Journal of Vasyl Stefanyk Precarpathian National University
http://journals.pnu.edu.ua
Vol. 12, No. 3 (2025), 169-185

doi: 10.15330/jpnu.12.3.169-185

ISSN 2311-0155 (Print)
ISSN 2413-2349 (Online)

THE IMPACT OF ARTIFICIAL INTELLIGENCE ON THE FORMATION OF A TEACHER'S DIGITAL TWIN IN THE METAVERSE

Oksana Domina, Kateryna Andriushchenko, Anastasiia Liezina, Yana Tsymbalenko, Olena Titova, Oksana Kyryliuk, Yevgen Vylgin*

*Corresponding author: lezya86@gmail.com

Abstract. Recently, higher education has undergone significant changes due to the use of digital technologies and innovations. The use of innovative platforms, hybrid models and online services cannot overcome the requirements of today. To solve these problems, the article proposes a hypothesis regarding the use of a digital twin of a teacher. The use of modeling, design and optimization of the pedagogical educational process based on a cyber-physical system built on mathematical modeling and synergy is suggested. The study presents the process of building cooperation between a teacher and a higher education student when creating a digital twin of the latter, which integrates a model of the subject area of knowledge for the educational process, takes into account the variable parameters of the education student and models the educational process based on the use of the latest artificial intelligence technologies. The proposed architecture includes Internet of Things (IoT) technologies, machine learning and big data analytics, which together reflect the digitalization of Industry 4.0 and support for the "live" learning process. The results of the study demonstrate the practical consequences of using artificial intelligence tools among students and teachers. The need to use significant computing and machine equipment to analyze the results of the implementation of a digital twin is emphasized. The results of a two-stage survey of higher education students and university teachers are presented. They indicate positive aspects, such as: work-life balance and flexibility of learning. At the same time, the disadvantages are obvious as psychological safety and ethics of data use. As a result, the authors concluded that the digital twin of a teacher is an individual, transparent, adaptive and motivational tool for improving the educational process. Its further implementation depends in the future on resolving issues related to the ethics of personal data and psychological support by creating a conference database, impartiality algorithms and a reliable methodological foundation for resolving potential conflicts.

Keywords*:* digital twin, teacher, digitalization of administration, digital portrait of a student, stages of digital twin development.

1. INTRODUCTION

The educational process is a primary aspect of societal development. Its main task is to train the new generation for future changes, which are immutable. In the current conditions, the educational process itself is constantly changing under the influence of the development of digital technologies. In recent years, the main lever of influence has been artificial intelligence.

Due to digital tools and artificial intelligence (AI), monotonous processes of the teacher have become automated, which provides the opportunity and, above all, time to prepare high-quality and

substantiated content, improving the efficiency of the educational process. Artificial intelligence is the property of intelligent systems to perform those functions and tasks that are usually characteristic of intelligent beings (Olmo & Alba, 2023). This can manifest itself in creativity, have a tendency to reason, generalize, and learn from previous experience, and so on. Its development in the direction of science, within which hardware or software modeling occurs. AI is often implied as a direction in IT, the main goal of which is intelligent actions and reasoning using computer systems.

The active introduction of new digital technologies into public life gives rise to new tasks of social and technological development. Globalization, acting as a trend of today, erases the boundaries between different social systems (Liezina et al., 2023). Under the influence of objective processes, society makes ever more demands on the education system, and the development of information resources creates additional competitive opportunities for educational structures (Andriushchenko et al., 2022; Autiosalo, 2018).

The impact of the "new digital reality" dictates the need to transfer the sphere of professional education to a qualitatively new level (Camacho & Loayza, 2023). Education, fulfilling the order of the labor market, uses innovative methods of organizing management and tools that increase the efficiency of various spheres of society's life as an additional resource for improvement (Pokataiev, Teteruk & Andriushchenko et al., 2023). This creates the opportunity to apply modern digital technologies used in the manufacturing sector of the economy in pedagogical activities (Sepasgozar et al., 2023).

The terms "distance learning" and "e-learning" have been identified with the use of digital technologies for over two decades to bring about a transformation in education, marking a shift to a technology-driven approach. With the rapid growth of digitalization in all spheres of life, teaching and learning methods must change to keep pace with this progress (Budnyk & Kotyk, 2024; Kümmel & Kimmerle, 2020). This shift has been further supported by the growing use of AI and data analytics in education in light of the COVID-19 pandemic and war, which has forced all educational institutions to shift to virtual classrooms and online platforms as a means for continuous interaction between teachers and students. (Gonzalez et al., 2021; Gu et al., 2023). However, over the years, the focus of online learning at the university level has been predominantly on content delivery and teaching methods, while important areas such as online pedagogy, social aspects and informal learning have fallen victim to this process. (Crawford et al., 2020).

Virtual classrooms, on the other hand, involve real-time interaction between teachers and students and offer plenty of opportunities for interaction through questions, discussions, and group activities (Al-Samarraie, 2019; Andriushchenko et al., 2020). In fact, these platforms even facilitate the cross-cultural adoption of technology in education, allowing students from different parts of the world to collaborate, share ideas, and support each other in study groups and team-based learning projects. In this case, the teacher creates tags (digital traces) as a conventional designation of typical tasks within the framework of completing assignments aimed at acquiring the ability to perform the necessary action, without making its implementation a conscious goal (Añez, 2023; Andriushchenko et al., 2025). However, the teacher must in each case evaluate the results of each student in order to determine which tags should be used to form the assignment. The digital trace of the teacher is considered as a set of aggregated statistical data, as well as the tag/tags that were determined by the teacher as relevant for forming an individual assignment for the student's digital trace data (Fathy, Jaber & Nadeem, 2021). The digital twin of the teacher is the result of modeling the activity of the teacher, who selects the appropriate tags based on the patterns of the teacher's digital traces (De Giusti, 2023; Chamorro-Atalaya et al., 2023).

Effective learning outcomes depend on engagement, and new approaches are needed to fill the gaps in existing virtual platforms. At the same time, the use of online and video conferencing helps apply different learning skills, such as: creativity, deep critical thinking, and increased attention to subject-specific tasks. It has quickly become a cornerstone of all forms of digital, hybrid, and blended learning models, providing face-to-face interactions when physical presence is not possible (Kovtun et al., 2020; Yatsenko et al., 2017). Apps such as Google Meet, Microsoft Teams, and Zoom facilitate collaboration—

using emoji reactions, live polls, question voting, and virtual whiteboards – making learning more dynamic and active. Traditional virtual learning platforms lack robust methods for checking in with students in real time and do not sufficiently account for differences in cross-cultural participation (Hassan & Izquierdo, 2021; Onaji et al., 2022).

The growing interest in learning engagement research is necessary due to the need to understand students' academic behavior. In this article, we discuss the existing limitations and tactics that can be used to engage students in online lectures (Pokataiev et al., 2023). It is noted that online education has led to radical changes in students' perceptions and participation in online courses. This article examines the effective use of various online platforms that have impacted student engagement (Andriushchenko et al., 2022).

PricewaterhouseCoopers estimates that the implementation of artificial intelligence will have increased global gross domestic product (GDP) by 14% by 2030, adding an additional US$15.7 trillion to the global economy. PWC also predicts that strategic investments in various types of AI technologies will contribute to significant increases in productivity and GDP of the global economy. It is predicted that by 2030, the demand for artificial intelligence systems and highly qualified labor of specialists with developed neuro-digital competencies will have increased significantly (Bond et al., 2023; Carvajal & Arenas, 2022).

2. THEORETICAL BACKGROUND

The latest technologies are driving factors of revolutionary breakthrough in the development and improvement of the educational process. The most significant ones include the use of artificial intelligence tools (robotics, machine learning, natural language processing), the creation of virtual, augmented and augmented reality, as well as the Internet of Things (IoT).

Let us turn to the experience of (Carbonell et al., 2023), who carried out a detailed analysis of digital tools that transform educational systems. The author identifies two key aspects of the scientific task of analysis based on big data: infrastructural-technological and competence-based. We should agree with the conclusion of (Carbonell et al., 2023) regarding the intensive development of various digital services and the presence of regulatory frameworks for the use of digital technologies in education, but at the same time insufficient improvement of the methods of "evidence-based management and methodology development" based on big data (Antonijevic et al., 2022).

Most researchers consider the most common digital technologies adapted to pedagogical tasks to be: distance learning, cloud technologies, augmented and virtual reality (Franco, 2022), (González, 2023). Less attention is paid to technologies such as: distributed registry system and blockchain, big data analysis, artificial intelligence (Guc, Viola & Chen, 2021; Han et al., 2023).

