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Прийняття: 12/08/2025
Рецензія: 20/08/2025
Публікація: 30/09/2025

DOI: https://doi.org/10.53920/ES-2025-3-1

ECONOMIC FEASIBILITY OF IMPLEMENTING TEACHERS' DIGITAL AVATARS IN THE HIGHER EDUCATION SYSTEM

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E24, I20, I25, N3

The article provides a theoretical and analytical justification of the economic feasibility of implementing teachers' digital avatars in the higher education system as an innovative component of the digital transformation of the educational and organizational environment. It highlights how digital avatars can expand the teaching functionality by enabling interactive communication, visualizing educational content, personalizing learning, and responding flexibly to students' academic needs. A multi-level classification of digital avatar functions has been formulated, based on their level of complexity, from elementary representative actions to complex simulations of pedagogical interaction, and their level of maturity, from prototype models to cognitively adaptive systems based on artificial intelligence. It has been established that the prospects for integrating avatars are directly related to the development of generative AI technologies, the possibilities of virtualizing the learning environment, and the formation of mixed educational ecosystems.

The main barriers to implementing teachers' digital avatars have been analyzed, covering technical, financial, institutional, and human resource factors, including software complexity, limited compatibility with existing infrastructure, and a shortage of specialists. Based on an interdisciplinary approach, the conditions for ensuring the sustainable implementation of such innovations have been identified, among which the key ones are: strategic management of digital change, improving the digital competencies of staff, investing in IT infrastructure, and developing policies for the ethical use of AI in education.

ISSN 2786-5339 (print)
ISSN 2786-5347 (online)

The experience of leading universities, particularly ETH Zurich, confirms the relevance of a proactive policy of introducing generative AI into the educational process, creating conditions for scaling innovation. Digital avatars are seen as an integral part of the academic ecosystem of a digital university, capable not only of transforming teaching activities and improving the quality, accessibility, and personalization of education. The research results form the basis for developing strategic decisions on implementing digital avatars in higher education practice and can be used to build institutional models of digital transformation.

Keywords: *teachers' digital avatars, digital university, personalization of education, digital transformation, artificial intelligence, digitalization.*

Наталія БОБРО

ЕКОНОМІЧНА ДОЦІЛЬНІСТЬ УПРОВАДЖЕННЯ ЦИФРОВОГО АВАТАРА ВИКЛАДАЧА В СИСТЕМІ ВИЩОЇ ОСВІТИ

У статті здійснено теоретико-аналітичне обґрунтування економічної доцільності впровадження цифрового аватара викладача в систему вищої освіти як інноваційного компонента цифрової трансформації освітньо-організаційного середовища. Акцентовано увагу на розширенні функціональності викладацької діяльності за допомогою цифрових аватарів, які здатні забезпечувати інтерактивну комунікацію, візуалізацію навчального контенту, персоналізацію навчання та гнучке реагування на освітні потреби студентів. Сформульовано багаторівневу класифікацію функцій цифрового аватара за рівнем складності — від елементарних репрезентативних дій до комплексної симуляції педагогічної взаємодії та за рівнем зрілості — від прототипних моделей до когнітивно-адаптивних систем на основі штучного інтелекту. Встановлено, що перспективи інтеграції аватарів безпосередньо пов'язані з розвитком генеративних ШІ-технологій, можливостями віртуалізації навчального середовища та формуванням змішаних освітніх екосистем.

Проаналізовано основні бар'єри впровадження цифрового аватара викладача, що охоплюють технічні, фінансові, інституційні та кадрові чинники, включаючи складність програмного забезпечення, обмежену сумісність із наявною інфраструктурою та дефіцит фахівців. На основі міждисциплінарного підходу визначено умови забезпечення стійкої реалізації таких інновацій, серед яких ключовими є: стратегічне управління цифровими змінами, підвищення цифрових компетентностей персоналу, інвестування в IT-інфраструктуру та розвиток політик етичного використання ШІ в освіті.

Досвід провідних університетів, зокрема ETH Zurich, підтверджує актуальність проактивної політики впровадження генеративного ШІ в навчальний процес, що створює умови для масштабування інновацій. Цифрові аватари розглядаються як складова частина освітньої екосистеми цифрового університету, спроможна не лише трансформувати викладацьку діяльність, а й сприяти підвищенню якості, доступності та персоналізації освіти. Результати дослідження формують підґрунтя для розробки стратегічних рішень щодо впровадження цифрових аватарів у практику вищої освіти та можуть бути використані для побудови інституційних моделей цифрової трансформації.

