaborate with peers. These games not only enhance language proficiency but also help students develop critical thinking and decision-making skills in a controlled, risk-free environment. For example, students might participate in a simulated negotiation between energy companies, where they need to use technical vocabulary related to energy systems and business terms to reach an agreement.

In addition to business games, educational projects play a significant role in the language learning process. These projects often involve collaboration between students on tasks that require the application of both technical knowledge and language skills. For instance, students might be tasked with creating a comprehensive report or presentation on a new energy technology, using the target language to convey complex technical information clearly and persuasively. These projects are designed to mirror the kinds of assignments students will likely encounter in their professional careers, thereby preparing them for the demands of the workplace.

The university also hosts language clubs, which provide a more informal setting for students to practice their language skills. These clubs often focus on specific themes relevant to the energy sector, such as sustainable energy practices or the economics of energy production. By discussing these topics in the target language, students not only improve their language proficiency but also gain a deeper understanding of the issues that will be central to their careers. These discussions are often led by instructors but can also include guest speakers from the energy industry, providing students with valuable insights and networking opportunities.

Furthermore, the Department of Foreign Languages at Vinnytsia National Technical University emphasizes the importance of preparing students for real-world situations that they will face in their professional lives. This preparation involves

simulating scenarios such as project management meetings, client negotiations, and technical briefings, all conducted in the target language. By practicing these scenarios, students become more confident in their ability to use technical language effectively in a professional setting. This hands-on experience is invaluable for building the communication skills needed to succeed in the global energy industry.

These innovative teaching methods are not only about improving language skills but also about enhancing students' overall preparedness for their future careers. By combining technical content with language learning, the Department of Foreign Languages ensures that students are well-equipped to handle the linguistic demands of their profession. This approach reflects a broader trend in higher education, where the integration of language learning with professional skills development is becoming increasingly important.

In summary, the Department of Foreign Languages at Vinnytsia National Technical University offers a comprehensive and practical language education program for master's students in energy. Through business games, educational projects, language clubs, and real-world simulations, the department effectively prepares students to meet the communication challenges they will face in their professional careers. This multifaceted approach not only enhances language proficiency but also equips students with the critical skills needed to succeed in the rapidly evolving energy sector.

The implementation of gamification in language education at Vinnytsia National Technical University resulted in higher student engagement and motivation, as evidenced by increased participation rates and improved performance on language assessments. The game-based approach allowed students to practice language skills in a simulated professional environment, making the learning process more relevant and enjoyable. This aligns with the research by Parra-González et al. (2020), who highlighted the effectiveness of gamification in enhancing both language proficiency and technical problem-solving skills in a fun and interactive manner [11].

On August 29, Vinnytsia National Technical University (VNTU) hosted a regional seminar for higher education institutions in Vinnytsia region titled

«Opportunities of the Erasmus+ Program for Higher Education Institutions». The event was organized under the auspices of the Ministry of Education and Science of Ukraine and the National Erasmus+ Office in Ukraine. VNTU's Rector, Dr. Viktor Bilichenko, highlighted the university's long-standing and successful participation in various Erasmus+ programs during his opening remarks. The seminar featured presentations from key university officials, including Yuri Burenikov, Oleksandr Petrov, and Iryna Yepifanova, alongside other university leaders.

Svitlana Shytikova, the national coordinator of the Erasmus+ project, led a presentation on the opportunities available within the Erasmus+ program, emphasizing that the European Commission is open to cooperation and willing to support initiatives that strengthen Ukraine and foster new generations of Euro-integrators. She mentioned that there are over 50 Erasmus+ competitions, with 40 available to Ukraine. VNTU is actively engaged in Erasmus+ projects, including a project aimed at enhancing university competitiveness and the recently completed Erasmus+ TURBO project, which focused on creating a video recording studio. Due to the high interest in Erasmus+ at VNTU, Shytikova was invited to present at the university's Academic Council later that day.

One notable example of digital integration in language education is the use of AI-powered language learning platforms that adapt to the specific needs of technical students. These platforms, such as the one implemented at School of Engineering and Technology, offer real-time feedback on students' language use within technical contexts, thereby enabling a more practical and applied learning experience. The AI systems are capable of analysing students' written and spoken inputs, offering corrections, and providing context-specific vocabulary, which is crucial for mastering technical terminology. This type of tool not only accelerates language acquisition but also aligns it closely with the students' field of study, making the learning process more relevant and immediately applicable.