A special place in the possibility of using digital technologies for educational purposes is occupied by a digital twin. Industry and public administration have accumulated experience in using Digital Twins technology in a short period of time. Education is just beginning to go this way.

The study was conducted using the following methods: analysis and generalization, formalization, modeling, synthesis and description. The main materials for the study were the results of research work devoted to issues of automated generation of educational subtasks based on the tag and criteria methodology.

3. RESEARCH OBJECTIVE, METHODOLOGY AND DATA

Based on domestic and foreign experience in the development of digital technologies, a hypothesis was formulated about the use of digital twins, which allows designing the pedagogical process, as well as analyzing the behavior of the built pedagogical environment. The technological component was based on information solutions used in industrial production and the real sector of the economy. In this study, a hypothesis was built using the mathematical modulation method of Harichandana et al. (2023)

and using information coding based on the theory of synergetic and self-organization of Kalantari et al. (2022), which are embedded in thinking processes. On this basis, the main components of the digital agent of the teacher were formed.

Besides, to strengthen the position of the authors and to prove the hypothesis, a mixed method of design science research (DSR) was used. This method is based on the isolation and further assessment of the meaningful memory of the teacher's digital twin and its potential model (Andriyuschenko et al., 2025). Collectively, the presented tools serve as a generalization for the accumulation, analysis and transformation of the entire array of information with the subsequent aim of creating a synergy effect and application with the exclusion of potential errors in the model's operation (Yatsenko et al., 2018).

In the process of analysis, collection and correction are carried out in three stages. The first stage is a thorough analysis of scientific achievements from open sources over the past five years, with special attention paid to international scientific metric databases (Scopus and Web of Science) by selecting the keywords "education", "learning", "digital twin", "artificial intelligence" and "metaverse". As a result, it is possible to identify the main shortcomings and niches for further scientific achievements. At the second stage, a semi-structured survey (12 in number) is created with the selection of experts (higher education teachers) competent in this area with relevant experience in using AI tools (Andriyuschenko et al., 2025). NVivo software was used for decoding, which emphasizes the importance of incorporating digital technologies for the development of science. From the point of view of proving the hypothesis are put forward, the key features, functionalities and shortcomings of the implementation of a digital double of a teacher are determined. The third stage is a re-determination and analysis of quantitative indicators of satisfaction of higher education students and employees of educational institutions regarding the implementation of a digital twin in everyday work. Special attention at this stage was paid to social, psychological and ethical aspects.

Definition of a digital twin largely reflects the possibility of its use for solving pedagogical problems. Thus, "a digital twin is a mathematical model consisting of a matrix of target indicators reflecting the requirements for an object and resource constraints when building it. The amount of data used to build a twin reflects the behavior of a real object at all stages of the life cycle. At the same time, changes made to the parameters of the object allow optimizing the system's operation and significantly reducing possible costs."

Engineering information reflects the parameters of the model elements: structure, functions, content. Such a characteristic of the information parameter is similar to the typology by which pedagogical modeling is carried out (Jones et al., 2020), with only one condition that the model should reflect both the structure and functions with content. It follows that the existing pedagogical models in digital twins will be engineering information about the proposed pedagogical project, or reflect the current pedagogical system.

Information on the operation of the model is a way of processing information by mathematical methods, i.e. "digitization of model parameters". This element involves specialized technologies. If it is not difficult to mathematically set the parameters of a physical system, then transferring data about a social system or about the thought processes of an individual is a much larger task. The work of researchers in the field of synergetics and self-organization (Kuts et al., 2020) can serve as a certain basis for identifying the mathematical parameters of the elements of the pedagogical system.

The most difficult thing will be to meet the requirements for transferring information about operations in real time (Lin, 2023). The focus of the problem is that between the physical object and its digital analogue, a person will act as an operator, and much will depend on the subjective factor of the individual (Abdullahi, Perinpanayagam & Hamidu, 2022).

Although innovative technologies have revolutionized teaching and learning methods, online learning has several limitations and challenges. The cultural background of the participants may influence their online learning experience in a remote learning environment (Garcia, 2023). Moreover, students are also shy about using webcams during video conferencing, so some of them do not

participate in the meeting (Corredor, 2022; Mourtzis, 2023). Interestingly, most students use the webcam feature in the meeting rooms or create synchronous online sessions by themselves.

The integration of the technology in higher education has great potential to create more engaging learning opportunities, but the current online education methods reduce student interaction in the virtual environment and limit their learning (Wang et al., 2022). Due to two-dimensional technologies and the development of common video platform tools such as Zoom, the behavioral and body cues used in online education today are limited.

Martinez et al. (2021) noted that specific and standardized rules in the educational space are extremely important for improving the quality of learning. However, according to the literature, a lack of knowledge about technology leads to a wide range of problems. For example, many people reported psychological effects of long video calls, known as "Zoom fatigue" (Mourtzis, 2023; Chiquito et al., 2020).

Since 2020, the academic community has been forced and rapidly transitioned to online learning due to the COVID-19 pandemic, which has become a turning point in the development of the educational process. Similarly, 97% of college students report that their schools have transitioned to online learning; but as more technology is used to support learning, more personal information about students is collected. This has raised several privacy concerns regarding the type of student information being collected and how it is used. Online courses are more vulnerable to cyber-attacks compared to traditional courses, especially around endpoint security, privacy, and process (Aloqaily et al., 2023; Andriushchenko et al., 2021). Moreover, students who misuse the biometric data collected from them, such as unauthorized sharing or reuse, create risks to student autonomy and data integrity.

Currently, the development of Industry 4.0 is very rapid and has an impressive speed of implementation. It is impossible to unequivocally state that Industry 4.0 still dominates, because many in the scientific community already single out digital technologies as the first stages and offspring of Industry 5.0. It is based on the concept of digital leadership, literacy and the dual nature of action. The development of tools and means (such as computing large data sets, cloud storage, interaction sensors, visualization of people, process phenomena, etc.) has become the key to the simultaneous creation of digital twins and the existence of prototypes in real life. Thus, "digital twins" make it possible to perform several operations simultaneously, improve time management and reach new levels of forecasting analytics of results. To optimize production processes, it has become possible to obtain the results of trial options without using the real process and accumulate the data obtained for future projects (Grisales, 2022).

To create reliable and scientifically based conceptual foundations of the presented proposals, a data validation protocol is already used at the initial stage of implementation (Raišienė et al., 2019; Kniazieva et al., 2023). The validity of the initial stage of data collection and analysis of scientific achievements has good results, and also takes into account the results of surveys, expert opinion (n = 7) of scientists, teachers and scientific and pedagogical staff. Based on the 5-point Likert scale, data analysis was carried out, the completeness of the model, its components and their mutual consistency were determined. The next step was the development of a methodological basis and the creation of a visual observational example for further empirical research and pilot implementation in the educational process.

4. RESULTS AND DISCUSSION

For students of new technologies, prompt personalized feedback and adaptive learning, the way the group got into intellectual education, which can effectively solve all problems in the field of education process.

Thus, the introduction of AI is not intended to replace a person, but, on the contrary, to become a great assistant. At the same time, it is necessary to understand that new technologies of artificial intelligence are highly dependent on a person and the requirements for the conditions of creation, in this

case there are no ready-made solutions. As the study showed, for the effective use of AI in education we need:

- use of computing power, accumulation of a large amount of data;
- highly qualified specialist's consultations on the creation and training of artificial intelligence models;
- time for this training.

Artificial intelligence (AI) should be viewed as both a long-term technological investment and a transformative tool that is already actively integrated into the field of education. Its implementation enables universities and schools to provide more flexible, adaptive, and in-depth learning opportunities. One of the most relevant applications of AI in education is the development of personalized teaching systems, where the content and pace of instruction are tailored to the individual capabilities, prior knowledge, and specific needs of each student.

Such systems have proven themselves most successfully in the exact sciences, in particular in medicine, as well-structured knowledge. The report Intelligence Unleashed: An Argument for AI in Education contains three models that underlie intelligent learning systems:

– Domain of knowledge model. AI needs knowledge about the discipline being studied: topics and connections between them. The more detailed and accurately the structured subjects of knowledge, the more efficiently the AI will work. Therefore, mathematics, physics, computer science and medicine are the most suitable subjects for organizing AI.

– Educational model of lifelong education. Artificial intelligence accumulates and generates all the information of the student regarding achievements, features of perception, difficulties, emotional state, empathy, etc.

