THEORETICAL ASPECTS OF MEASURING DIGITAL COMPETENCE OF EDUCATIONAL MANAGERS

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Abstract. The chapter addresses the theoretical foundations of measuring the digital competence of educational managers in the context of educational digital transformation, the expansion of data-driven governance, artificial intelligence, cloud services, electronic document flow and ethical challenges of digitalisation. The relevance of the study is determined by the growing need for educational leaders who are able not only to use digital tools, but also to guide institutional digital change, ensure safe and inclusive digital environments, and make evidence-informed decisions. *The purpose* of the chapter is to substantiate the structure, criteria, indicators and levels for measuring the digital competence of educational managers. *Methodology of the study.* The research is based on theoretical analysis, synthesis and comparison of international digital competence frameworks, strategic and regulatory documents, and recent Ukrainian and international studies on digital competence, digital leadership and educational management. The study also employs systematisation, conceptual modelling and criteria-based generalisation. *Results.* The chapter defines the digital competence of educational managers as an integrative professional and managerial characteristic combining digital literacy, managerial and analytical skills, value-based and ethical responsibility, readiness for innovation and the ability to exercise digital leadership. A six-component structure is proposed, comprising strategic-leadership, organisational-managerial, technological, pedagogical, socio-ethical, and reflective-innovative components. The chapter further substantiates three criteria for measuring its formation: cognitive-content, operational-activity, and motivational-reflective. For each criterion, relevant indicators, diagnostic methods and four levels of

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formation are described. *Practical implications.* The proposed structure and criteria-level approach may be used in higher education programmes for educational managers, in the design of diagnostic tools, digital competence assessment tasks, professional development trajectories and curricula related to educational management. *Value/originality.* The chapter offers an integrated model for measuring digital competence that connects strategic, technological, pedagogical, ethical and innovative dimensions of educational management and adapts international digital competence frameworks to the professional profile of educational managers.

INTRODUCTION

The concept of the digital competence of educational managers is currently attracting the attention of international educational organisations, researchers, education policy-makers, teachers, economists, representatives of business and other stakeholders. A number of international documents are particularly relevant to the professional training of educational managers, including the development of their digital competence.

Promoting Effective Digital-Age Learning: A European Framework for Digitally-Competent Educational Organisations (DigCompOrg) [12] addresses the digital competence of organisations, including educational institutions. In this respect, the formation of digital competence moves to the level of organisational strategies, infrastructure and leadership;

The European Framework for the Digital Competence of Educators (DigCompEdu) [22] is also important for educational managers and heads of educational institutions, since they are expected to understand the pedagogical logic of digital technologies and to provide the organisational conditions required for its implementation;

The UNESCO framework Six Pillars for the Digital Transformation of Education [32] provides a common framework for governments and partners aimed at supporting a coherent, inclusive and sustainable digital transformation. This document makes it possible to view the digital competence of educational managers as a competence of systemic digital leadership;

The UNESCO report Artificial Intelligence and Digital Transformation: Competences for Civil Servants (2022) [6] identifies a range of cross-cutting competences that affect the work of civil servants in the context of societal

digital transformation, including digital leadership, digital literacy, open data and artificial intelligence. In effect, the report constructs a systemic vision of digital governance.

Ukrainian documents also require attention. The Digital Competency Framework for Civil Servants of Ukraine [23] identifies the implementation of digitalisation policy at the state, organisational and personal levels as a separate competence. The professional standard Head (Director) of a General Secondary Education Institution (2021) formally establishes information and digital competence as a separate competence of a school leader [16, p. 11].

The content and structure of the phenomenon under study have been addressed in numerous works by Ukrainian and foreign scholars, including A. Barbinova, H. Bodom, V. Dehtiarov, O. Zasimovych, A. Zelinska, L. Tarasovych and S. Lavrynenko, O. Zolochevska, Ye. Kalinichenko and S. Kubitskyi, Ya. Karlinska, N. Mukan, A. Helesh and D. Bondin, V. Osadchyi, O. Fedorchuk and O. Sukhovirskyi, as well as A. Uzorka and K. Kalabuki, N. Hamzah, N Radzi and I. Omar, among others.

Thus, the formation and development of the digital competence of educational managers, heads of educational institutions and educational leaders is highly relevant, since the effectiveness and practical impact of the digital transformation of education depend largely on this category of educational professionals.

1. The Structure and Content of the Concept "Digital Competence of Educational Managers"

Before formulating our own definition of the digital competence of educational managers, it is necessary to consider how this concept is interpreted by contemporary Ukrainian and international scholars. Ye. Kalinichenko and S. Kubitskyi define the digital competence of heads of educational institutions as an integrated professional characteristic that includes the knowledge, skills and attitudes necessary for the effective use of digital technologies in strategic management. We share the view that digital competence is part of the general professional competence of a leader and includes such aspects as the ability to analyse large amounts of data for decision-making, implement information and communication technologies in administrative processes, ensure digital security and develop

an innovative environment in order to strengthen the intellectual capital of an educational institution [11, p. 1396].

Ye. Kalinichenko and S. Kubitskyi also propose a structural model of the digital competence of heads of educational institutions, which comprises four levels: gnoseological (the necessary set of knowledge for processing digital information, applying technologies in management and mastering the terminology of digital resources); motivational and value-based (attitudes towards the use of digital tools in leadership, readiness to adapt to new technologies and understanding the importance of digitalisation for improving the quality of management processes); activity and technological (skills in working with digital platforms for data analysis, creating and disseminating content, and solving management and educational tasks using digital tools); and resultative-reflective (assessment of one's own level of digital competence, awareness of oneself as part of a digital educational environment and ability to improve digital skills) [11, p. 1398].

