

2.3. INTELLIGENT EDUCATIONAL SYSTEMS AS A TOOL FOR MODERNISING MECHANISMS FOR ENSURING THE QUALITY OF VOCATIONAL AND PROFESSIONAL PRE-HIGHER EDUCATION

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The digital transformation of education drives the shift from paper-based documentation to integrated intelligent systems for managing educational data, which is especially relevant for vocational and pre-higher education under conditions of high learner mobility and an unstable educational environment. Intelligent educational systems (IES) provide personalized learning, automated assessment, and support for managerial decision-making based on big data analytics and artificial intelligence algorithms. The use of learning analytics enables early identification of academic risks, adaptation of learning trajectories, and increased transparency of internal quality assurance procedures. Effective integration of IES requires the development of a regulatory framework, digital maturity of educational institutions, and training of instructors and administrative staff. Beyond technical aspects, ethical standards, cybersecurity, and equal access to digital resources are essential. Implementing IES transforms educational process management and contributes to enhancing the efficiency, transparency, and resilience of the education system in the digital era.

Keywords: *digital transformation, intelligent educational systems, recognition of learning outcomes, digital micro-credentials, educational integration*

The digital transformation of education necessitates a shift from traditional paper-based documentation to integrated intelligent systems for managing educational data. In this context, the modernization of quality assurance mechanisms in vocational and professional pre-higher education acquires strategic importance, especially under martial law conditions characterized by increased learner mobility, the expansion of distance and blended learning formats, and the instability of the educational environment (Radkewycz & Pryhodij, 2025).

The application of a data-driven management approach involves the use of educational analytics systems and intelligent algorithms to process large volumes of data, enabling timely monitoring of learning outcomes, identification of risks of academic underachievement, and support for managerial decision-making based on objective indicators (Hegde et al., 2025, p. 7). Such an approach contributes to enhancing the transparency of internal quality assurance procedures, shifting from formalized reporting

to analytically grounded management, and fostering a digital educational environment in which the results of educational activities become the basis for improving educational programs and the strategic development of the educational institution.

The contemporary global scholarly discourse on the transformation of vocational and professional pre-higher education is characterized by a shift in focus toward the intellectualization of educational processes and the implementation of intelligent educational systems as tools for personalized learning. The concept of intelligent educational environments is associated with the transition to ubiquitous learning and the design of new pedagogical models based on adaptability and digital integration (Gros et al., 2016, pp. 3-23). Within this approach, intelligent tutors provide not only the automation of learning content delivery but also the adaptation of educational scenarios to the individual cognitive characteristics of the learner, the dynamics of their progress, and their learning style (Roll & Wylie, 2016, pp. 590–591).

A significant analytical tool supporting such systems is learning analytics, which is viewed as a means of systematically collecting, processing, and interpreting educational data to enhance learning effectiveness (Ifenthaler & Yau, 2020, p. 1984). Contemporary studies confirm that the use of analytics dashboards and predictive models makes it possible to identify academic risks at early stages and implement timely managerial interventions (Viberg et al., 2018, pp. 106, 108). In this context, comprehensive approaches to assessing the digital readiness of educational institutions are being developed, integrating indicators of institutional capacity for data-informed management (Chounta et al., 2024, p. 8).

A distinct research vector concerns the application of artificial intelligence to transform mechanisms of internal and external quality assurance in education. Scholarly literature emphasizes the potential of AI-driven quality assurance as a means of shifting from predominantly expert-subjective evaluation procedures to the analytics of large data sets, enabling more objective and evidence-based decision-making (Luckin et al., 2016, pp. 35–36). Systematic reviews demonstrate a rapid growth of research devoted to the use of AI in the educational sector while also highlighting the need to integrate the pedagogical dimension into technological solutions (Zawacki-Richter et al., 2019, p. 21).

