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BEYOND TOOL TRAINING: AN INSTITUTIONALLY EMBEDDED MODEL OF PROFESSIONAL DEVELOPMENT FOR ARTIFICIAL INTELLIGENCE IN HIGHER EDUCATION

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Introduction

Artificial intelligence (AI) is increasingly influencing almost every sphere of human activity, including scientific research, education, healthcare, engineering, information media, and social networks (Anđić et al., 2026). Higher education is particularly exposed to this transformation, as AI is simultaneously reshaping teaching and learning, assessment, research, academic writing, and administrative processes. Generative AI tools can support personalized learning, the development of teaching materials, feedback provision, data analysis, and the productivity of educators and researchers (Anđić, 2025a; Su et al., 2025). At the same time, their use raises serious concerns regarding the reliability of AI-generated outputs, academic integrity, authorship, data protection, algorithmic bias, inclusion, human agency, and overreliance on automated systems.

The pace at which AI tools are being adopted currently exceeds the capacity of many higher education institutions to develop appropriate policies, infrastructure, and support mechanisms. Previous research on educational technology has shown that the mere availability of digital tools does not automatically improve teaching and learning. Rather, their effects depend on educators' competencies, pedagogically sound design, alignment between technology and learning outcomes, and sustained institutional support (Anđić et al., 2022; Anđić et al., 2024; Anđić et al., 2025b; Fernández-López et al., 2026; Maričić et al., 2025). These insights are particularly relevant to AI, whose capabilities, increasing autonomy, and ethical implications place additional demands on university educators and institutions. A 2025 UNESCO survey, based on 400 responses from representatives of UNESCO Chairs and UNITWIN Networks across 90 countries, found that nine out of ten respondents were already using AI in their professional work. Nevertheless, more than half expressed uncertainty regarding its effective pedagogical or research applications, its technological foundations, or its broader implications for human rights, democracy, and social justice. Only 19% of respondents reported that their institutions had adopted a formal AI policy, while 42% indicated that relevant guidelines were still under development (UNESCO, 2025). These findings point to a substantial gap between the individual use of AI and institutional readiness to guide its adoption in responsible, pedagogically sound, and sustainable ways.

In this context, the key question is no longer limited to which AI competencies university educators should possess. It is equally important to determine how these competencies can be developed, who should support their development, how their transfer into teaching practice should be evaluated, and under which institutional conditions they can be sustained. Professional development for AI integration should not be reduced to short-term training in the use of individual tools. Instead, it should be understood as a continuous, institutionally supported,

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and evidence-informed process that integrates AI literacy, disciplinary pedagogy, ethical reasoning, assessment redesign, and critical reflection on the consequences of AI use.

What Competencies Do University Educators Need?

Several frameworks have been developed to describe the knowledge, skills, and values educators need to integrate AI responsibly. The UNESCO AI Competency Framework for Teachers (Miao & Cukurova, 2024) comprises 15 competencies organized into five interconnected dimensions: a human-centred mindset, ethics of AI, AI foundations and applications, AI pedagogy, and AI for professional learning. These competencies are developed across three progressive levels: acquiring foundational knowledge and skills (Acquire), applying them critically and contextually (Deepen), and creating innovative and responsible AI-enabled educational practices (Create). The value of this framework lies in its positioning of technical knowledge within a broader humanistic and professional context.

Celik (2023) proposed Intelligent-TPACK, an extension of the traditional TPACK model adapted to the pedagogical and ethical use of AI-based tools. The framework comprises five interconnected domains: Intelligent Technological Knowledge (Intelligent-TK), Intelligent Technological Pedagogical Knowledge (Intelligent-TPK), Intelligent Technological Content Knowledge (Intelligent-TCK), Intelligent Technological Pedagogical Content Knowledge (Intelligent-TPACK), and Ethics. Intelligent-TK refers to the knowledge required to understand and use the core functions of AI systems. Intelligent-TPK encompasses an understanding of the pedagogical affordances of AI, such as providing feedback, monitoring student learning, and supporting differentiated instruction. Intelligent-TCK refers to knowledge of AI tools and applications that are specific to a particular discipline. Intelligent-TPACK represents the integrated professional knowledge required to select and use AI tools in alignment with disciplinary content, pedagogical approaches, student characteristics, and intended learning outcomes. The ethical dimension refers to educators' ability to evaluate AI systems and their outputs in relation to transparency, fairness, accountability, and inclusiveness.

