

*Tishkov B.O., Candidate of Economic Sciences,  
Associate Professor, Kyiv National Economic  
University named after Vadym Hetman,  
Ustenko S.V., Doctor of Economic Sciences,  
Professor, Kyiv National Economic University  
named after Vadym Hetman,  
Vozniuk Y.Y., PhD student, Kyiv National  
Economic University named after Vadym  
Hetman*

## **INNOVATIVE TRENDS IN THE DEVELOPMENT OF DIGITAL EDUCATIONAL ACTIVITIES OF HIGHER EDUCATION INSTITUTIONS**

In the context of innovative development of information control systems and technologies, education is undergoing global changes in the direction of digital transformation, including the creation of a safe electronic educational environment, providing the necessary digital infrastructure of educational institutions, increasing the level of digital competence, as well as automating data collection and analysis [1], which leads to an improvement in the quality of educational services.

It is also known that one of the goals of sustainable global development [2] is to ensure inclusive and equitable quality education and to promote lifelong learning opportunities for all. The quality of education affects the level of well-being of society, and the opportunity for lifelong learning of each person renews the capital of responses to the challenges of our time. In turn, equitable access to low-cost vocational training, elimination of gender and material disparities, and ensuring universal access to education are clear guidelines for businesses on the way to achieving the Sustainable Development Goals. The defined goals of global sustainable development in the field of education are:

- ensuring the accessibility of vocational education;
- improving the quality of higher education and ensuring its close connection with science, promoting the formation of cities of education and science in the country;
- increasing the prevalence of knowledge and skills necessary for decent work and entrepreneurship among the population;
- creation of modern learning conditions in HEIs, including inclusive, based on innovative approaches [3].

**Digital transformation in the field of education and science** is a comprehensive work on building an ecosystem of digital solutions in the field of education and science, including the creation of a safe electronic educational environment, providing the necessary digital

infrastructure of educational and scientific institutions, increasing the level of digital competence, digital transformation of processes and services, as well as automating data collection and analysis [1].

The harmonization of Ukrainian and European educational spaces takes place according to the concepts of Education 4.0 and Industry 4.0, where one of the important steps on this path is to enter the pan-European qualifications space, the formation of joint institutions and the use of effective tools, ensuring educational and labor mobility. Education 4.0 is the fourth revolution in education, characterized by a new approach to education that is based on the use of technology to create more personalized and interactive learning [4]. Education 4.0 has several advantages over traditional education. It allows students to learn faster and more effectively, fosters critical thinking and creativity, and helps students become more adaptable to change.

The characteristic factors of the implementation of the concept of Education 4.0 include [5]:

- using technology to create more personalized learning;
- interactive learning that encourages students to collaborate and explore;
- lifelong learning;
- learning that builds on the skills that are essential for success in today's economy.

**The purpose of this work** is to analyze and identify key innovative trends in the development of digital educational activities in higher education institutions.

## 1. Learning Technologies

One of the key aspects is the widespread use of modern educational technologies and the introduction of progressive forms and methods of teaching. Evolving technologies are not only changing formal education and the structure of training, but they are also changing access to and relationship with information, which causes an inevitable change in the relationship between participants in the educational process. In the context of current challenges and threats to the national security of the state, the educational infrastructure is expanding, which should be aimed at the development of learning technologies, in particular new forms and approaches to adaptive learning, open education, game-based learning, and the implementation of online courses. These learning technologies are aimed at the introduction and implementation of competency-based and student-centered approaches, which allow you to build individual educational learning

trajectories. Also, the Law «On Education» [6] regulates some additions, in which such concepts as «individual educational trajectory», «individual development program», and «individual curriculum» were expanded, which expands the direction of assistance in the formation of individualized education and takes into account individual needs, intellectual abilities and acquisition of the potential of professional knowledge of each applicant.

### **1.1. Adaptive learning**

Adaptive learning is a technological pedagogical system of forms and methods that contributes to effective individual learning, and the combination of this technology with the capabilities of modern information and technical technologies has significant potential for education. The advantages of adaptive learning include individual pace, objectivity of assessment of learning outcomes, choice of individual learning trajectory, and growth of intellectual abilities [7, 8].