The synergy of Big Data and machine learning methods opens up opportunities for building comprehensive models of learners' educational behavior, which within the concept of educational data mining is interpreted as the creation of a conditional “digital profile” (Pryhodii et al., 2022) or a student “digital twin” (Kartashova et al., 2024). In a broader socio-political dimension, such processes are associated with the formation of new digital modes of educational governance, where data become a key resource of education policy (Williamson, 2017, pp. 44–48).

At the same time, the development of intelligent educational systems is accompanied by a number of ethical challenges, particularly regarding algorithm transparency, the prevention of discriminatory practices, and the protection of learners' personal data (Holmes et al., 2019, p. 174). The issue of the ethical use of learning analytics and the need to establish clear principles of privacy are thoroughly substantiated in the works of Pardo and Siemens (2014), who emphasize the importance of balancing analytical effectiveness with respect for the rights of participants in the educational process.

The managerial dimension of the digital transformation of education is associated with the transition to evidence-based management, which involves making strategic decisions based on systematic data analytics. The development of the digital maturity of vocational and professional pre-higher education institutions is considered a prerequisite for the effective integration of intelligent tools into quality assurance systems (Chounta et al., 2024, p. 14; Viberg et al., 2018, p. 98). Research on educational technologies also indicates the growing role of digital environments in enhancing student engagement (Bond et al., 2020, pp. 12–13).

Empirical studies confirm the positive impact of intelligent and digital learning environments on learning outcomes. In particular, the meta-analysis by Chen and Liu (2024) demonstrates a statistically significant effect of smart classroom technologies on learners' academic achievement (pp. 13–14). At the same time, the effectiveness of such systems largely depends on the quality of feedback, which, according to the concept of Hattie and Timperley (2007), is a key factor in learning progress (pp. 86, 90–101).

Overall, the integration of intelligent educational systems into quality assurance mechanisms is viewed not only as a technological modernization but as a paradigmatic shift in the model of educational governance in the context of digitalization. This process is accompanied by critical reflection on the role of technologies in rethinking teachers' professional activity and the institutional autonomy of educational institutions (Selwyn, 2019), highlighting the need for a comprehensive interdisciplinary approach to modernizing quality assurance systems.

Despite the rapid development of digital technologies and the growing interest in the application of artificial intelligence in education, intelligent educational systems remain insufficiently integrated into the official procedures for licensing educational institutions and accrediting educational programs. Existing mechanisms of external and internal quality assurance are primarily focused on documentary verification of compliance with standards and formalized indicators, while the potential of educational analytics and automated assessment of learning outcomes is utilized only fragmentarily (Verkhovna Rada of Ukraine, 2021a).

In the Ukrainian vocational and professional pre-higher education sector, there is a lack of comprehensive conceptual models for implementing intelligent systems within the structure of internal quality assurance. Scholars emphasize that modernizing quality management requires a shift toward analytically grounded decision-making and the digitalization of procedures for monitoring educational outcomes (Hurzhii et al., 2025b). At the same time, a teaching and methodological manual on the digitalization of the educational process highlights the need to create integrated digital tools for recording and assessing learners' achievements, in particular through the implementation of electronic portfolios and automated data collection systems (Pryhodii et al., 2023, pp. 261–313).

Regulatory and methodological gaps in the use of artificial intelligence for assessing learning outcomes limit the possibilities for the legitimate application of automated algorithms in state oversight procedures. Ukrainian education legislation defines the general principles of quality assurance but does not include clear mechanisms for integrating educational analytics tools and AI systems into official monitoring procedures (Verkhovna Rada of Ukraine, 2017a). This results in a kind of regulatory vacuum, within which digital innovations are implemented locally, without systematic alignment with state standards and accreditation criteria.

Researchers of the digital transformation of vocational education emphasize that the effective integration of intelligent systems requires the development of clear regulatory frameworks, standards for the digital maturity of educational institutions, and procedures for verifying algorithmic decisions (Radkevych et al., 2025, pp. 15–16). Without appropriate regulatory support, automated assessment risks remaining an auxiliary tool with no legally defined status within the quality assurance system.

