Original Article
IRSTI 14.35.07 10.51889/2960-1649.2025.65.4.011

AITZHANOVA ELMIRA[1], KHASSANOVA INKAR[2],*
DARGUZHIEVA ASSIMA[2], NABIYEVA ZHANARGUL[2]

[1]Abai Kazakh National Pedagogical University (Almaty, Kazakhstan)
[2]M. Utemisov West Kazakhstan University (Uralsk, Kazakhstan)

*Address of correspondence: Khassanova Inkar, Candidate of Pedagogical Sciences, West Kazakhstan University named aft. Makhambet Utemisov, Uralsk city, Nazarbayev st. 162, Republic of Kazakhstan, https://orcid.org/my-orcid?orcid=0000-0002-1317-9885, E-mail address: Khassanova.inkar@mail.ru

A Model for the Formation of a Digital Culture of Future Teachers of Preschool Education Based on Neurotechnologies

Abstract

Introduction. The article addresses the problem of qualitatively updating the methodological and technological substantiation of the system of preschool education, determined by the contemporary stage of global digital transformation. *The purpose* of the study is to identify the theoretical and methodological foundations and develop a structurally-functional model for the formation of the digital culture of future teachers of preschool education that ensures the development of neuropsychological indicators of cognitive activity: methodology *and Methods*. The methodological foundation of the study rests upon theoretical modelling, general didactic methods, and integrated interdisciplinary research. The work employs a four-component structural model of the formation of digital culture within the pedagogical process, integrating cognitive, structural, competency-theoretical, activity-theoretical, operational, and reflective-analytical modules. *Results.* The research has elaborated a structurally-functional model that integrates neuropsychological indicators into the process of professional training, thereby ensuring the development of psychological readiness for the commencement of pedagogical activity at a new level of professional competence development. *Scientific Novelty*. The key distinctive feature of the elaborated model resides in the integration of neuropsychological processes into the conditions of digital competence formation, ensuring the manifestation of professionally significant personal characteristics and the effectiveness of the professional training of future teachers of preschool education. *Practical Significance*. The proposed model enables the acquisition of contemporary professional pedagogical knowledge and facilitates the formation of digital culture, thereby contributing to the enhancement of professional pedagogical training and the preparation of future pedagogical professionals.

Keywords: digital culture, future pedagogues, preschool education, neuropsychology, neuropsychological development, professional training, model.

Introduction. Contemporary global digitalization (Hartong, 2019; Ronzhina, 2021) is forming a fundamentally new sociocultural environment where technologies permeate all spheres of human activity. The concept of digital culture (Giannini & Bowen, 2019) in this context extends beyond simple technical literacy, representing a complex system of values, practices, and competencies that define human interaction with the technological environment.

In the educational sphere, proficiency in digital culture (Ferreira, 2020; Mensan & Anagün, 2022) has become an integral component of a teacher's professional competence. A specialist lacking the relevant skills loses the ability to effectively use modern educational tools, keep curriculum content relevant, and adequately respond to the needs of the new, "digital" generation of children. The relevance of this study is driven by the profound transformation of the education system, which imposes qualitatively new demands on preschool teachers (Zhao & Li, 2015; El-Deeb, 2021; Bay & Hartman, 2025), altering the content and methodology of their work with young and preschool-aged children. Today, a preschool teacher tackles a wide range of interconnected tasks. These include: developing primary

technological skills in children, considering their age characteristics; applying interactive teaching methods; ensuring the safety of children in the digital space (Alvestad & Jernes, 2014; Ihmeideh & Alkhawaldeh, 2017); and building effective communication with parents through modern channels. Successfully addressing these tasks requires the teacher to possess a well-formed, holistic digital culture as a comprehensive personal quality that integrates knowledge, activity, and value-motivational components.

However, current practice in higher pedagogical education reveals a significant contradiction between the increasing demands for the digital culture of future teachers and the limited capacity of traditional approaches to its formation, which are not based on neurotechnology. The dominant training system often concentrates on the operational mastery of specific software products, insufficiently developing the fundamental cognitive abilities and meta-competencies that form the basis for the flexible application of digital technologies in professional practice.

