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Building the digital competence of future vocational education specialists: a conceptual model and conditions for its implementation

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Abstract

Introduction and purpose. The digital transformation of the labour market requires digital competence from future vocational education and training (VET) specialists, whereas the pedagogical practice of preparing such specialists mostly relies on separate technological solutions without an integral didactic instrumentarium that would combine them into a system. The purpose of the article is to substantiate an original structural-functional model of building the digital competence of future VET specialists, to define the principles of its construction, the pedagogical conditions of its implementation, and the criteria for diagnosing the outcome.

Brief description of the main findings. On the basis of an analysis of 24 sources, a three-level structure of the digital competence of a VET specialist is clarified - transversal, professional-pedagogical, and occupation-specific levels – and six principles of model construction are formulated: didactic priority, functional correspondence, cyclical feedback,

differentiation by occupational specificity, risk preventiveness, and contextual adaptability. A structural-functional model is proposed with five interrelated components – target, content, technological, organisational-methodological, and diagnostic; six pedagogical conditions for its implementation in Ukrainian VET institutions and four criteria of digital-competence formation with level-based indicators are defined.

Summary. The proposed model shifts the emphasis from a list of separate technologies to the didactic mechanism of their integration, in which the digital-didactic competence of the teacher is the system-forming variable. The model is conceptual in status and requires further empirical validation against indicators of graduates' professional performance.

Keywords: vocational education; digital competence; structural-functional model; digital technologies; pedagogical conditions; criteria of development level

Introduction and problem statement

The digital transformation of the economy has placed before the system of vocational education and training a requirement that only a decade ago held secondary status: a graduate must be ready to work in a digitally mediated production process irrespective of how traditional their future occupation may appear. Digital education plans at the European level fix digital competence as a constitutive part of qualification rather than as an optional addition to it [1]. At the same time, transferring this requirement into the pedagogical practice of preparing VET specialists runs into a contradiction: technological solutions – from generative artificial intelligence to virtual-reality simulators – are being introduced quickly and fragmentarily, while the didactic mechanism that would connect them into an integral system of preparation remains undeveloped.

Available framework documents describe the transversal digital competence of the citizen across five areas [2], but cover neither the professional-pedagogical competence of the VET teacher nor the occupation-specific digital competence formed within a given profession. A prior analysis of the challenges and opportunities of introducing digital technologies into vocational education [3] and of the role of these technologies in the educational process of preparing future specialists [4] established that, where a systemic didactic construct is lacking, the introduction of technology produces an unstable and poorly transferred outcome.

This contradiction is intensified under conditions specific to Ukraine: VET institutions are simultaneously integrating into the European educational space and operating under wartime constraints, in which digital technologies are not an instrument of modernisation but a condition of the continuity of the educational process. Designing a model that accounts for both dimensions – the European framework of digital competence and the specific conditions of the wartime and post-war period – is a pressing practical task.

The purpose of the article is to substantiate an original structural-functional model of building the digital competence of future VET specialists, to define the principles of its construction, the pedagogical conditions of its implementation in VET institutions of Ukraine, and the criteria for diagnosing the formation of digital competence.

The purpose is specified in four tasks:

1. to clarify the conceptual apparatus of the study and the three-level structure of the digital competence of the future VET specialist;
2. to formulate the principles of constructing a model for building digital competence;
3. to develop and substantiate a structural-functional model and to define the pedagogical conditions of its implementation;
4. to propose criteria, indicators, and levels of digital-competence formation as a diagnostic instrument.

Conceptual apparatus of the study

The study distinguishes the concepts of digitisation, digitalisation, and digital transformation: digitisation is the conversion of analogue resources into digital form; digitalisation is the use of digital technologies to perform existing pedagogical processes more efficiently; digital transformation is a change in the processes themselves and in the distribution of professional roles. The practice of preparing VET specialists is mostly at the stage of digitalisation, and it is precisely the lack of transition to transformation that explains the instability of the educational effects recorded in the empirical literature [4].

Following a three-level logic that emerges from juxtaposing the transversal digital competence framework [2] with research on professional preparation, the model distinguishes three levels of digital competence of a VET specialist. The first is the transversal level: information literacy, communication, content creation, safety, and problem solving [2]. The second is the professional-pedagogical level: the teacher's ability to design digitally mediated learning, to select a technology according to its didactic function, and to evaluate the outcome. The third is the occupation-specific level: the ability to apply digital tools within a given profession (a digital twin of equipment, electronic documentation, telemetry). It is

precisely the second and third levels that are not covered by transversal frameworks and that constitute the conceptual gap which the proposed model is intended to fill [3, 4].