#### **Varieties of systems and features of adaptive learning [9]:**

**A macro-adaptive system** is a system that adapts educational material for applicants at the macro level, grouping applicants into groups based on test results. Participants have a common learning trajectory in a group, but this approach leads to a deterioration in the individual learning trajectory of each applicant.

**A micro-adaptive system** is a system that adapts education at the micro level, constantly reviewing and analyzing the profile of applicants based on their activities and providing personalized instructions. This approach is more effective since the individual learning trajectory of each applicant is formed.

**An aptitude-treatment interaction system (ATI)** is a system that is designed for a large number of people but forms individual instructional strategies that are built based on specific inclinations and characteristics of the applicant (for example, intellectual abilities and cognitive style, knowledge, and learning style). Such a system allows the applicant to partially or completely establish the process of their learning.

**An intelligent learning system (ILS)** is a system that is implemented with the help of adaptive intelligence and is a hybrid combination of a Micro-adaptive system and an Aptitude-treatment interaction system. Such a system for the formation of adaptive learning strategies takes into account both the inclination and needs of the applicant, applying a complex structured model of the applicant.

**The Adaptive Hypermedia System (AHS)** is a hypermedia system built using artificial intelligence (AI) and uses a user model that

contains the applicant's personal information about knowledge, interests, and goals to adapt content and navigate the hypermedia space.

***The Adaptive Educational Hypermedia System (AEHS)*** is a specific adaptive hypermedia system applied in the context of learning and consists of a document space, an applicant model, and observation and adaptation components.

## **1.2. Open Educational Resources**

Open Educational Resources (OER), a term proposed at the 2002 UNESCO Forum, is educational content, materials, or open activities, meaning they are easily accessible to teachers and students. OER solutions include repositories for searching OER and software or other technologies that help create and distribute OER to students [9]. OER manifests itself as a trend, especially in scientific communities, conferences, round tables, trainings, workshops, and publications. OER can be an information source as an alternative to textbooks and allows you to reduce the cost of individual training of students. Opportunities for open educational resources include:

- Storage – the ability to download, store, and duplicate information;
- Reusability – the ability to use content in a variety of ways (in the lab, in the classroom, on the website, in video devices, etc.);
- Viewing – the ability to adapt, correct, change information (in particular, translate into other languages);
- Remix – the ability to combine original or modified content with other material to create something new (for example, include content in a mashup);
- Distribution means the right to share copies of the original content, your revisions, or your remixes with others (e.g., transfer a copy of the content to another applicant).

## **1.3. Gamification of learning**

Gamification is defined as the integration of game elements into a non-game environment [10], it is the process of adding game elements or mechanics to an experience. In the process of gamification, game elements are differentiated from educational content. As a result, we get a non-game-based learning activity using game principles. Unlike game-based learning, in which the game is an experience, in the process of gamification, game components are integrated into traditional learning.

## **1.4. Massive Open Online Courses**

Massive Open Online Course (MOOC) is a training course with mass interactive participation using e-learning technologies and open access via the Internet, as a form of distance education. They are intended for advanced training, retraining, and certification of specialists in various specialized areas of specialties [11].

## **2. Organizational Learning Models**

Due to the challenges of today, the process of obtaining education has undergone many changes, and one of the most significant has been the emergence of various forms of education and the rapid transition from traditional face-to-face to online, distance, blended, and hybrid learning. This was an unexpected and quite serious test for all participants in the educational process: teachers, students, and masters. But at the same time, it has significantly expanded the opportunities for students and training has become available to all groups of applicants, regardless of individual characteristics, professional skills, and in life circumstances. Teachers had to accept this challenge and quickly adapt to new realities, and the issue of developing models for organizing the educational process has become very relevant.

To ensure a full-fledged educational process in today's conditions, we will consider several models for organizing the educational process, including distance, blended, and hybrid learning.

### **2.1. Distance education**

Distance learning is a fundamentally different approach to the organization of the educational process, when the teacher may not meet with students in online broadcasts at all, but only accompany the lesson in the chat if necessary [12]. Such learning is asynchronous and operates in a separate mode, where a convenient time is chosen for studying the subject in the recording and performing individual tasks. Distance learning has a wide range of information and technical opportunities in the form of the use of educational products such as video lectures, online tests, and individual assignments. The main feature of this training is the careful monitoring of the applicants' progress, building their educational trajectory. Distance learning, as a combination of information technology and digital teaching methods, involves obtaining education without the mandatory presence of

applicants in educational institutions. Also, the advantages of this learning model are interactive interaction with the allocation of time for independent mastering of the material, consulting support, convenient use of interactive technologies, and learning management systems. It allows you to better use the principle of visibility and transparency of teaching.