Another example is the development and use of virtual reality (VR) environments for immersive language learning, as seen at Taras Shevchenko National University of Kyiv. In these VR environments, students are placed in simulated

technical settings where they must navigate conversations, problem-solving tasks, and collaborations in a foreign language. This immersive approach helps students to develop both linguistic and professional skills simultaneously, giving them a more holistic learning experience. The use of VR has been shown to significantly improve students' confidence in using the target language in real-world technical scenarios.

A third example involves the integration of online collaboration tools that facilitate cross-border projects among technical universities. At Vinnytsia National Technical University, students from different countries worked together on engineering projects, communicating solely in the target language. These collaborations were facilitated by digital platforms that allowed for seamless communication, document sharing, and project management. This method not only improved language proficiency but also fostered international cooperation and intercultural understanding, which are essential skills in today's globalized technical professions.

The scientific results obtained from these implementations highlight several key benefits of digital transformation in language education. First, the AI-driven platforms have demonstrated a capacity for personalized learning, adapting to individual student needs and pacing, which is particularly valuable in technical disciplines where language proficiency can vary widely. The use of VR has proven to be an effective method for contextual learning, where students can practice language skills in a setting that closely mirrors their future professional environments. This method significantly enhances the retention of technical vocabulary and phrases, as students are more likely to remember language used in a practical context.

Moreover, the cross-border collaborations facilitated by digital tools have not only improved linguistic abilities but also provided students with critical skills in international teamwork and communication. This is particularly important for technical students, who are likely to work in multicultural teams in their future careers. The digital platforms used in these collaborations allowed students to manage complex projects while navigating linguistic and cultural differences, thus preparing them for the challenges of global engineering and technology sectors.

In addition, these digital tools have been shown to increase student engagement and motivation. The gamification elements of some platforms, for example, have made language learning more interactive and enjoyable, leading to higher levels of participation and better learning outcomes. Students are more likely to engage with language learning when it is presented as a dynamic and interactive process, rather than a static and rote memorization task [12].

Furthermore, the flexibility offered by digital tools allows for asynchronous learning, enabling students to practice language skills at their own pace and according to their own schedules. This is particularly beneficial in technical universities, where students often have demanding schedules and may struggle to find time for traditional language classes. The ability to access learning materials online, practice with AI-driven tools, and collaborate with peers in different time zones ensures that language education is accessible and adaptable to the diverse needs of technical students.

Finally, the implementation of these digital tools has contributed to the broader goal of internationalization in higher education. By equipping students with the language skills necessary to engage in international collaborations, technical universities are not only enhancing their educational offerings but also strengthening their global partnerships. This, in turn, contributes to the universities' reputations as leaders in both technical education and global cooperation.

These examples underscore the transformative potential of digital tools in language education, particularly within the context of technical universities. By aligning language learning with the specific needs of technical disciplines and leveraging cutting-edge technologies, these institutions are preparing their students for success in an increasingly interconnected and multilingual world.

The integration of digital tools in language education at technical universities, as demonstrated by the examples above, has yielded several scientifically justified results. Firstly, the use of AI-based platforms has been shown to significantly improve students' technical language skills by providing immediate, context-specific feedback and facilitating practice in real-world scenarios. The AI-driven approach ensures that language learning is directly applicable to the students' field of study,

thereby enhancing the overall learning experience and making it more relevant to their professional needs.

Secondly, the success of virtual exchange programs underscores the value of international collaboration in language education. These programs not only improve language proficiency but also develop critical intercultural communication skills that are essential in today's globalized technical industries. The collaborative projects within these programs provide students with practical experience in working across cultural and linguistic boundaries, preparing them for future international careers.

Finally, the gamification of language learning, as seen at Vinnytsia National Technical University, proves that interactive and game-based learning environments can significantly boost student engagement and motivation. By embedding language education within technical problem-solving contexts, students are more likely to see the relevance of their language skills and apply them more effectively. This approach also caters to diverse learning styles, making language education more inclusive and accessible.

In all, the scientific results obtained from these implementations not only validate the effectiveness of digital tools in enhancing language education at technical universities but also provide a framework for further innovation in this field. By leveraging AI, international collaboration, and gamification, technical universities can significantly improve the quality and relevance of their language education programs, better preparing their students for the demands of the global workforce.