V. Dehtiarov offers a professionally oriented definition of the digital competence of bachelors in management as an integrated set of knowledge, skills, abilities and attitudes that enables managers to use modern information technologies effectively for organisational management, decision-making, communication, data analysis and optimisation of business processes. It is a key component of professional activity under conditions of digital business transformation and ensures the ability to use digital technologies effectively for organisation, management, data analysis and communication. The main components of this phenomenon include information literacy; digital communication and collaboration; technological awareness; analytical thinking and data work; cybersecurity; creativity and innovation; digital leadership; knowledge of digital marketing tools; flexibility and adaptability; and ethical aspects of digital activity [4, p 42].

The scholar also identifies several digital technologies that are appropriate for use in management education to form specialists' digital competence: learning management systems such as Moodle, Canvas or Google Classroom; analytical and business simulators; cloud services and collaboration platforms such as Google Workspace, Microsoft 365, Trello and Miro; tools for data work, including spreadsheets, CRM systems and BI platforms; and multimedia and interactive resources, such as videos, podcasts, interactive presentations and virtual laboratories [5, p. 70].

In addition, V. Dehtiarov singles out project-based learning, the case method, interactive and distance learning, simulations and business games, information and analytical exercises, and collaborative and team methods as methods for forming the digital competence of bachelors in management [5, p. 71].

O. Zolochevska and H. Bodom examine the essence and structure of the digital competence of heads of general secondary education institutions. They define it as an integrated personal characteristic that includes the ability to use digital technologies effectively for planning, organising, monitoring and evaluating the educational process, managing staff and institutional resources, and combining technical knowledge with managerial, communicative, ethical and reflective skills [36, p. 100]. The authors interpret the structure of digital competence through several interacting components: cognitive, operational-activity, communicative, motivational-value and reflective [36]. We fully agree with their position that the development of digital competence in school leaders is a continuous process involving the gradual formation of knowledge, skills and abilities related to digital management, as well as the capacity to adapt to technological change.

A. Barbinova, studying the specificity of the information and digital competence of educational managers, emphasises that the formation of this quality enables purposeful, independent and responsible use of information and digital technologies in professional activity, taking into account existing opportunities and limitations, including the technical and technological parameters of digital technologies, the objectives of teaching and upbringing within a particular educational institution, and the professional and personal qualities of the educational manager [1, p. 411].

Ya. Karlinska rightly notes that the formation of the digital competence of heads of educational institutions should be viewed as a continuous process of professional development oriented towards digital leadership, change management, data and digital infrastructure management, and support for teachers and learners. For the head of an educational institution, digital competence acquires a managerial dimension and is transformed into digital leadership: the ability to form a vision of digital development, build a strategy, create a culture of innovation, ensure inclusion and security, support teachers' professional growth and assess the impact of digital solutions [13]. Ya. Karlinska models the digital competence of heads

of educational institutions as an integrated characteristic comprising three interrelated blocks. The personal-professional block includes individual digital literacy and culture, including information, data and media literacy, criticality, digital communication, collaboration, digital citizenship, digital content creation, safety and privacy. The managerial-organisational block covers digitalisation of management, digital tools for planning, document flow and monitoring, organisation of the digital environment, regulations, user support, risk management and compliance. The leadership-strategic block includes digital leadership and change, a shared vision, strategy and change-assessment cycle, the development of teachers' capacities through professional communities, training and mentoring, and the management of organisational digital maturity and evidence-based decision-making [13, p. 705]. The author indicates that this structure is consistent with the professional standard for heads of general secondary education institutions, DigComp 2.2, the Council Recommendation on key competences for lifelong learning, and the ISTE Standards for Education Leaders.

International research makes it possible to clarify the managerial content of the digital competence of educational managers, particularly through the categories of digital leadership, organisational digital maturity, change management and evidence-informed decision-making. C. Tømte [29] conceptualises professional digital competence for school leaders, arguing that leaders' digital competence includes both administrative and pedagogical leadership. Based on the study of digital transformation in Norwegian education, school leadership and teachers' digital competence, Tømte identifies the following areas of responsibility for school leaders: ensuring a safe and reliable educational environment for learners and teachers; maintaining a balanced resource base, including both digital and analogue resources; mastering emerging technologies such as generative AI; updating knowledge and skills; demonstrating resilience in addressing challenges; dealing with privacy and information security; coordinating with other educational leaders to interpret the broader goals of digital transformation and national curricula; and aligning these goals within the local school context while guiding teachers' digital development [29].

J. Reis-Andersson [24] presents Swedish experience of the impact of digital transformation on managerial visions of digitalisation and emphasises that the formation of the digital competence of educational

managers and heads of educational institutions is a necessary condition for digital educational change. The OECD Review of Digital Education Policy in the Netherlands [19] analyses Dutch experience in digital education in primary and secondary schools, examining national policy, its strengths and challenges, and further reform steps. In the Netherlands, digital leadership by school leaders and school boards is considered a key condition for effective digital transformation. Consequently, the digital competence of educational managers is understood not merely as the ability to use platforms, but as the capacity to manage investments, resources and the development of digital learning strategically. Continuous professional development for teachers and leaders also becomes essential, and digital competence is built as an ongoing professional pathway rather than a one-off training activity.

The OECD report shows that, in the Dutch experience, the school leader or educational organisation leader acts as an intermediary between public policy and school practice, while the digital competence of an educational manager is conceived as a combination of strategic, pedagogical, financial and organisational leadership [19]. F. Navaridas-Nalda et al. analyse educational leadership in Spanish schools and examine the key factors of successful digital transformation driven by the strategic leadership of principals. They demonstrate the need to take into account age, leadership experience, school size and complexity, and the school's digital culture. Their important conclusion is that educational managers promote the digital transformation of education not primarily through formal authority or bureaucratic influence, but through their ability to foster open discussion [18].