**Online learning** is a type of distance learning that largely follows the techniques of face-to-face learning. Online learning involves conducting classes in synchronous mode, that is, tasks are also performed simultaneously: «completed – sent – received feedback». Also, online learning involves an asynchronous mode, where the interaction between the subjects of distance learning is carried out with a time delay. The advantages of online learning include the convenience of demonstrating presentations and videos, conducting online testing, and assessing knowledge in real time. If online education tries to imitate face-to-face learning, then distance education has a model of a computer game, new levels of which can be opened only when the previous ones have been passed.

## **2.2. Blended Learning**

Blended learning combines offline and online learning, where students interact with the teacher, material, and other applicants through both a physical classroom and an online platform. Usually, there may be an alternation of visits to educational institutions and distance learning outside the educational institution.

**Blended learning** is a type of hybrid methodology, where there is a combination of online learning, traditional and self-paced learning. This means not just the use of modern interactive technologies in addition to traditional ones, but a qualitatively new approach to learning that transforms and sometimes «flips» the audience [13].

There is a common thread between hybrid and blended learning. This is the use of modern computer and mobile technologies that facilitate the learning process. Hybrid learning allows you to uncover every kind of intelligence, depending on a person's mindset. When conducting blended or hybrid learning, various training programs are used to facilitate the receipt and transfer of information. The most common are Blackboard and Moodle. These programs help students gain more information than they would in classroom classes. Students have the opportunity to communicate remotely with teachers, solve test tasks, process materials on their own, and conduct open access to video lectures.

### **There are four types of blended learning [14]:**

1. **Rotation model.** This is the principle of rotation when students study in groups and also perform individual communication with teachers. Groups perform tasks at stations, one of them is distance learning.

2. **Second model (Flex model).** The main thing is online learning. Students work in classrooms, each is assigned a teacher who helps with assignments.

3. **Third model (A la carte model).** Online learning only. A student can work both at home and in the classroom, but communication with the teacher takes place only online.

4. **Fourth model (Enriched Virtual model).** It is carried out with the help of classical and distance learning. There is an opportunity to gain learning experience in the classroom and online learning.

### **2.3. Hybrid learning**

Hybrid learning involves students attending offline and online classes at the same time. This method combines both synchronous and asynchronous methods to create a flexible learning environment. Students learn independently and work in groups during classes. The content of an asynchronous lesson presented in a learning environment allows students to interact with work content anytime they can. For example, a teacher can stream live in-person lectures so that students can listen both in the classroom and from home. A recording of this lecture can then be shared for other students to review later if they attended the class synchronously. Hybrid learning creates a single space between two formats: distance and face-to-face.

Some researchers often use the terms hybrid learning and blended learning interchangeably. If you also do this, you need to understand that both learning styles are different. The key difference between the two learning styles is that blended learning only works by combining two things: e-learning and traditional learning, while hybrid learning allows applicants to choose whether to study directly in a classroom or participate online. This enables training for applicants, who do not have the opportunity to be directly present in the classroom at a certain time due to objective reasons (consequences of external risks), illness, or other personal circumstances, as they have the opportunity to attend online and not miss training. Hybrid learning offers «face-to-face and remote» applicants the same access to classrooms.

Forms and methods of teaching are used in educational programs on the principles of a student-centered approach, the essence of which is

primarily in the selection of the best organizational models of education, educational components, teaching practices, the maximum formation of competencies, and the achievement of program learning outcomes of educational programs.

### 3. Artificial Intelligence Technologies

Artificial intelligence (AI) as a direction of modern science is now being implemented in educational activities and is associated with the use of innovative technologies. AI is used to update and evaluate knowledge, develop an adaptive, individual, and differentiated approach to learning, virtualize learning, determine the rating of the teacher's activities, etc. Let's consider the trends in the use of AI technologies in educational activities.