Ключові слова: *цифровий аватар викладача, цифровий університет, персоналізація освіти, цифрова трансформація, штучний інтелект, діджиталізація.*

Problem statement. Modern transformational processes in higher education are taking place amid the rapid development of digital technologies, which are changing both the paradigm of learning and the functional architecture of educational institutions. In this context, there is growing interest in implementing teachers' digital avatars – intellectual and technological solutions representing a new form of interaction in the digital educational environment. Such avatars can act as automated support agents, adaptive learning tools, or cognitive systems with elements of artificial intelligence capable of modelling complex pedagogical scenarios, interpreting educational analytics, and forming a personalized trajectory of interaction with students. However, despite the high innovative potential of this technology, its systematic implementation is accompanied by a number of unresolved issues.

First and foremost, there is a lack of unified standards, methodological base, and practical models for economic assessment of the implementation of digital avatars in various organizational, cultural, and educational and institutional contexts. A significant part of the initiatives are still being implemented as pilot projects or fragmentary technological experiments. In addition, there is a lack of empirically verified research on the relationship between the costs and expected effects of implementing such tools in educational activities, including their impact on the quality of the educational process, academic mobility, student and teacher satisfaction, and organizational effectiveness.

Thus, the scientific problem lies in developing a theoretical and methodological basis for determining the economic feasibility of implementing teachers' digital avatars as a complex innovative solution in the higher education system. This includes systematizing the classification characteristics of such avatars,

analysing barriers and factors for successful integration, forming performance criteria, and determining strategic conditions for sustainable implementation within the framework of the digital transformation of universities.

Analysis of recent research and publications. The theoretical basis for researching the economic feasibility of implementing digital avatars in higher education is interdisciplinary research covering digital pedagogy, educational engineering, artificial intelligence, and the digital economy. In particular, R. Lisova et al. [1] consider digital transformation tools in the context of cost optimization and sustainable development. This is relevant to assessing the effectiveness of implementing digital avatars as elements of resource savings in the education sector.

The issues of social inclusion and reducing inequality in the digital environment are explored in research by A. Kozhyna [2], which emphasizes the importance of adapting innovative solutions to the conditions of the digital economy. B. Williamson, R. Eynon, and J. Potter [3] highlight the transformations in pedagogical practice during the pandemic and the growing role of digital technologies in distance education, which creates the conditions for integrating virtual agents into the educational process. In turn, research by O.O. Khomenko, M.V. Paustovska, and I.A. Onyshchuk [4] confirms the efficiency of interactive technologies as a means of improving the quality of education and the development of students, which opens up prospects for the use of digital avatars as didactic tools.

Approaches to implementing innovations in management and public administration are discussed in the publication by V. Bielikov et al. [5], where special attention is paid to digital transformation tools, which are also important in the management of educational institutions. The experience of globalization risk management in investment strategies, presented in the work of C. Safarli et al. [6], allows us to extrapolate the principles of adapting innovations to the education sector, taking into account risks and barriers.

The research by G. Kortemeyer, N. Dittmann-Domenichini, and C. Merki [7] provides empirical data on student behavior when choosing forms of education after the pandemic, which is important when developing educational models using digital agents. The research by O. Dushchenko [8] focuses on the current state of digital transformation of education in Ukraine, particularly in terms of regulatory and organizational support, which is a critical factor in the context of implementing digital avatars.

Finally, the work of N. Verina and J. Titko [9] reveals the conceptual foundations of digital transformation, which allows for a systematic approach to analyzing digital innovations in the educational process and outlines strategies to assessing their efficiency at the institutional level.

At the same time, despite the growing number of studies, there is a lack of comprehensive economic assessment of the implementation of teachers' digital avatars in scientific discourse, in particular, analysis of costs, efficiency, barriers, and scaling strategies in the context of the digital transformation of universities. The impact of such innovations on the productivity of the educational process, the intellectual capital of the university, the adaptability of educational models, and the sustainable development of academic institutions has also not been sufficiently studied. Therefore, the need for theoretical understanding, systematization, and assessment of the economic feasibility of implementing digital avatars as an innovative resource in higher education is a relevant and scientifically underdeveloped area.

