CRITERIA AND INDICATORS FOR ASSESSING PROSPECTIVE PRIMARY SCHOOL TEACHERS' COMPETENCE IN THE USE OF ARTIFICIAL INTELLIGENCE TECHNOLOGIES

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Abstract

This article addresses the problem of assessing prospective primary school teachers' competence in the use of artificial intelligence (AI) technologies within the context of the digital transformation of education. Based on a theoretical analysis of contemporary digital-competence frameworks and the specific requirements of primary education, the article substantiates a five-component system of criteria — cognitive–knowledge, technological–practical, methodological–pedagogical, value–ethical, and reflective–developmental — together with corresponding indicators and three levels of development (low, medium, high). The article further proposes a set of diagnostic tools for the practical assessment of this competence and discusses implications for curriculum design in pedagogical higher education. The proposed system is intended to serve as a methodological foundation for the objective, comprehensive and reproducible assessment of future primary school teachers' readiness to use AI technologies in professional activity.

Introduction

The rapid development of artificial intelligence technologies has become one of the defining forces shaping the future of education worldwide. Intelligent tutoring systems, adaptive learning platforms, automated assessment tools, generative content-creation applications and conversational AI assistants are increasingly penetrating classrooms at every level of the education system, including primary education. This process, commonly referred to as the digital transformation of education, requires a fundamental rethinking of the competences that teachers — and, above all, future teachers — must possess in order to work effectively in a technology-rich learning environment. Primary education occupies a particularly important place in this transformation. It is at this stage that children form their first attitudes toward learning, develop foundational literacy and numeracy skills, and begin to interact with digital tools under the guidance of a teacher. The primary school teacher therefore bears a special responsibility: to introduce AI-supported methods in a manner that is pedagogically sound, age-appropriate, ethically responsible and conducive to the harmonious cognitive and social development of the child. This responsibility can only be fulfilled if the teacher possesses a well-formed, multidimensional competence in the use of AI technologies.

At the same time, higher pedagogical education institutions that train future primary school teachers face a methodological challenge: the absence of a unified, empirically and theoretically grounded system of criteria and indicators for assessing this competence. Without such a system, it is difficult to diagnose the initial level of students' readiness, to design targeted educational interventions, to monitor progress during training, and to certify graduates' preparedness for professional activity in a digitally transformed educational environment. This article aims to address this gap by proposing a comprehensive, multi-criteria system for assessing prospective primary school teachers' competence in the use of AI technologies, illustrated through the case of the Information Technologies course taught within primary-education teacher-training programmes. The relevance of this study is determined by several interrelated factors. First, national and international education-policy documents increasingly emphasize the need to integrate AI literacy into teacher-training curricula. Second, employers — general secondary schools — expect graduates of pedagogical institutes to be capable of applying digital and AI-based tools from their very first days of professional activity. Third, the existing assessment practices in many pedagogical institutions remain oriented toward general digital literacy and do

not sufficiently capture the specific, AI-related dimensions of teacher competence. Addressing these gaps requires both a sound theoretical model and a set of practical diagnostic instruments, both of which are developed in the present article. Furthermore, the transition toward AI-enhanced education is not a distant prospect but an already unfolding reality. Many primary school teachers today encounter pupils who have already interacted with voice assistants, AI-powered games, and automated translation tools at home, long before these technologies appear in any formal curriculum. This means that future teachers must be prepared not only to introduce AI purposefully in the classroom, but also to respond competently to pupils' spontaneous questions and experiences related to AI, to correct misconceptions, and to channel children's natural curiosity about intelligent technologies into structured, developmentally appropriate learning activities. The problem addressed in this article can therefore be formulated as follows: how can the multidimensional, rapidly evolving competence of using AI technologies in primary education be captured through a stable, structured and pedagogically meaningful system of criteria and indicators that remains applicable despite the continuous evolution of specific AI tools. The answer proposed in this article is to focus the assessment system not on any particular software product - which may quickly become outdated - but on the underlying cognitive, practical, methodological, ethical and reflective capacities that allow a teacher to adapt to new AI tools as they emerge. This design choice ensures that the proposed framework retains its relevance even as the specific technological landscape continues to change. The theoretical foundation of this study draws upon several well-established frameworks in the field of teacher digital competence, adapted and extended to the specific context of AI technologies in primary education.