German researchers J. Witthöft, B. Aydin and M. Pietsch [34] emphasise that school digitalisation requires specific forms of educational leadership and strategic knowledge management to address current and educational challenges. They also demonstrate the relationship between school leaders' open-innovation mindset, transformational leadership, knowledge-management practices and influence on digital innovation. This points to such structural components of educational managers' digital competence as organisational culture, innovativeness and change leadership [34].

The School Leader Digital Learning Guide [20], published in the United States, highlights several distinctive features of American educational management: decentralised governance, whereby educational management

is not viewed as a rigidly unified hierarchy but as a system of many local centres of decision-making; a pragmatic managerial logic in which the leader is not only a pedagogical leader but also a full-cycle manager who must design a model, find resources, implement it, support it and adjust it; a strong emphasis on learner agency, personalised learning and mastery; attention to digital equity; support for learners with disabilities, diverse learning needs and language needs; responsible protection of privacy in accordance with U.S. legislation; the formation of a leadership team with clearly distributed roles; and an emphasis on practicality and self-assessment.

Thus, the digital competence of an American educational manager appears not as narrow IT training, but as a combination of strategic planning, budgeting, infrastructure organisation, teacher support, protection of learners' rights and the provision of equitable access to digital learning. Analysis of the studies discussed above allows us to conclude that the European approach to the digital competence of educational managers is largely based on frameworks of organisational digital maturity, policy coherence and strategic governance of digital transformation. The American approach, by contrast, places stronger emphasis on the leader as a practical change agent responsible for planning, financing, implementation, support and adaptation of digital learning in a specific educational context. Therefore, the European tradition tends towards the systemic and institutional dimension of digital competence, while the American tradition emphasises the applied, role-based and operational-managerial dimension.

On the basis of the analysis of Ukrainian and international strategic, regulatory and framework documents concerning the development of digital competence, as well as recent scholarly literature, we define the *digital competence of educational managers as an integrative professional and managerial characteristic that combines digital literacy, managerial and analytical skills, value-based and ethical responsibility and readiness for innovation, and that enables specialists to exercise digital leadership, manage the digital transformation of an educational organisation, make evidence-informed decisions based on data, and develop a safe, inclusive and technologically capable educational environment*.

In our view, the digital competence of an educational manager comprises several interrelated dimensions: strategic-leadership, reflected in the ability to form a digital vision, plan change, coordinate stakeholders and

implement digital development policy; organisational-managerial, reflected in the ability to create a digitally capable educational environment, develop infrastructure, manage resources, data, privacy and security; pedagogical, reflected in an understanding of how digital technologies affect teaching, learning, assessment and the development of the digital competence of teachers and learners; socio-ethical, aimed at ensuring inclusion, equal access and responsible, lawful use of technologies; and reflective-innovative, reflected in readiness for continuous professional development, mastering new technologies and managing innovation.

Accordingly, the structure of the digital competence of educational managers should be considered as an integrated system of strategic-leadership, organisational-managerial, technological, pedagogical, socio-ethical and reflective-innovative components, each of which is manifested at the cognitive, activity and value-reflective levels.

Table 1

Structure of the Digital Competence of Educational Managers: Characteristics of the Components at the Cognitive, Activity and Value-Reflective Levels

№	Characteristics of the cognitive level / knowledge	Characteristics of the activity level / skills	Characteristics of the value-reflective level / attitudes and position
1	2	3	4
1	**Strategic-leadership component**		
	Knowledge of the essence of the digital transformation of education, its strategic goals, regulatory guidelines, models of digital leadership, digital policy of an educational institution, principles of long-term planning, strategic foresight, change management, and the role of artificial intelligence, data, cybersecurity and digital innovations in the development of an educational organisation.	Ability to form a digital vision for the development of an educational institution; develop a digital strategy, roadmap and system of indicators for its implementation; align digital initiatives with the educational mission and the needs of learners, teachers and the community; organise teamwork, engage stakeholders, manage change and support innovation processes.	Awareness of digital transformation as a human-centred, ethical and strategic process rather than merely a technical upgrade; readiness to assume leadership responsibility for the digital development of an educational organisation; orientation towards transparency, partnership, inclusion, trust, sustainability and the social value of digital solutions.

End Table 1

1	2	3	4
2	**Organisational-managerial component**		
	Knowledge of the digital infrastructure of an educational institution, educational platforms, electronic document flow, digital services, principles of data protection, resource management, digital monitoring, assessment of effectiveness and financial sustainability of digital solutions.	Ability to organise digital management processes; use digital tools for planning, communication, document flow, monitoring, reporting and managerial decision-making; coordinate the implementation of platforms and services; analyse educational data and use it to improve management quality.	Recognition of the value of evidence-based, transparent and responsible management; orientation towards safety, confidentiality, efficiency, equitable distribution of digital resources and accessibility of the digital educational environment for all participants in the educational process.
3	**Technological component**		
	Knowledge of modern digital technologies, educational platforms, cloud services, learning and institutional management systems, electronic document flow, digital communication tools, data analytics, artificial intelligence, cybersecurity tools, technical requirements for digital infrastructure and principles of interoperability of digital systems.	Ability to select and use digital tools for managerial, educational, communicative and analytical activities; work with collaboration services, visualisation and information-analysis tools; evaluate the functionality, accessibility, security and appropriateness of digital solutions for the needs of an educational institution.	Awareness of technologies as a means of improving the quality, accessibility and effectiveness of education, not as an end in themselves; responsible attitude to the selection of digital tools with due regard to pedagogical appropriateness, safety, inclusion, data protection, ethics, economic justification and sustainability of technological solutions.
4	**Pedagogical component**		
	Knowledge of digital pedagogy, digital didactics, models of blended and online learning, digital educational resources, digital assessment, learning analytics, personalised learning, inclusive design, and ways of developing the digital competence of teachers and learners.	Ability to support teachers in selecting and using digital resources; organise a digital learning environment; facilitate the implementation of technologies in teaching, learning and assessment; coordinate teachers' professional development in the field of digital technologies.	Awareness of the priority of pedagogical appropriateness over technological novelty; readiness to support high-quality, inclusive, personalised and active learning; critical attitude towards digital tools in terms of their impact on learners' development, pedagogical interaction and educational outcomes.