The Digital Education Council AI Literacy Framework (2025) further emphasizes the specific needs of higher education. It adopts a human-centred approach and connects AI literacy with critical thinking, creativity, and emotional intelligence. In particular, it distinguishes between general AI literacy, which is required by all members of the academic community, and specialized competencies adapted to particular disciplines, professional fields, institutional roles, and regulatory contexts. This distinction is important because educators in medicine, history, engineering, and educational sciences do not require identical AI practices, although they all need a common foundation for the responsible and critical use of AI.

Existing frameworks represent an important advancement because they specify what educators should know and be able to do. However, they provide considerably less guidance on how these complex competencies can be developed, sustained, and evaluated in authentic higher education contexts. Awareness of a list of competencies does not automatically lead to changes in teaching practice, just as technical proficiency in using a tool does not guarantee its pedagogically sound application. This constitutes the missing link between the growing number of competency frameworks and the everyday practices of university educators**.**

From Defining Competencies to Their Systematic Development

Most contemporary research has focused on educators' self-reported competencies, attitudes, intentions, or perceptions concerning AI use, while the ways in which university educators develop these competencies and transfer them into practice remain insufficiently investigated (Li & Zhang, 2026; Prilop et al., 2024). Li and Zhang (2026) indicate that the rapid adoption and development of AI are transforming the professional contexts in which university educators work, including their responsibilities, academic roles, and perceptions of their own professional value. Professional development should therefore be understood not only as the acquisition of additional technical skills but also as a means of supporting educators in understanding changes in their professional identities and responsibilities.

Cotton et al. (2024) and Cai et al. (2025) emphasize the need for comprehensive professional development programmes that enable educators to develop the necessary competencies and harness the educational potential of AI in an ethically responsible manner. Similarly, Popescu et al. (2023), Yu and Wang (2024), and Zeb et al. (2024) identify proactive institutional policies and continuous professional development as interconnected conditions for the successful integration of AI into higher education. Cai et al. (2025) particularly emphasize the availability of appropriate AI tools and programmes through which educators learn to use their capabilities in pedagogically

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meaningful, critical, and ethical ways. The crucial importance of well-structured professional development is also highlighted by Bozkurt et al. (2021), Dogan et al. (2025), and Dogan (2026). Their findings and arguments suggest that implementing AI without adequate pedagogical and ethical preparation may not only leave the technology's potential underutilized but may also produce harmful consequences. These include the uncritical acceptance of inaccurate outputs, the reproduction of algorithmic biases, inappropriate data handling, the weakening of student agency, and the use of technology in ways that are not aligned with intended learning outcomes. According to Cai et al. (2025), professional development programmes should be aligned with institutional policies so that the expectations placed on educators are not disconnected from the support, resources, and regulations provided by their institutions.

Institutional policymaking, however, continues to lag behind practice. As UNESCO's (2025) data indicate, only 19% of respondents reported that their institutions had adopted a formal AI policy, while 42% stated that relevant guidelines were still under development. Importantly, these findings are based on responses from 400 representatives of UNESCO Chairs and UNITWIN Networks across 90 countries rather than on a representative sample of all universities worldwide. Nevertheless, they clearly reveal a gap between the widespread use of AI and institutions' capacity to govern it effectively. Chiu (2026) describes this problem as a governance gap requiring an urgent response to safeguard data sovereignty, promote the ethical and constructive use of AI, and protect student well-being.

Taken together, the existing literature points to a chain of interdependent institutional conditions: the adoption of clear and proactive policies, the provision of secure and pedagogically relevant AI tools, the organization of continuous professional development programmes, and the systematic promotion and exchange of critically evaluated examples of good practice. This sequence may initially be understood as a cascade, because insufficient support at one level constrains the outcomes of the next. Sustainable AI integration, however, requires this cascade to evolve into a continuous cycle: experiences gained through professional development and teaching practice should be evaluated and used to revise institutional policies, decisions concerning AI tools, and future support programmes.

