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TRAPITSYN SERGEY[1], TURSYNBAEVA AINUR[2]

[1]Herzen State Pedagogical University of Russia (St. Petersburg, Russian Federation)
[2]M. Auezov South Kazakhstan university (Shymkent, Kazakhstan)

*Address of correspondence: Tursynbayeva Ainur, 3rd year doctoral student, M. Auezov South Kazakhstan university, specialty 6D010300 Pedagogy and Psychology, Tauke khan avenue 5, Shymkent, Kazakhstan, ORCID ID: 0009-0001-3055-8617, E-mail: ainur.tursynbayeva@mail.ru

Formation of Information Competence in Future Teachers based on the Integration of Artificial Intelligence Technologies in Education

Abstract

Introduction. The modern education system is undergoing a period of fundamental transformations driven by the rapid development of digital technologies and the widespread integration of artificial intelligence into educational practice. Traditional approaches to developing teachers' information competence, based on mastering basic computer skills, prove insufficient for preparing specialists to work in the context of intelligent technology development. The integration of AI technologies in education actualizes the need to reconceptualize the content and structure of teachers' information competence, incorporating new components related to understanding the principles of intelligent systems operation and skills for critically evaluating their capabilities. *Methodology and Methods*. The research is based on the analysis of theoretical works by leading domestic and foreign scholars in the field of teachers' information competence and the application of artificial intelligence in education. Methods of theoretical analysis, systematization and generalization of scientific literature, and structural-functional analysis were used to identify components of information competence in the context of AI technologies. A comparative analysis of international standards and frameworks for teachers' ICT competence was conducted. *Results.* The structure of teachers' information competence has been defined as a multi-component system including cognitive, operational-activity, and motivational-value components. The interrelationship between the level of teachers' information competence and the effectiveness of AI technology application in various aspects of professional activity has been identified: from lesson planning to creating an inclusive educational environment. It has been established that AI acts as a catalyst for the transformation of information competence, actualizing the development of new data handling skills and critical analysis of automated solutions. *Scientific Novelty*. For the first time, a comprehensive analysis of the transformation of teachers' information competence under conditions of AI technology integration in education has been conducted. A theoretical model of the interrelationship between information competence components and various applications of artificial intelligence in pedagogical activity has been developed. The necessity of developing new digital age competencies in future teachers has been substantiated. *Practical Significance*. The research results can be used in developing educational programs for teacher training, creating teacher professional development systems, and forming standards of professional competence for educators in the context of digital transformation of education.

Keywords: information competence, artificial intelligence, teacher training, digital transformation of education, AI technologies in education.

Introduction. The modern education system is experiencing a period of fundamental transformations driven by the rapid development of digital technologies and the widespread integration of artificial intelligence into educational practice (Pedro, 2019; Chen, 2020). In the context of information society formation and the transition to a knowledge economy, the problem of preparing pedagogical personnel capable of effectively functioning in the new technological reality and ensuring quality education for the younger generation becomes particularly relevant.

The digital transformation of education (Mukul, 2023) presents fundamentally new requirements for teachers' professional

competence, with information competence becoming a key element as an integrative quality that ensures the ability to effectively search, analyze, evaluate, and use information in professional activities. Traditional approaches to developing information competence, based on mastering basic computer skills, prove insufficient for preparing teachers to work in conditions of widespread use of intelligent technologies.

Artificial intelligence, as a set of machine learning technologies, natural language processing, and big data analysis, radically transforms the educational landscape, providing new opportunities for learning personalization, automation of routine processes, and enhancing the effectiveness of pedagogical activities. At the same time, the integration of AI technologies in education actualizes the need to reconceptualize the content and structure of teachers' information competence, incorporating new components related to understanding the principles of intelligent systems operation, skills for interacting with them, and critically evaluating their capabilities and limitations (Huang, 2021).

Analysis of the current state of pedagogical preparation reveals a significant gap between rapidly developing technological capabilities and future teachers' readiness for their effective use. Therefore, in the present study, we have formulated the following *research question*: "What are the essence, structure, and characteristics of developing information competence in future teachers under conditions of artificial intelligence technology integration in education?"

