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Innovative models of vocational education: A symbiosis of artificial intelligence, neuropedagogy, and the competency-based approach

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■ **Abstract.** The modern world establishes new demands in education, necessitating innovative approaches to professional training. Integrating artificial intelligence, neuropedagogy, and the competency-based approach emerges as a cornerstone for creating effective vocational education models. This study aimed to develop and test innovative models that combine the capabilities of artificial intelligence (including smart robotics) with neuropedagogical competency-based strategies to enhance the effectiveness of vocational education. The research methodology encompassed an analysis of contemporary literature and practices, the development of experimental models integrating artificial intelligence into the educational process, and empirical investigations in educational institutions. Analysis, synthesis, modelling, observation, and experimentation methods were employed. The proposed innovative models include personalised learning platforms with adaptive algorithms, intelligent systems for analysing learners' emotional states, virtual environments and gamified simulations, as well as robotic automated assessment and reporting systems in vocational education. The integration of artificial intelligence into neuropedagogical processes facilitates personalised learning, enhances learners' motivation, and fosters the development of critical thinking. Artificial intelligence enables the creation of adaptive educational platforms that cater to the individual characteristics and needs of learners. Its implementation also automates routine tasks for educators, allowing them to focus on the creative aspects of the educational process. The findings highlight the significance of integrating artificial intelligence into vocational education as a means to enhance its competitiveness. Given the dynamic advancement of technologies, future research is expected to explore immersive neurointerfaces for developing engaging interactive learning environments, as well as the ethical considerations surrounding the use of artificial intelligence in education, with an emphasis on critical thinking. The results of the study are of practical value for the development of innovative educational technologies and approaches that meet the contemporary demands of the labour market and the expectations of progressive youth

■ **Keywords:** personalised learning; adaptive algorithms; individual learning trajectories; virtual environments; robotic automated assessment; critical thinking; vocational training

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Introduction

The realm of vocational education is rapidly evolving, combining cutting-edge technologies with a profound understanding of human learning. The integration of artificial intelligence (AI), neuropedagogy, and the competency-based approach unveils new possibilities for preparing future professionals. AI functions as a personal mentor through personalised learning platforms and adaptive algorithms, ensuring that each learner receives education tailored to their pace and needs. Robotics and virtual simulations provide realistic environments for hands-on experience, while intelligent systems analyse learners' emotional states, adjusting the educational process and sustaining motivation. Neuropedagogy harnesses the brain's potential by leveraging insights into its functioning, while neuropedagogical approaches make learning both engaging and effective. Various regions of the brain are activated, facilitating improved comprehension and retention of material. The competency-based approach focuses on developing practical skills and knowledge required for specific fields, shaping practitioners equipped to tackle the challenges of a competitive labour market. Modern vocational education, a strategically significant area supported by the Ministry of Education and Science of Ukraine, demands innovative approaches. The synergy of AI, neuropedagogy, and the competency-based approach leads to the development of symbiotic learning models. These models optimise educational processes, enhance learning outcomes, and cultivate essential competencies among vocational education learners (Piddubna *et al*., 2023).

Research in this field focuses on developing and testing innovative models that personalise the learning experience. According to R. Zhoga (2024), AI algorithms analyse data about learners, tailoring educational programmes and materials to their individual needs, learning pace, and information processing styles. V. Mykhailets (2023) emphasised that neuropedagogical methods, based on insights into brain function, make learning more engaging and captivating, enhancing learners' motivation and active participation. T. Luhova (2021) explored the use of gamification, virtual environments, and simulations combined with AI systems, enabling learners to apply knowledge in practice while developing critical thinking and problem-solving skills. O. Bazeliuk (2021) highlighted that AI systems automate routine tasks, such as marking assignments and assessing knowledge, freeing educators to focus on the more creative and strategic aspects of the educational process.

A significant portion of contemporary vocational education methods relies on the use of advanced technologies. Analysing existing theoretical sources, including prior research, provides a foundation for developing innovative vocational education models. This process involves designing new approaches and empirically testing various educational models. The study of I. Yildiz *et al.* (2021) demonstrated that gamification significantly enhances learner motivation, forming the basis for incorporating game elements into personalised learning platforms. L. Sharma & M. Srivastava (2019) emphasised the importance of motivating educators to adopt technologies, highlighting the need to foster a competency-based approach among teaching professionals. Research by A. Rakhmanina *et al*. (2022) revealed the substantial potential of robotics in developing critical thinking and practical skills, which contributed to the inclusion of robotic automated assessment systems in model design. M.S. Ramirez-Montoya *et al*. (2021) stressed the necessity of integrating innovative technologies into educational practices, shaping the strategy for developing four distinct models.

S. Lytvynova & N. Soroko (2022) highlighted the advantages of immersive technologies, which have become a foundation for creating effective virtual learning environments. N. Grigorieva *et al.* (2021) emphasised the importance of leveraging international experience in education, facilitating the adaptation of best practices to the Ukrainian educational system. O. Petrovych *et al*. (2022) underscored the significance of neuropedagogical approaches, which serve as the basis for developing effective teaching methods. L. Lysiak (2020) stressed the necessity of continuous monitoring of educational innovations, an essential component in model development. S. Fedko (2023) explored the emerging field of neuropsychology in learning, emphasising its importance for integration into vocational education. L. Elouafi *et al*. (2021) confirmed the positive impact of neuropedagogical methods on the educational process, while N. Bilonozhko (2021) analysed teaching quality in the context of educational internationalisation, focusing on innovative teaching methods.

According to T. Semigina & Yu. Rashkevych (2023), the effectiveness of innovative models is assessed through methods of systems analysis, pedagogical experimentation, and statistical forecasting. Research findings confirm that the integration of artificial intelligence, neuropedagogy, and a competency-based approach leads to personalised learning, where learners acquire knowledge and skills that align with their individual needs and goals; increased motivation, as learning becomes more engaging and exciting, leading to heightened interest and engagement among learners; the development of critical thinking, specifically the ability to apply knowledge in practice, solve problems, and make informed decisions; and improved learning outcomes, manifested in better material retention, increased knowledge and skill levels among learners.

Regarding the competency-based approach, it does not require a separate model, as it should be integrated into all four proposed models. For instance, personalised learning platforms can be designed to foster the development of specific competencies, virtual

environments can simulate real workplace scenarios, and robotic assessment systems can evaluate not only knowledge but also the skills necessary for success in a particular field or profession. The study aimed to develop and implement new educational models that leverage the potential of artificial intelligence and robotics in integration with neuropedagogical approaches, enhancing the learning process and fostering the development of professional competencies among learners. The research intended to evaluate the effectiveness of these models through practical trials in real educational settings, addressing the needs of a competitive labour market, mitigating the consequences of the war in Ukraine, and supporting the establishment of a newly European–integrated Ukrainian state.