Professional Development Is Not the Same as Training in Tool Use

Discussions about AI frequently conflate training, AI literacy, professional development, and institutional transformation. Training generally refers to short-term familiarization with the functions of a particular tool. AI literacy encompasses understanding AI systems, using them responsibly, and critically evaluating their outputs. Professional development represents a longer-term process involving changes in professional knowledge, pedagogical reasoning, teaching practice, and professional identity. Institutional transformation, finally, entails the alignment of policies, infrastructure, support systems, incentives, and organizational culture. These processes should be interconnected but not treated as equivalent. A one-off workshop on prompt writing may increase educators' confidence but does not necessarily improve the quality of student learning. An educator may become proficient in using AI to generate text, images, or quizzes without adequately evaluating accuracy, bias, accessibility, data protection, or the alignment of the activity with intended learning outcomes. Professional development should therefore begin with authentic educational challenges rather than with the functions of a currently popular tool. The starting question should not be "How can I use this tool?" but rather "What educational problem am I trying to address, what value can AI add, and what new risks might it introduce?".

This approach is particularly important given the pace of technological change. Professional development programmes centred on a single platform can quickly become outdated, whereas competencies in critical evaluation, pedagogical design, ethical decision-making, and transferring knowledge across tools have more enduring value. The aim of professional development is therefore not to cultivate uncritical users of AI but to develop academic professionals capable of making well-reasoned decisions about when, how, and under which conditions AI should be used, and when it should not be used.

An Institutionally Embedded Model of Professional Development for AI

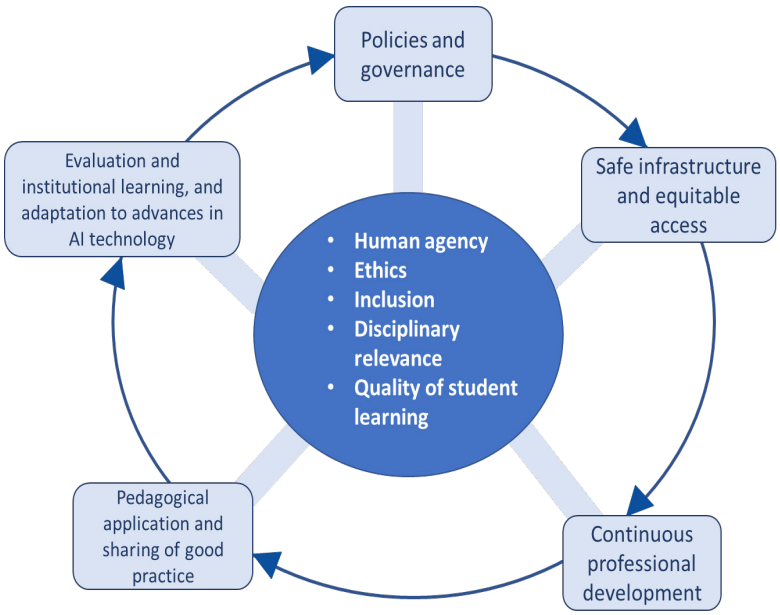
Drawing on the existing literature and the gaps identified above, we propose an Institutionally Embedded Model of Professional Development for AI in Higher Education. The model comprises five interconnected elements: (1) policies and governance, (2) secure infrastructure and equitable access, (3) continuous professional development, (4) pedagogical application and the sharing of good practice, and (5) evaluation, institutional learning, and adaptation to advances in AI technology. Together, these elements form a cyclical model of institutionally

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embedded professional development for AI integration in higher education (Figure 1). The proposed model is a literature-informed conceptual framework. It is intended to provide a theoretically grounded basis for institutional action and future empirical examination across diverse higher education contexts. The model demonstrates that responsible AI integration does not result from a single training intervention or an isolated institutional decision but from the continuous interaction of governance, infrastructure, professional development, teaching practice, evaluation, institutional learning, and ongoing technological change.

Figure 1
Institutionally embedded cyclical model of professional development for AI integration in higher education



The model begins with institutional policies and governance mechanisms that guide the selection and responsible use of AI tools. Universities should then provide secure infrastructure and equitable access to relevant AI technologies. On this foundation, continuous professional development programmes can be established, with the competencies developed through these programmes subsequently transferred into teaching practice and the sharing of examples of good practice. The cycle is completed through the evaluation of pedagogical effects, ethical risks, and the experiences of educators and students, together with continuous adaptation to advances in AI technology. These factors should inform the revision of institutional policies, infrastructure, and subsequent professional development programmes.