**3.1. Assessment of knowledge.** AI provides an opportunity to analyze the response based on automatic assessment, provide individual feedback, and create an individual learning plan for everyone using the following forms:

- adaptive learning – provides an opportunity to track the individual process of each applicant, his communication, and the teacher related to solving problems that arise in the learning process;
- individual training – provides an opportunity for everyone to choose the pace of learning, the level and gradualness of completing tasks, taking into account the interests and preferences of each applicant (*tutoring*);
- differentiated learning – provides an opportunity to consolidate educational material, which with the help of AI can be carried out in stages.

**3.2. Virtualization of learning.** Important components of training are to ensure the appropriateness of learning by prioritizing learning over teaching; transmission of the activity type of learning; organization of self-sustaining educational activities; increasing the motivation of learning with the help of the use of means of complex presentation and manipulation of audiovisual information; raising the level of emotional perception of information and the formation of skills to realize various forms of self-sufficient activity about the processing and analysis of information. The virtual educational environment is a typical environment of human self-development. The prevailing method in the virtual educational environment is the method of interactive self-learning with the constant cooperation of the subjects of teaching and the subjects of learning in the presence of continuous irreversible connections between them [15]. It also provides support for students in obtaining

education, for example, anthropomorphic presence, which includes virtual agents and persuasive intervention through digital applications. AI can complement human abilities. The idea of using technological systems to complement or enhance human abilities is not new, and it is referred to as increased intelligence (II). II focuses on the importance of presenting the learning process in real-time, in the efficiency of its presentation by the tools and means of AI used in the learning environment. For example, AI tools enable the enhancement and expansion of individualized and differentiated learning for all applicants. AI tools provide relevant and timely feedback to students.

3.3. ***Predicting the status of learning.*** It involves the process of dropping out students, forming risk groups, acquiring innovative abilities, career decisions, productivity or satisfaction, and improving the educational experience.

3.4. ***Automation of evaluation processes.*** AI systems can automate assessment and reporting processes, which reduces the burden on educators and allows them to focus on quality learning. Natural Language Processing (NLP) technologies can be used to assess written responses or automatically generate reports on learning progress. NLP technology allows you to process, analyze, and interpret natural language in the form of chatbots and digital assistants.

3.5. ***Machine learning and data analytics.*** The use of machine learning and data analytics allows you to analyze large amounts of learning data to identify trends, understand student needs, and improve curricula. Machine learning is used to create interactive and innovative learning materials, such as virtual labs, game-based learning environments, and other effective learning methods.

3.6. ***Development of chatbots and virtual assistants.*** Chatbots and virtual assistants can provide students and teachers with access to information and round-the-clock support. They can answer questions about study material, provide study advice, and help solve problems.

3.7. ***The use of generative AI*** is an artificial intelligence model that is designed to create new content in the form of written text, audio, images, or video. Generative AI can be used to create educational and scientific products of information control systems, train modern specialists based on the introduction of non-formal education, conduct student scientific and practical conferences, round tables, professional circles, etc.

## **4. Virtual and augmented reality (VR/AR) technologies**

4.1. **VR** is a computer-generated simulation that is a collection of images and sounds that represent a real-world place or situation that a

person can interact with, either in a real or physical way, using special electronic equipment. VR can convey visual, audible, and different sensations to users through a headset to make them feel like they are in a virtual or imaginary environment. That is, the user becomes part of the virtual world or immerses himself in this environment and, while there, can manipulate objects or perform a series of actions to determine what is happening in the environment [16].

4.2. **AR** is an extended version of reality, where there are direct or indirect views of the physical environment of the real world complemented by superimposed computer images on the user's real world, thus improving the current perception of reality. Simply put, users see layers of digital information covering images of the real world and enhancing their overall experience of reality.

The most common versions of AR are classified as:

- location-based – This system provides users with additional information based on their or their geolocation. It has incredible potential for application, in particular in the automotive industry and transport in general;
- projection-based – in this case, the AR software sends light to a physical object to create an interactive dashboard in a real-time environment;
- overlay-based – this type of AR allows users to completely or partially replace the actual image by adding new elements to the viewpoint. This type of AR is ideal for the fashion, architecture, and design industries.