Materials and Methods

The research methodology is grounded in a systemic approach encompassing both theoretical and empirical methods. Theoretical methods include the analysis and synthesis of contemporary scientific approaches, comparative analysis of methods and models employed in various countries, and the modelling of new approaches. These approaches incorporate personalised learning platforms, intelligent systems for emotional state analysis, virtual environments, gamified simulations, and automated assessment systems. The research drawn on a broad source base, including contemporary scientific publications, national and international regulatory frameworks, and analytical reports on the use of artificial intelligence and innovative technologies in education. Key methods of scientific inquiry employed in the study include the analysis and synthesis of the literature, comparative analysis of the effectiveness of various innovative teaching methods, modelling experimental educational frameworks, and testing these models in real-world settings. At the theoretical level, the model development process relied on SWOT analysis and illustrative schematic synthesis of contemporary theoretical concepts such as artificial intelligence, neuropedagogy, and the competency-based approach in vocational education. This approach facilitated the identification of the core aspects of each concept and their potential for integration into the educational process. At the empirical level, the study involved the implementation of personalised learning platforms, intelligent systems for analysing pupils' emotional states, the creation of virtual learning environments, gamified simulations, and the application of automated assessment systems for evaluating educational outcomes. The empirical investigations were designed to collect quantitative and qualitative data on the effectiveness of these approaches in improving the quality of learning and developing learners' professional competencies.

Experiments using virtual learning environments (VLEs) were conducted to assess their impact on pupils' motivation and engagement, providing valuable insights into the effectiveness of these innovative methods. As part of the experiments, several diverse VLEs were created, incorporating interactive lessons, virtual laboratories, and simulation games. Students had the opportunity to immerse themselves in a virtual environment where they completed tasks, interacted with virtual objects, and collaborated with other participants. The experiments involved the preparation and configuration of VLEs, including content creation, the development of interactive elements, and the setup of feedback systems. The integration of VLEs into the educational process included embedding virtual environments into regular lessons, where students were assigned tasks to complete within the VLE. This approach allowed them to apply theoretical knowledge in practice. Data collection and analysis during the experiment involved both quantitative and qualitative methods, such as surveys, interviews, observations, and automated data collection systems. These data were used to assess students' behaviour, activity, motivation levels, and engagement. Based on the collected data, a detailed analysis of the effectiveness of the VLEs was conducted. The experiment was carried out following the Declaration of Helsinki (2013). The results showed that the use of virtual environments contributed to increased student motivation, active participation in the learning process, and the development of collaborative skills. Students demonstrated a higher level of interest in learning, achieved better results in task completion, and showed greater engagement. Based on the results obtained, recommendations were developed for the continued use and integration of VLEs into the educational process. These recommendations included specific strategies and approaches that could enhance the effectiveness and quality of the learning process through the use of virtual learning environments.

Results and Discussion

The war in Ukraine has served as a catalyst for re-evaluating many aspects of life, including education. The destruction of infrastructure, loss of lives, and mass displacement of people have had a detrimental effect on the availability of a qualified workforce in the country. Outdated teaching methods are increasingly inadequate to meet the dynamic demands of the modern labour market and the challenges of the contemporary world. This situation underscores an urgent need for innovative models based on the principles of personalisation, efficiency, practicality, and accessibility. According to Yu. Boychuk & A. Boyarska-Khomenko (2023), a comprehensive approach to modernising infrastructure and ensuring stable funding is essential to address these issues. However, contrary to this view, the authors of this study argue that the integration of artificial intelligence, neuropedagogy, and the competency-based approach offers a more flexible and effective solution for vocational education. The integration and synergy

of these methodologies enable the creation of personalised educational platforms, adaptive algorithms, and intelligent systems capable of dynamically responding to the evolving demands of the labour market. This ensures more effective and practical learning outcomes.

The authors of this research proposed four key models that impact the learning and assessment processes of learners. The first model involves personalised learning platforms with adaptive algorithms, learners' students to learn at their own pace and focus on individual needs. These platforms enhance the efficiency of knowledge acquisition and the overall quality of education. The second model introduces intelligent systems for analysing the emotional state of learners, allowing educators to adjust the educational process to align with the emotional needs of learners while considering the ethical implications of data collection. The third model incorporates virtual environments and gamified simulations, offering practical experience without real-world risks by creating realistic conditions for professional activities. However, their implementation requires significant financial investment. The fourth model includes robotic automated systems for assessment and reporting, simplifying the evaluation process and providing accurate records of learner achievements while reducing reliance on technology. The implementation of these models significantly influences the quality and accessibility of vocational education in Ukraine.

I. MODEL OF A PERSONALISED LEARNING PLATFORM WITH ADAPTIVE ALGORITHMS

The personalised learning platform model, featuring adaptive algorithms (Fig. 1), has been specifically designed to meet contemporary demands for vocational education and incorporates identified key factors. The modelling process for this platform involved several stages, ensuring optimal efficiency and utility for learners.

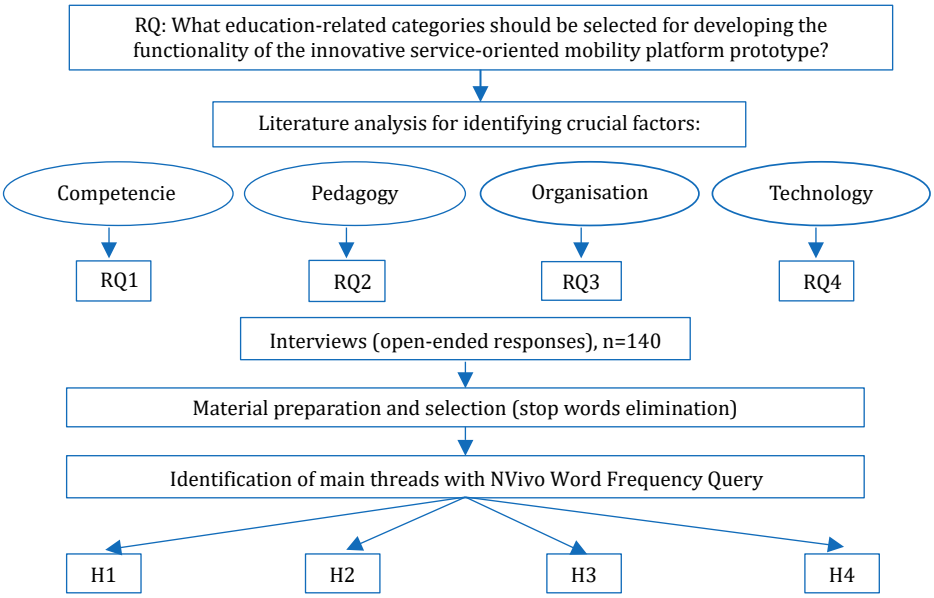

Figure 1. *Implementation of the NVivo Word Frequency Query Platform in personalised vocational learning*
Source: *created by the authors*

NVivo Word Frequency Query is a powerful tool for analysing unstructured data, including text documents, interviews, audio, and video recordings. The Word Frequency Query function in NVivo enables the analysis of textual data to determine the frequency of specific words or phrases within a dataset. The word frequency analysis counts the occurrences of particular words in selected text or texts. This approach aids in identifying central themes or keywords critical to specific research. Data visualisation can be presented as tables, charts, or word clouds. According to P. Mykytenko & O. Halytskyi (2021), word clouds are a popular visualisation technique, representing the most frequently used words in larger fonts, while less frequent words are displayed in smaller fonts. The effectiveness of word clouds may vary depending on the context and purpose of the visualisation. This highlights the potential for discussions on the optimal use of various visualisation methods tailored to different types of data and audiences.