Materials and Methods. Teachers' information competence (Sapaev, 2022) represents an integrative professional quality characterized by a combination of knowledge, skills, abilities, and personal qualities that ensure the effective use of information and communication technologies in educational activities. It includes the ability to search, analyze, critically evaluate, and systematize information from various sources, proficiency in modern digital tools and educational platforms, as well as the ability to adapt information resources to the specifics of the learning process and the age characteristics of students.

The problem of teachers' information competence has received fundamental theoretical and empirical development in the international research community through the works of leading foreign scholars.

The conceptual foundations of information literacy were laid by Christina S. Doyle, who conducted a large-scale study for the National Forum on Information Literacy from 1992-1994 using the Delphi method with 56 experts participating. Doyle defined information literacy as "the ability to access, evaluate, and use information from a variety of sources" and developed ten discrete attributes of an information literate person. Her work "Information Literacy in an Information Society: A Concept for the Information Age" became foundational for understanding the role of information literacy in educational reforms (Doyle, 1994).

The process approach to information seeking was developed by Carol Collier Kuhlthau, a professor at Rutgers University, who created the Information Search Process (ISP) model in the 1980s. The ISP model presents a holistic view of information seeking from the user's perspective in six stages: task initiation, selection, exploration, formulation of focus, collection, and presentation. Central to ISP is the concept that uncertainty, both affective and cognitive, increases and decreases throughout the information search process. Kuhlthau's work is among the most cited works by library and information science faculty and represents one of the conceptualizations most frequently used by information science researchers (Kuhlthau, 2010).

The Sense-Making Methodology was created by Brenda Dervin, Professor Emeritus at The Ohio State University, who has been developing the Sense-Making Methodology since 1972. Dervin studied individual sense-making, developing theories about the "cognitive gap" that individuals experience when trying to make sense of observed data. Her 1986 article "Information Needs and Uses" in the Annual Review of Information Science

and Technology is considered a foundational work and classic citation. The Sense-Making Methodology from the beginning sought to better understand communication from a more communicative (dialogical) perspective and apply this understanding to the design and implementation of formal communication efforts (Dervin, 1976).

The standardization of information literacy in higher education was accomplished by the Association of College and Research Libraries (ACRL). In 2000, ACRL developed and approved the "Information Literacy Competency Standards for Higher Education," defining information literacy as "a set of abilities requiring individuals to recognize when information is needed and have the ability to locate, evaluate, and use effectively the needed information." The current ACRL Framework for Information Literacy for Higher Education opens opportunities for librarians, faculty, and other institutional partners to reimagine instruction sessions, assignments, courses, and even curricula (American Library Association, 2000).

International frameworks for teachers' ICT competence were developed by UNESCO. The UNESCO ICT Competency Framework for Teachers (ICT CFT) provides a comprehensive set of competencies that teachers need to integrate ICT into their professional practice to facilitate students' achievement of learning objectives. The framework aims to create inclusive knowledge societies and considers the impact of recent technological advances on education and learning, such as artificial intelligence, mobile technologies, the Internet of Things, and open educational resources (Mtebe, 2020).

Empirical studies of teachers' information competence have been conducted in various national contexts. Taiwanese researchers developed "Information Literacy Competency Standards for Elementary and Secondary School Teachers," identifying three levels (standards, basic indicators, and secondary indicators) and three dimensions (knowledge, skills, and attitudes). Multi-level studies have shown that teachers' competence in developing students' information literacy depends on both individual factors and school-level factors (Wen, 2008).

The problem of teachers' information competence has been investigated by a wide range of Russian scholars who have made significant contributions to the theoretical understanding and practical development of this phenomenon.

The conceptual foundations of information competence were laid by A.V. Khutorskoy (Khutorskoy, 2004), who examined information competence in the context of key competencies of the personality-oriented education paradigm. S.V. Trishina, in collaboration with A.V. Khutorskoy, developed theoretical concepts about the information competence of specialists in the system of additional professional education, defining information competence as "an integrative quality of personality that is the result of reflecting the processes of selection, assimilation, processing, transformation, and generation of information into a special type of subject-specific knowledge, allowing for the development, adoption, forecasting, and implementation of optimal solutions in various spheres of activity".