The competence-based approach, widely used in contemporary pedagogical research, conceptualizes professional competence as an integrative characteristic of a specialist that combines knowledge, skills, values and personal qualities necessary for the successful performance of professional functions. Within this approach, competence is typically assessed not as a single, unitary trait, but as a structured set of interrelated components, each of which can be operationalized through observable indicators. This methodological logic underlies the five-criterion model proposed in the present article.

The Technological Pedagogical Content Knowledge framework, developed by Mishra and Koehler, describes teacher knowledge as the dynamic interaction of technological, pedagogical and content knowledge. This framework provides a useful lens for understanding why AI competence cannot be reduced to purely technical skill: effective use of AI in the primary classroom requires the simultaneous integration of subject-matter knowledge, pedagogical judgement, and technological fluency. Similarly, the European DigCompEdu framework for educators' digital competence, and the AI competency framework for teachers, both emphasize multidimensional structures that combine technical skills with pedagogical, ethical and reflective dimensions. The criteria system proposed in this article is conceptually aligned with these frameworks while being specifically adapted to the developmental characteristics of primary-school-age pupils and the corresponding requirements placed on their future teachers. Unlike general digital literacy, AI competence involves an additional layer of complexity: the ability to interact with systems that generate content, make probabilistic recommendations, and sometimes produce inaccurate or biased outputs. For a primary school teacher, this raises particular pedagogical and ethical questions - for example, how to critically evaluate AI-generated materials before presenting them to young children, how to protect pupils' personal data when using AI-based platforms, and how to model responsible technology use for children who are only beginning to develop critical-thinking skills. These specific considerations justify the inclusion of a dedicated value–ethical criterion, alongside the more commonly discussed cognitive and technological dimensions found in general digital-competence models.

National education-development strategies in Uzbekistan increasingly stress the digitalization of the educational process and the modernization of teacher-training curricula in line with global technological trends. Within this policy context, pedagogical higher-education

institutions are expected to prepare graduates capable not merely of using computers and standard office software, but of engaging critically and creatively with emerging technologies, including AI. The Information Technologies course within the Primary Education programme occupies a strategically important position in this respect, as it represents one of the primary institutional channels through which future primary school teachers can systematically develop AI-related competence before entering professional practice. The criteria system proposed in this article is designed to be directly applicable within the structure of this course, as well as within related pedagogical-practice modules.The review of theoretical frameworks presented above reveals a recurring pattern: virtually all contemporary models of teacher digital and AI competence combine (a) a knowledge dimension, (b) a practical-technological dimension, and (c) values or ethics as a distinct dimension, while pedagogical application and reflective growth are treated with varying degrees of explicitness. Building on this pattern, and adapting it specifically to the developmental needs of primary-school-age pupils, the present article proposes a five-criterion model that makes explicit all five dimensions — cognitive–knowledge, technological–practical, methodological–pedagogical, value–ethical, and reflective–developmental — as equally weighted, mutually reinforcing components of a single, integrated competence. This explicit five-part structure is intended to prevent the common pitfall, observed in some teacher-training programmes, of over-emphasizing technical skill at the expense of pedagogical judgement and ethical responsibility.

This methodological approach allows the proposed system to be both theoretically grounded and practically applicable. It is intended not as a final, closed classification, but as a flexible instrument that can be refined and empirically validated through subsequent pilot testing in the educational process of pedagogical higher-education institutions, including through student surveys, expert evaluation and analysis of learning outcomes. Based on the theoretical analysis presented above, the competence of prospective primary school teachers in the use of AI technologies can be assessed through five interrelated criteria, summarized in Table 1 and elaborated in the subsections that follow.