When filtering and excluding words, queries are configured to remove common or irrelevant terms, known as "stop words", such as conjunctions and prepositions. This process ensures greater focus on significant terms. Alongside frequency analysis, NVivo also examines the context in which these words appear, providing insights into how key terms are utilised within texts. The application of the NVivo Word Frequency Query is beneficial

in social sciences, educational research, marketing, and other professional fields. It facilitates the identification of core themes, understanding of trends in textual data, and supports theoretical analysis. The modelling process consisted of several stages. The initial phase involved a detailed literature review, which identified the key factors to be considered in designing the platform model. The authors of this study concentrated on four primary categories: competencies (RQ1), pedagogy (RQ2), organisation (RQ3), and technology (RQ4).

This stage established the theoretical foundation and identified existing approaches and methods that could be integrated into the new model. The subsequent step involved conducting 140 interviews with experts and educators, who provided open-ended responses regarding the needs and requirements for the platform. These interviews offered an in-depth understanding of specific demands and preferences that needed to be considered in the platform's design. The responses gathered from the interviews were instrumental in understanding the practical aspects and needs in the field of vocational education, forming the basis for the following research phases. After data collection, rigorous preparation and selection of materials were undertaken, including the removal of stop words to ensure data quality for further analysis. This process enabled the refinement of material for the subsequent stages of development. The cleaned data ensured the accuracy and relevance of the analysis results, which is critical for building an effective platform. Identification of key information flows was conducted using the NVivo Word Frequency Query (Mitcheltree, 2021), which helped determine the most significant themes and categories for inclusion in the platform's functionality. The use of NVivo facilitated a systematic approach to text data analysis, highlighting key terms and themes most relevant to platform development. This phase guided the platform design towards the most crucial aspects of vocational learning, ensuring alignment with the needs and expectations of end users.

As a result of the conducted research, a prototype of an innovative service-oriented mobility platform was developed. This prototype effectively integrates artificial intelligence, neuropedagogy, and the competency-based approach into vocational education. It provides a personalised learning experience with adaptive algorithms, facilitating the development of essential skills and competencies for learners. Thus, NVivo Word Frequency Query is recommended as a powerful tool for analysing textual data, aiding educators in identifying key terms and themes relevant to further pedagogical research. This tool is particularly useful for examining unstructured data across various professional domains. Its use enables the systematic organisation and visualisation of data, which is crucial for developing effective educational programmes and approaches. Overall, NVivo Word Frequency Query proves to be an invaluable resource for educators working with large volumes of text data, allowing the identification of key terms and themes important to their research. It provides deep insights into the content and structure of textual data, supporting a more accurate and informed analysis of educational needs and trends. To evaluate the personalised learning platform model with adaptive algorithms, which offers a flexible and efficient approach to vocational learning while accounting for the individual characteristics of each learner, conducting a SWOT analysis was deemed appropriate (Table 1).

Table 1. *SWOT analysis of the personalised learning platform model with adaptive algorithms in the context of a competency-based approach to vocational education*

Strengths	Weaknesses
The platform tailors the educational process to the individual needs of each learner, considering their knowledge, skills, experience, and learning styles	High costs associated with the development and implementation of a personalised platform
Interactive teaching methods and personalised content make learning more engaging and motivating for learners	Developing adaptive algorithms and personalised content is complex and labour-intensive
Adaptive algorithms assist learners in better mastering educational material by focusing on their strengths and weaknesses	Effective platform operation requires large volumes of data on learners and their academic performance
The personalised platform enables learners to assimilate educational content more quickly, improving overall learning outcomes	Adaptive algorithms may be biased if the data they are based on is not representative
The platform supports learners to develop the essential competencies for successful professional performance	Learners may require additional support when using the personalised platform

Table 1. Continued

Opportunities	Threats
The personalised platform facilitates the integration of a competency-based approach in vocational education, focusing on developing competencies rather than merely acquiring knowledge	Rapid technological advancements may render personalised platforms obsolete
Customisation of education for diverse groups of learners with varying needs and goals	Risk of misuse of data for unethical purposes
The platform can support informal education and self-directed learning, helping learners develop competencies throughout their lives	Learners or educators may resist or lack the skills to use personalised platforms effectively
Data collection on learners' competencies can improve teaching and assessment processes	Learners and educators may not receive adequate support when working with the personalised platform
The personalised platform enhances learners' competencies for professional success, boosting their competitiveness in the labour market	Development and implementation of personalised platforms may face insufficient funding from governments, educational institutions, or private investors

Source: *created by the authors*

This analysis revealed that the model of a personalised learning platform with adaptive algorithms offers significant strengths and opportunities that should be leveraged to enhance the quality of vocational education. However, it also presents certain weaknesses and threats that require attention to maximise its effectiveness. Recommendations include: reducing development and implementation costs; improving data availability; providing adequate support for learners and educators; conducting further research; promoting collaboration among government bodies, educational institutions, the private sector, and civil society to support the development and implementation of personalised platforms.

The implementation of personalised platforms has a profound impact on vocational education, making it more individualised, effective, and aligned with the demands of the modern labour market. According to research by O. Bilier *et al*. (2023), innovative educational technologies, including neuropedagogy, play a critical role. The authors emphasise that such technologies significantly enhance the quality of education by adapting learning materials to the individual needs of learners. This approach fosters deeper knowledge acquisition and better preparation for the requirements of labour market. This study highlights that the effectiveness of innovative technologies in vocational education can vary depending on the context and the methods of implementation, raising questions about the optimal approach to modernising the educational process. It is essential to recognise and address potential challenges associated with this model to ensure it is applied ethically and responsibly. In addition to considering knowledge, skills, and learning styles, attention must also be paid to learners' emotional states, as these factors significantly influence motivation, engagement, and learning outcomes.

II. MODEL OF INTELLIGENT SYSTEMS FOR ANALYSING THE EMOTIONAL STATE OF LEARNERS IN VOCATIONAL EDUCATION

This model integrates the emotional state of learners into the vocational learning process. By employing emotion recognition technologies, the system identifies learners' emotional reactions to educational materials and adjusts the content to align with their needs. According to G. Dermott *et al.* (2023), affective computing is utilised to adapt the learning process in real-time. Their research supports the notion that artificial intelligence analyses emotional data collected from learners and modifies educational videos, interactive tasks, and other resources to suit the emotional state of each participant.

The model offers several advantages. Firstly, it enables the personalisation of vocational learning through the use of affective computing and emotional analysis, which fosters motivation and engagement. Secondly, effective knowledge acquisition is achieved through the use of video and a theoretical framework (Fig. 2), which helps structure and visualise the learning material. Thirdly, video content based on real-world professional scenarios provides learners with the opportunity to gain practical experience in a safe and controlled environment. Finally, by considering the emotional state of learners, the model creates a comfortable and motivating learning environment, which helps reduce stress and enhance learning outcomes.

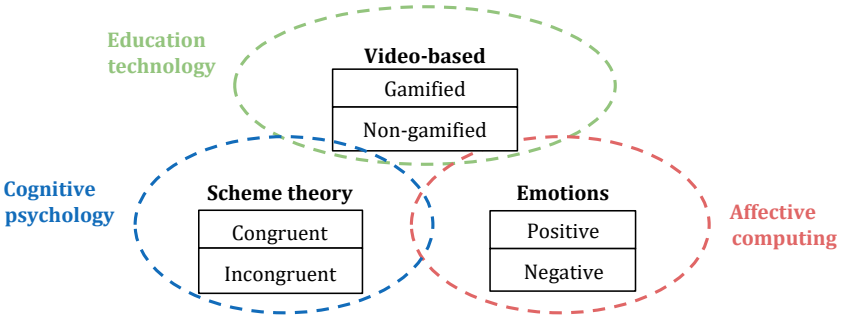

Figure 2. *Symbiosis of the utilised video, emotional analysis, and the theoretical framework*
Source: *created by the authors*

The model of intelligent systems for analysing the emotional state of vocational education learners introduces a range of innovative approaches to create a personalised and effective educational environment. It integrates video-based learning, scheme theory, emotion analysis (Emotions), and affective computing to establish a tailored and efficient learning process. Videobased learning employs educational video materials designed around calculated professional scenarios and simulations of real working conditions.