Traditional methodologies do not fully account for the neurophysiological characteristics of perceiving and processing digital information, leading to fragmented knowledge acquisition, a low level of digital resilience, and an unpreparedness for creative professional self-realization in a dynamically evolving digital educational environment. Meanwhile, the potential of neurotechnologies in the educational process remains almost unstudied, despite their proven effectiveness in the field of cognitive development and forming stable skills in children. Thus, the research problem lies in the necessity to scientifically substantiate and create a model for developing digital culture in future preschool teachers based on neurotechnologies, a model capable of ensuring a qualitatively new level of professional training that is adequate to the challenges of the digital era.

Materials and Methods. The model for developing digital culture in future preschool teachers based on neurotechnologies represents a theoretical solution to a current scientific problem, defining the specifics of the study's methodological framework. The *research question* is: What are the structural-content components and pedagogical conditions for developing a digital culture in future preschool teachers that integrates neurotechnologies into the educational process? The methodological basis of the model consists of a set of theoretical research methods. Analysis allowed for the examination of the digital culture formation process as an integral pedagogical phenomenon, revealing its structure and external connections. Modeling served as a tool for constructing the model itself, defining the logic of interaction between its components and the neurotechnological element.

The evolutionary development of requirements for a teacher's professional competence, in the context of the progressive technologization of the educational space, has driven a transformation in the conceptual and terminological framework, reflecting the changing paradigm of professional training. The initial conceptualization of professional requirements focused on the operational and technical aspects of computer proficiency, reflected in the concept of "computer literacy" (Satharasinghe, 2006), which included knowledge of personal computer architecture, principles of operating systems, and proficiency in basic software.

The subsequent stage of conceptual development, driven by the exponential growth of information volume and the increasing complexity of information-analytical tasks, was marked by a transition to the more comprehensive concept of "information culture" (Nguyen & Nguyen, 2019). This concept emphasized cognitive-analytical competencies, including the ability to purposefully search for, critically analyze, synthesize, and rationally use information resources in professional activities.

In modern sociocultural conditions, characterized by the total integration of digital technologies into all spheres of human activity, the formation of new modes of communicative interaction, and the transformation of mechanisms for creating sociocultural values, the use of the concept "digital culture" (Artemieva

et al., 2020) becomes conceptually justified. The phenomenon under study represents a qualitatively new level of professional competence, transcending the boundaries of narrowly technical or information-search competencies. The digital culture of a preschool teacher is an integrative personal and professional attribute, characterizing their systemic readiness and ability for effective, critically conscious, and safe professional activities within the digital educational environment. The essential content of this process is the organic unity of cognitive, operational, and axiological components that ensure the conscious acceptance of the digital society's value orientations and the adequate fulfillment of professional functions in accordance with the ethical norms and standards of digital interaction (Bay, 2022).

However, fostering the *digital culture of a preschool teacher* as an integrative personal and professional attribute requires fundamentally new approaches to professional training. Traditional methods for developing technical skills and information competencies prove insufficient for building systemic readiness to operate in a digital environment, as they do not account for the neurophysiological mechanisms of acquiring and applying digital technologies. In this regard, the need for scientifically grounded technologies capable of providing objective diagnosis and targeted development of the cognitive, emotional, and regulatory components of digital culture, based on data about brain activity, becomes highly relevant.

In the context of modernizing teacher education, neurotechnologies (Privitera & Du, 2022; Alipoor & Pourrashidi, 2025) open up fundamentally new, instrumentally substantiated possibilities for optimizing the professional training of future teachers. Neurotechnologies are understood as an interdisciplinary field of knowledge and practice that combines methods and tools enabling the registration, analysis, and targeted influence on the activity of the central nervous system to solve practical tasks. Their integration into the educational process elevates teacher training to a qualitatively new, scientifically grounded level, based on objective data about the neurophysiological mechanisms of learning and development.

From a didactic perspective, the most relevant for teacher education are neurointerfaces (Brain-Computer Interfaces, BCI), particularly electroencephalography and functional near-infrared spectroscopy, which provide real-time information on the brain's bioelectrical activity and hemodynamics, allowing for the assessment of cognitive states, levels of concentration, mental fatigue, and emotional arousal. Biofeedback technologies, based on the feedback principle, enable the conscious regulation of brain activity parameters through the visualization of neurophysiological processes in a perceptually accessible form. Cognitive training programs, developed based on neuroscience data and implemented in an interactive game format, are designed for the targeted development of specific cognitive functions, including working memory, information processing speed, and cognitive flexibility (Nouri, 2025).