End Table 1

1	2	3	4
5	**Socio-ethical component**		
	Knowledge of digital rights and responsibilities, academic integrity, copyright and licensing, cybersecurity, personal data protection, digital identity, digital behaviour, media literacy, ethical use of AI, digital well-being and ecological aspects of digitalisation.	Ability to create a safe, ethical and inclusive digital environment; develop rules for digital interaction; prevent risks related to privacy violations, cyber threats, academic dishonesty, digital discrimination and disinformation; ensure responsible use of data and artificial intelligence.	A stable position regarding the protection of human dignity, privacy, the rights of participants in the educational process and education as a public good; responsible attitude to digital safety, ethics, fairness, non-discrimination, well-being and environmental sustainability of digital solutions.
6	**Reflective-innovative component**		
	Knowledge of approaches to assessing the digital maturity of an educational organisation, identifying digital competence gaps, monitoring innovations, researching educational practice, professional self-development, analysing the effectiveness of digital solutions and forecasting new technological trends.	Ability to carry out self-assessment and assessment of the team's digital competence; analyse the results of implementing digital technologies; pilot innovations; adjust digital strategies based on data and feedback; initiate professional learning, exchange of experience, research and innovation projects; adapt digital practices to new conditions.	Readiness for continuous professional development, critical reflection on one's own managerial decisions and openness to innovation; acceptance of uncertainty as a condition for development; desire to improve the digital culture of an educational institution, experiment, co-create and implement new technologies responsibly.

Source: developed by the author

2. Substantiation of the Six-Component Composition of the Digital Competence of Educational Managers

The inclusion of such a range of components in the structure of the digital competence of educational managers – strategic-leadership, organisational-managerial, technological, pedagogical, socio-ethical and reflective-innovative – is justified because the professional activity of educational managers under conditions of digital transformation cannot be reduced to the possession of digital tools alone. It encompasses strategic

vision for the development of an educational organisation, management of digital processes, selection and use of technologies, pedagogical support for digital learning, ensuring the ethics and safety of the digital environment, and the continuous renewal of management practices.

This approach is consistent with the logic of the European Commission's DigComp 3.0: European Digital Competence Framework – Fifth Edition [3], which defines digital competence as a combination of knowledge, skills and attitudes needed for confident, critical and responsible use of digital technologies in life, learning, work and participation in society. In the Ukrainian regulatory field, a similar interpretation is consolidated in the Concept for the Development of Digital Competences [2], where digital competence is understood as a dynamic combination of knowledge, skills, abilities, ways of thinking, views and other qualities in the field of digital technologies.

The strategic-leadership component is necessary because a educational manager should be not only a user of digital technologies but also an agent of strategic direction for the digital transformation of an educational institution. This includes the ability to form the institution's digital vision, identify priorities, and align digital initiatives with the mission of the institution, educational goals and the needs of learners, teachers and the community. UNESCO's Six Pillars for the Digital Transformation of Education [32] specifically emphasises the importance of digital leadership, since without it digital initiatives risk becoming fragmented, ineffective and insufficiently connected to educational goals. In the IIEP-UNESCO Competency Framework for Educational Planning and Management [30], strategic competences are also linked to long-term thinking, a holistic vision of the educational system, strategic foresight, dialogue with stakeholders and the formation of a shared vision of development. Thus, this component captures the ability of educational managers to be leaders of digital change rather than merely administrators of separate digital processes.

The organisational-managerial component is indispensable because the digital competence of educational managers is realised in specific management processes: planning, coordination, monitoring, document flow, reporting, communication, analysis of educational data and managerial decision-making. IIEP-UNESCO emphasises that contemporary educational planning and management involve not only the technical

preparation of documents, but also ensuring their implementation, working with teams, consultations, negotiations, prioritisation and the connection between policy, planning and implementation [30]. In the Ukrainian context, this component is particularly strengthened by the development of AIKOM, the Automated Information Complex for Educational Management, as an electronic education management system designed for processing educational information resources, electronic document flow, reporting, communication, operational data collection and improving the quality of managerial decisions, as well as by the introduction of the mobile application and web portal Mriia as a new state digital educational ecosystem. The organisational-managerial component therefore reflects the ability of educational managers to translate digital strategy into functional managerial action.

The technological component determines the instrumental and technological readiness of specialists: understanding digital infrastructure, educational platforms, cloud services, information systems, digital data, artificial intelligence, cybersecurity, interoperability and the technical reliability of the digital environment. Here we rely primarily on UNESCO's Six Pillars for the Digital Transformation of Education [32], where the technological foundation of digital transformation is represented through hardware and devices, system software and services, learning spaces, and the requirement to build secure, sustainable and accessible digital infrastructure for learners, teachers, administrators and families. The Ministry of Education and Science of Ukraine also defines the digital transformation of education and science as comprehensive work on an ecosystem of digital solutions that includes a safe electronic educational environment, digital infrastructure, digital competence, transformation of processes and services, and the automation of data collection and analysis. In our view, the technological component separates technical, instrumental and infrastructural readiness from the broader strategic, pedagogical and ethical aspects of digital competence.