According to K. Zavalko (2022) and T. Nikulochkina *et al*. (2022), video provides both visual and auditory representations of the learning material, facilitating better retention of information and the development of practical skills. In this study, scheme theory, proposed for structuring learning content and organising knowledge, opens up new opportunities. It enables learners to easily navigate the material, understand the connections between general concepts, and effectively absorb new information. Thus, both approaches can play an important role in enhancing the learning process, depending on the context and characteristics of the educational programme, and they provide grounds for further discussion on the optimal use of various methods of visualisation and content structuring.

The model of intelligent systems for analysing the emotional state of learners opens up new possibilities in the field of personalised learning, considering both the cognitive and emotional aspects of the learning process. This model uses artificial intelligence to analyse the emotional state by employing various methods, such as the analysis of facial expressions, body language, tone of voice, and physiological data, to determine the learner's emotional condition. The use of this model involves providing feedback to learners on how their emotions affect their learning, as well as dynamically adapting the learning process to their emotional state. For example, in the case of anxiety, according to N. Ilyashenko & A. Rosokhata (2023), the system may offer additional resources or adjust the pace of learning, thereby supporting the learner's emotional well-being. This model enhances motivation and engagement in the learning process, improves material retention, and supports learners' emotional health. Adapting the learning process to the emotional state of the learners makes education more personalised and effective, helping them achieve their learning goals and become more competitive in the job market.

The competency-based approach permeates each of the models discussed, including the model of intelligent systems for analysing emotional stat, and ensures a synergistic effect from their interaction. An important aspect is the examination of the strengths and weaknesses of this model, as well as the opportunities and threats it may face during implementation, which is reflected in the SWOT analysis (Table 2).

Table 2. *SWOT analysis of the intelligent systems for analysing the emotional state of learners in vocational education within the context of the competency-based approach*

Strengths	Weaknesses
Intelligent systems analyse learners' emotions more objectively than humans, who may be prone to biases. This helps educators provide learners with more accurate and impartial feedback on their work	The need for large volumes of data and powerful computational resources to process emotional reactions, as well as substantial computational power for data analysis
Emotion analysis helps educators better understand how emotions affect learners' perception of the material, motivation, engagement, and overall learning outcomes	Emotion analysis systems can sometimes make errors, leading to incorrect conclusions about learners' emotional states. It is essential to use these systems ethically, respecting learners' privacy and rights
Based on emotion analysis, the learning process is personalised, offering individual tasks, support, and teaching methods that align with learners' emotional states and needs	Emotional reactions can vary depending on culture, context, and personal characteristics. Emotion analysis systems must be adapted to these differences to ensure accuracy and ethical use
Emotion analysis helps educators identify learners who need additional motivation and/or support, enhancing their engagement in the learning process	Developing, implementing, and maintaining emotion analysis systems can be costly, which may limit their availability for a wider range of educational institutions

Table 2. Continued

Opportunities	Threats
The increasing popularity of personalised learning and the use of artificial intelligence is driving demand for emotion analysis systems for learners	Some learners and educators may not be ready for their emotions to be analysed by computer systems
The rapid development of machine learning and artificial intelligence technologies is improving the accuracy, reliability, and ethical standards of emotion analysis systems	Misuse of data on the emotional state of learners for unethical purposes, potentially harming learners
Support from governments, educational institutions, and the private sector in terms of funding for the development, implementation, and research of emotion analysis systems	The lack of standards and regulations governing the development and implementation of such systems

Source: *created by the authors*

Table 2 illustrates how the model of intelligent systems for analysing the emotional state of learners integrates various aspects of a competency-based approach, thereby creating a strong foundation for building modern vocational education. This approach is particularly important in the context of overcoming the challenges of the war in Ukraine, as it contributes to the development of vocational education as a strategically important direction. It helps not only to improve the quality of education but also to provide emotional support to learners, which is a key factor in their success and resilience.

The model of intelligent systems for analysing the emotional state of learners offers a new approach to personalised learning that takes into account not only cognitive but also emotional aspects of learning. Using artificial intelligence, the system analyses facial expressions, body language, tone of voice, and physiological data to determine learners' emotional states. Based on the analysis of emotional states, the system provides learners with feedback on how their emotions affect their learning. The system dynamically adapts the educational process, taking into account the emotional state of learners. For example, if a participant feels anxious, the system may offer them additional resources or adjust the pace of learning. The emotional well-being of learners is supported, their motivation and engagement are increased, learning is individualised, and leads to better retention of the material (Melnyk & Petryk, 2022).

Thus, the model of intelligent systems for analysing the emotional state of learners is an innovative approach to personalised learning that helps learners learn better, achieve their goals, and become more competitive in the job market (Szőköl *et al*., 2023). It uses artificial intelligence to analyse learners' emotional states, helping them to better absorb material, be more motivated, and improve their emotional well-being. Moreover, as argued by T. Kramarenko *et al*. (2023), it is also important to create learning conditions for learners that promote their engagement, motivation, and practical application of knowledge.

The model of virtual environments and gamified simulations complements the previous two models by offering learners interactive and engaging virtual environments in the form of simulations of real-world professional scenarios, where learners can apply their knowledge and skills in practice. Gamified elements, such as the use of game mechanics like points, badges, and leaderboards, make learning more interesting and motivating. A personalised experience, tailored to the individual needs and emotional state of each learner, ensures an optimal learning experience.

III. THE MODEL OF VIRTUAL ENVIRONMENTS AND GAMIFIED SIMULATIONS

According to N. Folomieieva *et al*. (2024), the use of virtual environments and gamified simulations in Ukrainian vocational education represents a novel innovative approach. These technologies offer significant potential for improving the effectiveness and outcomes of learning. However, their successful implementation requires attention to technical, methodological, and organisational aspects, as well as consideration of potential challenges related to the availability of technical resources and the training of pedagogical staff.

Virtual spaces are created that simulate real-world professional environments such as laboratories, hospitals, factories, offices, and so on. Interactive simulations are developed that allow learners to apply their knowledge and skills in practice, make decisions, solve problems, and receive feedback. The system adapts to the individual needs and emotional state of each learner, ensuring an optimal learning experience (Fig. 3).

The schema illustrates a multi layered architecture of the process of creating gamified educational videos. The data used to create e-learning videos consists of video files recorded from webcams, video conferences, and digital (virtual) participants. The content layer contains e-learning video materials created using the data. Video materials can be either gamified or non-gamified, and can also have different levels of complexity. Another layer uses artificial intelligence to detect emotions and create a congruence model. Artificial intelligence is also used to adapt content to individual user needs. Educators and educational discipline developers create curricula and courses, as well as develop educational materials. Policymakers O. Sagan (2023) and R. Nacional (2024) apply rules and regulations that govern the use of the e-learning video material system. Overall, the e-learning video material system is a powerful tool that should be used to create a personalised and engaging learning experience.