Policies and governance provide the normative foundation of the model. Universities should define responsibilities, permitted and prohibited forms of AI use, requirements concerning transparency, data protection, authorship, academic integrity, and oversight of automated decision-making. Institutional policies, however, should not function solely as mechanisms of prohibition and sanction. They should also enable pedagogical experimentation, safeguard human agency, and establish clear procedures for addressing emerging dilemmas.
Secure infrastructure and equitable access encompass institutionally approved tools, technical support, data protection, accessibility, and measures to prevent the emergence of new digital inequalities. If educators and students are expected to use AI responsibly, they cannot simultaneously be directed exclusively towards free consumer tools, personal accounts, and unclear terms of use. However, technology procurement should be guided by clearly defined pedagogical and ethical needs rather than preceding their identification.
Continuous professional development connects general AI literacy with discipline-specific needs. It should include a foundational understanding of AI systems, practical application, evaluation of AI-generated outputs, the redesign of teaching and assessment, ethical case studies, and reflection on AI's influence on professional identity. Educators with different levels of prior knowledge and experience should be offered differentiated development pathways combining self-directed learning, workshops, mentoring, and ongoing consultative support.

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Pedagogical application and the sharing of practice facilitate the transfer of acquired competencies into authentic teaching contexts. Communities of practice, peer consultation, open educational resources, and collections of critically evaluated examples can reduce educators' professional isolation and prevent the repeated duplication of similar experiments. Examples of good practice, however, should present not only the tool and activity employed but also the pedagogical problem, institutional and disciplinary context, intended outcomes, associated risks, limitations, and evidence of effectiveness.

Evaluation, institutional learning, and adaptation to advances in AI technology complete the cycle. Evaluation should address not only educators' satisfaction with professional development programmes but also changes in teaching design, the quality of assessment tasks, educators' capacity for ethical reasoning, students' experiences, and, where possible, learning outcomes. These findings, together with continuous monitoring of developments in AI technology, should inform subsequent professional development programmes, procurement decisions, infrastructure development, and the revision of institutional policies.

At the centre of all these elements are human agency, ethics, inclusion, disciplinary relevance, and the quality of student learning. Professional development should therefore be understood as a shared institutional responsibility rather than an individual obligation that educators are expected to fulfil outside their recognized workload and without adequate resources.

Principles of High-Quality Professional Development

Seven principles emerge from the proposed model. First, professional development should be continuous, because both AI tools and institutional conditions are changing rapidly. Second, it should be pedagogically oriented, beginning with questions of teaching and learning rather than with technological novelty. Third, it should be discipline-sensitive, because the affordances, standards of evidence, risks, and acceptable uses of AI vary across disciplinary fields. Fourth, it should be ethically grounded, ensuring that ethics is not treated as an isolated final module but embedded in every practical activity and professional decision. Fifth, it should be differentiated and inclusive, accommodating educators' different levels of experience, institutional roles, languages, and professional needs. Sixth, it should be collaborative and adequately supported through mentoring, communities of practice, and interdisciplinary cooperation. Seventh, it should be evidence-informed, with systematic monitoring of the transfer of competencies into practice and their consequences for students and student learning. Institutional commitment to these principles requires more than simply offering courses. Universities should recognize the time required for professional development within educators' formal workloads, provide pedagogical, technical, and legal expertise, support the development and sharing of high-quality examples of practice, and incorporate the competent use of AI into systems for evaluating and recognizing teaching. Without these conditions, even well-designed workshops may remain isolated interventions with no sustained impact.