The aim of the article is to conduct a comprehensive study of the economic feasibility of implementing teachers' digital avatars in the higher education system, taking into account current trends in digital transformation, personalized learning models, cost-effectiveness, and institutional readiness of establishments. Particular attention is paid to the analysis of the functional levels of avatars, barriers to their implementation, as well as the potential for improving the quality of the educational process, optimizing resources, and forming new digital pedagogy.

Presentation of the main research material. In the context of intensifying global competition and growing demands for quality educational services, the introduction of advanced digital technologies, in particular the concept of digital avatars as personalized virtual representatives of teachers, is becoming increasingly important. Similar to the use of digital twins in the real economy, where they are used to optimize production processes, reduce costs, and increase system reliability, digital avatars in education can serve as a tool for improving the efficiency of the learning process, individualizing interaction with students, and maintaining the quality of educational services in a digital environment.

A digital avatar is not an isolated tool, but functions as an integrated component of the educational and organizational ecosystem of a digital university. Its key advantage lies in its ability to model simulation scenarios of educational interaction, ensure learning adaptability, automate routine operations, and

generate real-time feedback. This allows for more efficient distribution of the educational load, prediction of the behavior of participants in the educational process, and creation of personalized learning paths that take into account the needs and learning styles of students.

The current transformation of higher education is accompanied by the growth of digitalization, the increasing complexity of educational products and services, the need to ensure academic integrity, the flexibility of educational programs, and the enhancement of the scientific and innovative component [1;3;8]. In this context, the use of digital avatars in combination with the principles of partnership pedagogy, learning analytics, and adaptive platforms contributes to the optimization of management decisions, the improvement of educational management quality, and the formation of a sustainable educational ecosystem.

Digital avatars may eventually help to design, monitor, and improve educational processes, including lesson planning, educational resource logistics, workload distribution among teachers, learning outcome assessment, and educational interaction management. The implementation of digital avatars as components of a new form of university, digital, opens up opportunities for significantly reducing organizational costs, reducing the institutional workload on teachers, and enhancing the efficiency of the educational process as a whole. Thus, a teacher's digital avatar, as an innovative tool of a digital university, has a number of positive effects that determine its economic and functional feasibility (Figure 1).

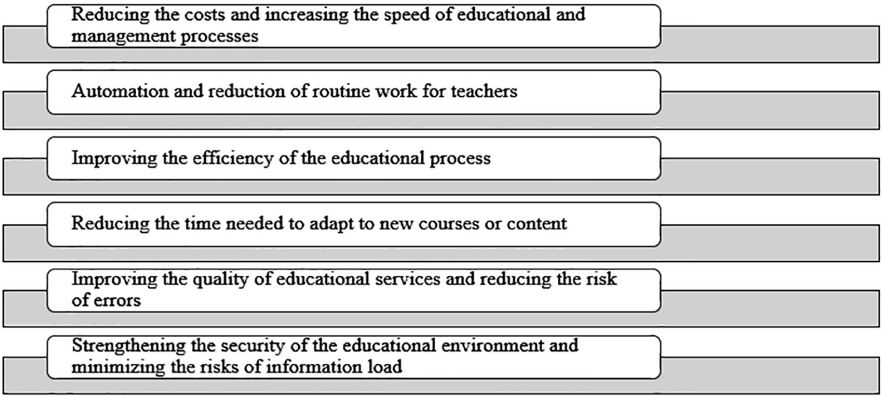

Figure 1. Benefits of using teachers' digital avatars at universities

Source: compiled by the author independently

Figure 1 shows the key benefits of implementing teachers' digital avatars in the higher education system, which have a comprehensive impact on improving the efficiency of the educational process and the university's management functions. In particular, this refers to reducing costs and speeding up educational and administrative procedures through automated support, adaptation of educational content, and delegation of routine tasks. This reduces the workload on academic staff and ensures continuous interaction with students. In addition, digital avatars facilitate rapid adaptation to new courses, improve the quality of educational services through algorithmic communication management, minimize errors, and reduce the risk of cognitive overload. As a multifunctional tool of the digital university, the avatar enhances the flexibility of the educational ecosystem, increases its adaptability, and contributes to the formation of a safe and effective learning environment.