The didactic potential of neurotechnologies (Williamson et al., 2025) in training future preschool teachers is multifaceted and enables the targeted development of key professional competencies. The development of self-regulation through neurofeedback fosters the ability for conscious control of one's psychophysiological state, ensuring emotional stability and an optimal level of mental activity in stressful situations of pedagogical interaction. Enhancing concentration through the objective diagnosis and training of attention stability creates a neurophysiological basis for effectively conducting the educational process and responding promptly to the individual needs of students. The development of emotional intelligence, based on understanding one's own emotional states through neurophysiological indicators, contributes to the formation of empathy and the creation of an emotionally favorable climate in the educational environment. Building stress resilience through regular self-regulation training increases the adaptive capacity of the nervous system, ensuring maintained performance under conditions of high professional workload. Thus,

neurotechnologies serve as a didactic tool that enables a transition from general pedagogical recommendations to the personalized, scientifically-grounded development of fundamental, professionally important qualities in future preschool teachers, based on objective neurophysiological data.

Results and Discussion. The model for developing digital culture in future preschool teachers using neurotechnologies represents a systemic set of interconnected structural components that ensure the integrity and effectiveness of the process. This is achieved through the integration of neurotechnologies into the educational process of professional training. The model's constituent components are: the target component, the methodological component, the content component, the technological component, and the outcome component (Figure 1).

The target component of the model for developing digital culture in future preschool teachers using neurotechnologies serves a system-forming function. It defines the strategic direction of the entire educational process and ensures the conceptual unity of all the model's structural elements. The scientific rationale for this component is based on understanding the goal as an ideal image of the desired outcome, which determines the content, methods, and means of pedagogical influence. The goal of the model is to form the digital culture of future preschool teachers as an integrative personal and professional quality, ensuring their readiness for effective, critically conscious, and ethically responsible pedagogical activities within the digital educational environment.

The conceptual justification for this goal stems from the understanding of digital culture not as a mechanical set of technical skills, but as a systemic personal and professional attribute that integrates cognitive, activity-based, and value-motivational aspects of readiness for professional work in a digitized educational space. The integrative nature of digital culture is necessitated by the need to organically combine theoretical knowledge about digital technologies, practical skills in their use, and value-ethical guidelines for professional activity in the digital environment.

The specifics of preschool education as a unique educational stage, characterized by the distinct age-related features of the children, determine particular requirements for the teacher's digital culture. Working with preschool children necessitates the adaptation of digital technologies to the characteristics of children's perception, ensuring a balance between digital and traditional teaching methods, and creating a safe and developmental digital environment. This creates the need to foster a specific digital culture in future preschool teachers, one that considers the psychological and pedagogical patterns of development in young and preschool-aged children (Alvestad & Jernes, 2014).