From Perceived Readiness to Demonstrated Competence

A substantial proportion of existing research relies on educators' self-assessments, their intentions to use AI, or their general perceptions of their own competencies. Such data can provide insights into attitudes and the development of self-confidence, but they cannot independently demonstrate that an educator is capable of designing a pedagogically sound activity, identifying inaccurate or biased AI-generated outputs, protecting confidential data, or evaluating the consequences of AI use for student learning. The field should therefore move beyond measuring perceived AI readiness towards examining demonstrated professional competence. Programme evaluation may include analyses of authentic teaching plans and materials, ethical decision-making scenarios, assessments of AI-generated outputs, observations or documentation of teaching practice, student perspectives, and longitudinal monitoring of the transfer of competencies into practice. It is particularly important to distinguish between immediate programme outcomes, such as increased knowledge and confidence, medium-term changes in teaching practice, and long-term consequences for the quality, equity, and sustainability of student learning.

Research Agenda

Building a robust evidence base requires research that addresses several questions. Which characteristics of professional development lead to sustained changes in university teaching? How do professional development needs differ across disciplines, institutions, and groups of educators? Which institutional conditions enable or hinder

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the transfer of training into practice? How can demonstrated AI competencies be measured rather than relying solely on self-assessment? How do professional development programmes affect the quality of student learning, student agency, and critical thinking? How can students be involved as partners in shaping responsible AI pedagogy? How can professional development reduce rather than deepen digital and social inequalities? Finally, how can institutions ensure that policies, infrastructure, and professional development evolve alongside technological advances without uncritically pursuing every new tool? Addressing these questions will require longitudinal and comparative research, intervention studies, multiple sources of data, analyses of authentic cases from practice, and greater representation of diverse national, institutional, and disciplinary contexts. Research should also examine unsuccessful interventions and the unintended consequences of professional development. The assumption that more training automatically produces higher-quality practice should be tested empirically, particularly because some programmes may normalize the excessive use of AI or prioritize efficiency over learning.

Summing-up

Higher education cannot integrate AI responsibly by relying solely on individual enthusiasm, educators' independent experimentation, or occasional workshops on popular tools. Competency frameworks clearly demonstrate the breadth of knowledge, skills, and values educators require, but translating these competencies into practice demands systemic institutional support. Policies without professional development remain difficult to implement; tools without a pedagogical purpose encourage superficial use; professional development without infrastructure and incentives is unlikely to transfer into practice; and implementation without evaluation does not enable institutional learning. Professional development for AI should therefore be treated as a long-term strategic function of universities and a shared responsibility of institutional leaders, centres for teaching and learning, educators, professional services, and students. Its purpose is not merely to increase AI use but to develop the capacity to make well-reasoned, ethical, and pedagogically sound decisions about when, how, and why AI should be used. The future quality of higher education will depend not on how rapidly universities adopt AI tools but on how thoughtfully they develop the people and institutions capable of governing their use.

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No potential conflict of interest was reported by the author.

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References

Anđić, B., Helm, C., Weinhandl, R., Maričić, M., Radlmair, A., Bleckenwegner, V., & Ebner, M. (2026). Empowering preservice biology teachers as designers of pedagogical AI agents: Moving beyond data feeding toward pedagogical design. *Research in Science Education*, 1–24. https://doi.org/10.1007/s11165-026-10359-0

Anđić, B. (2025a). Artificial intelligence and deepfake learning in higher education. *Journal of Baltic Science Education, 24*(1), 4–6. https://doi.org/10.33225/jbse/25.24.04

Anđić, B., Šorgo, A., Stešević, D., & Lavicza, Z. (2022). The factors which influence the continuance intention of teachers in using the interactive digital identification key for trees in elementary school science education. *EURASIA Journal of Mathematics, Science and Technology Education, 18*(8), Article em2140. https://doi.org/10.29333/ejmste/12239

Anđić, B., Maričić, M., Weinhandl, R., Mumcu, F., Schmidthaler, E., & Lavicza, Z. (2024). Metaphorical evolution: A longitudinal study of secondary school teachers' concepts of 3D modelling and printing in education. *Education and Information Technologies*, *29*(11), https://doi.org/10.1007/s10639-023-12408-x

Anđić, B., Weinhandl, R., Maričić, M., & Dünser, B. (2025b). Pre-service biology teachers as developers of mobile augmented reality teaching materials: Enhancing, not replacing, science practices and connections with the natural environment. *Thinking Skills and Creativity*, Article 102019. https://doi.org/10.1016/j.tsc.2025.102019

Bozkurt, A., Karadeniz, A., Baneres, D., Guerrero-Roldán, A. E., & Rodríguez, M. E. (2021). Artificial intelligence and reflections from educational landscape: A review of AI studies in half a century. *Sustainability, 13*(2), Article 800.