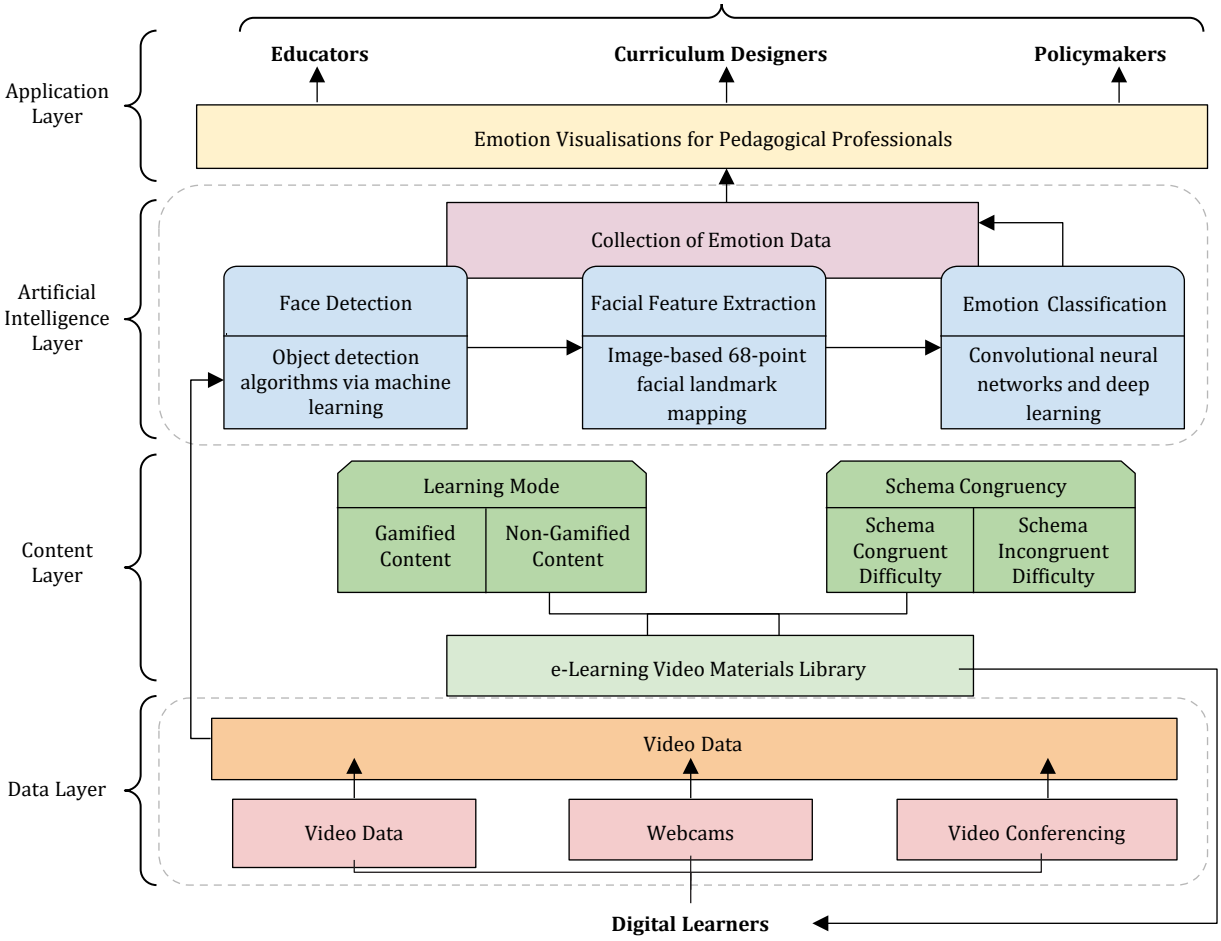

Figure 3. *Layers of the e-learning video materials system*
Source: *created by the authors*

The use of e-learning video material systems offers numerous opportunities for vocational education. According to O. Bazeliuk (2023), the system personalises content, facilitating individualised learning for each user. The presence of both gamified and non-gamified materials makes the learning process more engaging and varied. However, it is important to consider that collecting data on user progress and providing feedback may require significant computational resources, limiting the system's accessibility to a wide range of users. Thus, while the system has the potential to enhance the effectiveness of professional training, its use requires careful planning and consideration of various aspects related to ensuring the quality and accessibility of educational services (Table 3).

Table 3. *SWOT analysis of the virtual environments and gamified simulations model in the context of the competency-based approach to vocational education*

Strengths	Weaknesses
Virtual environments and gamified simulations make learning more engaging and immersive, leading to increased learner involvement and motivation	High cost of developing and implementing virtual environments and gamified simulations
Virtual environments and gamified simulations help learners develop problem-solving, critical thinking, and decision-making skills	Learners and educators often need technical skills to work with virtual environments and gamified simulations
Virtual environments and gamified simulations allow learners to experiment and make mistakes safely, helping them better understand the material	Virtual environments and gamified simulations must be carefully designed to be effective and align with learning objectives
Virtual environments and gamified simulations make learning more accessible to learners who cannot attend inperson classes	Technical issues may arise when working with virtual environments and gamified simulations, potentially disrupting the learning process
Virtual environments and gamified simulations help learners develop collaboration and teamwork skills	Virtual environments and gamified simulations need to be adapted to different learning styles to be effective for all learners

Table 3. Continued

Opportunities	Threats
Growing interest in using technology in education	Some learners and educators may not be ready to use virtual environments and gamified simulations
Development of virtual and augmented reality technologies makes virtual environments and gamified simulations more realistic and engaging	Misuse of virtual environments for malicious purposes, such as spreading disinformation and/or propaganda
Governments and educational institutions may allocate funding for the development and implementation of virtual environments and gamified simulations	Lack of standards and regulations for the development and use of virtual environments and gamified simulations, which may lead to compatibility and ethical issues

Source: *created by the authors*

The SWOT analysis has confirmed the hypothesis that this model contributes to a better understanding of knowledge and the development of practical skills through interactive and motivating learning methods. At the same time, the competency-based approach, which permeates this model, ensures that the learning process corresponds to the real needs of the labour market and prepares competitive specialists. The e-learning video material system has the potential to revolutionise professional training, as it uses artificial intelligence to adapt content to individual user needs; can be used to create both gamified and non-gamified learning materials; can be used to restore user progress and provide them with feedback; and can be used to create personalised learning plans.

Through interactivity, gamification, and visual appeal, vocational learning becomes more engaging and motivating for learners. The practical application of knowledge in virtual simulations contributes to a better understanding and retention of information. Learners have the opportunity to develop practical skills necessary for successful professional careers, such as decision-making, teamwork, and problem-solving. Virtual simulations allow learners to feel more confident and better prepared for real-world professional challenges. However, in addition to interactive learning, it is important to provide an objective and transparent assessment system that allows for the evaluation of learners' knowledge and skills and provides them with feedback on their own progress.