Structural-functional analysis of information competence was developed in the works of O.G. Smolyaninova, who considers information competence as "universal ways of searching, obtaining, processing, presenting and transmitting information, generalizing, systematizing and transforming information into knowledge." The researcher developed a multi-component model of information competence, including cognitive, operational, and motivational components (Smolyaninova, 2022).

The component composition of information competence was analyzed in detail in the research of E.V. Danshina, who identifies cognitive, value-motivational, and activity components of information competence, as well as V.L. Akulenko, M.G. Dzugoeva, O.B. Zaitseva, N.Yu. Tairova, O.M. Tolstykh, who consider information competence as a multi-level pedagogical category (Danshina, 2009).

The specifics of information competence in pedagogical activities were investigated by

E.V. Petrova, who defines teachers' information competence as a complex of knowledge and skills in the field of information technologies, combined with abilities to search, analyze, select, process, transmit, and store information (Petrova, 2012). The concept of "information competence of future teachers" has been explored by V.V. Vorobyeva, T.A. Gudkova, N.A. Ershova, O.B. Zaitseva, O.V. Ivanova, S.A. Pestov, V.I. Petrova, L.B. Senkevich, E.V. Sidorova, O.G. Smolyaninova, I.N. Sokolovskaya, A.A. Temerbekova, O.M. Tolstykh, F.Kh. Khabibullin, and others (Ilyasova, 2016).

Psychological aspects of information competence were developed by O.S. Grebenyuk within the framework of the concept of human individuality, which allowed examining information competence through the lens of personality's mental capabilities and identifying internal factors of its development (Grebenyuk, 2000).

Results. The collective research of these authors formed a comprehensive scientific foundation for understanding the phenomenon of teachers' information competence as an integrative professional quality, including cognitive, operational-activity, and motivational-value components, necessary for effective functioning in the modern information-educational environment.

The structure of teachers' information competence (Berkimbaev, 2012) represents a multi-component system including three interconnected elements, each characterized by specific content and functional orientation (Table 1).

Table 1. *Components of teachers' information competence*

Cognitive Component	forms the theoretical-methodological foundation of professional activity in the digital educational environment. The content of the cognitive component includes systematized knowledge about the patterns of education informatization processes, understanding of the conceptual foundations of digital didactics, and mastery of terminological apparatus in the field of educational technologies. Teachers must possess knowledge about the psychological and pedagogical characteristics of information perception and processing by students in the digital environment, understand the principles of interactivity and multimedia in learning, and be aware of the didactic possibilities of various types of digital educational resources. The cognitive component presupposes knowledge of the regulatory and legal foundations for using information technologies in education, including issues of information security, personal data protection, and copyright compliance when working with digital content.
Operational-Activity Component	represents a set of practical skills and abilities that ensure effective application of information and communication technologies in pedagogical practice. The operational-activity component encompasses teachers' technical literacy, including confident mastery of basic software, operating systems, and office applications. Teachers must demonstrate skills in creating, editing, and managing digital educational content, including presentations, interactive assignments, multimedia materials, and online tests. The operational-activity sphere presupposes the ability to work with educational platforms and learning management systems, conduct searches and critical evaluation of educational resources on the internet, and integrate various digital tools into a unified methodological system. An important component of the operational-activity block is the ability to provide technical support to students when using digital technologies and solve emerging technical problems in the educational process.
Motivational-Value Component	reflects teachers' internal readiness for professional development in the field of information technologies and awareness of their significance for improving education quality. The motivational-value component is characterized by sustained motivation for mastering new digital tools and teaching methods, striving for innovative pedagogical activity, and readiness for continuous self-education in the rapidly developing field of educational technologies. The motivational-value

	sphere includes awareness of the pedagogical potential of information technologies for individualizing learning, increasing student motivation, and developing their key 21st-century competencies. Teachers must demonstrate readiness to overcome technophobia, a critical attitude toward traditional teaching methods when they are ineffective in the digital environment, and the ability to reflect on their own professional activity in the context of using information technologies. The motivational-value block presupposes the formation of a value-based attitude toward continuous professional development and recognition of the need to adapt pedagogical practice to the requirements of digital society.

Artificial intelligence in modern teachers' work (Jamal, 2023) represents a complex of technological solutions based on machine learning algorithms and natural language processing that automate and optimize various aspects of pedagogical activity. The effective use of these capabilities directly depends on the level of teachers' information competence and simultaneously contributes to its development (Table 2).