– Teaching model of higher education. In this case, AI uses information about the teacher's approaches in the educational process, providing feedback to the student, the ability to evaluate the work performed, and the formation of skills for creating an educational context.

Thanks to artificial intelligence, digital technology interfaces adapt to the user and the abilities of each student in real time. A personalized approach allows to fill in the gaps in education and reinforcement of material based not on the general picture of changeability, but on the capabilities of a specific student.

For example, the voice assistant Merlin AI and Poe AI are used as a digital assistant for teachers, created on the basis of artificial intelligence. It is a voice assistant that can provide the necessary presentation, quickly find images, and set a timer for a short knowledge check. Merlin allows the teacher to save time and focus on really important tasks. In this vast ocean of AI options, Poe AI and Merlin AI have attracted significant attention due to their unique capabilities and applications. Merlin AI is a set of tools for all writing needs, whether it is for work, a large research project, or just an attempt to make every day email more interesting. It has more than 70 writing tools that seamlessly integrate with more than 5,00,000 web pages and applications. Poe AI can decode complex features such as context, tone, and semantics, making it ideal for deployment in a variety of industries. It works by creating bots for a variety of use cases.

Chatbots can also become virtual assistants for teachers. The role of a teacher can be performed by chatbots, available to students around the clock, which makes it possible to convey the material to students. Chatbots can also mark gaps in each student's knowledge.

The ALP (Kidaptive) cloud platform is able to create a psychometric profile of each student and adjust the educational process to this data. The platform is also able to predict the ability of students in certain areas of science. This is a powerful and flexible platform for assessment and reporting, designed to collect data from various sources. The data is combined into a universal system and analyzed to create a personalized student profile for each user. ALP allows you to customize interaction with students based on carefully researched pedagogical principles.

The core application included a Kidaptive-developed Java application running on EC2 using an

application load balancer, event processing using Apache Kafka, and AI processing based on HBase, Spark, and Oozie.

Knewton is a platform that delivers tailored learning for higher education. Software products skillfully fill in the gaps and, in particular, the gaps in the educational environment regarding the specifics of the educational context due to machine learning and artificial intelligence. These predict possible potential steps of education seekers in their intentions for cognition. Knewton applies AI to tailor educational content to the needs of individual students, making the learning experience more personalized and helping students achieve their best learning outcomes. Knewton is an AI-powered platform that uses carefully curated educational content to tailor individual lesson plans for each student. Knewton has attracted significant scholarly and professional attention within the education industry. Since its founding in 2008, the company has raised over $180 million in funding and has provided over $15 billion in personalized recommendations to students (Fig. 1).

One of the most famous assistant chatbots is Jill Watson, a virtual assistant based on the IBM artificial intelligence system. A professor of computer science at the Georgia Institute of Technology has "created" an assistant that will quickly answer the most popular questions of students. The machine learning algorithm studied more than 40,000 messages on the Internet, and as a result, it surveyed students on questions of interest to them. Many did not even realize that they were communicating with a chatbot. Checking homework, filling out documents, preparing reports on the work done, drawing up a lesson plan, which takes up 50% of the teacher's working time, is very important. This task is fully automated and the teacher focuses his attention on teaching students.

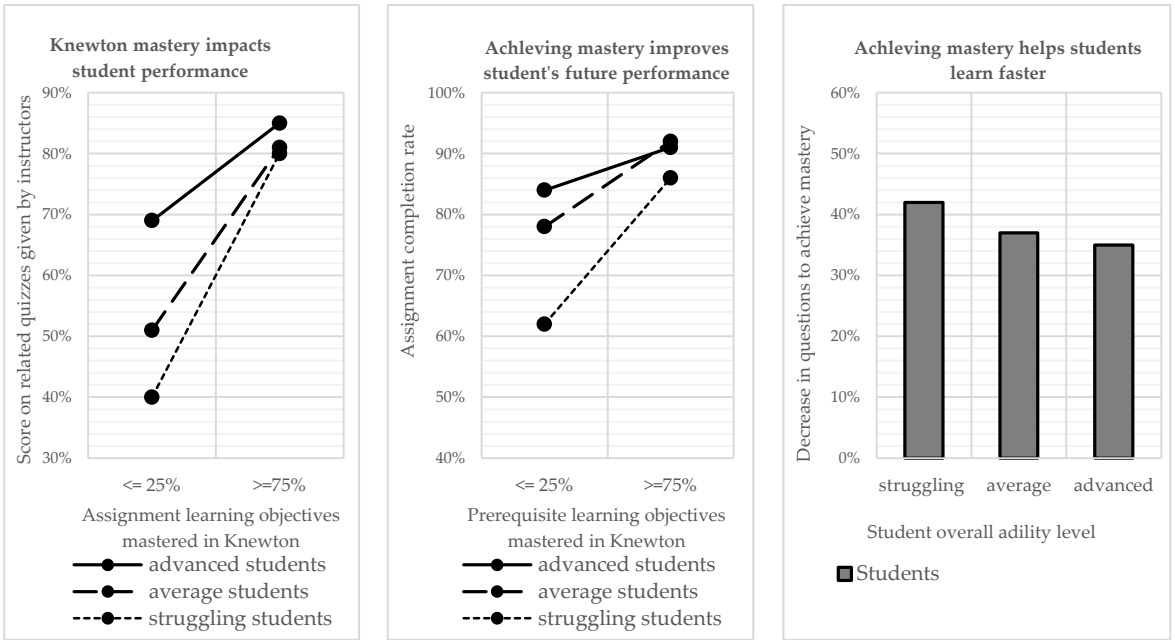

Fig. 1. Knewton Student Learning Outcomes

Source: development by the author's

Some Chinese schools have already implemented programs based on artificial intelligence to assess students' knowledge. In large-scale testing (in which 120 million people participated), the virtual "teacher" fully justified itself. The virtual "teacher" received the qualification of a teacher, as in 92% of testing cases he did not make a mistake.

In the USA, the Gradescope project developed by specialists of the University of California at Berkeley was implemented to identify students' knowledge, where a virtual teacher estimated students' knowledge without errors by as much as 90%. Gradescope can be used as a standalone application or as a free integration with Canvas for teachers and students. The integration allows you to link the busy schedule and tasks, and the grades will be automatically sent to the Canvas grade journal.

The British company Century Tech used cognitive neuroscience to identify gaps in students' knowledge. He proposed educational material, where students' answers to a certain science course are automatically recorded and their correctness is automatically analyzed. Teachers monitor the accuracy of individual components of the task, both for each student and for the students of the entire class with the help of special tools.

AI algorithms process data from all models. The processing results are presented in the student's interface in the form of adaptive educational content (text, sound, video, animation, tasks). As soon as the student begins to interact with the content, he leaves a digital trace, which is also analyzed by using AI methods. The latter were studied in the work and have a descriptive and quantitative result, which indicates the relevance of introducing digital twins in teaching.

The results of the digital trace analysis serve as the basis for feedback and new adaptation of educational content. During this process, large amounts of data are cyclically fed to the system for dynamic optimization and self-improvement. The cycle is repeated until the student achieves the educational result.

Dialogue-based learning systems are based on:

- pedagogical model;
- student model;
- knowledge domain model.

However, the difference is that such systems do not provide adapted educational content that simulates a dialogue with students changes to help find the necessary solution, assess knowledge and determine their level of assimilation of the material being studied, to consolidate the topic studied using specific examples. In this context, the Watson Tutor software product serves as an illustrative example of the practical application of artificial intelligence in education. As a dialogue-based learning system developed by Pearson and IBM for universities, it is designed to deeply immerse students in a particular topic of study. The program offers additional materials, tracks student responses and adapts the conversation and makes a summary depending on the responses. Based on this approach, we have generalized the logic of cooperation between the teacher and the student (Fig.2).