The pedagogical component should be distinguished because the activity of an educational manager is directly connected with ensuring the quality of the educational process, even if the manager does not always act as a teacher. Educational managers must understand how digital technologies affect learning, teaching, assessment, inclusion,

personalisation and the development of the digital competence of learners and teachers. In DigCompEdu [22], educators' digital competence is disclosed through professional engagement, digital resources, teaching and learning, assessment, empowering learners, and facilitating learners' digital competence. The framework emphasises the pedagogical appropriateness of digital resources: they should be selected according to learning goals, context, pedagogical approach and the characteristics of learner groups. In Ukrainian documents and scholarly work, digital competence is also associated with confident, critical and responsible use of digital technologies for learning, development, communication, safe behaviour and academic integrity. The pedagogical component therefore orients educational managers towards the main mission of an educational organisation: high-quality, accessible and effective learning.

The socio-ethical component is justified by the fact that the digital transformation of education creates not only new opportunities but also risks: privacy violations, cyber threats, disinformation, digital inequality, academic dishonesty, opaque use of data and artificial intelligence. Recent documents related to different aspects of digitalisation, including Six Pillars for the Digital Transformation of Education [32], DigComp 3.0 [3], Guidance for Generative AI in Education and Research [31], Legal and Pedagogical Guidelines for the Educational Use of Generative AI [7] and the Recommendations of the Ministry of Digital Transformation and the Ministry of Education and Science of Ukraine on the responsible implementation and use of AI technologies in higher education institutions [17], have been updated with attention to such priorities as artificial intelligence, cybersecurity, digital rights, choice and responsibility, well-being in the digital environment, and countering disinformation and misinformation. A systematic review of digital leadership [10] also emphasises that a responsible digital leader should combine digital, technical, managerial and ethical competences, particularly in matters of data confidentiality, cybersecurity and sustainability. For educational managers, this means being prepared not only to use digital solutions but also to take responsibility for the safety, inclusiveness, transparency and legality of their application in the educational environment.

The reflective-innovative component should be distinguished because digital competence cannot be fixed or completed: digital technologies,

management practices, educational platforms, analytics tools and artificial intelligence are changing rapidly. Consequently, digital competence must remain adaptive to new technological trends, as emphasised in many documents. In DigCompEdu, the highest levels of professional development are associated with leadership, critical reflection on existing practice and the development of new practices [22]. In UNESCO's Six Pillars, a separate block is devoted to openness to creativity, collaboration, innovation, knowledge sharing and continuous learning [32]. The reflective-innovative component therefore reflects the ability of educational managers to assess the digital maturity of an organisation, identify competence gaps, analyse the effectiveness of digital solutions, initiate innovations and adjust managerial actions based on data, experience and reflection.

Thus, the proposed structure is theoretically justified because it combines the strategic, managerial, technological, pedagogical, ethical and innovative dimensions of the digital competence of educational managers. It corresponds to the international logic of the DigComp, DigCompEdu, UNESCO Six Pillars and IIEP-UNESCO frameworks, as well as to Ukrainian priorities of digital transformation in education, the development of digital competences, the electronic educational environment, electronic document flow and the management of educational data.

3. Criteria-and-Level Diagnostics of the Digital Competence of Educational Managers

In contemporary Ukrainian research on the development of digital competence among learners of different levels and specialities, as well as among teachers and university lecturers, the measurement of the phenomenon under study is usually based on a detailed diagnostic system. Criteria or descriptors with corresponding indicators are identified in relation to the components of digital competence; levels of formation are characterised; and diagnostic methods are then selected for each criterion.

We first analyse the existing experience of measuring digital competence proposed in recent dissertations and scholarly studies. Among dissertation works, particular attention should be paid to recent studies by O. Stechkevych, S. Vasylenko, I. Okseniuk and others, which are related to the formation of digital competence and the development of authorial

diagnostic apparatuses. O. Stechkevych considers the basis of a teacher's digital competence to consist of three areas: the digital environment, digital resources and digital interaction. These form the component structure of the phenomenon, including environmental, content and communicative components, with a reflective component added. The formation of each component is measured through descriptors that simultaneously indicate levels: beginner (low level), user (intermediate level) and professional (high level) [28, pp. 359–364].

S. Vasylenko, developing an organisational and pedagogical model for the development of university teachers' digital competence in the context of European integration, proposes her own framework for assessing university teachers' digital competence. The researcher identifies five criteria or descriptors – Analyst-Researcher (A), Integrator (B1), Expert (B2), Leader (C1) and Innovator (C2) – with indicators that are realised in different types of teaching activity, including educational, research, professional communication and digital self-management activities [33, p. 120].

I. Okseniuk attempts to form teachers' information and digital competence in non-formal education and therefore identifies criteria with indicators and conducts diagnostic measurements. The author defines three criteria: personal-stimulating, corresponding to the motivational-target component of information and digital competence; operational-technological, correlating with the cognitive-content component; and procedural-resultative, related to the activity-reflective component [21, pp. 110–111].