Table 2. *Interrelationship between teachers' information competence and AI application in education*

AI in Education	What is required from the teacher	The role of information competence
Lesson Planning and Preparation Using AI	Intelligent systems generate lesson plans and didactic materials, but teachers must be able to select quality sources, verify proposed content, and adapt materials to the specifics of their class.	Information competence manifests in the need for developed skills in formulating precise information queries and critically evaluating the results proposed by the system, actualizing such components as the ability to critically analyze information and integrate various data sources.
Personalization of Learning	Teachers must understand the principles of data collection and analysis, be able to identify patterns in information about student progress, and transform statistical indicators into specific methodological decisions.	Information competence manifests in the ability to work with large volumes of structured information and make informed decisions based on it.
Assessment Automation	Teachers must possess information competence for critically evaluating the quality of automatic analysis of student work, identifying potential system errors, and supplementing machine analysis with professional expertise.	Information competence manifests in the ability to understand algorithmic principles and skill in comparing automated results with personal observations to ensure assessment accuracy.
Monitoring Student Progress through AI Dashboards	Actualizes the need for developing visual information literacy and statistical analysis skills. Teachers must be able to interpret graphs, charts, and other forms of data visualization, identify trends and anomalies in information about class progress.	Information competence manifests in the ability to transform visual information into pedagogical insights and actionable student support strategies.
Administrative Tasks Automated with AI	Require teachers to develop skills in working with digital information systems and understanding the principles of digital document management.	Information competence manifests in the need to possess technical skills for effective interaction with AI assistants, as well as information literacy to ensure the security and confidentiality of processed data.

Methodological Support through AI Recommendations	Teachers must be able to analyze methodological solutions proposed by the system, compare them with their own pedagogical experience and scientific data, and adapt general recommendations to the specifics of a particular educational context.	Information competence manifests in the ability to critically evaluate and integrate various sources of methodological information for making informed pedagogical decisions.
Working with Parents with AI Support	Teachers must be able to interpret automatically generated reports, supplement them with qualitative observations, and present information about the child's progress in a form accessible to parents.	Requires a high level of information competence in the area of communication, including the ability to adapt technical information for various target audiences.
Professional Development Using AI Recommendations	Contributes to the formation of self-directed information search skills and continuous learning. Teachers must critically evaluate development programs proposed by the system, independently search for additional sources of professional information, and integrate various forms of professional knowledge.	Information competence is expressed in the ability for independent information search, critical evaluation of sources, and synthesis of knowledge from various fields for continuous professional development.
Creating an Inclusive Environment with AI Tools	Requires teachers to understand the principles of adapting information for various categories of students and the ability to work with diverse formats of data presentation.	Information competence manifests in the ability to select optimal ways of presenting information for each student and adapt AI-generated materials to individual needs.

Thus, the integration of artificial intelligence into pedagogical activities not only requires a high level of information competence from teachers but also creates new opportunities for its development. AI acts as a catalyst for the transformation of teachers' information competence, actualizing the need to develop new skills in working with data, critical analysis of automated solutions, and effective interaction with intelligent systems. Modern teachers' information competence is formed in a symbiosis of traditional information skills and new competencies of the digital age, where human expertise is complemented by artificial intelligence capabilities.

Key artificial intelligence technologies in education (Chen, 2020) represent a complex of interconnected technological solutions based on machine learning methods, natural language processing, and big data analysis, which transform traditional approaches to organizing the educational process (Table 3).

Table 3. *Artificial Intelligence Technologies in Education*

Adaptive Learning	represents a technology for personalizing the educational process based on machine learning algorithms that analyze individual characteristics of each student's learning activity and dynamically adjust content, pace, and teaching methods. The technology uses collaborative filtering algorithms and recommender systems to create individual educational pathways that take into account cognitive abilities, learning style, prior knowledge, and current student progress. Adaptive systems continuously collect data on student interaction with educational content, analyze patterns of errors and successes, and then automatically modify task complexity, provide additional explanations, or suggest alternative ways of studying the material.
Educational Data Mining	represents an interdisciplinary field that combines methods of statistical analysis, machine learning, and data visualization to extract meaningful patterns from large