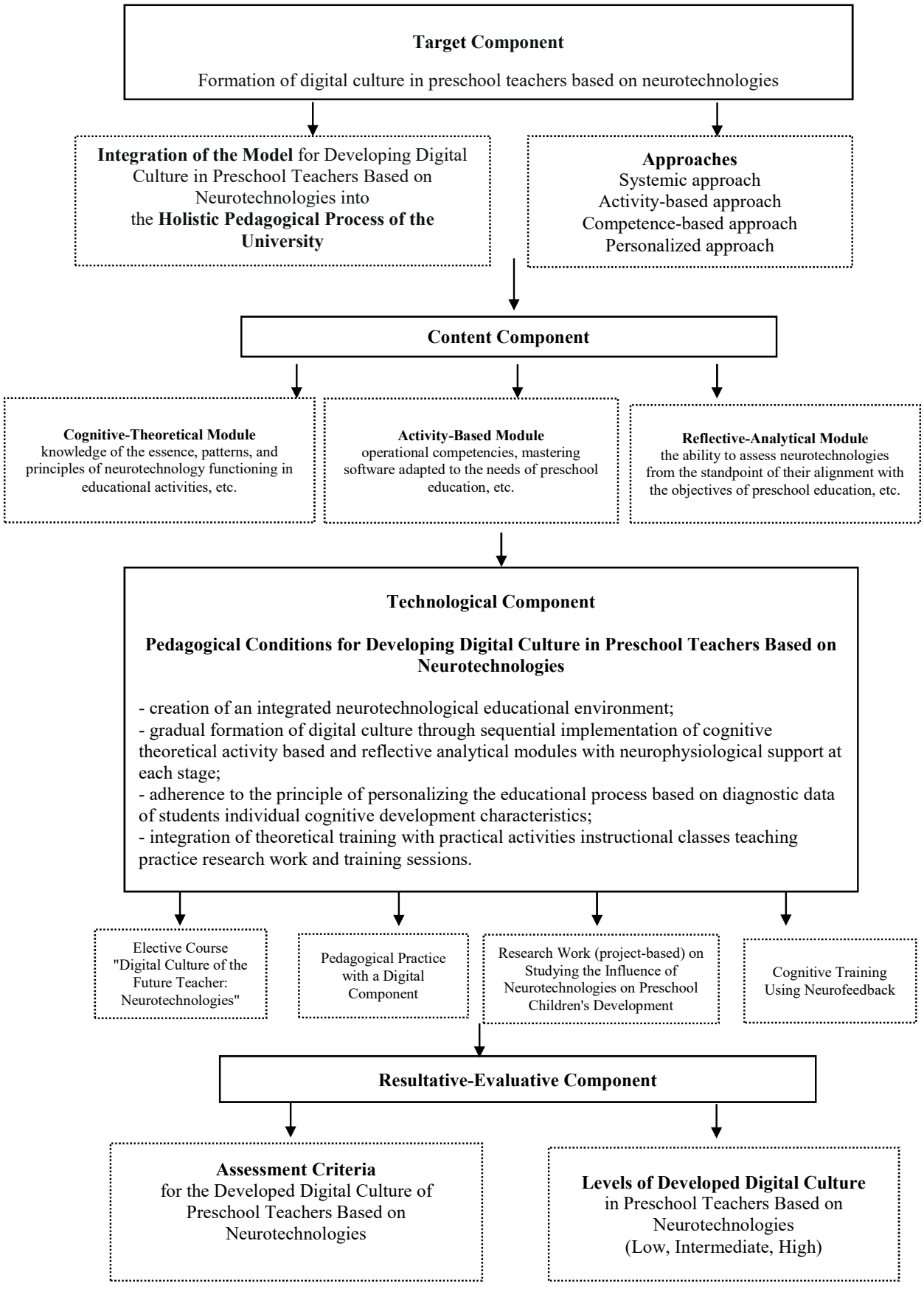
The innovative nature of the proposed model is defined by the integration of neurotechnologies into the process of forming digital culture, enabling a transition from intuitive approaches to scientifically grounded, personalized teacher training. The use of neurotechnologies allows for the objectification of the process of developing professionally significant qualities, accounts for the individual neurophysiological characteristics of students, and ensures optimal conditions for the formation of stable professional competencies**.**

The strategic significance of the set goal is determined by its alignment with modern trends in educational development, the requirements of professional standards, and the needs of preschool education practice in the context of digital transformation. Achieving this goal will ensure the preparation of teachers who are not only capable of adapting to changing professional conditions but also of acting as active agents of innovative development in preschool education in the digital era.

The predictive function of the target component lies in defining prospective directions for the development of professional training for preschool teachers and creating a foundation for the further improvement of educational technologies within the context of digitalization and the implementation of neuroscience achievements in pedagogical practice.

Figure 1

Model for developing digital culture in future preschool teachers based on neurotechnologies



The methodological component of the model for developing digital culture in future preschool teachers using neurotechnologies constitutes the theoretical foundation of the study, defining the conceptual bases, principles, and logic for constructing the educational process. The choice of an integrative methodological foundation, combining systemic, activity-based, competence-based, and personalized approaches, is necessitated by the complexity and multifaceted nature of the phenomenon under investigation - digital culture - as well as the innovative nature of the neurotechnologies employed.