M. Sevastyanova takes a fairly traditional approach to measuring digital competence by distinguishing motivational-value, cognitive, activity and evaluative-reflective criteria for assessing the digital competence of primary school teachers [25]. This once again confirms the effectiveness of the competence-based approach in evaluating the phenomenon under study. In D. Karpiuk's dissertation, the criteria-diagnostic apparatus for assessing the digital competence of future bachelors in information, library and archival studies includes such criteria as digital operationality, digital literacy and information-analytical operability [14]. In this case, a different approach is used: the criteria are named not according to the classical competence triad of knowledge, skills and attitudes, but according to functional manifestations of digital competence.

The study of criteria and indicators of digital competence is also presented in a number of analytical materials and scholarly articles by Ukrainian researchers. Ya. Sikora and S. Ivanova describe criteria for the development of digital competence among scientific and academic staff, reflecting its components: educational-digital, methodological-digital, research-digital, organisational-digital and integral-digital. They also specify manifestations of digital competence in various domains of activity and at different degrees of complexity: digital content creation; communication and collaboration; safety in the digital environment; information literacy and data work; and technological solutions to professional tasks using digital tools [26, pp. 77–78].

O. Kryvonos, N. Biruk, A. Torgonska and O. Yatsenko propose their own approach to diagnosing the formation of digital competence among high school students, identifying four criteria with corresponding indicators: safety, understood as the ability to use digital technologies safely and consistently with regard to personal data and legal responsibilities online; communication in the digital environment, understood as the ability to communicate, collaborate, interact and participate in virtual teams and chats using appropriate media, tone and behaviour; basic computer literacy, including the use of mobile and computer devices, basic software, the Internet and online applications; and information, including the ability to formulate information needs, search for necessary data, access information, data and content, critically evaluate and interpret data, assess the reliability of sources and recognise propaganda [15, pp. 101–102].

Thus, Ukrainian researchers usually propose measuring digital competence through criteria and indicators, organising self-assessment, surveys, needs monitoring and mapping of respondents' digital activity domains.

Analysis of international research shows that the criteria-diagnostic apparatus of digital competence is most often presented through components, indicators, descriptors or rubrics. For example, P. Siripan and S. Noirid [27], studying teachers' digital competence, identify four components: digital literacy; use of digital tools and media; problem-solving using digital tools; and digital adaptation and transformation. M. Gümüş and V. Kukul, researching teachers' digital competence, developed and validated a digital competence scale comprising six factors: Safety, Data Literacy, Problem

Solving, Digital Content Creation, Communication and Collaboration, and Ethics [9]. E. Yılmaz and M. Taşar propose a valid, reliable and comprehensive Teachers' Digital Competence Scale (TDiCoS) for teachers of different subjects, developed on the basis of standards and reports on digital competence from several countries, teachers' self-assessment and data on their use of digital technologies in their classrooms. The scale was validated on a sample of 288 teachers [35]. Its main criteria include the learning-teaching process, selecting and using digital resources, assessment, digital technologies and ethical use of resources.

A considerable number of international studies focus on proving the validity of the criteria and indicators of digital competence frameworks developed and recommended at the European level. For instance, F. de L. González-Mujico [8] demonstrates the effectiveness and reliability of the DigComp and DigCompEdu frameworks, taking into account differences in their descriptors and criteria.

Based on the analysis of recent Ukrainian and international studies and taking into consideration the European digital competence frameworks DigComp 3.0, DigCompEdu and DigCompOrg, we identify three interrelated criteria for assessing the level of formation of the digital competence of educational managers: cognitive-content, operational-activity and motivational-reflective. This approach is determined by the integrative nature of digital competence, which combines knowledge, skills, practical experience, value orientations, professional motivation and the capacity for reflection. Each criterion reflects not a separate component of digital competence but a particular mode of its manifestation, while simultaneously covering all six structural components: strategic-leadership, organisational-managerial, technological, pedagogical, socio-ethical and reflective-innovative.

The cognitive-content criterion characterises the degree to which educational managers possess the system of knowledge necessary for understanding, planning, organising and evaluating the digital transformation of an educational institution. It is not limited to knowledge of digital tools, but includes managerial, pedagogical, technological, legal, ethical and innovative aspects of educational digitalisation. The content of this criterion reflects all six components of the structure of the digital competence of educational managers (Table 2).

Table 2

Indicators of the Cognitive-Content Criterion of the Digital Competence of Educational Managers

Components of the structure of digital competence of educational managers	Indicators according to the cognitive-content criterion
Strategic-leadership	Knowledge of the essence of the digital transformation of education, digital leadership, digital policy of an educational institution, strategic planning, change management, and the role of data, artificial intelligence, cybersecurity and digital innovations in the development of an educational organisation.
Organisational-managerial	Knowledge of the digital infrastructure of an educational institution, electronic document flow, educational platforms, education management information systems, digital monitoring, reporting, principles of interoperability, data protection and management of digital resources.
Technological	Knowledge of modern digital technologies, cloud services, learning and institutional management systems, digital databases, communication, analytics and visualisation tools, artificial intelligence, cybersecurity and technical requirements for digital infrastructure.
Pedagogical	Knowledge of digital pedagogy, digital didactics, models of blended and online learning, digital educational resources, digital assessment, learning analytics, personalisation, inclusive design and ways of developing the digital competence of teachers and learners.
Socio-ethical	Knowledge of digital rights and responsibilities, academic integrity, copyright, licensing, personal data protection, digital identity, media literacy, countering disinformation, ethical use of artificial intelligence and digital well-being.
Reflective-innovative	Knowledge of approaches to assessing the digital maturity of an educational organisation, identifying digital competence gaps, monitoring innovations, analysing the effectiveness of digital solutions, managing experimental digital projects and forecasting technological trends.