On this basis, the digital competence of the future VET specialist is defined as an integrative personal quality that combines a motivational-value attitude toward the use of digital technologies in professional activity, knowledge of their didactic and occupational functions, the ability to select and apply a technology in accordance with a learning or production task, and the capacity for reflexive evaluation of the outcome. This definition serves as the starting point for constructing the model in the following section.

Principles of constructing the model for building digital competence

The construction of the model rests on six principles that generalise the contradictions recorded in the empirical literature and translate them into normative requirements for designing the educational process. The principles and the mechanisms of their implementation in the model are systematised in Table 1.

Table 1. Principles of constructing the model for building the digital competence of future vocational education specialists

Principle	Essence	Mechanism of implementation in the model
Didactic priority of technology	Technology is subordinated to the didactic goal rather than the reverse; independent command of a tool is not itself a learning objective	The technological component of the model is activated only through a predetermined didactic form (the organisational-methodological component), not as a self-standing element of preparation
Functional correspondence	The choice of technology is determined by its didactic function (generation, personalisation, procedural rehearsal, certification of outcomes) rather than by novelty	The content and technological components are linked by a taxonomy of technologies organised by didactic function, which precludes an arbitrary choice of tools
Cyclical feedback	The results of diagnosis are returned to the target and content components and correct further instructional design	The diagnostic component is closed into a feedback loop with the target component of the model
Differentiation by occupational specificity	Content and technologies are selected with regard to the requirements of a specific occupation, not only to generic digital skills	The content component provides for occupation-specific digital content alongside transversal content

Principle	Essence	Mechanism of implementation in the model
Risk preventiveness	Risks to academic integrity, cybersecurity, and cognitive overload are accounted for at the design stage rather than remedied post factum	The content component includes a module on ethics and integrity; the diagnostic component includes monitoring of cognitive load
Contextual adaptability	The model retains functionality under conditions of infrastructural disruption and wartime constraints	The organisational-methodological component provides for offline-resilient and asynchronous formats as an equal alternative to synchronous ones

Structural-functional model of building the digital competence of future vocational education specialists

On the basis of the stated principles, a structural-functional model has been developed comprising five interrelated components – target, content, technological, organisational-methodological, and diagnostic (Figure 1). Unlike a mere inventory of technological solutions, the model defines the place of each technology in the didactic process and the mechanism through which the achieved outcome affects the subsequent design of instruction.

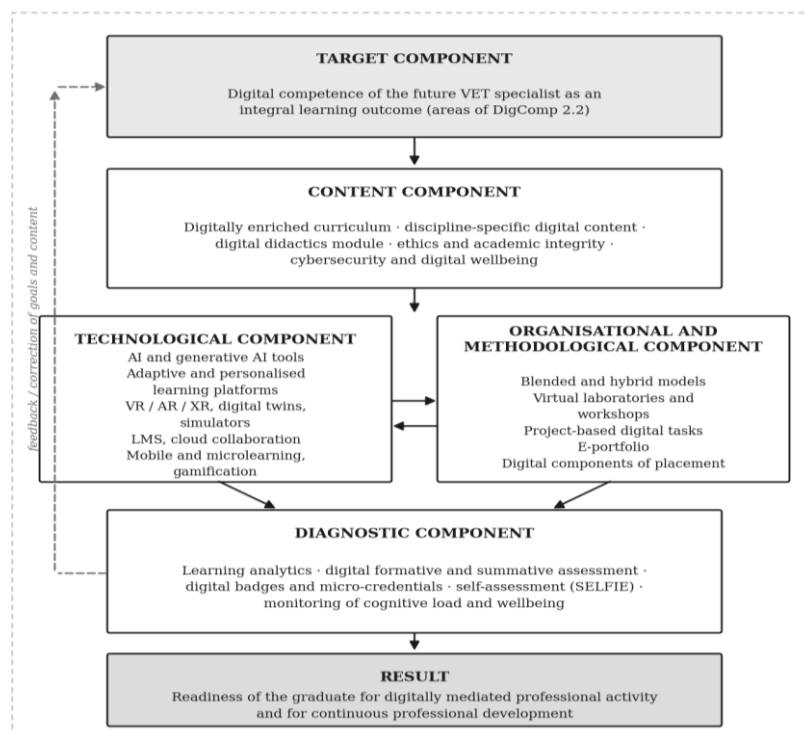


Figure 1. Structural-functional model of building the digital competence of future vocational education specialists

Note: the model is conceptual in status and has not undergone empirical validation within this article.