The systemic approach serves as the general methodological foundation of the study, ensuring the consideration of digital culture as a holistic, multi-component phenomenon interconnected in all its structural elements. The necessity of applying the systemic approach is because digital culture represents a complex integrative attribute comprising cognitive, activity-based, and value-motivational aspects, which cannot be adequately understood or developed in isolation. The systemic approach enables the identification of internal connections between the components of digital culture, determines the hierarchy of their interaction, and ensures a synergistic effect from their joint development. In the context of using neurotechnologies, the systemic approach provides an understanding of neurophysiological processes as a system of interconnected brain functions (Williamson et al., 2025), allowing for a comprehensive impact on various aspects of students' cognitive development.

The activity-based approach determines the practice-oriented nature of digital culture formation through students' active learning and professional activities. The theoretical justification for the necessity of this approach is based on fundamental principles of psychological activity theory, according to which personality development occurs through the process of active interaction with the environment via various types of activities. In the context of forming digital culture, the activity-based approach ensures a transition from the passive assimilation of theoretical knowledge about neurotechnologies to their active mastery through solving professionally oriented tasks (Elkina, 2018).

The necessity of applying the competence-based approach (Mulder, 2012) is driven by modern trends in higher education, which require a focus on forming not abstract knowledge, but specific abilities for professional activity. In the context of digital culture, the competence-based approach allows for structuring educational content in accordance with the real needs of a preschool teacher's professional activity in a digital environment. The integration of neurotechnologies within the competence-based approach ensures an objective assessment of the formation of professional competencies by measuring corresponding neurophysiological indicators and creates opportunities for their targeted development.

The personalized approach (Ruotsalo et al., 2009), implemented through neurotechnologies, ensures the consideration of individual neurophysiological characteristics of students and creates a foundation for building individual educational trajectories. The scientific rationale for the necessity of applying a personalized approach is based on data from modern neuropedagogy, which indicates significant individual differences in the neurophysiological mechanisms of learning and development. The use of neurotechnologies allows for the objective diagnosis of individual characteristics of students' cognitive functioning, identifying their strengths and weaknesses, and determining optimal learning strategies. The personalized approach is particularly important in the context of forming digital culture, as the perception and processing of digital information are characterized by significant individual variability, determined by differences in information processing speed, working memory capacity, attention stability, and other cognitive functions.

Thus, the choice of a methodological foundation that integrates systemic, activity-based, competence-based, and personalized approaches is scientifically justified and ensures the adequacy of the methodological tools to the research objectives, the specifics

of the study object, and the innovative nature of the technologies used. Each of the selected approaches addresses a specific aspect of the overall problem: the systemic approach ensures the holistic consideration of the phenomenon; the activity-based approach defines the mechanisms of its formation; the competence-based approach focuses on practical results; and the personalized approach accounts for the individual characteristics of the subjects in the educational process.

The model for developing digital culture in future preschool teachers based on neurotechnologies structurally integrates content and technological components. The content component represents a systematically organized subject matter, the integrity of which is ensured by the cross-cutting integration of neurotechnologies through three interconnected modules.

The cognitive-theoretical module forms the conceptual foundation of digital culture, where neurotechnologies serve as a key element. Its content covers the fundamental principles of neurophysiology concerning cognitive processes and emotional-volitional regulation in preschool age, the functioning principles of non-invasive brain-computer interfaces, and neuro-monitoring methods. Studying the methodological foundations of neurodata analysis using machine learning algorithms creates a basis for the objective assessment of children's cognitive load and functional state. A structural element of this module is the mastery of the principles of neuroethics and safety in working with neurodata, including issues of confidentiality and informed consent.

The activity-based module is focused on developing operational competencies for applying neurotechnologies in professional practice. Its content is structured around mastering hardware-software systems adapted for preschool settings, involving the acquisition of skills for working with biofeedback equipment and gaming neurointerfaces aimed at developing self-regulation and cognitive control in children. Methodologies for integrating neurotechnologies into the educational process include principles for selecting neuro-enriched content and designing lessons using neuromonitoring data for their personalization.

The reflective-analytical module aims to develop critical thinking and the capacity for meta-analysis of neurotechnology applications. The module's content involves forming skills for a multifaceted assessment of neuropedagogical tools from the perspectives of their age-appropriateness, effectiveness, and ethical permissibility. Within this module, the ability to analyze the educational potential of specific neurotechnologies for addressing developmental tasks, as well as to forecast potential risks, is developed. An element of the module is the ability to conduct reflection on one's own pedagogical practice based on objective data about children's neurophysiological responses.