IV. MODEL OF ROBOTIC AUTOMATED ASSESSMENT AND REPORTING SYSTEMS IN VOCATIONAL EDUCATION

A model of robotic automated assessment and reporting systems in vocational education serves as a complement to previous models, offering objective and unbiased evaluation. The use of computer algorithms and automated systems minimises human error and ensures a more objective and impartial assessment of learners' knowledge and skills. Fast and efficient assessment automates the professional learning process, significantly reducing the time required to check assignments and provide feedback. Detailed analysis and reporting, i.e., the generation of detailed reports on learners' learning outcomes, are used to track their progress, identify strengths and weaknesses, and make informed decisions about further professional development.

Personalised feedback helps learners better understand their mistakes and improve the competencies required for professional development. This approach fosters a deeper understanding of the material, develops independent thinking, and increases motivation to learn. The symbiosis of all four models creates a comprehensive and flexible system of vocational education that combines a competency-based approach to interactive learning with objective assessment and personalised feedback. This allows for the integration of various teaching methods and technologies, ensuring the all-round development of learners and improving the quality of the educational process. This helps learners better acquire learning material, develop practical skills, critical thinking, and also receive an objective assessment of their knowledge and skills. As a result, they can achieve success in their professional careers, be better prepared for the challenges of the modern labour market, and gain a competitive advantage.

The study (Fig. 4) was conducted over a six-week period and involved 18 participants in the anthropomorphic robot group and 19 participants in the traditional education group. According to M. Mihai & D. Mapheto (2024), the anthropomorphic robot method used to facilitate interaction between participants and an anthropomorphic robot teaching them rules and tasks represents a significant step towards interactive learning. The robot employed various teaching methods, including visual cues, audio instructions, and tactile feedback, contributing to increased engagement and effectiveness of the learning process. However, research by S. Prasad Bhatt (2021) and Yu. Cui & H. Zhang (2021) indicate a need for further research into the optimal use of anthropomorphic robots in educational settings, especially considering the individual characteristics of students and pedagogical tasks. Thus, the introduction of anthropomorphic robots into the educational process opens up a field for discussion regarding their impact and effectiveness, requiring a competency-based approach and further research.

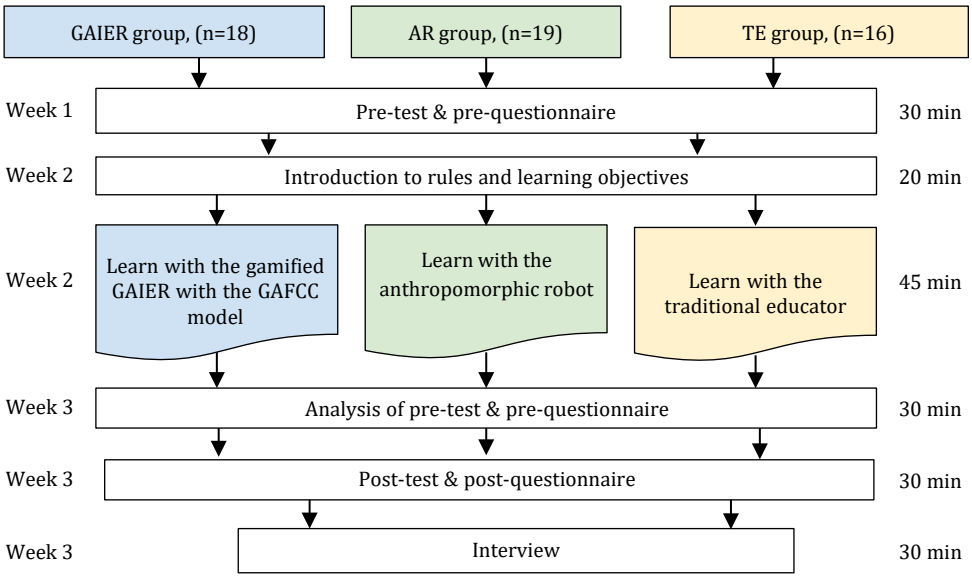

Figure 4. *Comparison of the effectiveness of anthropomorphic robots and traditional education*
Source: *created by the authors*

The traditional education method involved participants receiving instructions from a human educator. The educator used various teaching methods such as lectures, demonstrations, and practical exercises. The study evaluated the effectiveness of the two teaching methods using the following measures: pre-test and post-test, where participants completed tests before and after the study to assess their knowledge of the rules and tasks; interviews, where participants took part in interviews after the study to share their experiences of learning with an anthropomorphic robot or a traditional educator. The results of the study showed that the anthropomorphic robot method was more effective than the traditional education method. Participants in the anthropomorphic robot group performed better on the post-test and gave more positive feedback about their learning experience. The authors of this study suggest that the anthropomorphic robot method was more effective because it provided greater interactivity and engagement among participants (participants in the anthropomorphic robot group were more involved in the learning process and had the opportunity to actively interact with the robot). At the same time, O. Dushchenko (2021) and R.A.Z. El Islami *et al*. (2022) highlighted that the robot provided participants with more personalised and timely feedback, contributing to better material acquisition. In the context of the growing use of intelligent robots in the educational process, the presence of potential threats and advantages of this model necessitated a SWOT analysis (Table 4) of the robotic automated assessment and reporting model in vocational education.

Table 4. *SWOT analysis of the robotic automated assessment and reporting systems model in vocational education in the context of the competency-based approach*

Strengths	Weaknesses
Robotic assessment systems are objective and unbiased	Large volumes of data on learner performance are required for effective operation of robotic assessment systems, along with powerful computational resources for processing
Robotic assessment systems are personalised for each learner, which promotes a better understanding of the material	Robotic assessment systems can make errors, leading to inaccurate grading and unfair treatment of learners. Ethical use of these systems, and respecting learners' rights, are essential
Robotic assessment systems significantly reduce the time required for assessment, freeing up educators' time for other tasks	The need to adapt to various learning styles and assessment formats
Learners have 24/7 access to their grades and feedback, helping them better understand their progress	The development, implementation, and maintenance of robotic assessment systems are costly, limiting their availability to a wide range of educational institutions
Opportunities	**Threats**
Artificial intelligence is becoming an increasingly popular tool in education, leading to higher demand for robotic assessment systems	Some learners and educators may not be ready for their learning outcomes to be assessed by computer systems

Table 4. Continued

Opportunities	Threats
Rapid development of digital technologies will improve the accuracy, reliability, and ethics of robotic assessment systems	Data on learners' results could be misused, leading to negative consequences for learners
Support from governments, educational institutions, and the private sector in the form of funding for the development, implementation, and research of robotic assessment systems	The lack of unified standards for the development and use of robotic assessment systems could lead to compatibility and ethical issues
Integration with other systems, such as Learning Management Systems (LMS) and e-portfolio systems	Potential negative impact on the emotional well-being of learners

Source: *created by the authors*

According to the conducted SWOT analysis, this model has demonstrated significant potential in improving the quality of vocational education and has proven the sufficient effectiveness of anthropomorphic robots as tools for vocational learning. Anthropomorphic robots can be used to complement traditional teaching methods or to provide training in cases where traditional teaching methods are not viable. A common concept for all four models is their potential to improve vocational education through the integration of technologies that facilitate personalised learning, increase efficiency, and provide access to knowledge and assessments at any time. Each model demonstrates strengths in the form of objectivity of assessment and time saving but requires attention to challenges such as the need for large amounts of data and ethical considerations. For the further successful implementation of these models, it is important to develop standards and promote their compatibility with existing educational practices.