	arrays of information about the educational process. This technology includes predictive analytics for forecasting academic performance and dropout risk, cluster analysis for identifying groups of students with similar characteristics, sequence analysis for understanding learning strategies, as well as sentiment analysis for assessing students' emotional states. Learning analytics technologies allow for identifying hidden patterns in student behavior, optimizing curricula, and providing evidence-based recommendations for improving educational outcomes.
Intelligent Chatbots and Virtual Assistants	represent convergent technologies that combine natural language processing, dialogue systems, and knowledge bases to provide automated support for students and educators. Modern educational chatbots use transformer neural network architectures and large language models to understand query context, generate relevant responses, and maintain multi-step dialogues. They are capable of providing instant answers to frequently asked questions, directing students to appropriate resources, explaining complex concepts through interactive dialogue, and collecting feedback for further improvement of the educational process.
Automated Assessment Systems	are based on computer vision technologies, natural language processing, and semantic analysis to automate the processes of checking and evaluating various types of academic work. For assessing written assignments, text analysis algorithms are used, including grammar checking, stylistics, logical structure, and compliance with assessment criteria. Automated code assessment systems apply static and dynamic analysis to check correctness, efficiency, and programming style. Computer vision technologies enable automatic evaluation of graphic works, diagrams, and handwritten mathematical calculations.
Speech Recognition and Synthesis Technologies	are integrated into educational systems to provide multimodal interaction and support inclusive education. Automatic Speech Recognition (ASR) is used for transcribing lectures, creating real-time subtitles, and analyzing students' oral responses. Text-to-Speech (TTS) technologies provide audio rendering of textual materials, which is particularly important for students with visual impairments or dyslexia. Modern systems are capable of analyzing prosodic characteristics of speech to assess emotional state and level of student engagement.
Image and Video Analysis Technologies for Monitoring the Educational Process and Creating Interactive Learning Environments	classroom behavior analysis systems use eye-tracking technologies, emotion recognition, and gesture analysis to assess students' attention levels and engagement. Augmented Reality (AR) and Virtual Reality (VR) create immersive educational environments that allow students to interact with three-dimensional models of complex objects and processes.
Recommender Systems in Education	adapt collaborative and content-based filtering methods to provide personalized recommendations for learning materials, courses, and activities. These systems analyze student profiles, their preferences, activity history, and learning outcomes to suggest optimal educational resources. Hybrid recommender systems combine various approaches to improve the accuracy and diversity of recommendations.

The integration of all the listed technologies creates an intelligent education ecosystem where various AI components interact to provide comprehensive support for the educational process, requiring an interdisciplinary approach that combines achievements from computer science, pedagogy, psychology, and cognitive sciences to create effective and ethically sound educational solutions.

Discussion. The integration of artificial intelligence into pedagogical preparation represents one of the most relevant and debatable topics in contemporary pedagogical education (Chen, 2020; Pedro, 2019), generating

active debates among researchers, practicing educators, and educational technology developers, touching upon fundamental aspects of future teachers' professional preparation and requiring comprehensive analysis of various perspectives.

Proponents of active implementation of AI technologies in pedagogical preparation (Jamal, 2023) present compelling arguments in favor of digital transformation of the educational process. They argue that modeling pedagogical situations using artificial intelligence creates unprecedented opportunities for safe practice for future educators, allowing students to experiment with various methodological approaches without the risk of negative impact on real students. Intelligent systems are capable of generating diverse scenarios of pedagogical interactions, modeling behavior of students with different educational needs, and providing immediate feedback on decisions made. Proponents pay special attention to personalization of educational pathways (Mukul, 2023), asserting that AI systems can analyze individual needs, learning styles, and professional deficits of each student, automatically adjusting curricula and suggesting additional resources for problem areas.

Automated feedback in performing practical assignments is viewed by proponents as a revolutionary achievement (Wen, 2008), capable of fundamentally changing the quality of professional preparation. AI systems for analyzing pedagogical activity can evaluate the quality of developed lesson plans, analyze video recordings of conducted classes, and provide detailed recommendations for improving methodological approaches. Virtual mentors and tutors based on AI technologies provide round-the-clock support for students in the process of mastering pedagogical disciplines, which is particularly effective for correspondence and distance learning forms, compensating for limited contact with instructors.