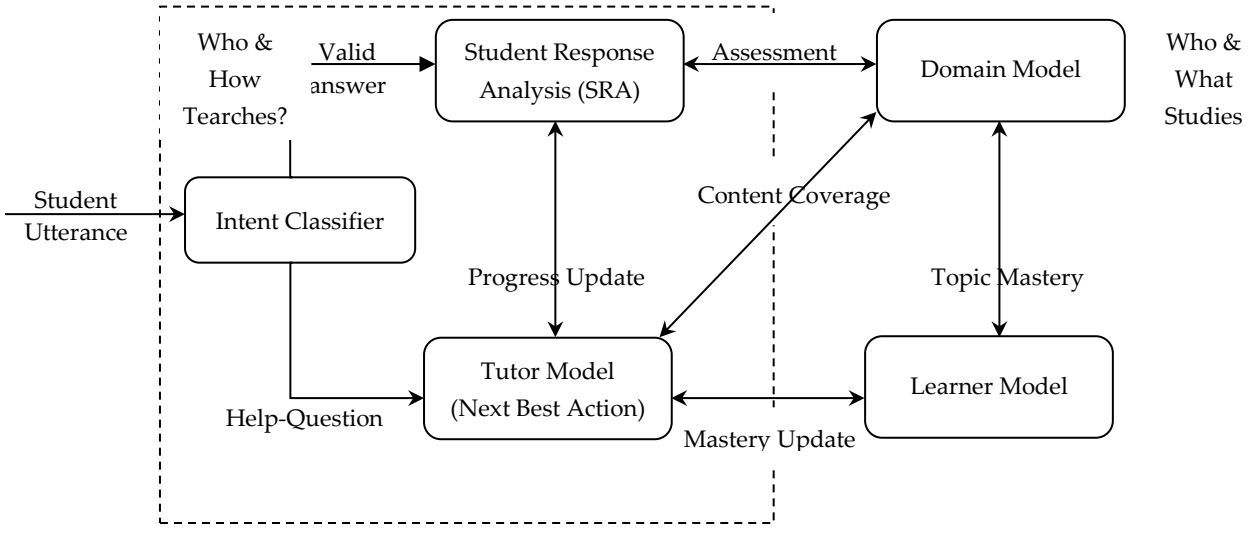

Fig.2. Graphical representation of cooperation between a student and a teacher in the digital space
Source: development by the authors

"The digital twin of the teacher" is a program developed by the University of Pittsburgh – a dialogue, which is based on a complex of neural networks, answers students' questions. Another technology is Deep Fake, which allows you to superimpose the image of the teacher's face on a 3D doll to simulate the effect of Representation. This technology is most widely used in universities in Pittsburgh.

The practical significance of using digital twins lies in two main possibilities: an ontological digital model will reflect the behavior of a real pedagogical system and predict possible crises and defects; a digital model, as an imitation of existing real processes, can become a new method of scientific research in the design of the educational process.

Thus, the digital twin of the pedagogical model will be presented in the form of the following parameters (Fig. 3): parameters of the subjects of the educational process; structure, functions and content of the model; mathematical apparatus that transforms information; time and converted data.

In the foreseeable future, the logic of constructing research in pedagogical sciences will be oriented towards digitalization and innovation, which, in turn, can give an additional impetus to the study of the possibility of constructing digital twins in education. In addition to the possibility of using the technology in question as a method of scientific knowledge, it is permissible to use its potential and resources in solving fragmented educational problems. For example, a departmental system of personnel training can implement the technology of digital twins for designing social behavior in order to improve preventive work to prevent destructive and deviant behavior of citizens.

The result of the digital design stage is the development of a digital twin of a teacher. Here, it is necessary, first of all, to create a methodological basis for its use, a technology for managing it (to conduct a simulation of possible events).

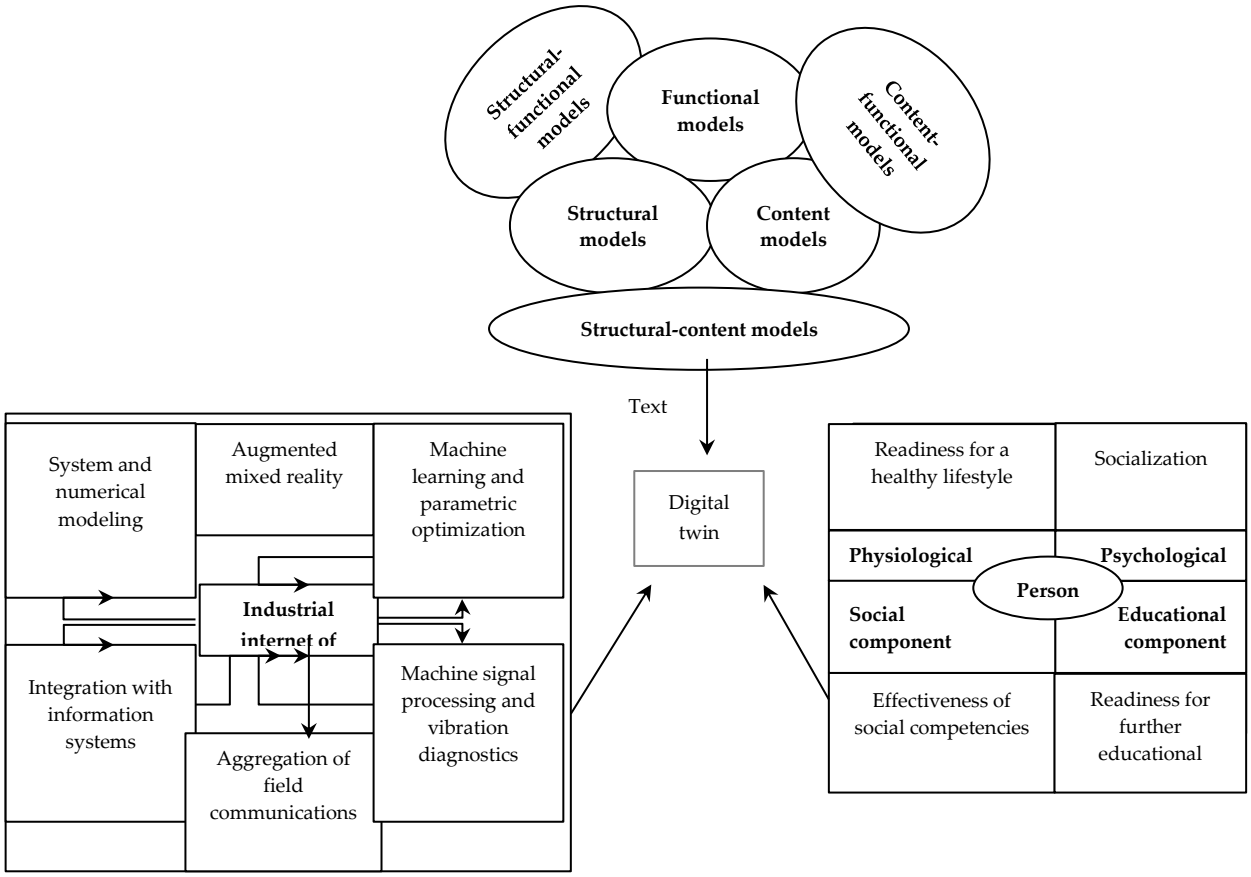

Fig. 3. Structure of the digital twin of the pedagogical model

Source: development by the authors

Simulation of the behavior of virtual prototypes of a teacher seems possible, for example, on the basis of agents. In order for the use of a digital twin of a teacher to bring results when conducting experiments (solving various classes of problems on it), dynamic simulation models can also be designed in the presentation of data, their analysis and use. The digital twin of a teacher combines virtual and physical environments, which include a physical system, external sensors, communication interfaces, etc. (Fig. 4).

These data include information from physical systems, external sensors, information systems, etc.,

they are transferred to the virtual environment to update the model in the digital twin. For example, the management of an educational institution may also consider information systems that will serve as a database. These include repositories of final works of applicants (diplomas), information bases of distance courses, security systems, etc. It is assumed that there is a hardware and software complex that simulates the work of an educational institution and the actions of students, teaching staff and employees in it, due to which it solves certain classes of problems on the digital twin of the student.

For data processing, it is logical to use the mechanism of building a complex double - this is a set of all currently known technologies for data aggregation, modeling, analysis and visualization. The entire information base ("Big Data") is formed at the base, which becomes the basis for decision-making as a factor of possible action. The information field is created using open sources and its own database.