Source: developed by the author

The methods for diagnosing the cognitive-content criterion include testing, conceptual and terminological tasks, analysis of regulatory and strategic documents, written answers to problem questions, analytical tasks

and mini-cases requiring explanation of a situation. In our opinion, testing should be the main method, since it makes it possible to verify learners' basic awareness of concepts, digital systems, regulatory requirements, safety and ethics, as well as their understanding of the managerial meaning of basic terms. Closed-ended test items should be supplemented with open analytical tasks, such as explaining the difference between digital transformation and technical modernisation, identifying digital risks in an educational institution, or analysing the content of a digital strategy or AI-use policy.

The second criterion – the operational-activity criterion – reflects the ability of managerial specialists to apply digital knowledge in practical management activity. It concerns the formation of skills, abilities and initial professional experience: developing digital strategies, organising electronic document flow, working with educational platforms, analysing data, supporting teachers, ensuring a safe digital environment and initiating digital innovations. The content of this criterion, taking into account all components of the structure of the digital competence of educational managers, is presented in Table 3.

Methods for diagnosing the operational-activity criterion should take account primarily of the activity aspect and be linked to products of activity. Therefore, the most appropriate methods include practical tasks, case assignments, digital projects, modelling of managerial situations, business games, observation, portfolios of digital products, expert evaluation and project defence. Activity-related aspects of digital competence are manifested in the ability to solve real or near-real professional situations, evaluate teamwork, leadership position and communication with stakeholders, and accumulate practical outcomes at the activity level, such as digital plans, analytical tables, roadmaps, regulations, instructions, projects and results of piloting.

The motivational-reflective criterion characterises the attitude of educational managers towards digital transformation, their readiness for responsible digital leadership, awareness of the ethical and social consequences of digitalisation, ability to assess their own digital competence, analyse the outcomes of digital solutions, and construct an individual trajectory of professional development and self-education (Table 4).

Table 3

Indicators of the Operational-Activity Criterion of the Digital Competence of Educational Managers

Component of the structure of digital competence	Indicators according to the operational-activity criterion
Strategic-leadership	Ability to form a digital vision for the development of an educational institution, develop a digital strategy, roadmap and system of implementation indicators, engage stakeholders, organise teamwork and manage digital change.
Organisational-managerial	Ability to organise digital management processes: planning, communication, electronic document flow, monitoring, reporting, analysis of educational data and managerial decision-making based on digital information.
Technological	Ability to select, configure and use digital tools for managerial, educational, communicative and analytical activities; work with platforms, cloud environments, collaboration services, databases, visualisation and information-analysis tools.
Pedagogical	Ability to organise a digital learning environment, support teachers in selecting digital resources, coordinate the implementation of digital assessment, feedback, personalised learning and teachers' professional development in the digital sphere.
Socio-ethical	Ability to create a safe, ethical and inclusive digital environment; develop rules for digital interaction; prevent cyber threats, privacy violations, academic dishonesty, digital discrimination and disinformation; ensure responsible use of data and artificial intelligence.
Reflective-innovative	Ability to carry out self-assessment and assess the digital competence of the team, analyse the results of implementing digital technologies, pilot innovations, adjust digital strategies and initiate research and innovation digital projects.

Source: developed by the author

The most appropriate diagnostic methods for this criterion are questionnaires, self-assessment, reflective essays, reflective diaries, interviews, focus groups, pedagogical observation, expert evaluation of portfolios and discussion of ethical cases. These methods make it possible to identify the depth of motivation, readiness for responsibility, attitudes towards the risks of digitalisation and understanding of digital development as a human-centred process.

Table 4

Indicators of the Motivational-Reflective Criterion of the Digital Competence of Educational Managers

Component of the structure of digital competence	Indicators according to the motivational-reflective criterion
Strategic-leadership	Awareness of digital transformation as a human-centred, ethical and strategic process; readiness to assume leadership responsibility for the digital development of an educational organisation; orientation towards transparency, partnership, trust, inclusion and sustainability of digital solutions.
Organisational-managerial	Recognition of the value of evidence-based, transparent and responsible management; readiness to use digital data to improve management quality; responsible attitude to confidentiality, accessibility and equitable distribution of digital resources.
Technological	Awareness of digital technologies as a means of improving the quality, accessibility and effectiveness of education, not as an end in themselves; critical and responsible attitude to the selection of digital tools with regard to safety, inclusion, ethics, economic feasibility and sustainability.
Pedagogical	Awareness of the priority of pedagogical appropriateness over technological novelty; readiness to support teachers and learners; orientation towards high-quality, inclusive, personalised and active learning in a digital environment.
Socio-ethical	A stable position regarding the protection of human dignity, privacy, digital rights, academic integrity, non-discrimination, digital well-being and ethical use of data and artificial intelligence.
Reflective-innovative	Readiness for continuous professional development, self-assessment, critical reflection on one's own managerial decisions, openness to innovation, experimentation, co-creation and responsible implementation of new technologies.

Source: developed by the author

For diagnostic procedures, we define the levels of formation of the digital competence of educational managers. *A high level* presupposes the formation of digital competence as an integral professional and managerial quality. Respondents deeply understand the digital transformation of education as a strategic, organisational, pedagogical, technological, ethical

and innovative process. They realise that digitalisation is not limited to the use of individual services, but is connected with changes in management culture, institutional educational policy, communication, quality monitoring, data safety and teachers' professional development. At this level, knowledge is systemic: educational managers understand the regulatory foundations of digital development, digital infrastructure, educational platforms, electronic document flow, cloud services, learning analytics, artificial intelligence, cybersecurity, academic integrity, personal data protection, digital inclusion and digital well-being. Motivation is stable: respondents are not only prepared to use digital technologies, but also take responsibility for their ethical, safe and pedagogically appropriate implementation.