The target component defines digital competence as an integral learning outcome correlated with the three-level structure described above: the transversal level relies on the reference vocabulary of the citizen digital competence framework [2], while the professional-pedagogical and occupation-specific levels are formulated in view of the lack of corresponding transversal instruments [4].

The content component embeds digital didactics, ethics and academic integrity, cybersecurity, and digital wellbeing into the educational programme rather than adding them as separate optional courses. The need for such integration, rather than addition, is confirmed by data on overreliance on generative tools and superficial learning documented in studies of the use of artificial intelligence in programming education [5] and in vocational education generally [6].

The technological component brings together four groups of instruments, each performing a distinct didactic function. Generative artificial intelligence is used for generating and adapting instructional materials and for formative feedback; its rapid normalisation in educational practice is confirmed by systematic reviews [7], and its role in shaping professional judgement – by studies of how this tool is perceived by learners and teachers in vocational education [8] and even in narrowly specialised fields of preparation such as dental education [9]. Adaptive platforms and learning analytics personalise the educational trajectory and enable early identification of difficulties, as confirmed by a meta-analysis of AI-supported skill assessment in higher vocational education [10]. Immersive technologies – virtual, augmented, and mixed reality – provide safe, repeated rehearsal of procedural and safety-critical operations: a meta-analysis of mixed reality in vocational education [11], a study of practical skills in science and engineering education [12], a comparative study in practical vocational training [13], a synthesis of research on virtual reality in workplace training [14], and a review of applications for building soft skills [15] consistently confirm a positive, if heterogeneous, effect. Digital credentialing – badges, micro-credentials, e-portfolios – documents and makes learning outcomes portable, changing the unit of curricular design from an informal addition into a tradable element of qualification.

The organisational-methodological component realises these technologies through blended and hybrid learning, virtual laboratories and workshops, project-based digital tasks, and e-portfolios. An important empirical caveat for this component is the established distinction between learning with digital tools and learning through them: transferring

independent control of the tool to learners does not by itself improve the perceived usefulness of the tool [16], and a scoping review of teacher preparation for a practice-intensive field records a scarcity of designs that measure the effect on graduates' professional performance rather than merely on their perception [17].

The diagnostic component closes the loop of the model through learning analytics, digital assessment, micro-credentials, and institutional self-assessment, returning information to the target and content components. Data on teachers' self-assessed readiness and the barriers to integrating digital technology [18], and on the association between the use of information technology and research activity and professional development [19], confirm that diagnosis must evaluate not only the learner but also the teaching staff.

Pedagogical conditions for implementing the model in VET institutions of Ukraine

The effectiveness of the model depends not only on its internal logic but also on the conditions under which it is implemented. For Ukrainian vocational education, these conditions are shaped by the superimposition of two processes – European integration and functioning under wartime constraints. An analysis of the digital transformation of relocated higher education institutions shows that information technology has ensured the continuity of the educational process while simultaneously exposing the fragility of this arrangement [20], and national practice regards digital educational innovation as an instrument for building a reliable and competitive educational environment [21] and for the post-war reconstruction of the sector [22]. Six pedagogical conditions for implementing the model are systematised in Table 2.

The listed conditions are not equal in manageability: the first largely lies beyond the control of an individual institution, whereas the second, fifth, and sixth conditions are a direct object of managerial decision at the institutional level. This determines the sequencing of the model's implementation: investment in teacher competence and in the redesign of assessment should be undertaken before investment in equipment, since the former retain value under infrastructural disruption while the latter do not. These internal and external factors of the model's implementation are summarised in Figure 2.