Cai, L., Msafiri, M. M., & Kangwa, D. (2025). Exploring the impact of integrating AI tools in higher education using the Zone of Proximal Development. *Education and Information Technologies, 30*(6), 7191–7264.

https://doi.org/10.33225/jbse/26.25.576

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Celik, I. (2023). Towards Intelligent-TPACK: An empirical study on teachers' professional knowledge to ethically integrate artificial intelligence (AI)-based tools into education. *Computers in Human Behavior, 138*, Article 107468. https://doi.org/10.1016/j.chb.2022.107468

Cotton, D. R. E., Cotton, P. A., & Shipway, J. R. (2024). Chatting and cheating: Ensuring academic integrity in the era of ChatGPT. *Innovations in Education and Teaching International, 61*(2), 228–239.

Chiu, T. K. (2026). AI governance and ethics in education: research gaps, future directions, and methodological approaches. *Interactive Learning Environments, 34*(6), 3627–3630.

Digital Education Council. (2025). Digital Education Council AI Literacy Framework. https://www.digitaleducationcouncil.com/post/digital-education-council-ai-literacy-framework

Dogan, S. (2026). Designing effective AI professional development: A framework grounded in intelligent-TPACK. *Computers and Education Open*, *10*, Article 100337.

Dogan, S., Nalbantoglu, U. Y., Celik, I., & Agacli Dogan, N. (2025). Artificial intelligence professional development: A systematic review of TPACK, designs, and effects for teacher learning. *Professional Development in Education, 51*(3), 519–546.

Fernández-López, A., Maričić, M., Soeharto, S., Anđić, B., & Lavicza, Z. (2026). Teachers' perceptions within emerging technology STEM/STEAM environments: Psychometric analysis with moderation effects. *Education and Information Technologies*, 1–34.

Li, J., & Zhang, Q. (2026). Teacher identity negotiation in AI-enhanced higher education and its implications for professional development. *Teaching and Teacher Education*, *176*, Article 105499.

Maričić, M., Anđić, B., Mumcu, F., Marić, M., Gordić, S., Ranitović, M. G., & Cvjetićanin, S. (2025). Enhancing student engagement through instructional STEAM learning activities and self-explanation effect. *Eurasia Journal of Mathematics, Science and Technology Education, 21*(1), Article em2560.

Miao, F., & Cukurova, M. (2024). *AI competency framework for teachers*. UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000391104

Popescu, R. I., Sabie, O. M., & Truşcă, M. I. (2023). The contribution of artificial intelligence to stimulating the innovation of educational services and university programs in public administration. *Transylvanian Review of Administrative Sciences*, 85–108.

Prilop, C. N., Mah, D.-K., Jacobsen, L. J., Hansen, R. R., Weber, K. E., & Kleinknecht, M. (2024). *Generative AI in teacher education: Using AI-enhanced methods to explore teacher educators' perceptions* [Preprint]. OSF. https://doi.org/10.31219/osf.io/szcwb

Su, M., Wijaya, T. T., Miricic, M., Anđić, B., & Lavicza, Z. (2025). Understanding AI dependency among pre-service teachers: A UTAUT2-based analysis using PLS-SEM and fsQCA. *Interactive Learning Environments*, 1–20.

UNESCO. (2025). UNESCO survey: *Two-thirds of higher education institutions have or are developing guidance on AI use*. https://www.unesco.org/en/articles/unesco-survey-two-thirds-higher-education-institutions-have-or-are-developing-guidance-ai-use

Yu, J., & Wang, L. (2024). Research on the integration path and practice of AI intelligent technology and English teaching reform in higher vocational colleges and universities. *Applied Mathematics and Nonlinear Sciences, 9*(1). https://doi.org/10.2478/amns-2024-0442

Zeb, A., Ullah, R., & Karim, R. (2024). Exploring the role of ChatGPT in higher education: Opportunities, challenges and ethical considerations. *International Journal of Information and Learning Technology, 41*(1), 99–111. https://doi.org/10.1108/IJILT-04-2023-0046

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