However, not all specialists share the enthusiasm for total digitization of pedagogical preparation. Critics express (Edwards, 2018) serious concerns about potential negative consequences of excessive dependence on technological solutions. The main criticism concerns the risk of reduced development of critical thinking and creative abilities in future educators, as well as the loss of important interpersonal interaction skills. Opponents of active AI integration argue that automation of many processes may lead to the formation of "technologically dependent" educators, incapable of independent decision-making in non-standard situations. Representatives of the traditional pedagogical school emphasize that pedagogy is primarily the art of human interaction, and no algorithms can replace live communication between teacher and student.

Serious concern in the scientific community is raised by the problem of algorithmic bias in AI systems (Berkimbaev, 2012), which may exacerbate existing inequalities in education and lead to discrimination against certain groups of students. Issues of privacy and data security become critically important when processing personal information about students and their academic achievements, especially in the context of modern requirements for personal data protection. Technological unpreparedness of educational institutions and faculty for implementing AI solutions may create digital inequality and reduce the quality of preparation in less equipped institutions.

Financial limitations also become a subject of heated discussions (Khanzode, 2020). High costs for developing, implementing, and maintaining AI systems may become a barrier to widespread technology adoption, especially in developing countries and regions with limited resources, creating a risk of deepening educational inequality at the global level, where access to quality pedagogical preparation will be determined by the economic capabilities of the region or institution.

Ethical dilemmas of using AI in pedagogical preparation include questions of future educators' autonomy in making professional decisions, transparency of assessment algorithms, and risks of dehumanizing the educational process. Opponents of excessive technologization argue that pedagogical education should maintain its humanistic orientation, and artificial intelligence can only supplement, but not replace, human relationships in the educational process. The

need to maintain balance between technological efficiency and human values requires the development of clear ethical frameworks for using AI technologies in pedagogical education.

In the course of academic discussions, voices increasingly call for finding a reasonable compromise between technological capabilities and traditional pedagogical values. Many researchers agree that successful integration of artificial intelligence requires a systematic approach (Thomas, 2025), including the development of appropriate curricula, faculty preparation, creation of technological infrastructure, and formation of ethical standards for using AI technologies. Only with a thoughtful implementation strategy and constant monitoring of results can artificial intelligence become an effective tool for improving the quality of pedagogical personnel preparation for the digital future of education, presupposing gradual implementation of AI technologies with constant assessment of their impact on the formation of professional competencies and adjustment of strategies depending on the experience gained, which allows utilizing the advantages of artificial intelligence while minimizing associated risks.

Conclusion. The conducted research allows us to conclude that the transformation of teachers' information competence under conditions of artificial intelligence integration into education represents a natural evolutionary process, reflecting the adaptation of the pedagogical profession to the challenges of the digital age. The multi-component structure of information competence identified through analysis, including cognitive, operational-activity, and motivational-value components, demonstrates a qualitative increase in the complexity of professional requirements for modern teachers. The established interrelationships between the level of information competence and the effectiveness of AI technology application in pedagogical activities indicate the formation of a new type of professionalism based on the symbiosis of human expertise and intelligent systems capabilities.

The prospects for developing this research direction are connected with the need to develop diagnostic tools for assessing the level of teachers' information competence formation in the context of AI technologies, as well as creating methodological recommendations for integrating corresponding modules into pedagogical education programs. The further study of ethical aspects of using artificial intelligence in education and the development of mechanisms for ensuring balance between technological efficiency and humanistic values of pedagogy appears critically important. The research results actualize the need for interdisciplinary collaboration among specialists in pedagogy, psychology, information technologies, and ethics to create a comprehensive concept for preparing pedagogical personnel for professional activity under conditions of widespread adoption of intelligent educational technologies.

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Information about authors:

Trapitsyn Sergey, Doctor of Pedagogical Sciences, Professor, Herzen State Pedagogical University of Russia, St. Petersburg, Russian Federation, ORCID ID: 0000-0003-3752-8848, email: trapitsin@gmail.com

Tursynbayeva Ainur, 3rd year doctoral student, M. Auezov South Kazakhstan University, specialty 6D010300 "Pedagogy and Psychology", Shymkent, Kazakhstan, ORCID ID: 0009-0001-3055-8617, email: ainur.tursynbayeva@mail.ru