Table 2. Pedagogical conditions for implementing the model of building digital competence of future vocational education specialists

Condition of implementation	Mechanism of provision	Expected effect
Institutional resilience of digital infrastructure under wartime constraints	Designing the educational process for low-bandwidth conditions; asynchronous duplication of synchronous content; autonomous power supply [20]	Continuity of the educational process irrespective of the stability of connectivity and power supply
Systemic preparation of teachers in digital didactics within initial teacher education	Embedding a digital-didactics module in the programmes preparing VET teachers, rather than only in continuing-education courses [18, 19]	Formation of the professional-pedagogical level of digital competence as a standard rather than an optional outcome
Use of international experience in the digitalisation of vocational education	Borrowing institutional mechanisms - an obligation of implementation monitoring, a cycle of core-curriculum review, short certified units of learning [23]	Accelerated and systemic, rather than fragmentary, implementation of technology at the institutional level
Integration of digital and practical training by occupational specificity	Combining work on simulators and in digital laboratories with practice on real equipment; accounting for equipment cost in planning [13, 14]	Transfer of formed skills into real professional activity
Prevention of academic-integrity risks	Redesigning assessment in favour of process evidence, oral defence, and workplace demonstration [5, 6]	Preservation of assessment validity under conditions of access to generative tools
Monitoring of cognitive load and learner wellbeing	Limiting the duration of immersive sessions; regular monitoring of the psychological state of learners studying under prolonged stress [24]	Prevention of a decline in learning effectiveness and of deterioration in wellbeing

Source: compiled by the authors on the basis of sources [5, 6, 13, 14, 18, 19, 20, 23, 24].

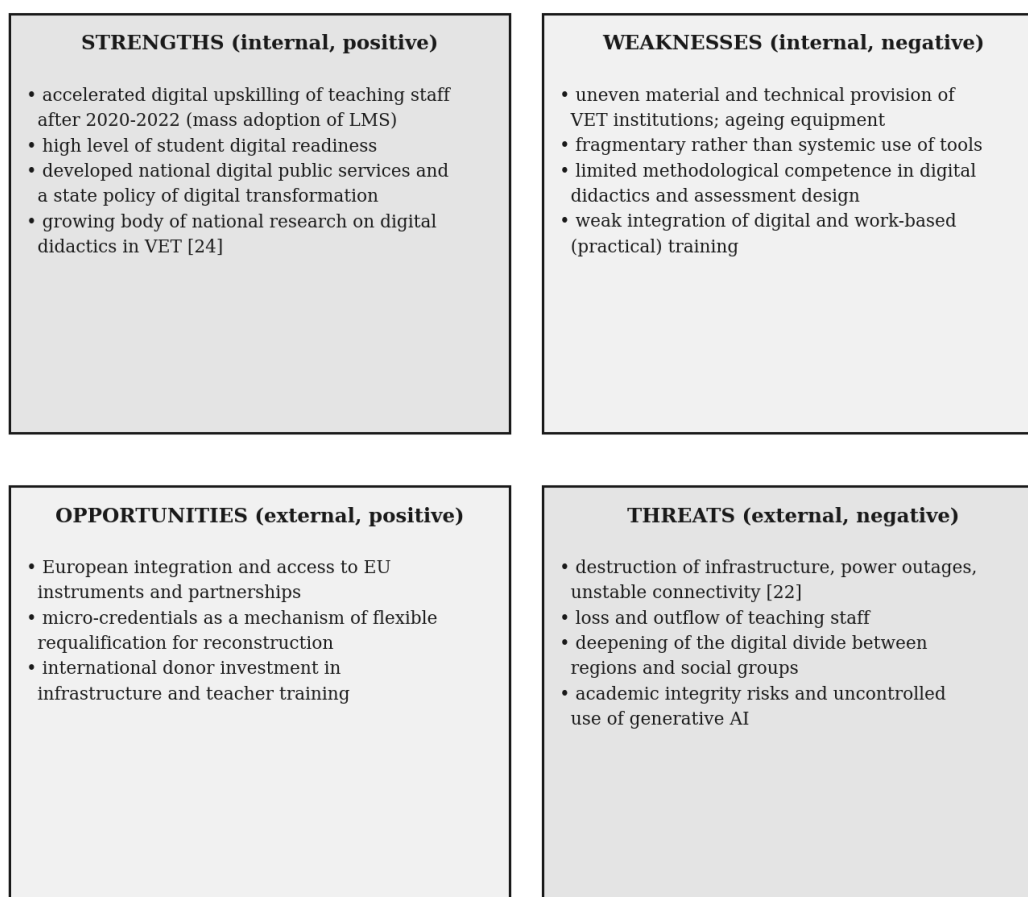


Figure 2. Matrix of internal and external factors in implementing the model in VET institutions of Ukraine

Source: compiled by the authors on the basis of sources [21, 22, 20]. *Note:* the matrix is an analytical generalisation and does not report survey data.