A teacher's digital avatar is not a separate technology, but rather an integration platform that combines various digital tools – from artificial intelligence to educational data analytics – to create a holistic virtual model of teaching activities. Such an avatar is the result of the synthesis of technologies capable of modeling, predicting, and optimizing educational processes in real time. At the same time, the lack of unified standards and typical solutions for building digital avatars in the higher education system complicates their widespread implementation at the institutional level.

Despite this, there is an active search for individualized approaches, which indicates a gradual transition to the formation of unified architectural and functional models of digital teachers. The classification of digital avatars in higher education can be carried out according to several criteria (Figure 2).

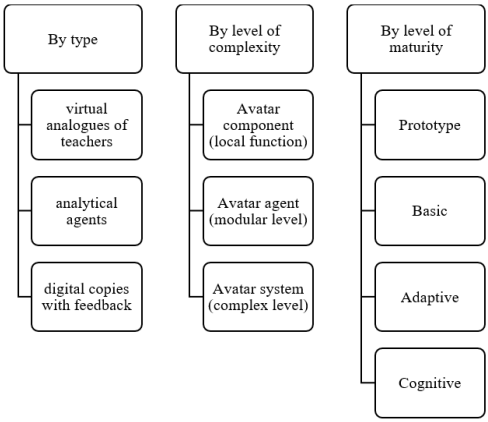

Figure 2. Classification of digital avatars in higher education

Source: compiled by the author independently

The structured classification of digital avatars in higher education is based on three key parameters: type, level of complexity, and level of maturity, each of which reflects different aspects of the functioning and development of this type of technology in the educational environment. By type, digital avatars are divided into: virtual analogues of teachers, representing personalized interaction with the digital environment; analytical agents focused on processing and interpreting educational data; and digital copies with feedback that model the dynamics of teacher behavior with the possibility of correction based on information received from the user.

By level of complexity, they can be structured as follows: avatar component – an autonomous digital module that performs a limited set of tasks (e.g., answering frequently asked questions or notifying students); avatar agent – capable of functioning within an educational block or course (e.g., monitoring academic activity or adapting educational content); and avatar system – a comprehensive intellectual tool that simulates all pedagogical activities, including planning, assessment, dialogical interaction, and reflective support.

By level of maturity, four successive stages of avatar development can be distinguished: prototype (a test model with minimal functionality), basic (a standardized interface with reactive behavior), adaptive (capable of personalizing interaction based on learning analytics), and cognitive (an autonomous self-learning system with elements of artificial intelligence that performs a predictive and corrective function in the educational process).

This classification provides a methodological basis for systematic analysis, gradual implementation, and strategic development of digital avatars in the context of the digital transformation of higher education.

The generalized classification of teachers' digital avatars in higher education not only outlines potential formats for their implementation but also sets benchmarks for the deployment of educational practices within the framework of digital transformation. At the same time, determining the types, levels of complexity, and maturity of such technologies requires correlation with the actual state of their implementation in universities. Thus, back in 2022, the use of teachers' digital avatars in the educational process was almost exclusively limited to several pilot projects. In particular, in the fall of 2022, Meta, in partnership with the educational VR platform VictoryXR, launched 10 digital twins of university campuses – so-called "metaversities" [10]. These virtual 3D campuses replicated real universities and allowed students to attend classes in the

form of their own avatars. By the end of 2022, only a small proportion (less than 1%) of universities worldwide had experimented with such technologies in practice.

In 2023, the implementation of teacher avatars accelerated significantly, especially in the US. Meta's initiative to expand the "metaversities" network was a significant impetus. In the fall of 2023, Meta donated 300 Oculus Quest 2 virtual reality headsets to 15 US universities that were implementing VR in education [11]. Among these institutions are Stanford University, the University of Iowa, and other innovative colleges where digital avatars and virtual classrooms have become part of the educational process. Accordingly, during 2023, the number of US universities using avatars or VR platforms in education grew to several dozen. According to analysts' estimates, by the end of 2023, at least 25-30 American universities actively used technologies of teachers' digital avatars or their elements in the educational process.

European universities began similar experiments a little later, but by 2024, this wave had reached the EU. In the fall of 2024, the first "metaversities" in Europe were announced. In particular, the University of Leeds in the UK launched a theatre arts course in the metaverse, and the University of the Basque Country (Spain) launched virtual classes in physiotherapy and anatomy. In Germany, schools in Hanover plan to introduce immersive classes at the beginning of the 2025 academic year [12].