Thus, the lack of systematic regulation for the use of IES in licensing and accreditation procedures hinders the modernization of quality assurance mechanisms in vocational and professional pre-higher education. Bridging this gap requires the development of a conceptual model for integrating AI into the state quality monitoring system, the harmonization of the regulatory framework, and the implementation of standards for evidence-based (data-informed) management of the educational process.

An intelligent educational system is defined in contemporary scholarly literature as a complex hardware–software environment capable of dynamically adapting to the individual needs of the user based on artificial intelligence algorithms and machine learning technologies (Luckin et al., 2016, p. 18; Zawacki-Richter et al., 2019, p. 19). The key distinction of an IES from traditional learning management systems (LMS) is its three-component structure, which includes:

Student model – a profile of knowledge, cognitive styles, and psychotype that enables the prediction of a learner's behavior and educational needs (Baker, 2019, pp. 9–10; Holmes et al., 2019, pp. 97–98).

Subject area model – a knowledge ontology that structures learning content and defines the relationships between concepts (Chen & Liu, 2024, p. 2).

Pedagogical model – a teaching strategy that governs the individualization of the educational process and provides interactive real-time feedback (Hattie & Timperley, 2007, pp. 88–90; Roll & Wylie, 2016, p. 587).

This approach enables the system to function as a personalized tutor, simulating the behavior of an experienced educator and supporting active learning in the dynamic conditions of the educational process (Chounta et al., 2024, p. 6).

By functional purpose, IES can be classified into several main categories:

1. Adaptive platforms – adjust the complexity of content based on the learner’s performance and progress, providing a personalized learning trajectory (Ifenthaler & Yau, 2020, pp. 1981–1982).

2. AI-driven decision support systems – assist administration in optimizing educational programs and resource planning (Bond et al., 2020, pp. 4–6; Hegde et al., 2025, p. 15).

3. Advanced educational analytics tools – allow visualization of hidden learning patterns, prediction of academic failure risks, and the formation of evidence-based decisions to improve educational processes (Viberg et al., 2018, p. 108; Williamson, 2017, pp. 28–32, 35–37).

4. Intelligent assessment systems and digital tutors (chat assistants) – automate routine communication, knowledge assessment, and provide rapid feedback, minimizing the human factor and enhancing learning efficiency (Luckin et al., 2016, p. 24; Chen & Liu, 2024, pp. 2–3).

The foundation of modern IES lies in machine learning and big data analytics technologies, which enable the system to autonomously improve based on experience gained from user interactions (Baker, 2019, pp. 4, 8, 10; Holmes et al., 2019, pp. 87–93). Natural language processing methods open up possibilities for automated assessment of open-text responses and essays, which previously could only be evaluated by humans (Roll & Wylie, 2016, pp. 584–586; Chen & Liu, 2024, pp. 2, 12). In addition, predictive analytics becomes an indispensable tool for the early identification of academic failure risks, allowing learners who require additional support to be identified in a timely manner before critical learning gaps occur (Ifenthaler & Yau, 2020, pp. 1980–1981; Hegde et al., 2025, p. 15).

Before integrating IES into vocational and professional pre-higher education institutions, it is important to understand their multi-level impact. intelligent educational system do not merely automate processes – they create an environment for continuous monitoring, analysis, and adaptation of learning, enabling the personalization of educational trajectories and enhancing the effectiveness of managerial decisions. In other

words, intelligent educational system become a bridge between data, pedagogical strategies, and the strategic management of the institution (Table 2.4).

Table 2.4. Intelligent educational systems as a tool for modernisation

Application Area of IES	Description and Functions
Transformation of the internal quality assurance system	Transition from one-time inspections to continuous automated monitoring. Collecting and processing data on student activity allows for the personalization of learning trajectories and the adjustment of programs based on progress. This enhances resource management flexibility and transparency in quality control.
Intelligent support for managerial decisions	Use of interactive dashboards and analytics for instant identification of problem areas in learning. Scenario modeling for institutional development allows assessment of risks when launching new programs or methodologies. Data-driven management ensures the effectiveness of strategic decisions.
Automation of assessment procedures	Implementation of electronic portfolios and AI-based automated testing systems ensures objectivity and transparency in evaluation. Students receive immediate feedback, while instructors are relieved from routine tasks. Digital traces are used to adapt materials in real time.
Educational analytics as a quality management tool	Implementation of evidence-based policy through in-depth analysis of student activity data. Predictive models forecast risks of academic failure, enable program adaptation to labor market needs, and identify in-demand skills. This increases management efficiency and supports continuous improvement of education quality.