Criteria, indicators, and levels of digital-competence formation

For diagnosing the outcome produced by the model, four criteria for the formation of digital competence of the future VET specialist are proposed, each disclosed through indicators and three levels – low, medium, and high (Table 3). The criteria correspond to the components of the model: the motivational-value and cognitive criteria relate to the target and content components, the operational-technological criterion – to the technological and organisational-methodological components, and the reflexive-evaluative criterion - to the diagnostic component.

Table 3. Criteria, indicators, and levels of digital-competence formation of future vocational education specialists

Criterion	Indicators	High level (brief)
Motivational-value	Awareness of the significance of digital competence for professional activity; readiness for independent mastery of new tools; an attitude toward technology as a means rather than an end in itself	Stable intrinsic motivation to master digital tools, linked to occupational rather than merely academic tasks
Cognitive	Knowledge of the didactic functions of the main groups of digital technologies [7, 11]; understanding of the limits of a technology's applicability and of the risks of its use [5]	Free orientation in the taxonomy of technologies by didactic function; ability to justify the choice of instrument
Operational-technological	Ability to apply digital tools to solve occupational and learning tasks [12, 13]; ability to document digital learning outcomes (portfolio, micro-credentials)	Independent and correct application of technologies in line with occupational specificity, without excessive dependence on the tool
Reflexive-evaluative	Ability to assess the quality of one's own digital solution; ability to critically evaluate output generated by artificial intelligence [6, 10]	Systematic reflection on one's own progress and adjustment of the learning strategy on the basis of diagnostic data

Source: compiled by the authors on the basis of sources [5, 6, 7, 10, 11, 12, 13].

Discussion

The proposed model differs from existing approaches in the literature in two respects. First, it does not attempt to catalogue every available digital technology but instead defines the didactic function through which any technology – existing or future – enters the preparation process; this approach is consistent with the finding that independent command of a tool is not by itself an indicator of formed competence [16]. Second, it explicitly includes the reflexive-evaluative criterion and the diagnostic component as a feedback loop rather than as a final stage of preparation, which directly responds to empirical evidence of learners' overreliance on generative tools [5, 6] and of the decline in learning effectiveness from prolonged, unmonitored use of immersive technologies [24].

The model is unevenly aligned with the available meta-analytic evidence base: evidence on the effects of immersive technologies [11, 12, 13, 14, 15] and of AI-supported assessment [10] is comparatively strong for narrowly defined procedural outcomes, but none of these studies measures integrative professional judgement – an outcome that the model

assigns to the responsibility of the teaching staff rather than to the technology itself. This limitation is inherent not in the proposed model but in the state of the empirical evidence base generally, and it should be taken into account in the further validation of the model.

The model has three main limitations. First, it is a conceptual development that has not undergone empirical testing on a sample of learners or VET institutions; each of its components is substantiated by literature data rather than by the authors' own experiment. Second, the proposed criteria and indicators of digital-competence formation require operationalisation in the form of a concrete diagnostic instrumentarium (questionnaires, scales, tasks) before practical application. Third, the pedagogical conditions for implementing the model have been formulated on the basis of the Ukrainian context and require adaptation for transfer to other national systems of vocational education.

The practical value of the model lies in providing the institution with a decision-making instrument: before introducing a new technology, it is advisable to determine which component of the model it corresponds to, which didactic function it performs, and how the outcome of its application will feed back into the feedback loop. Further research should be directed at the empirical validation of the model against indicators of graduates' professional performance, the development of diagnostic instrumentarium for the proposed criteria, and the study of the long-term transfer of skills formed in a digitally intensive educational environment to the real workplace.

Conclusions

1. The digital competence of a future vocational education specialist has a three-level structure – comprehensive, professional-pedagogical, and discipline-specific – of which the latter two are not covered by existing cross-cutting framework documents [2] and constitute a conceptual gap that the proposed model aims to fill.