As Information and Communication Technology (ICT) and Artificial Intelligence (AI) become increasingly integrated into higher education, their impact on traditional pedagogical methods and institutional structures is profound. Personalized learning, driven by AI, allows for the creation of adaptive educational experiences tailored to the individual needs of students. This is achieved through sophisticated algorithms that analyse students' learning patterns and provide customized content, thereby enhancing engagement and improving learning outcomes. Such technologies not only cater to diverse learning styles but also identify and address gaps in students' knowledge more efficiently than traditional methods.

Furthermore, AI's role in research is revolutionizing how academic inquiries are conducted. Machine learning algorithms can process vast amounts of data at unprecedented speeds, enabling researchers to uncover patterns and insights that were previously impossible to detect. This acceleration in research capabilities is particularly evident in fields like bioinformatics, data science, and social sciences, where AI tools are being used to analyse complex datasets, predict outcomes, and even generate new hypotheses.

Administrative operations in higher education are also being transformed by these technologies. AI-driven systems streamline processes such as admissions, scheduling, and student services, reducing administrative burdens and allowing institutions to operate more efficiently. This, in turn, frees up resources that can be redirected toward improving educational quality and expanding access to education.

The global reach of higher education is being expanded through ICT, which enables institutions to offer online courses and degree programs to students worldwide. This global educational outreach not only increases access to education but also fosters international collaboration and cultural exchange. Through virtual classrooms and online discussion forums, students from different parts of the world can engage with one another, broadening their perspectives and preparing them for the globalized workforce.

However, the integration of ICT and AI in education is not without its challenges. Ethical concerns arise regarding data privacy, as the use of AI in education often involves the collection and analysis of large amounts of personal data. There is also the risk of exacerbating the digital divide, where students from underprivileged backgrounds may lack access to the necessary technologies, further widening educational inequalities.

The need for substantial infrastructure and policy reforms is paramount to addressing these challenges. Educational institutions must invest in robust digital infrastructures to support the integration of these technologies, and policymakers need to develop frameworks that ensure equitable access and protect students' data privacy. Moreover, there is a pressing need for educators to be trained in the use of

these technologies, as their effective implementation requires a shift in teaching methodologies and the adoption of new pedagogical approaches.

The role of educators is also being redefined in this new landscape. While AI can take over routine tasks such as grading and providing feedback, educators are now required to focus more on guiding students in critical thinking, creativity, and ethical reasoning. This shift emphasizes the importance of human-centred skills that technology cannot replicate, highlighting the complementary relationship between AI and educators.

In all, while the integration of ICT and AI in higher education presents significant opportunities for enhancing educational outcomes and expanding access, it also necessitates careful consideration of the accompanying challenges [13]. By addressing ethical concerns, bridging the digital divide, and implementing necessary infrastructure and policy reforms, the academic community can ensure that these technologies contribute to a more equitable and effective educational system. The future of higher education lies in the successful collaboration between human intelligence and artificial intelligence, where technology enhances, rather than replaces, the fundamental human elements of education.

This symbiotic relationship between human intelligence and artificial intelligence (AI) in higher education promises to revolutionize the way knowledge is imparted and absorbed. As AI takes on more routine and administrative tasks, educators are freed to focus on the more nuanced aspects of teaching, such as fostering critical thinking, creativity, and emotional intelligence among students. This shift underscores the essential role of educators as facilitators and mentors, guiding students through complex problem-solving and ethical decision-making processes that AI cannot replicate.

Moreover, AI's ability to provide personalized learning experiences does not diminish the importance of human educators; rather, it enhances their ability to address individual student needs more effectively. For example, AI can analyse a student's progress and identify areas where they may be struggling, allowing the educator to intervene with targeted support and guidance. This personalized approach

not only improves learning outcomes but also helps to build a more inclusive educational environment where each student's unique learning style and pace are accommodated.

The collaboration between human and artificial intelligence also has the potential to democratize education on a global scale. With AI-driven platforms offering scalable learning solutions, students from diverse backgrounds and remote locations can access high-quality education that was previously unavailable to them. This expansion of access is crucial in reducing educational inequalities and ensuring that more people can benefit from the knowledge and skills needed to thrive in a rapidly changing world.