The technological component of the model defines the specific tools and pedagogical conditions for implementing the content. Its operationalization occurs through the creation of a specialized educational environment, the core of which is an instructional neuro-laboratory equipped with the necessary hardware-software complex. Organizational forms include project-based activities for developing and testing lesson segments with neurointerfaces, conducting neurotraining sessions and biofeedback sessions that provide personal self-regulation experience, and analyzing case studies based on real neuromonitoring data. The integration of neurotechnologies into the technological component allows for monitoring students' neurophysiological indicators during the learning process, creating a foundation for personalizing their educational trajectory and objectively assessing the level of competency formation.

The model for developing digital culture in future preschool teachers based on neurotechnologies is realized through a system of interconnected pedagogical conditions that create an optimal environment for professional development.

The creation of an integrated neurotechnological educational environment serves as a fundamental condition, ensuring the organic combination of traditional pedagogical approaches with the innovative capabilities of neurointerfaces and biofeedback systems. This

involves not only technically equipping the educational process with modern equipment but also developing corresponding software-methodological support and specialized training for the teaching staff.

The gradual formation of digital culture is carried out through the sequential implementation of the cognitive-theoretical, activity-based, and reflective-analytical modules with continuous neurophysiological support. This allows for structuring the educational process according to the logic of cognitive activity and the patterns of professional competency formation, ensuring control over the effectiveness of each learning stage and timely correction of the educational process.

The principle of personalizing the educational process based on neurophysiological diagnostic data creates opportunities for accounting for individual characteristics of students' cognitive development. The differentiation of instruction considers variations in information processing speed, working memory capacity, attention stability, and other cognitive functions, which is realized through the development of individual educational trajectories and the adaptation of teaching methods.

The integration of theoretical preparation with practical activity is achieved through a system of complementary forms of learning organization, instructional classes, teaching practice, scientific research work, and training programs unified by constant neurophysiological monitoring. This approach ensures the formation of a holistic digital culture as a unity of the knowledge, skills, abilities, and personal qualities necessary for professional activity in the digital educational environment.

The reflective nature of the educational process is supported by the systematic use of self-analysis and self-regulation technologies employing neurofeedback. This fosters the development of students' metacognitive abilities and the formation of self-control and self-regulation skills, which constitute the foundation for continuous professional development within a dynamically changing digital environment.

The elective course "Neurotechnologies in Shaping the Future Teacher's Digital Culture" serves as the core organizational form for implementing the model. Within this course, all components of digital culture are developed through: lecture sessions incorporating neurophysiological monitoring of attention; interactive seminars utilizing biofeedback; laboratory-practical classes focused on mastering specialized software; project-based activities; and reflective seminars incorporating neurofeedback.

Pedagogical practice with a digital component enables the testing of developed competencies in the real professional setting of a preschool organization. During this practice, students analyze the digital educational environment, apply neurotechnologies in their work with children, create interactive educational materials, and organize digital communication with parents, while simultaneously developing skills for the reflective analysis of their own pedagogical activities.

Student research work, conducted in the form of projects, integrates theoretical knowledge and practical skills by studying the influence of neurotechnologies on the development of preschool children, analyzing international experience in educational digitalization, and developing and experimentally testing digital educational resources. This research activity includes analyzing the effectiveness of digital educational technologies, investigating the risks associated with their application, and developing a system for assessing the quality of the digital educational environment.

Professional development training programs ensure the targeted formation of professionally significant qualities through cognitive training using neurofeedback, the practice of practical skills for working with digital devices, and the development of critical thinking. Individual educational trajectories are realized through personalized support based on neurophysiological diagnostics, including individual consultations, the development of personal theoretical training programs, and the selection of digital tools in accordance with the psychophysiological characteristics of the students.

The results component of the model defines the system of expected educational outcomes,

reflecting qualitative changes in professional training. Cognitive results are characterized by the development of digital thinking, information-analytical abilities, and a deep understanding of the principles underlying digital technologies. Activity-based results are manifested in the confident mastery of digital tools for professional activity and the ability to apply them creatively in the educational process. Personal results include the formation of a value-based attitude towards digital technologies and a readiness for continuous professional development in the context of educational digitalization. The integrative nature of the results component ensures the formation of a holistic digital culture in the future preschool teacher. The use of neurotechnologies creates a scientifically grounded system for assessing the effectiveness of the model's implementation.