2. The construction of the model is substantiated by six principles – didactic priority, functional correspondence, cyclical feedback, differentiation by occupational specificity, risk preventiveness, and contextual adaptability - which translate the contradictions recorded in the empirical literature into normative requirements for designing the educational process.

3. The developed structural-functional model unites five components – target, content, technological, organisational-methodological, and diagnostic - linked by a feedback loop; the technological component systematises four groups of instruments (generative artificial intelligence, adaptive platforms, immersive technologies, digital credentialing) by their didactic function rather than by technical class.

4. Six pedagogical conditions for implementing the model in VET institutions of Ukraine have been defined, which are unequal in manageability: investment in teacher competence and in the redesign of assessment should be undertaken before investment in equipment, since these retain value under infrastructural disruption.

5. Four criteria for the formation of digital competence are proposed – motivational-value, cognitive, operational-technological, and reflexive-evaluative – each disclosed through indicators and three levels of formation, giving the institution an operational diagnostic instrument.

6. The model shifts the emphasis from a list of separate technologies to the didactic mechanism of their integration, in which the digital-didactic competence of the teacher is the system-forming variable; this is directly consistent with empirical evidence that independent command of a tool does not by itself improve the outcome [5, 16].

7. The model is conceptual in status and requires further empirical validation against indicators of graduates' professional performance, the development of diagnostic instrumentarium for the proposed criteria, and adaptation of the pedagogical conditions for transfer to other national contexts.

Disclosure

Author Contributions. Conceptualization, M.M. and I.H.; methodology, M.M.; formal analysis, M.M.; investigation, M.M.; writing-original draft preparation, M.M.; writing-review and editing, I.H.; visualization, M.M.; supervision, I.H. Both authors have read and agreed to the published version of the manuscript.

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References

1. European Commission. Digital Education Action Plan 2021-2027: resetting education and training for the digital age. Communication COM(2020) 624 final. Brussels: European Commission; 2020. Available from: <https://education.ec.europa.eu> (Accessed: [DD.MM.2026]).

2. Vuorikari R, Kluzer S, Punie Y. DigComp 2.2: The Digital Competence Framework for Citizens. With new examples of knowledge, skills and attitudes. Luxembourg: Publications Office of the European Union; 2022. <https://doi.org/10.2760/115376>
3. Mindrul M. Challenges and opportunities of implementing digital technologies in vocational education. In: Models of interdisciplinary and intersectoral educational and educational-scientific programmes under martial law: challenges and implementation options: Proceedings of the IV International Conference; 2024; Odesa, Ukraine. p. 44-46. Ukrainian.
4. Mindrul M. The role of digital technologies in the educational process of training future vocational education specialists. *Naukovi Zapysky*. 2025; 2(164):78-84. <https://doi.org/10.31392/NZ-udu-164-2.2025.09> Ukrainian.
5. Elnaffar S, Rashidi F, Abualkishik AZ. Teaching with AI: a systematic review of chatbots, generative tools, and tutoring systems in programming education. *International Journal of Learning, Teaching and Educational Research*. 2026; 25(1):1-28. <https://doi.org/10.26803/ijlter.25.1.1>
6. Nakar S, Park E, Misselke L, Khan SI. Leveraging AI in vocational education: a systematic review of theory, barriers and opportunities. *Marketing Intelligence & Planning*. 2026. <https://doi.org/10.1108/MIP-03-2025-0244>
7. Wu F, Dang Y, Li M. A systematic review of responses, attitudes, and utilization behaviors on generative AI for teaching and learning in higher education. *Behavioral Sciences*. 2025; 15(4):467. <https://doi.org/10.3390/bs15040467>
8. Chan S, editor. *Artificial Intelligence in Vocational Education and Training: Understanding Learner and Teacher Perspectives on the Integration of Generative AI through Participatory Action Research*. Singapore: Springer; 2025. 200 p. ISBN 978-981-96-6000-1. <https://doi.org/10.1007/978-981-96-6001-8>
9. Baxmann M, Kárpáti K, Baráth Z. The potentials and challenges of integrating generative artificial intelligence in dental and orthodontic education: a systematic review. *BMC Oral Health*. 2025;25:905. <https://doi.org/10.1186/s12903-025-06070-7>
10. Sun X, Tian H. AI-enhanced skill assessment in higher vocational education: a systematic review and meta-analysis. *Informatics*. 2026;13(2):20. <https://doi.org/10.3390/informatics13020020>
11. Bödding R, Schriek SA, Maier GW. A systematic review and meta-analysis of mixed reality in vocational education and training: examining behavioral, cognitive, and affective training outcomes and possible moderators. *Virtual Reality*. 2025;29(1):44. <https://doi.org/10.1007/s10055-025-01118-z>