The experience of Switzerland is interesting, as leading universities demonstrate a systematic approach to the implementation of innovative digital solutions in the educational process, particularly artificial intelligence and virtual reality technologies. One of the flagships of digital transformation in higher education is the Swiss Federal Institute of Technology Zurich (ETH Zurich), which in 2024 officially adopted internal guidelines on the use of generative AI in learning and teaching. The document encourages teachers to experiment with tools such as ChatGPT, Claude, Copilot, etc., provided that academic integrity is maintained, their use is transparent, and the results are critically evaluated. Particular attention is paid to the formation of new formats of educational interaction, where AI technologies, in particular avatar platforms, are seen as potential partners for teachers in modeling the learning environment [13]. This creates the basis for the emergence of full-fledged teachers' digital avatars in Swiss universities in the near future.

Although as of 2024, the proportion of European universities using teacher avatars is still insignificant, this trend is steadily gaining momentum in various EU

countries and neighboring states. Global implementation indicators for 2024 show a sharp increase in the involvement of universities in digital avatar technology. According to VictoryXR, a global leader in the creation of virtual learning environments, more than 150 colleges and universities worldwide already use its licensed VR platforms (metaversities), and about 50 institutions have full-fledged digital twins of their campuses [14].

In other words, between 2022 and 2024, the number of universities participating in such projects increased tenfold – from a handful to more than a hundred worldwide. Institutions in North America and Western Europe are participating particularly actively, accounting for the majority of the ~150 participants in the global network of metaversities. These figures confirm that teachers' digital avatars are no longer just an experimental innovation, but are entering a phase of wider practical implementation.

As of early 2025, the use of digital avatars has not yet become widespread, but there is a clear trend toward their expansion. Most universities are still in the early stages of digital transformation, but examples set by technological leaders are encouraging other institutions to follow suit. In particular, by 2025, several dozen higher education institutions in the US have already integrated avatar teachers or AI assistants into the learning process, and in Europe, at least a dozen leading universities are testing similar solutions within individual programs or courses [14]. At the same time, a global UNESCO survey conducted in 2023 showed that less than 10% of educational institutions worldwide have developed formal policies or guidelines for the use of generative AI in education [15]. This indicates that institutional adoption of the technology is still in its early stages: most universities are still experimenting with AI avatars without a developed strategy or clear rules. However, the rapid growth in the number of practical examples and the positive results of their application are creating a critical mass of experience for the further spread of the technology.

For example, at Morehouse College (USA), learning in VR classrooms with digital twins of the campus showed success rates that were no lower than, and in some cases higher than, traditional full-time learning [16]. Such successes reinforce the arguments in favor of wider implementation of VR and teacher avatars. Expert forecasts for 2025-2028 agree that the implementation of teachers' digital avatars around the world will accelerate rapidly. According to a forecast by research company Gartner, by 2028, a quarter of all educational institutions will have introduced metaverse technologies into the educational process. This is consistent with current trends: virtually all new digital education development programs now take into account the capabilities of AI avatars and virtual reality.

The European Union is expected to actively support university projects aimed at teaching digitalization, in particular through special grants and experience exchange programs between member states. The US, where competition for applicants and the need to improve online education are particularly high, is likely to remain the leader in implementation: by 2028, it is predicted to have the largest share of "digital universities" using avatars in teaching. At the same time, interest in this innovation is growing in Asia. China, for example, has already announced plans to introduce AI "professors" in universities starting in 2025 [17]. Such initiatives are expected to significantly increase the number of avatars in global education in the second half of the decade. If current trends continue, by the end of the decade, teachers' digital avatars may become a common feature of the educational environment at universities around the world.

Economic forecasts by experts confirm this possibility. The global market for digital avatars (across all industries) is growing at an extremely rapid pace – about 50% per year – and is estimated to reach approximately US$270 billion in 2030 [18]. A significant share of this market will be accounted for by the education segment – primarily personalized AI tutors, virtual trainers, and teacher avatars. According to consulting research, the market for AI solutions for personalized learning will grow from $5.2 billion in 2022 to ~$48.7 billion in 2030 [19]. This reflects the scale of AI avatar integration into education. In other words, in 5-7 years, most leading universities in the US, EU, and East Asia will have teachers' digital avatars as an integral part of their educational programs – whether in the form of virtual assistants for students or full-fledged AI teachers for typical lecture courses. Such avatars are expected to significantly expand access to quality education significantly, allowing students to interact with "digital professors" virtually 24/7 and receive individualized feedback.