Conclusion. The conducted theoretical study has achieved its goal and resolved the key scientific contradiction between the updated requirements for the digital culture of the future teacher and the limited potential of traditional pedagogical approaches. As a result, the essence of the digital culture of a preschool teacher has been clarified and scientifically substantiated as an integrative personal and professional attribute synthesizing cognitive, operational-activity, and axiological components. This conceptual position, in turn, confirmed the necessity of integrating neurotechnological tools into the university's educational process.

As a methodological response to this challenge, an innovative model was developed, representing an integrated system of target, content, technological, and results components. The implementation of the model is possible under a set of pedagogical conditions, such as creating an integrated neurotechnological educational environment, ensuring the gradual formation of digital culture with neurophysiological support, and personalizing learning based on neurodiagnostic data. The theoretical significance of the work lies in expanding scientific understanding of the structure of digital culture and substantiating the new possibilities of neurotechnologies in teacher education. The practical value resides in the model's potential for the qualitative renewal of the content and technologies for training future teachers. Prospects for further research are associated with testing the model in a real educational process, developing corresponding diagnostic tools, and creating methodological recommendations for its implementation into the system of teacher training.

References

Alipoor, J., & Pourrashidi, H. (2025). A critical study on the researches about the application of neurotechnology in education. *International Journal of Neuroscience*, *135*(4), 496-503. https://www.tandfonline.com/doi/abs/10.1080/00207454.2024.2311231

Alvestad, M., & Jernes, M. (2014). Preschool teachers on the implementation of digital technology in Norwegian Kindergartens. In *Forum on Public Policy: A Journal of the Oxford Round Table* (pp. NA-NA). Forum on Public Policy. https://go.gale.com/ps/i.do?id=GALE%7CA497796475&sid=googleScholar&v=2.1&it=r&linkaccess=abs&issn=1556763X&p=AONE&sw=w

Artemieva, V. V., Voronina, L. V., & Utyumova, E. A. (2020). Development of information culture of future teachers in the conditions of digitalization of education. In *2nd International Scientific and Practical Conference "Modern Management Trends and the Digital Economy: From Regional Development to Global Economic Growth" (MTDE 2020)* (pp. 841-847). Atlantis Press.

Bay, D. N. (2022). The perspective of preschool teachers on the use of digital technology. *Southeast Asia Early Childhood Journal*, *11*(2), 87-111. https://www.academia.edu/download/95965992/the_perspective_of_preschool_teachers_on_the_use_of_digital_technology.pdf

Bay, D. N., & Hartman, D. K. (2025). Digital Technology in Kindergarten: Kindergarten Teachers' Practices and Their Effects on Children. *Journal of Research in Childhood Education*, 1-29. https://www.tandfonline.com/doi/abs/10.1080/02568543.2025.2514028

El-Deeb, R. M. (2021). The Digital Etiquette of the Kindergarten Teacher Pre-Service When Using Electronic Educational Platforms from the Point of View the Faculty Members. *International Journal of Instructional Technology and Educational Studies*, *2*(3), 28-33. https://journals.ekb.eg/article_204568.html

Elkina, E. E. (2018). Digital Culture as a Field of Interdisciplinary Research: Methodological Approaches and Tendencies of Development. *International Journal of Open Information Technologies*, *6*(12), 67-78. http://injoit.org/index.php/j1/article/view/649

Ferreira, J. D. L. (2020). Digital Culture and Teacher Education: an analysis from the perspective of undergraduate students in Pedagogy. *Educating in Review*, *36*, e75857. https://www.scielo.br/j/er/a/vDPPCznRr6dfVsYKqJS979L/?lang=en

Giannini, T., & Bowen, J. P. (2019). Digital culture. In *Museums and Digital Culture: New Perspectives and Research* (pp. 3-26). Cham: Springer International Publishing. https://link.springer.com/chapter/10.1007/978-3-319-97457-6_1