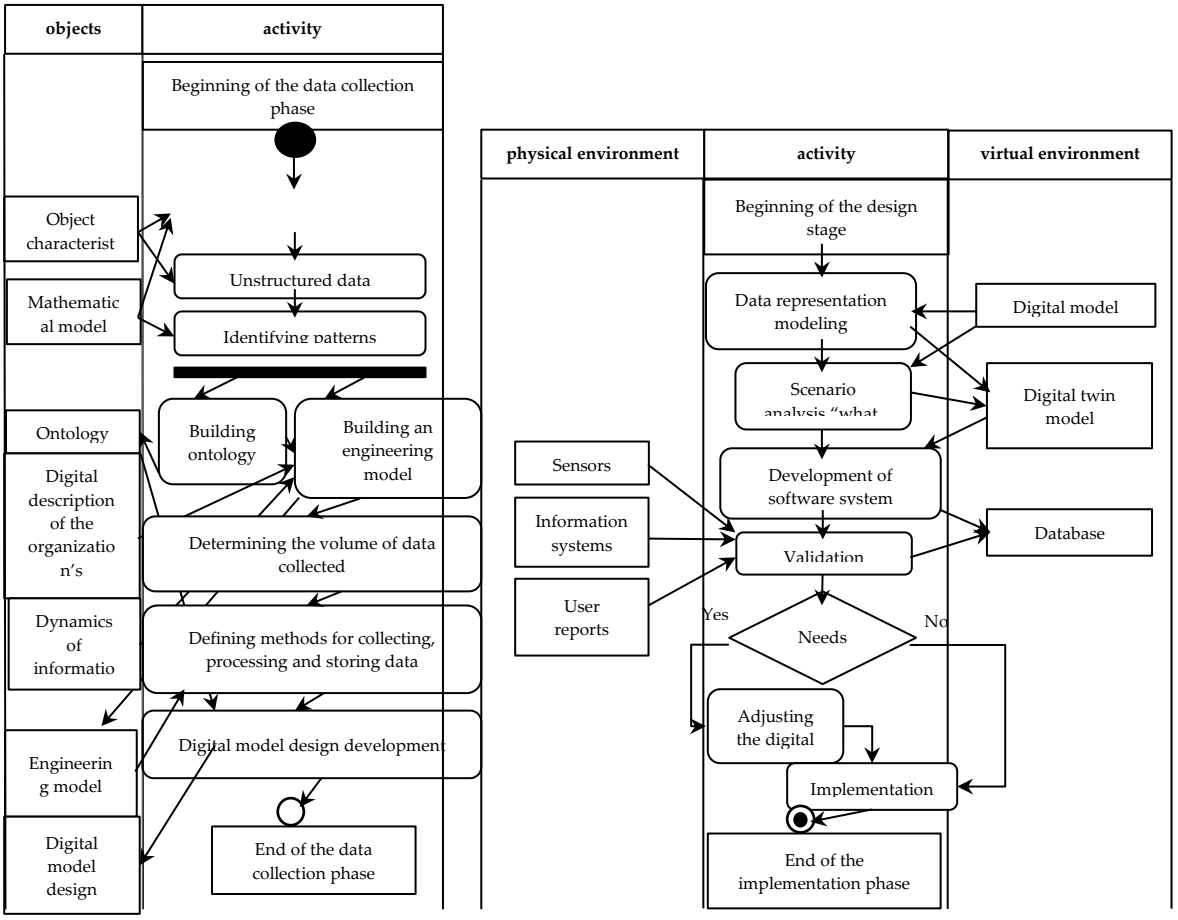

Fig. 4. Data collection, design and implementation stages when creating a digital twin of a teacher
Source: development by the authors

The synthesis of all information is created as a predictive model, in which the next step is the most likely action from all the specified factors and events. In this case, an action scenario is formed based on the "intuitive" development of events. And from the point of view of saving money – this is an indicator of their preservation and multiplication in the absence of costs. To confirm the hypothesis put forward in this study, the authors, based on the methods described above and the data obtained by the Association of European Universities, calculated the positive impact of artificial intelligence and the creation of a digital twin of a teacher (Needs and wellbeing of students and staff, 2023).

The survey was conducted in two stages: the first stage formed a collective understanding of respondents about well-being and the parameters of its measurement (to emphasize ethical norms), the second stage identified the factors that most influence the individual well-being of participants in the educational process. As a result, according to respondents, artificial intelligence tools and the creation of

a digital twin of a teacher include several aspects - physical, psychological, social, emotional and cultural, which are structured into three groups: 1) community and culture; 2) policy and practice; 3) institutional elements. The analysis of the assessment of the impact of factors on the well-being of students and university staff showed the following results (Fig. 5).

Analysis of the impact of digital or hybrid education on well-being using digital twins showed that out of 17 factors that are directly or indirectly influenced by digital technologies, a positive effect is observed in only 2 – "work-life balance" and "flexible approaches to learning and teaching". Digital technologies have a maximally neutral impact on a fairly large group of factors. However, it should be noted that a smaller proportion of responses for all factors were given by students: a particularly noticeable difference compared to employees is noted in the assessment of the impact of digital technologies on "psychological safety" (20.39%), which may indicate an underestimation of this impact by university employees.

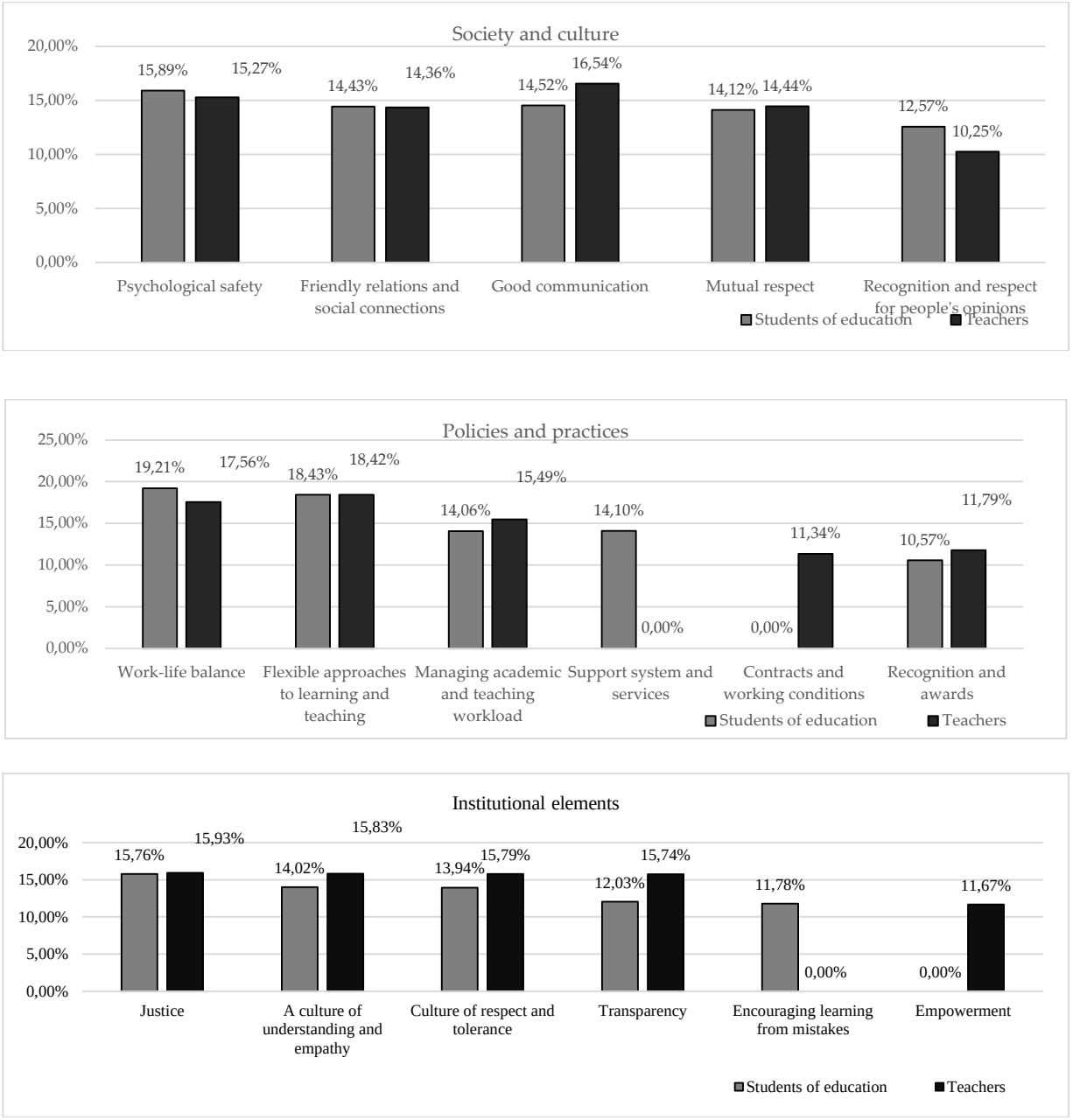

Fig. 5. AI tools and teacher digital twin creation that have the greatest impact on the well-being of students and university staff

Source: calculated by the authors

Considering the digital double of a teacher as one of the tools for creating an adaptive educational

environment, it is worth remembering that of all aspects of its application in the educational environment – working with big data, computer calculations, educational values – the last aspect will always be a priority. The implementation of educational values is possible only on an ethical basis (Vasianovych et al., 2023). Ethics is a kind of filter that filters out decisions that can negatively affect education and the person in it. Therefore, the issue of using artificial intelligence in the educational process must undergo an ethical assessment in order to minimize the possible risks of errors and malicious use. Today, issues remain relevant, in particular:

- finding criteria for ethically acceptable artificial intelligence technology in education;
- determining the ethical obligations of companies and educational organizations that are engaged in the development and research of digitalization products for educational purposes;
- combining the changing goals, interests and emotions of different groups of students with the ethics of using artificial intelligence;
- ethical implications of displaying personal information in large data sets, which additionally raises the issue of data confidentiality and user identity security.