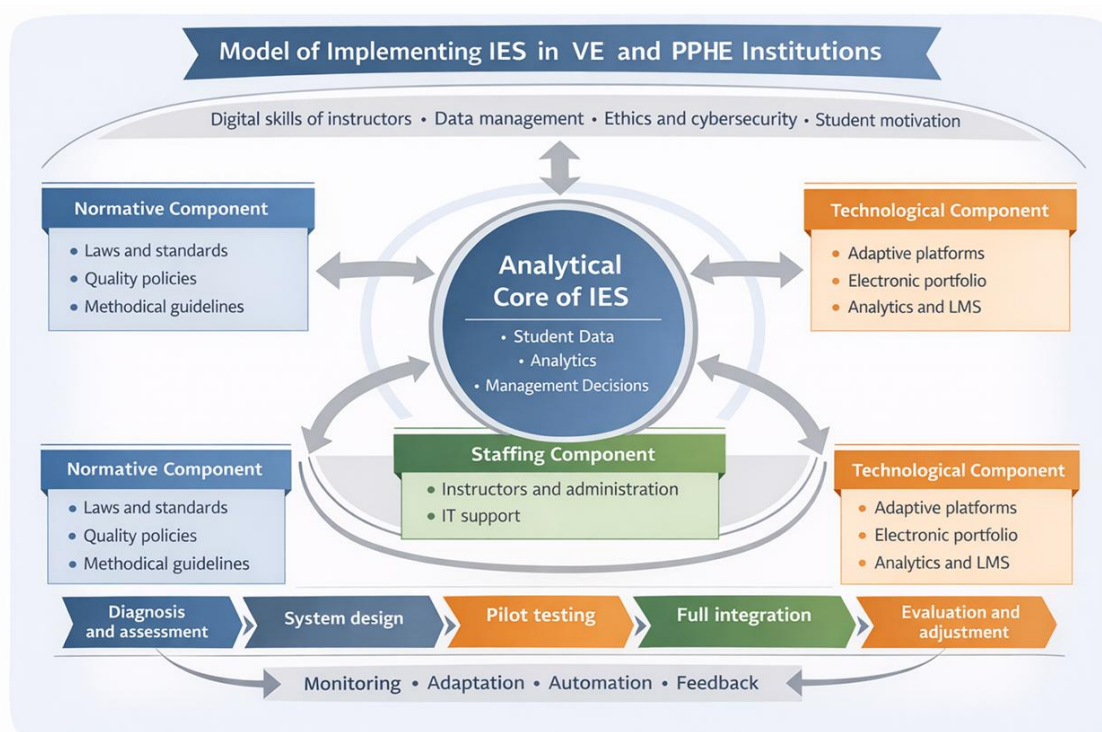
The proposed conceptual model for implementing IES in vocational and professional pre-higher education institutions is based on a triune approach, integrating regulatory, technological, and human resource components into a unified educational ecosystem (Figure 2.2):

The *regulatory component* encompasses the legal, methodological, and standard frameworks that govern the internal quality assurance system, the responsibilities of instructors and administration, as well as the rules for handling digital data and electronic resources.

The *technological component* involves the architecture of the IES, which includes a knowledge management module, an adaptive learning engine, an analytics system, and integration with students' electronic portfolios. It provides continuous collection, processing, and analysis of learning data in real time, enabling the creation of personalized learning trajectories and the rapid adjustment of educational programs.