Conclusions

Innovative models of vocational education play a pivotal role in Ukraine's strategic development, particularly in the context of overcoming the challenges of military aggression. All four models: personalised learning platforms with adaptive algorithms, intelligent systems for analysing the emotional state of learners, virtual environments and gamified simulations, and robotic automated assessment and reporting systems – form a powerful synergistic symbiosis permeated by a competency-based approach. Each of these models independently increases the efficiency and personalisation of learning, and their combination creates an exceptionally strong complex educational process. This allows for consideration of both cognitive and emotional aspects of learning, adaptation of the material to the individual needs of learners, and ensuring constant support and feedback.

The competency-based approach, which is not a separate element but permeates each model, allows for the creation of a learning environment focused on developing the key competencies required for the modern labour market. Personalised learning platforms with adaptive algorithms use data on the individual needs and characteristics of each learner, allowing for the creation of individualised learning trajectories. This contributes to the development of both professional and general competencies, such as critical thinking, creativity, and the ability to work in a team. Intelligent systems for analysing the emotional state of learners not only help to adapt the learning process to the emotional needs of students but also support the development of emotional intelligence, which is an important element of the competency-based approach.

Virtual environments and gamified simulations create opportunities to acquire practical experience in conditions that closely resemble real-world professional situations. This allows learners to develop practical skills and competencies in a safe environment, contributing to better preparation for real-world challenges in the workplace. Gamified elements, such as game-based tasks and simulations, increase learner motivation and engagement, positively influencing the learning process and the development of professional competencies. Robotic automated assessment and reporting systems ensure objective and fair assessment of learners' knowledge and skills, which is essential in shaping a competency-based approach. Research has confirmed the great potential of integrating artificial intelligence, neuropedagogy, and a competency-based approach, which improve the quality of learning and develop professional skills. The implementation of such approaches is a strategic priority for the development of Ukraine's education systems, which meet the challenges of the modern labour market.

The strategic importance of such a comprehensive approach to vocational education is particularly relevant in the context of overcoming the challenges of military aggression in Ukraine. Innovative models, permeated by a competency-based approach, ensure not only a high level of professional training but also support the emotional well-being of learners, which is critically important in difficult circumstances. This integrated approach helps to create a resilient and competitive vocational education system capable of effectively responding to the challenges and needs of the modern labour market, contributing to the recovery and

development of Ukraine's economy. Future research includes the creation of digital interfaces for interactive immersive vocational education environments, which will allow for further increasing the quality of education and preparing learners for real-world professional challenges. Thus, the implementation of these models is not only an educational but also a strategically important step for Ukraine's future.

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Conflict of Interest

There is none.

References

[1] Bazeliuk, O. (2021). Main trends and challenges of digitization in higher education. *Pedagogical Discourse*, 31, 36-44. doi: 10.31475/ped.dys.2021.31.05.

[2] Bazeliuk, O. (2023). The role of digital culture in the professional activity of teachers in vocational education institutions. *Innovative Professional Education*, 2(9), 81-85. doi: 10.32835/2786-619X.2023.2.9.81-85.

[3] Bilier, O., Reshetniak, V., Vasko, O., Drokina, A., Klanichka, Yu., & Barda, S. (2023). Innovative learning technologies for future elementary school teachers in the context of neuropedagogy. *BRAIN. Broad Research in Artificial Intelligence and Neuroscience*, 14(4), 66-81. doi: 10.18662/brain/14.4/492.

[4] Bilonozhko, N. (2021). Some aspects of the ESP quality of teaching in the process of internationalization. *Perspectives and Innovations of Science*, 5(5), 28-35. doi: 10.52058/2786-4952-2021-5(5)-28-35.

[5] Boychuk, Yu., & Boyarska-Khomenko, A. (2023). Internationalization of activities of higher pedagogical education institutions in the conditions of martial law and post-war reconstruction. *Problems of Modern Transformations. Series: Pedagogy and Psychology*, 1, 17-22. doi: 10.54929/pmtp-2023-1-02-01.

[6] Cui, Yu., & Zhang, H. (2021). Educational neuroscience training for teachers' technological pedagogical content knowledge construction. *Frontiers in Psychology*, 12, article number 792723. doi: 10.3389/fpsyg.2021.792723.

[7] Declaration of Helsinki. (2013). Retrieved from https://www.wma.net/what-we-do/medical-ethics/declaration-of-helsinki/.

[8] Mc Dermott, G., Byrne, A., McLaughlin, R., O'Connor, N., & Griselain, S. (2023). Exploring the use of immersive technologies to enhance the student experience. *Ubiquity Proceedings*, 3(1), 283-288. doi: 10.5334/uproc.98.

[9] Dushchenko, O. (2021). Current state of digital transformation of education. *Physical and Mathematical Education*, 28(2), 40-45. doi: 10.31110/2413-1571-2021-028-2-007.

[10] El Islami, R.A.Z., Anantanukulwong, R., & Faikhamta, C. (2022). Trends of teacher professional development strategies: A systematic review. *Shanlax International Journal of Education*, 10(2), 1-8. doi: 10.34293/education.v10i2.4628.

[11] Elouafi, L., Lotfi, S., & Talbi, M. (2021). Progress report in neuroscience and education: Experiment of four neuropedagogical methods. *Education Sciences*, 11(8), article number 373. doi: 10.3390/educsci11080373.

[12] Fedko, S. (2023). Neuropsychology of learning as modern interdisciplinary field: Perspectives and limitation. *Scientific Perspectives*, 1(31), 556-566. doi: 10.52058/2708-7530-2023-1(31)-556-566.

[13] Folomieieva, N., Pelekh, V., Haidamashko, I., Sivak, N., & Koriakin, O. (2024). Gamification in the educational process of higher education institutions. *Amazonia Investiga*, 13(73), 331-343. doi: 10.34069/AI/2024.73.01.28.

[14] Grigorieva, N., Fedorova, S., & Honchar, N. (2021). Innovation of preschool education: Foreign practices and domestic experience of their implementation. *Perspectives and Innovations of Science*, 5(5), 36-47. doi: 10.52058/2786-4952.

[15] Ilyashenko, N., & Rosokhata, A. (2023). Trendwatching as the tool of definition of strategic directions of development. *Marketing and Management of Innovations*, 1, 29-35. doi: 10.21272/mmi.2011.1-02.

[16] Kramarenko, T., & Kochina, O.S. (2023). The use of immersive technologies in teaching mathematics to vocational students. *Journal of Physics: Conference Series*, 2611, article number 012006. doi: 10.1088/1742-6596/2611/1/012006.

[17] Luhova, T. (2021). Game-design-oriented approach to the development of educational disciplines in higher education institutions. *Information Technologies and Learning Tools*, 81(1), 235-254. doi: 10.33407/itlt.v81i1.3265.

[18] Lysiak, L. (2020). 21st century innovations: Librarians, trend-watching, and the warning signs of fads. *Pennsylvania Libraries: Research & Practice*, 8(2), 76-83. doi: 10.5195/palrap.2020.232.

[19] Soroko, N., & Lytvynova, S. (2022). The benefits of using immersive technologies at general school. In *ICTERI 2021 workshops. Communications in Computer and Information Science* (pp. 247-257). Cham: Springer. doi: 10.1007/978-3-031-14841-5_16.