Digital twins of teachers actively use this technology in the transitional stage in Industry 5.0, since the collection and accumulation of all available data allows analyzing the behavior of a real object and managing it. Processing digital twin data involves the exchange of a huge amount of information, which comes, as noted earlier, both in structured and unstructured form. The sources of this data are diverse and heterogeneous. The problem is not only the diversity of the collected information, but also the limited bandwidth of the data transmission system from information collection systems to information processing systems. Here, high-bandwidth highways for transmitting information, cloud storage schemes, and systems for ensuring the security of this data are needed. The features of big data also include the fact that they are not created for research purposes, but cover the entire population, provide an idea of \u200b\u200bpeople's behavior at the micro level and are generated and processed in real time. This is very important in the study of human social behavior, since it gives an idea of \u200b\u200bthe real actions and interests of students. Analysis of such data using Big Data technologies allows you to effectively perform important management functions. The results of big data processing allow us to identify trends and patterns, on the basis of which various forecasts can be made. Digital twin data can be used for analysis, development of strategies and making the right decisions when forming its life trajectory. It is further proposed to create an intelligent decision-making system in a certain class of problems based on the obtained results of processing the digital twin data of a person.

5. CONCLUSIONS

The conducted brief analysis leads to the conclusion that the hypothesis about the possibility of using the digital modeling tool for pedagogical processes is confirmed by the presence of the elements required for the implementation of the technology. The digital twin allows for a complete analysis of all factors affecting the quality of the pedagogical process. Despite the fact that the technology under consideration in education is currently only a hypothetical possibility, the digital twin is capable of improving the quality of the educational process, leveling out the negative consequences of various influencing factors. Accompanying the educational process with digital imitation helps to identify hidden problems, which will subsequently have a positive effect on the quality of the formation of the student's worldview. The most important condition for creating a digital twin of the pedagogical process is the competent definition of all parameters of the pedagogical model, as well as high-quality aggregation, analysis and visualization of information transmitting the system parameters. The basis for the development of scientific thought in the field of technologization of professional education can be the technological frontier of domestic and international engineering thought, which over almost thirty years of accumulation of experience in the use of "intelligent assistants" has generated various digital platforms that allow optimizing production cycles and the operation of the entire production system.

The construction of digital replicas of pedagogical models fits harmoniously into the updated passports of specialties for the training of teachers and lecturers, providing researchers with the opportunity to use modern digital resources in the context of the digital transformation of professional education. Further development of pedagogical thought can be associated, among other things, with the construction of "digital ontological models" of the process of teaching and upbringing of an individual, as a specific method of scientific knowledge in pedagogy.

Author Contributions:

Each author contributed equally to all aspects of this research, including Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Supervision, Validation, Visualization, Writing – original draft, and Writing – review & editing.

Acknowledgment: This research did not receive any outside support, including financial support.

Conflict of interest: The authors declare no conflict of interest.

REFERENCES

[1] Abdullahi, I., Perinpanayagam, S., & Hamidu, I. (2022). A fog computing-based approach towards improving asset management and performance of wind turbine plants using digital twins. *In: 2022 27th International Conference on Automation and Computing (ICAC),* 1–5. https://doi.org/10.1109/ICAC55051.2022.9911170

[2] Al-Samarraie, H. (2019). A Scoping Review of Videoconferencing Systems in Higher Education. *The International Review of Research in Open Distributed Learning,* 20 (3). https://doi.org/10.19173/irrodl.v20i4.4037

[3] Aloqaily, M., Bouachir, O., Karray, F., Al Ridhawi, I., & Saddik, A. E. (2023). Integrating digital twin and advanced intelligent technologies to realize the metaverse, *IEEE Consumer Electronics Magazine,* 12(6), 47–55. https://doi.org/0.1109/MCE. 2022.3212570

[4] Andriushchenko, K., Khaletska, A., Ushenko, N., Zholnerchyk, H., Ivanets, I., Petrychuk, S., & Uliganets, S. (2021). Education process digitalization and its impact on human capital of an enterprise. *Journal of Management Information and Decision Sciences,* 24(5), 1-9. https://www.researchgate.net/publication/377329779_Education_process_digitalization_and_its_impact_on_human_capital_of_an_enterprise

[5] Andriushchenko, K., Kovtun, V., Cherniaieva, O., Datsii, N., Aleinikova, O., & Mykolaiets, A. (2020). Transformation of the educational ecosystem in the singularity environment. *International Journal of Learning, Teaching and Educational Research*, 19(9), 77–98. https://doi.org/10.26803/ijlter.19.9.5

[6] Andriushchenko, K., Liezina, A., Lavruk, V., Sliusareva, L., & Rudevska, V. (2022). Intelligent enterprise capital control based on Markov chain. *Acta Innovations,* 45, 18-30. https://doi.org/10.62441/actainnovations.v45i.295

[7] Andriushchenko, K., Liezina, A., Slavkova, A., Logvinov, P., Lavruk, V., Petrukha, S., & Storozhenko, A. (2025). The Impact of Energy-Efficient Technologies on the Development of the Agricultural Industry. *Journal of Environmental & Earth Sciences*, 7(1), 423–437. https://doi.org/10.30564/jees.v7i1.7635

[8] Andriushchenko, K., Liezina, A., Vasylchak, S., Manylich, M., Shterma, T., & Petrynyak, U. (2022). Management of the development of the innovative potential of the region. *TEM Journal*, 11(1), 339–347. https://doi.org/10.18421/TEM111-43

[9] Andriushchenko, K., Riepina, I., Buriachenko, A., & Kyryliuk, O. (2025). Determining the capabilities of artificial intelligence on the development of cryptotrading and blockchain technology. *Technology Audit and Production Reserves*, *3*(4(83), 42–52. https://doi.org/10.15587/2706-5448.2025.330463

[10] Antonijevic, P., Iqbal, M., Ubakanma, G., & Dagiuklas, T. (2022). The metaverse evolution: toward future digital twin campuses. *in: 2022 Human-Centered Cognitive Systems (HCCS), IEEE*. 1–8. https://doi.org/ 10.1109/HCCS55241.2022.10090250

[11] Añez, R. J. (2023). Modeling and virtual commissioning of the digital twin of a Flowpack machine with the Melsoft Gemini tool. Ms. Thesis, Control Engineering, Automation and Robotics, Universidad de País Vasco, Bilbao, Spain. https://addi.ehu.es/handle/10810/62801

[12] Autiosalo, J. (2018). Platform for industrial internet and digital twin focused education, research, and innovation: Ilmatar the overhead crane. IEEE World Forum on Internet of Things, WF-IoT 2018 - Proceedings, 2018-January, 241–244. https://doi.org/10.1109/WF-IoT.2018.8355217

[13] Bond, M. Buntins, K. Bedenlier, S. Zawacki-Richter, O., & Kerres, M. (2020). Mapping research in student engagement and educational technology in higher education: a systematic evidence map. *International Journal of Educational Technology in Higher Eduation*, 17(2). https://educationaltechnologyjournal.springeropen.com/articles/10.1186/s41239-019-0176-8

[14] Budnyk, O., & Kotyk, M. (2024). Information and Communication Technologies in Teaching Students with Special Educational Needs. In O. Budnyk & S. Sydoriv (Eds.), *The space of inclusive education: Voices from Ukraine and beyond* (pp. 224–233). BRILL https://doi.org/10.1163/9789004688131_024

[15] Camacho, J. P. C., & Loayza, L. M. H. (2023). Development of a digital twin of the handling and sorting stations of the Festo MPS 500 modular production system. *Thesis, Electronic Engineering Career, Salesian Polytechnic University, Cuenca, Ecuador*. https://dspace.ups.edu.ec/handle/123456789/24619