The *human resource component* focuses on the digital and pedagogical competence of instructors, the administration's readiness to manage data and innovative technologies, and the involvement of IT specialists to support the system's infrastructure.

Figure 2.2. Conceptual model for the implementation of IES in vocational and professional pre-higher education institutions



These three elements are interconnected through the system's analytical core, which consolidates data on student progress, teaching effectiveness, and the outcomes of managerial decisions. The core ensures flexible interaction between components, allowing the educational program to be adapted to student needs, labor market requirements, and quality standards.

The implementation of IES in vocational and professional pre-higher education institutions occurs sequentially and includes several key stages:

Stage 1: infrastructure diagnosis – assessment of existing equipment, network resources, the digital literacy of instructors and administration, and the compliance of internal regulations with quality standards.

Stage 2: system architecture design – identification of the key IES modules, integration with LMS, digital libraries, and databases, and the creation of adaptive learning and analytics algorithms.

Stage 3: pilot testing – verification of the system modules’ functionality on a limited sample of students and courses. At this stage, feedback from students and instructors is collected, and the effectiveness of adaptation and predictive algorithms is analyzed.

Stage 4: full integration into the educational process – gradual implementation of the system across all institutional units, connection of electronic portfolios, interactive dashboards, and automated assessment tools.

Stage 5: evaluation and adjustment – regular analysis of IES performance, updating adaptation algorithms and management models, and taking into account changes in the regulatory environment and labor market needs.

Each stage includes quality control and feedback mechanisms, which ensure the continuous improvement of educational practice and the system’s resilience to external challenges, such as changes in curricula or employer requirements.

The effectiveness of IES depends on a range of pedagogical and organizational conditions:

- digital and pedagogical competence of instructors – the ability to use IES for personalized learning, data analysis, and generating recommendations for students;
- administration readiness to work with AI – includes data management, analytics-based decision-making, and modeling institutional development scenarios;
- adherence to ethical standards and cybersecurity – protection of students’ and instructors’ personal data, ethical use of predictive and assessment algorithms, and ensuring transparency in decision-making;
- student motivation and support – involves training students to use digital platforms, understand the principles of adaptive learning, and actively participate in the assessment process.

The system becomes effective only when technologies, people, and processes operate in synchrony, and the institution’s leadership fosters a culture of data use for decision-making and continuous improvement of education quality.

The main challenges in implementing intelligent educational systems include algorithmic bias in artificial intelligence, which can lead to unfair assessment or discrimination against certain student groups. This requires the development of transparent algorithms, ongoing model auditing, and system adjustments in accordance with ethical standards. Another critical aspect is ensuring the confidentiality and security of personal data in cloud and online services, as centralized storage of large volumes of information makes them potential targets for cyberattacks.

In addition to technical and ethical challenges, the socio-pedagogical factor is also important. Teaching staff may often resist changes due to a lack of digital competence or fear of losing control over the learning process. Therefore, a critical condition for successful implementation is the systematic training of instructors, digital literacy workshops, and the creation of a supportive environment for sharing experience.

Equally important is the issue of digital infrastructure: uneven access to high-speed internet and modern computing resources across regions can limit the effectiveness of IES and create additional barriers for students. This requires an integrated approach, including government support for the development of digital networks, the establishment of local server solutions, and offline access to educational materials.

The practical implementation of the model requires a comprehensive approach, which includes updating the regulatory framework, establishing local educational analytics centers, developing human resources, and enhancing the digital literacy of instructors and administration. Additionally, adherence to ethical standards, protection of personal data, and ensuring equal access to digital resources for students across different regions are essential.

The successful implementation of IES in vocational and professional pre-higher education institutions requires a comprehensive approach to addressing technical, ethical, and social challenges, combining technological innovation with the enhancement of instructors' digital competence, the provision of cybersecurity, and equal access to resources for all participants in the educational process.

Thus, the integration of IES into vocational education institutions not only modernizes quality assurance mechanisms but also transforms the paradigm of educational process management, ensuring the efficiency, transparency, and resilience of the education system in the digital age.