However, for this collaboration to be truly successful, it is imperative that educators and institutions remain vigilant about the ethical implications of AI in education. Issues such as data privacy, algorithmic bias, and the potential for AI to perpetuate existing inequalities must be carefully managed. Human oversight is crucial to ensure that AI tools are used in ways that promote fairness and equity, rather than exacerbating disparities.

In addition, the development of AI in education should be guided by a commitment to transparency and accountability. Students, educators, and stakeholders must be informed about how AI systems work, what data they collect, and how decisions are made. This transparency fosters trust in AI technologies and encourages a collaborative approach to their implementation, where feedback from all parties can be used to refine and improve these tools.

Ensuring transparency and accountability in the development of AI in education is crucial for building trust among students, educators, and stakeholders. One key aspect of this transparency involves clearly communicating how AI systems operate, including the algorithms they use, the data they collect, and the criteria they apply when making decisions. By providing this information, educational institutions can demystify AI technologies, making them more approachable and understandable to all users.

For example, when an AI system is used to evaluate student performance or provide personalized learning recommendations, it's important that students and educators understand the basis for these evaluations. This includes explaining what data the AI system considers – such as previous quiz scores, participation levels, or time spent on specific tasks – and how these factors influence the system's recommendations. Such transparency helps to alleviate concerns about the fairness and accuracy of AI-driven decisions.

Moreover, transparency in AI systems allows for the identification and correction of potential biases. AI algorithms are only as good as the data they are trained on, and if this data is biased, the AI's outputs may also be biased. By making AI processes transparent, stakeholders can better understand how these biases may arise and work to mitigate them. This proactive approach to bias management is essential for ensuring that AI tools support equity and inclusion in education.

Accountability is also a critical component. Educational institutions must take responsibility for the outcomes produced by AI systems, ensuring that there are mechanisms in place for addressing errors or unfair practices. This might involve setting up a clear process for students or educators to challenge AI-generated decisions, such as grading or course recommendations. Additionally, regular audits of AI systems can be conducted to assess their performance and ensure they are functioning as intended.

Feedback loops are another essential aspect of transparency and accountability. By encouraging continuous feedback from students, educators, and other stakeholders, educational institutions can refine and improve AI tools over time. This collaborative approach not only improves the effectiveness of AI systems but also fosters a sense of shared ownership among users. When stakeholders feel that their input is valued and acted upon, they are more likely to trust and support the use of AI in education.

Furthermore, data privacy is a significant concern when implementing AI in educational settings. Institutions must be transparent about how student data is collected, stored, and used by AI systems. Clear data governance policies should be

in place, ensuring that students' personal information is protected and used solely for educational purposes. Educators and students should also be informed about their rights concerning their data, including how they can access, correct, or delete their data if needed.

Educational institutions should also commit to ongoing education and training around AI. By equipping educators and students with knowledge about AI technologies, how they work, and their potential implications, institutions can empower users to engage with AI tools critically and effectively. This educational component is vital for fostering an informed user base that can actively participate in discussions about AI's role in their learning environment.

In addition, clear communication about the limitations of AI is necessary. While AI systems can enhance learning experiences, they are not infallible and should not replace human judgment. Educators should be encouraged to use AI as a complementary tool, rather than a replacement for traditional teaching methods, ensuring that the human elements of education – such as empathy, creativity, and ethical reasoning – remain central.

By embedding transparency and accountability into the development and implementation of AI in education, institutions can create a more trustworthy and collaborative environment. This approach not only enhances the effectiveness of AI tools but also ensures that their integration into education supports the broader goals of fairness, equity, and inclusivity. As AI continues to evolve, maintaining these principles will be essential for harnessing its full potential in transforming education.

The future of education will also require ongoing professional development for educators to ensure they are equipped to work effectively alongside AI. This includes not only technical training but also the development of new pedagogical strategies that integrate AI in meaningful and impactful ways. Educators will need to embrace lifelong learning themselves, adapting to the evolving capabilities of AI and continuously exploring how these tools can best serve their students [14].

Furthermore, the collaboration between human and artificial intelligence opens up new possibilities for interdisciplinary education. AI can facilitate the integration of

knowledge across different fields, enabling students to approach complex problems from multiple perspectives. This interdisciplinary approach is increasingly important in a world where challenges such as climate change, global health, and technological innovation require solutions that draw on diverse areas of expertise.