[16] Carbonell, M. R., Fontanillas, T. R., Catasús, M. G., & Quemada, P. B. (2023). Digital transformation in higher education: The case of the UOC. *RIED-Ibero-American Journal of Distance,* 26(1), 163-179. https://doi.org/10.5944/ried.26.1.33998

[17] Carvajal, C. A. R., & Arenas, N. A. G. (2022). Approach to digital transformation in higher education institutions through the theory of change. *En Contexto Journal*, 10(17), 229-263. https://doi.org/10.53995/23463279.1163

[18] Chamorro-Atalaya, O., Olivares-Zegarra, S., Sobrino-Chunga, L., Guerrero-Carranza, R., Vargas-Diaz, A., Huarcaya-Godoy, M., Rasilla-Rovegno, J., Suarez-Bazalar, R., Poma-Garcia, J., & Cruz-Telada, Y. (2023). Application of the Chatbot in University Education: A Bibliometric Analysis of Indexed Scientific Production in SCOPUS, 2013-2023. *International Journal of Learning, Teaching and Educational Research*, 22(7), 281-304. https://doi.org/10.26803/ijlter.22.7.1

[19] Chiquito, V. M, Plua, G. J. C., Chong, B. M, & Chong, B. C. (2020). Digital twins and their evolution in the industry. *Scientific Journal World of Research and Knowledge*, 4(4), 300-308. https://doi.org/10.26820/recimundo/4.(4).noviembre.2020.300-308

[20] Corredor, S. D. F. (2022). Industry 4.0 and digital twins in construction. Thesis. Faculty of engineering, Militar University of New Granada, Bogotá, Colombia. https://repository.unimilitar.edu.co/handle/10654/43852

[21] Crawford, J., Butler-Henderson, K., Rudolph, J., Malkawi, B., Glowatz, M., Burton, R., Magni, P. A., & Lam, S. (2020). COVID-19: 20 Countries' Higher Education Intra- Period Digital Pedagogy Response. *Journal of Applied Learning and Teaching*, 3, 9-28. https://doi.org/10.37074/jalt.2020.3.1.7

[22] De Giusti, A. E. (2023). Digital Transformation in Higher Education. Possibilities and Challenges. *Ibero-American Journal of Technology in Education and Technology Education*, 35(1), 9-15. https://doi.org/10.24215/18509959.35.e1

[23] Fathy, Y., Jaber, M., & Nadeem, Z., (2021). Digital twin-driven decision making and planning for energy consumption. *Journal of Sensor and Actuator Networks,* 10(2):37. https://doi.org/10.3390/jsan10020037

[24] Franco, R. G. (2022). Digital Twins and Virtual Worlds: Driving Workplace Transformation. *Thesis: Tecno Campus, Universitat Pompeu FaBra, Barcelona, Spain*. https://repositori.tecnocampus.cat/handle/20.500.12367/2323

[25] Garcia, D. S. E. (2023). Digital twin in AR of the Automation Plant of the Santo Tomás University. *Thesis: Mechatronics Engineering, Universidad Santo Tomás, Bucaramanga, Colombia*. https://repository.usta.edu.co/handle/11634/53052

[26] Gonzalez, P., Mueller, B., Merry, K., Jones, C., & Kelder, J.A. (2021). Changing teaching practice: The evolving purpose of the teacher in higher education. *Journal University Teaching Learning Practice*, 18, 1–11. https://doi.org/10.53761/1.18.6.1

[27] González, C. M. T. (2023). Digital twins applied to biomedicine. *Canarian Pediatric Journal*, 47(2), 128-134. https://scptfe.com/gemelos-digitales-aplicados-a-la biomedicina/

[28] Grisales, G. A. D. J. (2022). Prospects for appropriation of digital twins in learning factories for decision-making. *EDUTEC 2022, Palma XXV International Congress*, 73-77. https://dspace.uib.es/xmlui/handle/11201/160460?show=full

[29] Gu, J., Wang, J., Guo, X., Liu, G., Qin, S., & Bi, Z. (2023). A metaverse based building evacuation training system with deep reinforcement learning. *IEEE Transactions on Systems, Man, and Cybernetics: Systems* 53 (4), 2209–2219. https://doi.org/10.1109/TSMC.2022.3231299

[30] Guc, F., Viola, J., & Chen, Y. (2021). Digital Twins Enabled Remote Laboratory Learning Experience for Mechatronics Education. *Proceedings 2021 IEEE 1st International Conference on Digital Twins and Parallel Intelligence, DTPI 2021*, 242–245. https://doi.org/10.1109/DTPI52967.2021.9540196

[31] Han, Y., Niyato, D., Leung, C., Kim, D. I., Zhang, K., Feng, S., Shen, X., & Miao, C. (2023). A dynamic hierarchical framework for iot assisted digital twin synchronization in the metaverse, *IEEE Internet of Things Journal*, 10(1), 268–284. https://doi.org/10.48550/arXiv.2203.03969

[32] Harichandana, B., Misra, S., Nagendra, K., V., & Anandaraj, S. (2023). Introduction of Virtual Environment with Personalized Content Recommendation for Realistic Avatar Creation in Online Platform using Machine Learning. *2023 Second International Conference on Augmented Intelligence and Sustainable Systems (ICAISS)*, Trichy, India, 540-545. https://doi.org/10.1109/ICAISS58487.2023.10250673

[33] Hassan, B., & Izquierdo, E. (2021). Apparelnet: Person verification encompassing auxiliary attachments variation. *In Proceedings of the 2021 IEEE 23rd International Workshop on Multimedia Signal Processing (MMSP), Tampere, Finland, 6–8 October 2021*; IEEE: NewYorkCity, NY, USA, 1–6. https://doi.org/10.1109/MMSP53017.2021.9733523

[34] Jones, D., Snider, C., Nassehi, A., Yon, J., & Hicks, B. (2020). Characterising the digital twin: A systematic literature review. *CIRP journal of manufacturing science and technology*, 29, 36–52. :https://doi.org/10.1016/j.cirpj.2020.02.002

[35] Kalantari, S., Pourjabar, S., Xu, T.B., & Kan, J. (2022). Developing and user testing a Digital Twins prototyping tool for architectural design. *Automation in Construction Journal*, 135(1), 1-14. https://doi.org/10.1016/j.autcon.2022.104140

[36] Kniazieva, T., Kazanska, O., Orochovska, L., Tsymbalenko, Y., & Dergach, A. (2023). Analysis of the impact of digitalization on the quality and availability of public services in Ukraine – a comparative approach with insights from Estonia. *Statics Politics and Police,* 3, 375-398. https://doi.org/10.1515/spp-2023-0012

[37] Kovtun, V., Andriushchenko, K., Horbova, N., Lavruk, O., & Muzychka, Y. (2020). Features of the management process of anbidextrouos companies. *TEM Journal*, 9(1), 221-226. https://doi.org/10.18421/TEM91-31

[38] Kümmel, E., & Kimmerle, J. (2020). The effects of a university's self-presentation and applicants' regulatory focus on emotional, behavioral, and cognitive student engagement. *Sustainability*, 12(23), 10045. https://doi.org/10.3390/su122310045

[39] Kuts, V., Otto, T., Bondarenko, Y., & Yu, F. (2020). Digital twin: Collaborative virtual reality environment for multi-purpose industrial applications. *ASME International Mechanical Engineering Congress and Exposition Proceedings (IMECE),* November 16–19, 2B-2020, 1-7. https://doi.org/10.1115/IMECE2020-23390

[40] Liezina, A., Lavruk, A., Matviienko, H., Ivanets, I., Tseluiko, O., & Kuchai, O. (2023). Impact of econometric modeling and perspectives of economic security of the cross-industry complex. *ACTA INNOVATIONS*, 47, 73–83. https://doi.org/10.62441/actainnovations.v47i.315

[41] Lin, J. (2023). Development of digital twins of simple linear elastic structures. *Thesis, Barcelona School of Engineering, Universidad Politécnica de Catalunya, Barcelona, Spain*. https://upcommons.upc.edu/handle/2117/389759

[42] Martinez, E. M., Ponce, P., Macias, I., & Molina, A. (2021). Automation Pyramid as Constructor for a Complete Digital Twin, Case Study: A Didactic Manufacturing System. *Sensors*, 21(14), 1-29. https://doi.org/10.3390/s21144656

[43] Mourtzis, D. (2023). Digital twin inception in the era of industrial metaverse. *Frontiers in Manufacturing Technology*, 3. https://doi.org/10.3389/fmtec.2023.1155735

[44] Needs and wellbeing of students and staff. Thematic Peer Group Report. (March, 2023). *University of St Andrews, United Kingdom* . https://surl.li/lfjuym