This criterion reflects the depth and systematicity of a future teacher’s theoretical knowledge about artificial intelligence. It includes understanding of basic AI concepts and terminology (such as machine learning, generative models, algorithmic bias), awareness of the didactic capabilities and limitations of specific AI tools relevant to primary education, and knowledge of how AI can support the formation of pupils’ literacy, numeracy and creative skills. A teacher with a high level of this criterion is able to explain, in accessible terms, how a given AI tool functions and what its appropriate pedagogical use might look like in a primary-school lesson.

This criterion reflects the practical ability to operate AI tools within real pedagogical activity. Its indicators include the skill of selecting AI tools appropriate to the age and developmental level of primary-school pupils, the ability to design digital learning materials and interactive tasks with the assistance of AI, and the ability to integrate AI applications into the structure of a lesson without disrupting its pedagogical logic or the coherence of the learning process. This criterion emphasizes not mere technical operation of software, but purposeful, curriculum-aligned application. This criterion captures the extent to which a future teacher is able to use AI in a pedagogically sound and methodologically justified manner. Indicators include the ability to differentiate and individualize instruction using AI-generated materials, the ability to design AI-supported formative assessment tasks that provide meaningful feedback to pupils, and the ability to combine AI-based methods with traditional primary-education methodologies rather than treating AI as a substitute for sound pedagogy. This criterion reflects a future teacher’s awareness of the risks and responsibilities associated with the use of AI among young children. Indicators include understanding of data-privacy and child-safety requirements when using AI-based platforms, the ability to critically evaluate the accuracy, appropriateness and potential bias of AI-generated content before presenting it to pupils, and the ability to model responsible, ethical digital behaviour that pupils can, in turn, learn to emulate.

This criterion reflects the future teacher's capacity for self-assessment and continuous professional growth in a rapidly evolving technological environment. Indicators include the ability to reflect on and realistically evaluate one's own level of AI competence, willingness to update knowledge and skills in line with new AI developments, and active participation in professional-development activities-seminars, workshops, self-directed learning - related to AI in education. In accordance with the criteria described above, three levels of AI competence can be distinguished among prospective primary school teachers: low (reproductive), medium (adaptive), and high (creative). Table 2 presents a detailed characterization of each level across all five criteria.

The low, or reproductive, level is characterized by fragmentary and superficial knowledge of AI, an inability to apply AI tools independently, the use of AI without clear pedagogical justification, limited awareness of ethical risks, and infrequent reflection on one's own competence. Students at this level require substantial guidance and structured support.

The medium, or adaptive, level reflects sufficient theoretical knowledge combined with the ability to use ready-made AI tools under guidance. Students at this level can partially align AI use with lesson goals, recognize ethical risks even if they do not always address them consistently, and periodically engage in self-assessment. This level represents a realistic target for the majority of students by the end of a well-designed training programme. The high, or creative, level is characterized by deep, systemic understanding of AI principles and their didactic potential, independent and pedagogically justified selection and adaptation of AI tools, the design of fully integrated, goal-aligned AI-supported lesson scenarios, consistent ethical and critical use of AI, and systematic self-development, including the capacity to mentor peers. This level should be regarded as an aspirational benchmark, attainable by the most motivated and digitally engaged students.

The practical value of any system of criteria and indicators depends on the availability of concrete diagnostic tools capable of measuring them. Table 3 summarizes a set of diagnostic instruments proposed for the assessment of prospective primary school teachers' AI competence, mapped to the criteria they are best suited to measure. It is recommended that these diagnostic tools be applied in combination, rather than in isolation, since each tool captures a different facet of the overall competence. For example, a knowledge test alone cannot reveal a student's practical ability to design an AI-supported lesson, just as a practical assignment alone cannot fully capture a student's ethical awareness. A comprehensive assessment strategy should therefore combine written, practical, reflective and observational components, administered at different stages of the training programme - for instance, as an initial diagnostic at the start of the Information Technologies course, formative assessments throughout the semester, and a final integrated assessment incorporating portfolio review and micro-teaching observation during pedagogical practice.