[20] Melnyk, O., & Petryk, O. (2022). Current approaches to organizing the educational process in primary school: A neuroscientific approach. *Brain Broad Research in Artificial Intelligence and Neuroscience*, 13(1), 1-21. doi: 10.18662/brain/13.1Sup1/299.
[21] Mihai, M.A, & Mapheto, D. (2024). Teachers' and learners' acceptance of the use of robotics in the intermediate phase. In C. Bosch, L. Goosen & J. Chetty (Eds.), *Navigating computer science education in the 21st century* (pp. 206-240). Hershey: IGI Global Scientific Publishing. doi: 10.4018/979-8-3693-1066-3.ch011.
[22] Mitcheltree, C.M. (2021). Enhancing innovation speed through trust: A case study on reframing employee defensive routines. *Journal of Innovation and Entrepreneurship*, 10, article number 4. doi: 10.1186/s13731-020-00143-3.
[23] Mykhailets, V. (2023). Neuropedagogy as a perspective direction of vocal educational work. *Problems of Interaction Between Arts Pedagogy and the Theory and Practice of Education*, 68, 88-106. doi: 10.34064/khnum1-68.05.
[24] Mykytenko, P., & Halytskyi, O. (2021). The use of modern cloud technologies in the educational process of higher education. *Educational Discourse: Collection of Scientific Papers*, 33(5), 7-17. doi: 10.33930/ed.2019.5007.33(5)-1.
[25] Nacional, R. (2024). Gamifying education: Enhancing student engagement and motivation. *Puissant*, 5(5), 1511-1524.
[26] Nikulochkina, O., Teslenko, T., Kokhanko, O., Sevastiuk, M., Yankovska, I., & Teletska, L. (2022). Neuro-pedagogical aspects of forming the professional competence of elementary school teachers and their interaction with students. *Revista Românească pentru Educaţie Multidimensională*, 14(4), 128-154. doi: 10.18662/rrem/14.4Sup1/663.
[27] Petrovych, O., Vinnichuk, A., Poida, O., Tkachenko, V., Vakaliuk, T., & Kuzminska, O. (2022). The didactic potential of cloud technologies in professional training of future teachers of Ukrainian language and literature. *CTE Workshop Proceedings*, 9, 259-277. doi: 10.55056/cte.119.
[28] Piddubna, O., Maksymchuk, A., Lytvychenko, D., Revutska, O., Moskalenko, M., & Sopina, O. (2023). Implementing neuropedagogical innovation in schools: From theory to practice. *BRAIN. Broad Research in Artificial Intelligence and Neuroscience*, 14(2), 37-58. doi: 10.18662/brain/14.2/443.
[29] Prasad Bhatt, S. (2021). Self-directed professional development: EFL teachers' understanding. *International Journal of Language and Literary Studies*, 3(4), 196-208. doi: 10.36892/ijlls.v3i4.737.
[30] Rakhmanina, A., Pinchuk, I., Vyshnyk, O., Tryfonova, O., Koycheva, T., Sydorko, V., & Illienko, O. (2022). The usage of robotics as an element of STEM education in the educational process. *Modern Education*, 7, 108-115. doi: 10.22937/IJCSNS.2022.22.5.90.
[31] Ramirez-Montoya, M.S., Andrade-Vargas, L., Rivera-Rogel, D., & Portuguez-Castro, M. (2021). Trends for the future of education programs for professional development. *Modern Education*, 13(13), article number 7244. doi: 10.3390/su13137244.
[32] Sagan, O. (2023). Gamification as a modern educational trend. *Collection of Research Papers "Pedagogical Sciences"*, 100, 12-18. doi: 10.32999/ksu2413-1865/2022-100-2.
[33] Semigina, T., & Rashkevych, Yu. (2023). Problem issues and models of professional qualifications assignment by higher education institutions. *International Scientific Journal of Universities and Leadership*, 15, 5-16. doi: 10.31874/2520-6702-2023-15-5-16.
[34] Sharma, L., & Srivastava, M. (2019). Teachers' motivation to adopt technology in higher education. *Journal of Applied Research in Higher Education*, 12(4), 101-112. doi: 10.1108/JARHE-07-2018-0156.
[35] Szőköl, I., Pšenáková, I., & Kováč, O. (2023). The influence of innovative teaching methods on student motivation. *Modern Education*, 1, 196-203. doi: 10.53349/resource.2023.is1.a1203.
[36] Yildiz, İ., Topçu, E., & Kaymakci, S. (2021). The effect of gamification on motivation in the education of pre-service social studies teachers. *Thinking Skills and Creativity*, 42, article number 100907. doi: 10.1016/j.tsc.2021.100907.
[37] Zavalko, K. (2022). Neuropedagogy: Theory and methodology of Orff approach in music education. *Innovative Pedagogy*, 1(51), 80-85. doi: 10.32782/2663-6085/2022/51.1.15.
[38] Zhoga, R. (2024). *Designing a personal educational environment for the professional training of music teachers*. (Doctoral dissertation, Ukrainian Engineering Pedagogics Academy, Kharkiv, Ukraine). doi: 10.5281/zenodo.10823195.

Інноваційні моделі професійної освіти: симбіоз штучного інтелекту, нейропедагогіки та компетентнісного підходу

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■ **Анотація.** Сучасний світ диктує нові правила освіти, вимагаючи інноваційних підходів до підготовки фахівців. Інтеграція штучного інтелекту, нейропедагогіки та компетентнісного підходу стає ключем до створення ефективних моделей професійної освіти. Метою дослідження були розроблення й апробація інноваційних моделей, які поєднують можливості штучного інтелекту (зокрема смарт-робототехніки) з нейропедагогічними компетентнісними підходами, для підвищення результативності професійної освіти. Методологія дослідження базувалася на аналізуванні сучасної літератури та практик, розробці експериментальних моделей інтеграції штучного інтелекту до навчального процесу, а також на проведенні емпіричних досліджень у закладах освіти. У дослідженні використано методи аналізу, синтезу, моделювання, спостереження й експерименту. У якості інноваційних моделей запропоновано персоналізовані навчальні платформи з адаптивними алгоритмами, інтелектуальні системи аналізування емоційного стану здобувачів освіти, віртуальні середовища та гейміфіковані симуляції, а також роботизовано-автоматизовані системи оцінювання та звітності в професійній освіті. Інтеграція штучного інтелекту до нейропедагогічних процесів сприяє персоналізації навчання, підвищенню мотивації здобувачів освіти та розвитку їх критичного мислення. Використання штучного інтелекту дозволяє створити адаптивні освітні платформи, які враховують індивідуальні особливості та потреби здобувачів освіти. Впровадження штучного інтелекту сприяє автоматизації рутинних завдань викладачів, що дозволяє їм зосередитися на креативних аспектах освітнього процесу. Висновки дослідження підкреслюють значущість інтеграції штучного інтелекту до професійної освіти як засобу підвищення її конкурентоспроможності. З огляду на динамічний розвиток технологій очікується, що в майбутньому будуть досліджені як імерсійні нейроінтерфейси для створення захоплюючих інтерактивних навчальних середовищ, так і етичні аспекти використання штучного інтелекту в освіті з урахуванням критичного мислення. Результати дослідження мають практичне значення для розроблення нових освітніх технологій і підходів, що відповідають сучасним вимогам ринку праці та потребам прогресивної молоді

■ **Ключові слова:** персоналізація навчання; адаптивні алгоритми; індивідуальні освітні траєкторії; віртуальні середовища; роботизовано-автоматизоване оцінювання; критичне мислення, професійна підготовка