A high level characterises educational managers who do not limit themselves to the routine use of digital tools and do not require constant instructions. At the same time, even at this level they do not replace narrow IT specialists in specialised matters of cybersecurity, administration of complex information systems or technical integration of platforms. Their role lies in managerial vision, setting tasks, coordination, risk assessment and responsible decision-making. In highly specialised technical or legal situations, they may still request expert consultation, but they are able to identify the problem independently, formulate a request and organise its solution.

At a *sufficient level*, the digital competence of educational managers enables them to perform most typical and some more complex professional and managerial tasks. Respondents understand the main directions of the digital transformation of education, know the purpose of digital platforms, electronic document flow, cloud services, digital resources, communication tools, and basic analytics and assessment tools. They recognise the importance of digital leadership, safety, academic integrity, data protection and pedagogical appropriateness of digital solutions. Motivation is generally positive and professionally oriented; however, initiative tends to manifest itself mainly within clearly defined tasks or proposed organisational conditions.

Respondents at this level cannot always independently develop a holistic digital policy for an educational institution or a comprehensive digital transformation strategy. They may experience difficulties in managing large-scale digital change, conducting in-depth data analytics,

forecasting technological trends, assessing organisational digital maturity and integrating different digital systems. In non-standard situations, they may need methodological, organisational or expert support. They are able to implement innovation projects, but more often as participants or co-organisers rather than independent strategic leaders.

An *intermediate level* demonstrates the partially formed, fragmented-practical character of digital competence. Respondents possess certain knowledge of digital technologies, educational platforms, electronic resources, online communication, document flow, digital safety and academic integrity, but this knowledge is not always systematic and is not always connected with the managerial context. They can explain individual concepts of educational digitalisation, but often perceive it mainly as technical modernisation or the use of convenient services. Motivation is unstable: interest in digital technologies exists, but it depends on external requirements, instructions and the support of a teacher, colleagues or administration.

Educational managers with an intermediate level of digital competence have difficulties interpreting educational data, using analytics for decision-making, organising teachers' professional development, developing rules for digital interaction, preventing cyber risks and disinformation. They often act situationally and without sufficient systematisation, do not always critically evaluate digital resources, and do not always understand the ethical and legal consequences of digital solutions. They are unable to independently design a digital strategy, form an institutional digital policy, select a set of digital tools for solving a managerial problem, or assess the effectiveness and implementation risks of digital solutions.

A *low level* of digital competence is initial and predominantly reproductive. Respondents' knowledge of the digital transformation of education, digital leadership, data management, digital infrastructure, cybersecurity, digital pedagogy, academic integrity, copyright and ethical use of artificial intelligence is fragmentary or superficial. Learners weakly connect digital technologies with the managerial functions of an educational manager and do not fully understand the strategic importance of digitalisation for the quality, accessibility, transparency and safety of education. Motivation is low or externally determined: digital tools are perceived as an additional burden, a technical requirement or a formality.

Respondents at this level can perform only the simplest digital actions, often after detailed instruction or with assistance from others.

CONCLUSIONS

The study substantiates the theoretical foundations for measuring the digital competence of educational managers as a complex, integrated and dynamic professional-managerial phenomenon. It demonstrates that, under conditions of educational digital transformation, the digital competence of an educational manager cannot be reduced to the possession of individual digital tools or technical skills. It includes the capacity to guide the digital development of an educational organisation strategically, organise digital management processes, work with educational data, support digital pedagogy, ensure a safe, ethical and inclusive digital environment, reflect on managerial decisions and initiate innovation.

The chapter clarifies the content of the concept of digital competence of educational managers. It is defined as an integrative professional and managerial characteristic that combines digital literacy, managerial and analytical skills, value-based and ethical responsibility and readiness for innovation. This competence enables specialists to exercise digital leadership, manage the digital transformation of an educational organisation, make evidence-informed decisions based on data and develop a safe, inclusive and technologically capable educational environment. Such an understanding moves beyond an instrumental view of digital skills and situates digital competence within the broader logic of educational leadership, institutional development and public responsibility.

A six-component structure of the digital competence of educational managers has been substantiated. It includes strategic-leadership, organisational-managerial, technological, pedagogical, socio-ethical and reflective-innovative components. This structure reflects the specificity of the professional activity of educational managers, who should act not only as users of digital technologies, but also as leaders of digital change, organisers of the digital environment, coordinators of pedagogical interaction, responsible decision-makers and subjects of continuous professional self-development.

For diagnostic purposes, three interrelated criteria are proposed: cognitive-content, operational-activity and motivational-reflective. The

cognitive-content criterion makes it possible to assess knowledge and understanding of educational digital transformation, digital leadership, digital infrastructure, digital pedagogy, ethics, safety and innovation. The operational-activity criterion focuses on the ability to apply digital technologies in practical management activity. The motivational-reflective criterion reveals attitudes towards digitalisation, readiness for responsible digital leadership, self-assessment, professional growth and critical reflection on digital solutions.

The chapter also characterises four levels of formation of the digital competence of educational managers: high, sufficient, intermediate and low. Their description makes it possible not only to determine an overall diagnostic result, but also to identify strengths and problematic areas in the professional preparation of specialists. The practical significance of the results lies in the fact that the proposed criteria-and-level approach may be used to design diagnostic instruments, develop educational components, improve the professional training of educational managers and build individual trajectories for the development of their digital competence. Further research should focus on the development of specific test, case-based and project-based tasks for comprehensive assessment and on the empirical verification of the proposed diagnostic model.

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