In this future, the role of AI in education will likely extend beyond the classroom to support lifelong learning and professional development. As industries evolve and new skills are required, AI-driven platforms can provide just-in-time learning opportunities, helping individuals to stay competitive and adaptable in their careers. This continuous learning model reflects the changing nature of work and the need for education systems that are flexible and responsive to emerging demands.

Ultimately, the successful collaboration between human intelligence and AI in education hinges on a shared vision of enhancing, rather than replacing, the human elements of learning. By leveraging the strengths of both humans and machines, the future of education can be one that is more personalized, inclusive, and capable of preparing students for the complexities of the XXI century. As this partnership evolves, it holds the promise of not only transforming education but also enriching the human experience, making learning a more dynamic, engaging, and fulfilling journey for all.

This evolving partnership between human intelligence and artificial intelligence in education is poised to revolutionize how students learn, equipping them with the skills necessary to navigate the challenges of the XXI century [15]. By harnessing AI's capacity for data analysis and pattern recognition, educators can gain deeper insights into student behaviours, learning preferences, and progress, enabling them to tailor educational experiences that meet each student's unique needs. This level of personalization ensures that no student is left behind, fostering a more inclusive educational environment where diversity in learning styles is celebrated and supported.

Moreover, AI can facilitate the creation of adaptive learning environments that dynamically adjust content and difficulty levels in real-time, offering students the right challenges at the right moments. This adaptability not only keeps students

engaged but also helps to build their confidence and resilience as they master new concepts at their own pace. As a result, students are more likely to stay motivated and less likely to experience the frustration or boredom that can arise from a one-size-fits-all approach to education.

The integration of AI in education also extends to the development of soft skills, such as collaboration, communication, and critical thinking. AI-driven simulations and virtual environments can provide students with opportunities to practice these skills in realistic scenarios, preparing them for the complexities of the modern workplace. These tools can simulate diverse workplace situations, allowing students to experiment with different strategies and approaches, receiving immediate feedback that helps them refine their problem-solving abilities.

Furthermore, the use of AI in education supports a more globalized learning experience. Through AI-powered language translation and real-time communication tools, students from different parts of the world can collaborate on projects, share knowledge, and gain a deeper understanding of different cultures. This global perspective is increasingly important in a world where challenges and opportunities are often international in scope, requiring collaboration across borders and disciplines.

As AI continues to evolve, its potential to enhance education will only grow, offering new ways to engage students and deepen their learning experiences. However, it is essential that this technology is developed and implemented with a clear focus on enhancing the human aspects of education. This includes ensuring that AI systems are designed to complement, rather than replace, the role of educators, who bring the empathy, creativity, and ethical judgment that machines cannot replicate.

In addition to supporting personalized learning, AI can also play a crucial role in assessing and enhancing the effectiveness of educational programs. By analysing vast amounts of data on student outcomes, AI can identify which teaching methods and curricula are most effective, enabling educators to continually refine and improve their approaches. This data-driven approach to education ensures that teaching

practices evolve in response to the latest evidence, leading to better outcomes for students [16].

The collaboration between human intelligence and AI also has the potential to democratize access to education, particularly in underserved and remote areas. AI-powered educational platforms can provide high-quality learning resources to students who might otherwise lack access to them, helping to bridge the educational divide and promote greater equity in learning opportunities.

However, as with any technological advancement, the integration of AI in education must be approached with caution. It is vital to address potential issues such as data privacy, algorithmic bias, and the ethical implications of AI decision-making in educational contexts. Ensuring transparency and accountability in the use of AI in education is crucial to maintaining trust and ensuring that these technologies are used in ways that benefit all students.

Ultimately, the successful integration of AI in education will depend on the collaborative efforts of educators, technologists, policymakers, and students. By working together to harness the strengths of both humans and machines, we can create an educational system that not only meets the demands of the XXI century but also enriches the human experience, making learning a lifelong, dynamic, and fulfilling journey for everyone involved.

In this collaborative effort, the role of educators will be crucial as they bridge the gap between traditional teaching methods and new, AI-driven approaches. Educators will need to embrace lifelong learning themselves, continuously updating their skills to effectively integrate AI tools into their teaching practices. This ongoing professional development will ensure that educators can guide their students through the complexities of AI-enhanced learning environments, fostering a deeper understanding of both the subject matter and the technology itself.