Hartong, S. (2019). The transformation of state monitoring systems in Germany and the US: Relating the datafication and digitalization of education to the global education industry. In *Researching the global education industry: Commodification, the market and business involvement* (pp. 157-180). Cham: Springer International Publishing. https://link.springer.com/chapter/10.1007/978-3-030-04236-3_8

Ihmeideh, F., & Alkhawaldeh, M. (2017). Teachers' and parents' perceptions of the role of technology and digital media in developing child culture in the early years. *Children and Youth Services Review*, *77*, 139-146. https://www.sciencedirect.com/science/article/pii/S0190740917301330

Mensan, N. Ö., & Anagün, S. S. (2022). Primary School Teachers' Perceptions of Digital Culture. *International Journal of Progressive Education*, *18*(1), 397-410. https://eric.ed.gov/?id=EJ1332723

Mulder, M. (2012). Competence-based education and training. *The Journal of Agricultural Education and Extension*, *18*(3), 305-314. https://www.tandfonline.com/doi/full/10.1080/1389224X.2012.670048

Nguyen, T. T. H., & Nguyen, T. M. (2019). Information technology and teaching culture: Application in the classroom. In *Smart Education and E-Learning 2019* (pp. 343-355). Singapore: Springer Singapore. https://link.springer.com/chapter/10.1007/978-981-13-8260-4_32

Nouri, A. (2025). A scoping review of educational neurotechnology: Methods, applications, opportunities, and challenges. *Review of Education*, *13*(2), e70070. https://bera-journals.onlinelibrary.wiley.com/doi/abs/10.1002/rev3.70070

Privitera, A. J., & Du, H. (2022). Educational neurotechnology: Where do we go from here?. *Trends in Neuroscience and Education*, *29*, 100195. https://www.sciencedirect.com/science/article/pii/S2211949322000230

Ronzhina, N., Kondyurina, I., Voronina, A., Igishev, K., & Loginova, N. (2021). Digitalization of modern education: problems and solutions. *International Journal of Emerging Technologies in Learning (iJET)*, *16*(4), 122-135. https://www.learntechlib.org/P/220004/

Ruotsalo, T., Mäkelä, E., Kauppinen, T., Hyvönen, E., Haav, K., Rantala, V., ... & Matskin, M. (2009, September). Personalized Context-aware Access to Digital Cultural Heritage. In *Proceedings of the International Conferences on Digital Libraries and the Semantic Web, Trento, Italy* (pp. 8-11). http://seco.cs.aalto.fi/publications/2009/Ruotsalo-Smartmuseum-2009.pdf

Satharasinghe, A. (2006). Computer literacy of teachers. *Retrieved October*, *19*, 2015. http://www.statistics.gov.lk/Resource/en/ComputerLiteracy/Surveys/ComputerLiteracyTeachers2006.pdf

Williamson, B., Pykett, J., & Kotouza, D. (2025). Learning brains: educational neuroscience, neurotechnology, and neuropedagogy. *Pedagogy, Culture & Society*, 1-21. https://www.tandfonline.com/doi/abs/10.1080/14681366.2025.2521458

Zhao, P., & Li, X. (2015). Arts Teachers' Media and Digital Literacy in Kindergarten: A Case Study on Finnish and Chinese Children using a Shared Blog in Early Childhood Education. *International Journal of Digital Literacy and Digital Competence (IJDLDC)*, *6*(1), 1-17. https://www.igi-global.com/article/arts-teachers-media-and-digital-literacy-in-kindergarten/128286

Information about authors:

Aitzhanova Elmira, PhD Doctoral Student of Educational Program 8D01201 Preschool Education and Upbringing, Abai Kazakh National Pedagogical University, ORCID ID: 0000-0002-0604-5133, email: aytzhanova.1971@gmail.com

Khassanova Inkar, Candidate of Pedagogical Sciences, M. Utemisov West Kazakhstan University, ORCID ID: 0000-0002-1317-9885, email: Khassanova.inkar@mail.ru

Darguzhieva Assima, lecturer, M. Utemisov West Kazakhstan University, ORCID ID: 0009-0008-4655-1728, email: assimok_dar@mail.ru

Nabiyeva Zhanargul, master's degree of Pedagogical Sciences, senior lecturer, M. Utemisov West Kazakhstan University, ORCID ID: 0000-0003-2706-7857, email: nabi.zhanar@inbox.ru