At the same time, this contributes to the emergence of new challenges related to both the scale and complexity of the technology itself and the barriers inherent in most digital innovations. Despite the high potential of digital avatars as a tool for transforming the educational process, their full-fledged implementation remains limited due to technical, technological, and organizational and commercial factors (Figure 3).

Among the key barriers, it is worth highlighting the high cost of implementing such projects, which is associated with software complexity, the need for multi-level modeling of educational scenarios, and integration with the existing university infrastructure. An important deterrent is the shortage of specialists capable of working with avatar modeling technologies, especially at the intersection of pedagogy, artificial intelligence, and big data analytics.

In addition, a common problem is the limited access to qualitative data for training avatar algorithms, which complicates their adaptation to different academic environments and types of student interaction. Commercial barriers manifest themselves in the difficulty of attracting investment in the development and maintenance of digital avatars due to the lack of proven business models and long-term financial forecasts. Institutional complications are also caused by the need to align technological solutions with regulatory and legal requirements in the field of education, the ethics of AI application, and cybersecurity of personal data. The creation, training, and integration of teacher avatars requires significant investment in the university's digital infrastructure, including cloud solutions, computing resources, and virtual interaction platforms. That is why the sustainable implementation of teachers' digital avatars requires the development of comprehensive strategies for the digital development of universities, the improvement of human resources, and the strengthening of interdisciplinary cooperation between educators, engineers, IT specialists, and managers.

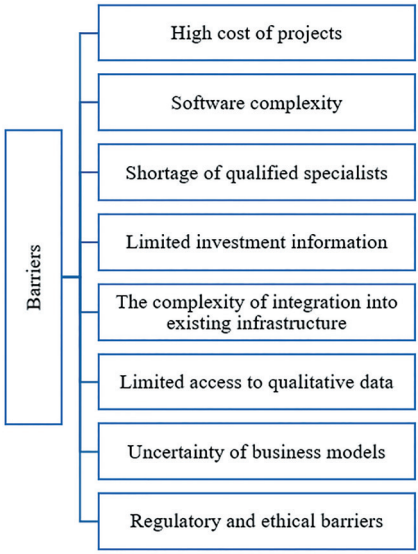

Figure 3. Barriers to the implementation of teachers' digital avatars in the higher education system

Source: compiled by the author independently

Conclusions and proposals. In the context of the digital transformation of universities, the teacher's digital avatar is not only an innovative technology but also an institutional tool that contributes to the improvement of the educational process, the individualization of interaction with students, and the optimization of academic workload. Its application opens up opportunities for creating personalized learning paths, predicting educational behavior, automating routine processes, and improving the quality of management decisions in higher education.

The positive impact of teachers' digital avatars is due to the integration of components such as artificial intelligence, educational analytics, virtual inter-

action platforms, and adaptive learning algorithms. Their use contributes to the development of new formats of pedagogical activity, increased flexibility of the educational environment, and the formation of an open digital ecosystem at the university.

At the same time, the process of implementing digital avatars is accompanied by a number of engineering and technological, personnel, regulatory, and financial barriers. Among the main limitations are the high cost of development, a shortage of specialists at the intersection of education and digital technologies, the lack of unified standards for building and implementing avatars, and limited institutional readiness for systemic changes. In addition to this, it is important to formulate policies for the ethical use of AI in education and to ensure the cybersecurity of user data.

In this context, the sustainable implementation of teachers' digital avatars requires a number of systemic prerequisites: the formation of strategies for the digital transformation of universities, the development of a multi-level educational infrastructure, the modernization of regulatory and legal support, and the improvement of the digital competence of academic and administrative staff. Of particular importance is the interdisciplinary integration of knowledge and practices in the fields of pedagogy, artificial intelligence, educational analytics, and digital management, which provides the conditions for the development, adaptation, and scaling of functional models of digital avatars according to the characteristics of the educational environment.

The transition to a new educational paradigm, in which the teacher's digital avatar is seen as an integral and fully functional component of educational interaction, should be evolutionary, taking into account the principles of academic autonomy, strategic priorities of institutional development, and the growing public demand for an inclusive, high-quality, and technologically advanced higher education system.

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