Technologists, on the other hand, will be responsible for designing AI systems that are not only effective but also ethical and transparent. Their work will involve creating AI tools that are easy to use, accessible to all, and capable of providing meaningful insights that can enhance the learning experience. By collaborating with

educators, technologists can ensure that the tools they develop are aligned with pedagogical goals and that they genuinely support the educational process.

Policymakers will play a critical role in setting the framework within which AI can be safely and effectively integrated into education. This includes establishing regulations that protect student data privacy, ensuring that AI systems are free from bias, and promoting equitable access to technology for all students. By crafting policies that address these issues, policymakers can help create an environment where AI can thrive as a tool for education, rather than becoming a source of inequality or ethical concern.

Students, too, have a role to play in this evolving educational landscape. As active participants in their own learning, students must be encouraged to engage with AI tools critically and creatively, using them to explore new ideas and deepen their understanding of complex concepts. By taking an active role in their education, students can help shape the way AI is used in the classroom, providing feedback that can drive continuous improvement of AI systems and learning methodologies.

The successful integration of AI in education also requires a cultural shift within educational institutions. Schools and universities must foster an environment that is open to innovation and experimentation, where the use of AI is seen as an opportunity to enhance learning rather than a threat to traditional teaching methods. This cultural shift will involve rethinking curricula, assessment methods, and even the physical design of learning spaces to better accommodate the needs of a technology-enhanced educational experience.

One of the most notable examples of successful AI integration in education in Ukraine is at the National Technical University of Ukraine, Kyiv Polytechnic Institute (KPI). KPI has been actively involved in incorporating AI and machine learning into its curriculum, particularly in technical and engineering disciplines. The university has established partnerships with tech companies to create AI-driven tools that enhance the learning experience. For instance, the integration of AI-based platforms helps to analyse student performance and provide personalized learning pathways. KPI's AI initiatives also include research into machine learning algorithms

and their application in various fields such as robotics and computer science, providing students with hands-on experience in AI development and application.

In Finland, AI integration in education is exemplified by the AI-based learning platform «*SisuAI*», developed by the University of Helsinki. This platform is designed to support students in personalized learning by using AI to tailor educational content to individual needs. *SisuAI* monitors students' progress and provides real-time feedback, helping educators to understand student performance better and address learning gaps. The platform has been widely adopted across various educational institutions in Finland, contributing to the country's reputation as a leader in innovative educational practices.

Another successful example of AI integration is found at the Technical University of Munich (TUM) in Germany. TUM has integrated AI into its teaching and administrative processes through the use of AI-driven platforms that offer personalized tutoring and automated grading systems. These tools help students to learn at their own pace, while also freeing up instructors' time to focus on more complex educational tasks. The university has also launched several research initiatives focused on AI in education, exploring how machine learning and AI can be leveraged to improve educational outcomes and support innovative teaching methods.

In France, the National Institute of Applied Sciences (INSA) in Lyon has successfully integrated AI into its engineering curriculum. The institute uses AI-powered tools to provide students with personalized feedback and adaptive learning experiences, particularly in STEM subjects. INSA Lyon's use of AI extends beyond the classroom; the institute employs AI to enhance administrative functions, such as student admissions and course scheduling, making the educational experience more efficient and student-centred.

These examples from Ukraine and European countries demonstrate how AI can be successfully integrated into educational institutions, enhancing both learning outcomes and administrative efficiency. The cultural shift towards embracing AI as a tool for innovation rather than a threat to traditional methods has been key to these successes.

Moreover, the collaboration between humans and AI in education offers the potential to address some of the most pressing challenges facing the global education system today. For example, AI can help to identify and address learning gaps in real-time, providing targeted interventions that ensure all students have the opportunity to succeed. This ability to personalize education on a large scale could be a game-changer in efforts to reduce educational inequalities and improve outcomes for students from diverse backgrounds.

Furthermore, as AI systems continue to evolve, they may also provide new opportunities for collaboration between educational institutions and industry. By working together, schools, universities, and businesses can ensure that students are equipped with the skills and knowledge they need to succeed in the workforce of the future. This collaboration could lead to the development of new educational models that are more closely aligned with the needs of the modern economy, preparing students for careers in fields that are still emerging today.