12. Yang C, Zhang J, Hu Y, Yang X, Chen M, Shan M, Li L. The impact of virtual reality on practical skills for students in science and engineering education: a meta-analysis. *International Journal of STEM Education*. 2024;11(1):1-15. <https://doi.org/10.1186/s40594-024-00487-2>
13. Long Y, Zhang X, Zeng X. Application and effect analysis of virtual reality technology in vocational education practical training. *Education and Information Technologies*. 2025;30:9755-9786. <https://doi.org/10.1007/s10639-024-13197-7>
14. Carvalho SA, Conceição ES, Marques ICP. The impact of virtual reality on employee training and learning in organisations: a systematic literature review. *Applied Sciences*. 2025;15(19):10459. <https://doi.org/10.3390/app151910459>
15. Dubiel A, Kamińska D, Zwoliński G, Ramić-Brkić B, Agostini D, Zancanaro M. Virtual reality for the training of soft skills for professional education: trends and opportunities. *Interactive Learning Environments*. 2025;33(5):3261-3281. <https://doi.org/10.1080/10494820.2025.2450634>
16. Klostermann A, Etterlin T. Learning with digital tools vs. learning through digital tools in physical education: impacts on student perceptions. *Current Issues in Sport Science*. 2025;10(2). <https://doi.org/10.36950/2025.2ciss033>
17. Østerlie O, Kristensen GO, Holland SK, Camacho Miñano MJ, Whatman S. Digital technology use in physical education teacher education: a scoping review. *Sport, Education and Society*. 2025:1-15. <https://doi.org/10.1080/13573322.2025.2474631>
18. Saiz-González P, Sierra-Díaz J, Iglesias D, et al. Exploring physical education teachers' willingness and barriers to integrating digital technology in their lessons. *Education and Information Technologies*. 2025;30:5965-5987. <https://doi.org/10.1007/s10639-024-13060-9>
19. Zhao B, Chen J, Yang J, Su Y. Digital empowerment for innovative teaching: application and mediating effects of information technology in physical education teachers' practices. *Frontiers in Sports and Active Living*. 2025;7:1612745. <https://doi.org/10.3389/fspor.2025.1612745>
20. Alieksieieva H, Kravchenko N, Horbatiuk L, Nestorenko T, Zhyhir V, Kalinichenko A, Glazova Y. Digital transformation of relocated higher education institutions in Ukraine under martial law. *Problems and Perspectives in Management*. 2025;23(2-si):71-85. [https://doi.org/10.21511/ppm.23\(2-si\).2025.06](https://doi.org/10.21511/ppm.23(2-si).2025.06)

21. Yatsukh O. Educational innovations and digital technologies as an opportunity to improve the educational environment in Ukraine during martial law. *European Humanities Studies: State and Society*. 2025;1(1):68-81. <https://doi.org/10.38014/ehs-ss.2025.1.06>
22. Pyshchuk O. Digital technologies in vocational education: prospects for the reconstruction of the country. *Innovative Vocational Education*. 2024;6:518-525. <https://doi.org/10.32835/2786-619X.2024.6.19.518-525> Ukrainian.
23. Mindrul M. International experience of implementing digital technologies in the training of vocational education specialists: lessons for Ukraine. In: *Models of interdisciplinary and intersectoral educational and educational-scientific programmes under martial law: challenges and implementation options: Proceedings of the V International Conference*; 2025; Odesa, Ukraine. p. 98-100. Available from: https://onu.edu.ua/pub/bank/userfiles/files/ggf/naukova_diyalnist/naukovi_konf_GGF/zbirnik_modeli_mijdistsiplinarnih_ta_mijgaluzevix_op_ta_onp_2025.pdf (Accessed: 05.05.2026). Ukrainian.
24. Han X, Luo H, Wang Z, Zhang D. Using virtual reality for teacher education: a systematic review and meta-analysis of literature from 2014 to 2024. *Frontiers in Virtual Reality*. 2025;6:1620905. <https://doi.org/10.3389/frvir.2025.1620905>