Discussion

The proposed system of criteria and indicators has several important implications for the organization of teacher training in pedagogical higher-education institutions. First, it suggests that curricula aimed at developing AI competence among future primary school teachers should not be limited to technical instruction in the use of specific software tools. Instead, such curricula should be designed to develop all five dimensions of competence in an integrated manner, with particular attention to the methodological–pedagogical and value–ethical criteria, which are often underemphasized in purely technology-focused training programmes.

Second, the differentiation of three levels of competence development provides a practical basis for individualized learning trajectories. Students who enter the programme at the low level may require additional foundational modules on AI concepts and basic digital tools, while students who already demonstrate a medium level may benefit more from advanced practical workshops focused on lesson design and ethical case analysis. This differentiated approach is consistent with contemporary pedagogical principles of personalized and student-centred learning.

Third, the proposed diagnostic tools can be integrated into the existing structure of the Information Technologies course and related pedagogical-practice modules without requiring a complete redesign of the curriculum. Knowledge tests can be incorporated into regular coursework, practical assignments can be embedded in seminar sessions, portfolios can be maintained throughout the entire period of study, and expert observation can be conducted during scheduled teaching-practice placements in partner schools. This integrative feasibility increases the likelihood that the proposed system can be adopted in real institutional contexts without excessive additional resource demands.

At the same time, several limitations of the present study should be acknowledged. The system proposed here is the result of theoretical analysis and synthesis rather than large-scale empirical validation. Future research should therefore focus on piloting the proposed criteria, indicators and diagnostic tools with actual cohorts of students, statistically analyzing the reliability and validity of the instruments, and refining the level descriptors based on empirical evidence. Comparative studies across different pedagogical institutions and different national contexts would also strengthen the generalizability of the proposed model. In order to translate the theoretical model presented above into concrete pedagogical practice, this section offers illustrative examples of how each criterion can be addressed within the Information Technologies course and related practicum activities for future primary school teachers. A feasible institutional implementation of the proposed system may follow a staged timeline within a single academic semester. In the first two to three weeks, an initial diagnostic assessment can be administered, combining a short knowledge test with the self-assessment questionnaire, in order to establish each student's baseline level across the five criteria. During the middle of the semester, practical assignments and case-study analyses can be used as formative assessment points, allowing instructors to provide targeted feedback and to adjust the pace and focus of instruction. Toward the end of the semester, a final integrated assessment can combine portfolio review, a culminating micro-teaching demonstration, and a repeated self-assessment questionnaire, allowing both students and instructors to observe measurable growth from the initial baseline. During subsequent pedagogical-practice placements in partner schools, expert or mentor-teacher observation can provide an additional, authentic-context data point, further validating the classroom-readiness of each future teacher's AI competence.

Conclusion and Recommendations

This article has proposed a comprehensive, five-component system of criteria cognitive–knowledge, technological–practical, methodological–pedagogical, value–ethical, and reflective–developmental — together with corresponding indicators, three levels of development, and a set of diagnostic tools for assessing prospective primary school teachers' competence in the use of artificial intelligence technologies. The proposed system addresses an important gap in the methodology of pedagogical higher education by providing a structured, theoretically grounded and practically applicable framework for diagnosing, developing and certifying this competence. Based on the analysis presented in this article, the following recommendations can be formulated for pedagogical higher-education institutions engaged in the training of future primary school teachers. First, the Information Technologies course, and related disciplines, should be redesigned to explicitly address all five criteria of AI competence rather than focusing narrowly on technical skills. Second, diagnostic instruments aligned with the proposed criteria should be integrated at multiple stages of the training programme, from initial diagnosis to final certification. Third, particular institutional attention should be devoted to the value–ethical criterion, given its critical importance for the safe and responsible use of AI with young children. Finally, the proposed system should be treated as a living framework, subject to ongoing empirical refinement as AI technologies and their educational applications continue to evolve.

In sum, the systematic, criterion-based assessment of AI competence among prospective primary school teachers is not merely a matter of academic interest, but a practical necessity for ensuring that the next generation of primary educators is fully prepared to meet the challenges and opportunities of the digital transformation of education.

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