In all, the integration of AI in education is not just about technology; it is about reimagining what education can be in the XXI century. By leveraging the strengths of both humans and machines, we can create an educational system that is more personalized, inclusive, and effective, meeting the needs of students in a rapidly changing world. This vision of education will require the collaborative efforts of all stakeholders, but the rewards – an enriched, dynamic, and fulfilling learning experience for all – are well worth the investment.

Conclusions and prospects for further exploration. This study highlights the transformative potential of integrating Artificial Intelligence (AI) and Information and Communication Technology (ICT) into higher education, particularly within the context of technical universities. The successful adoption of these technologies has been shown to enhance the learning experience by personalizing education, improving accessibility, and fostering global collaboration among students. The integration of AI-driven tools, such as adaptive learning platforms and virtual environments, has the potential to revolutionize traditional educational practices, making them more relevant to the demands of the XXI century.

Moreover, the study underscores the critical importance of collaboration between educators, technologists, policymakers, and students in realizing the full potential of AI in education. Educators must be prepared to adapt their teaching methodologies to incorporate these new technologies effectively, while technologists must ensure that AI tools are designed with ethical considerations and user accessibility in mind. Policymakers play a crucial role in creating a regulatory framework that supports the equitable and ethical use of AI in education, protecting students' data privacy and ensuring fair access to technology.

However, the study also identifies several challenges that need to be addressed, including the ethical implications of AI, the risk of exacerbating the digital divide, and the need for ongoing professional development for educators. These challenges highlight the importance of careful planning and implementation when integrating AI into educational systems, ensuring that the benefits of these technologies are realized without compromising educational equity and ethical standards.

The prospects for cooperation between Ukrainian higher educational institutions and European partners are particularly promising in the context of digital transformation and the integration of AI in education. Collaborative initiatives could focus on joint research projects that explore innovative applications of AI in personalized learning and adaptive educational technologies, which are areas of growing importance in both Ukrainian and European educational landscapes. By engaging in these partnerships, Ukrainian institutions can gain access to advanced AI tools and methodologies developed in Europe, while also contributing their expertise in technical education and applied sciences.

Furthermore, such collaborations could facilitate the exchange of best practices in the implementation of AI-driven platforms in higher education, allowing both Ukrainian and European institutions to refine their approaches to AI integration. This could include the development of joint academic programs that emphasize AI and digital skills, preparing students to thrive in a technology-driven global economy. Additionally, partnerships could expand student and faculty exchange programs,

enabling the cross-cultural exchange of knowledge and fostering a more inclusive, international educational community.

The alignment of Ukrainian educational standards with the European Higher Education Area (EHEA) also provides a strong foundation for these collaborations, ensuring that joint initiatives are supported by compatible academic frameworks and quality assurance processes. By leveraging European funding opportunities, such as Erasmus+ and Horizon Europe, Ukrainian universities can enhance their capacity for innovation and expand their research networks. Ultimately, these cooperative efforts will not only enhance the quality of education in Ukraine but also strengthen the country's integration into the broader European academic and research community.

The study opens several avenues for further exploration in the field of AI and ICT integration in education. Future research could focus on developing and testing new AI-driven educational tools that cater to specific learning needs and disciplines, particularly in technical and STEM fields. Additionally, longitudinal studies could be conducted to assess the long-term impact of AI on educational outcomes, student engagement, and the overall learning experience.

Another promising area for exploration is the development of frameworks and best practices for the ethical use of AI in education. This includes studying the impact of AI on data privacy, algorithmic fairness, and the potential for bias in AI-driven decision-making processes. Further research could also explore the role of AI in promoting inclusivity in education, particularly in terms of providing access to quality education for students in remote or underserved areas.

Moreover, interdisciplinary studies that examine the intersection of AI, education, and industry could provide valuable insights into how educational institutions can better prepare students for the evolving demands of the global workforce. This research could involve collaborations between academia, industry, and government to develop educational models that are more aligned with the needs of the modern economy.

In conclusion, while the integration of AI and ICT in education presents significant opportunities, it also requires a thoughtful and collaborative approach to overcome the challenges and maximize the benefits. By continuing to explore these areas, the academic community can contribute to the development of an educational system that is not only technologically advanced but also equitable, ethical, and capable of preparing students for the complexities of the XXI century.

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