[45] Watson Tutor. (2025). *Showcase.* https://iaied.org/showcase/6hRMxzuPi8sYwCw6YiU8YS

[46] Olmo, M. M., & Alba, B. G. (2023). Training in digital competence for primary and early childhood education teachers in Spain: A bibliometric review of the literature. *Publications*, 53(1), 137–162. https://doi.org/10.30827/publicaciones.v53i1.27990

[47] Onaji, I., Tiwari, D., Soulatiantork, P., Song, B., & Tiwari, A. (2022). Digital twin in manufacturing: conceptual framework and case studies. *International Journal of Computer Integrated Manufacturing*, *35*(8), 831–858. https://doi.org/10.1080/0951192X.2022.2027014

[48] Pokataiev, P., Liezina, A., Andriushchenko, A., & Petukhova, H. (2023). The role of biotechnology in the development of the bioeconomy. *ACTA INNOVATIONS*, 46, 18–33. https://doi.org/10.62441/actainnovations.v46i.303

[49] Pokataiev, P., Teteruk, K., & Andriushchenko, A. (2023). A biotechnological business incubator as an instrument of innovation entrepreneurship. *Recent Trends in Business and Entrepreneurial Ventures*, 2023, 37–60. https://search.worldcat.org/title/1498519189?oclcNum=1498519189

[50] Raišienė, A.G., Yatsenko, O., Nitsenko, V., Karasova, N., & Vojtovicova, A. (2019). Global dominants of Chinese trade policy development: Opportunities and threats for cooperation with Ukraine. *Journal of International Studies*, 12(1), 193-207. https://doi.org/10.14254/2071-8330.2019/12-1/13

[51] Sepasgozar, S. M., Khan, A. A., Smith, K., Romero, J., G., Shen, X., Shirowzhan, S., Li, H., & Tahmasebinia F. (2023). Bim and digital twin for developing convergence technologies as future of digital construction. *Buildings*, 13(2), 441. https://doi.org/10.3390/buildings13020441

[52] Vasianovych, H., Budnyk, O., Melnyk, Ya., & Fomin, K. (2023). The educator as a subject of the spiritual development of student youth. *Caritas et Veritas,* 2(13), 38-50. https://doi.org/10.32725/cetv.2023.020

[53] Wang, Z., Su, Y., Fu, L., & Wei, Y. (2022). Educational 5G Edge Computing: Framework and Experimental Study. *Electronics (Switzerland)*, 11(17), 1-22. https://doi.org/10.3390/electrónica11172727

[54] Yatsenko, O., Nitsenko, V., Karasova, N., William, H.M., & Parcell, J. L. (2017). Realization of the Potential of Ukraine – EU Free Trade Area in Agriculture. *Journal of International Studies*, 10(2), 258-277. https://doi.org/10.14254/2071-8330.2017/10-2/18

[55] Yatsenko, O., Nitsenko, V., Mardani, A., & Tananaiko, T. (2018). The impact of global risks on the world trade and economic environment. *Financial and credit activity: problems of theory and practice*, 4(27), 435-444. https://doi.org/10.18371/fcaptp.v4i27.154279

Oksana Domina, PhD, Grant-funded Researcher, Faculty of Social Sciences, University of Helsinki, Helsinki, Finland;
ORCID ID: 0000-0003-4242-6344
Address: University of Helsinki, Yliopistonkatu, 4, Helsinki, 00100, Finland.
E-mail: oksana.domina@helsinki.fi

Kateryna Andriushchenko, Doctor of Economics, Professor, Professor of the Department of Business, Economics and Entrepreneurship, Kyiv National Economic University named after Vadym Hetman, Kyiv, Ukraine;
ORCID ID: 0000-0002-6274-5310
Address: Kyiv National Economic University named after Vadim Hetman, 54/1, Beresteyskyi Avenue, Kiev, 03057, Ukraine.
E-mail: katya373@i.ua

Anastasiia Liezina, Candidate of Economic Sciences (PhD in Economics), Associate Professor in the Department of Business Economics and Entrepreneurship, Kyiv National Economic University named after Vadym Hetman, Kyiv, Ukraine;
ORCID ID: 0000-0003-0516-6598
Address: Kyiv National Economic University named after Vadim Hetman, 54/1, Beresteyskyi Avenue, Kiev, 03057, Ukraine.
E-mail: lezya86@gmail.com

Yana Tsymbalenko, PhD in Public Administration, Associate Professor, Authorized Person for the Prevention and Detection of Corruption**,** Department of Management Theory and Practice, National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Kyiv, Ukraine;
ORCID ID: 0000-0003-0442-7549
Address: National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Kyiv, 03056, Ukraine.
E-mail: uprav@kpi.ua

Olena Titova, Candidate of Economic Sciences (PhD in Economics)**,** Department of International Management, Kyiv National Economic University named after Vadym Hetman, Kyiv, Ukraine;
ORCID ID: 0000-0001-9378-0904
Address: Kyiv National Economic University named after Vadim Hetman, 54/1, Beresteyskyi Avenue, Kiev, 03057, Ukraine.
E-mail: titova.olena@kneu.edu.ua

Oksana Kyryliuk, PhD, Associate Professor, Department of Business Economics and Entrepreneurship, Kyiv National Economic University named after Vadym Hetman, Kyiv, Ukraine;
ORCID ID: 0000-0001-8667-5858
Address: Kyiv National Economic University named after Vadim Hetman, 54/1, Beresteyskyi Avenue, Kiev, 03057, Ukraine.
E-mail: ksanaksana95@gmail.com

Yevgen Vylgin, Doctor of Science in Public Administration, Associate Professor, Professor in the Department of State Administration, Public Administration and Economic Policy, Simon Kuznets Kharkiv National University of Economics, Kharkiv, Ukraine;
Address: Simon Kuznets Kharkiv National University of Economics, 9A, Nauky Avenue, Kharkiv, 61166, Ukraine.
ORCID ID: 0000-0003-3607-2711
E-mail: rvps@ukr.net

Received: July 29, 2025; **revised**: August 06, 2025; **accepted**: September 11, 2025; **published**: September 30, 2025.

Дьоміна Оксана, Андрющенко Катерина, Лєзіна Анастасія, Цимбаленко Яна, Тітова Олена, Кирилюк Оксана, Вилгін Євген. Вплив штучного інтелекту на формування цифрового двійника викладача в метавсесвіті. *Журнал Прикарпатського університету імені Василя Стефаника*, **12** (3) (2025), 169-185.

Останнім часом вища освіта підвладна змінам через застосування цифрових технологій. Використання інноваційних платформ, гібридних моделей та онлайн-сервісів повною мірою не забезпечують вимоги до надання якісних освітніх послуг. Для вирішення цих завдань в статті запропоновано гіпотезу щодо використання цифрового двійника викладача. Представлено на основі кіберфізичної системи, побудованої на математичному моделюванні та синергії застосовувати моделювання, проєктування та оптимізацію освітнього процесу. В дослідженні висвітлено процес побудови співпраці цифрового двійника викладача і здобувача вищої освіти, в результаті якого інтегровано модель предметної області знань для навчання, враховує змінні параметри здобувача освіти та здійснено моделювання освітнього процесу на основі використання новітніх технологій штучного інтелекту. Запропонована архітектоніка включає технології Інтернет речей (IoT), машинне навчання та аналітику великих даних, що в сукупності відображає цифровізацію індустрії 4.0 та підтримку "живого" процесу навчання. Результати дослідження демонструють практичні наслідки використання інструментів штучного інтелекту серед здобувачів освіти та викладачів. Підкреслено необхідність застосування обчислювальної техніки та машинного спорядження для аналізу результатів впровадження цифрового двійника. Презентовано результати двоетапного опитування здобувачів вищої освіти та викладачів університетів, які вказують на позитивні сторони, такі як: баланс між життям та роботою, гнучкість навчання. Але в той же час присутні недоліки – психологічна безпека та етика використання даних. У результаті авторами підсумовано, що цифровий двійник викладача є індивідуальним, прозорим, адаптивним і мотиваційним інструментом для удосконалення освітнього процесу. Його подальше впровадження залежить у майбутньому від вирішення питань щодо етики особових даних та психологічної підтримки за рахунок створення конференційної бази даних, алгоритмів неупередженості та надійної методологічної бази врегулювання потенційних конфліктів.

Ключові слова: цифровий двійник, викладач, цифровізація управління, цифровий портрет учня, етапи розробки цифрового двійника.