Teaching based on VR/AR technologies promotes personalized learning as a way to get the best out of each applicant. The technology offers a personalized learning experience, allowing applicants to learn at their own pace. Using AR or VR gadgets, anyone can conduct classes both inside and outside the educational institution. In terms of teaching methodology, it is possible to distinguish between two different systems – **closed** and **open** learning.

The closed learning system uses VR headsets as a means of learning. This method is called closed because it isolates the subject from external influences, emphasizing individual work.

The most important characteristics of a closed education system include the following factors:

- focus on one subject: VR headsets completely captivate students and make them concentrate on one subject of study by 100 %;
- combination of theory and practice: VR technology allows applicants to see or feel everything they have read about in theory;

- application of gamification elements: applicants learn well during the game, which makes VR equipment the most attractive learning tool in education.

**The open learning system** is based on context-controlled learning algorithms. AR is constantly improving learning processes and adapting according to the needs of each user individually. AR adds value to training courses because it takes into account the need to showcase contextual information related to the subject of study.

The most important characteristics of an open learning system are:

- learning support: unlike closed systems, these systems do not take full control over the learning process, instead, AR increases learning productivity by displaying a variety of contextual information when needed;

- improved engagement: while VR technology isolates users, AR does the opposite. The system improves interaction because it allows all users to engage and comment on the current topic that interests them.

AR and VR technologies can be used to create virtual classrooms with students within related educational and professional programs of specialties in IT industries. Features of learning with the help of AR and VR: advantages – the ability to test, and improve interaction with the audience, and the ability to use various forms and methods of teaching; *Disadvantages* are a decrease in interpersonal communication, lack of control over the actions of participants, and the need for specialized equipment.

The combination of VR/AR technologies and generative AI in the area of education forms a transformational synergy that improves the efficiency of the educational process. This integration fosters personalized learning, thanks to generative AI that tailors learning content and simulations in VR/AR environments to meet individual student needs and the pace of learning in modern educational systems. Dynamic scenario generation immerses applicants in interactive, engaging educational environments, providing an opportunity for hands-on study of subjects. Adaptive assessment, natural language interactions with virtual tutors, and the creation of additional resources improve engagement and comprehension.

## 5. E-learning platforms

E-learning is a way of e-learning, online learning, or online learning, which is implemented through digital tools, the Internet, satellite broadcasting, CD, or interactive television. Technological development requires modern approaches to modern educational education systems.

Education is becoming widespread due to the increase in online courses and the opportunity to gain knowledge from the best leading experts in Ukraine and the world. The question of technological characteristics of learning management systems. From an organizational and technical point of view and areas of use, the following systems have been developed: LMS – Learning Management System; CMS – Course Management System; LCMS – Learning Content Management System; VLE – Virtual Learning Environments; VC – Virtual Classroom (virtual classroom system).

Figure 1 depicts the traditional E-learning architecture of existing and most-used e-learning systems, consisting of three layers:

- Client who connects to the online learning platform (administrator, teacher, applicant);
- E-learning platform deployed on a web server (LMS, CMS, VLE, LCMS, VC);
- Database – Allows you to store data, learning resources, user activities, and more.

**LMS** are the most common learning management systems, which include means of organization, control of the use of courses and training, and administration of the educational process. Most LMSs allow administrators and teachers to create educational projects for conducting classes, and adjust and track the educational process flexibly by all its forms and methods. The most popular examples of learning management systems today are:

- MOODLE (Modular Object-Oriented Dynamic Learning Environment) is a modular object-oriented dynamic learning environment designed to organize interaction between a teacher and a student, to organize all forms of learning. Using the MOODLE system, the teacher can create courses, fill them with content in the form of texts, auxiliary files, presentations, and questionnaires, and conduct knowledge testing [17].

- CATS (Care About the Students) system allows you to implement all components and components of the educational process, keep an electronic log of attendance and defense of laboratory work, monitor the progress of course and diploma design, test students' knowledge, form electronic educational and methodological support [17].

- Google Classroom is a free learning monitoring system that is a blended learning platform developed by Google for higher education institutions. The platform today is no less popular than the above-mentioned one – Moodle, but it is characterized more as a CMS – course management system. The system is actively and successfully used during distance learning. It allows you to create courses and

assignments for them, and exchange information between course authors and participants in the educational process. Teachers can create video conferences, subject classes, and individual professional tasks, evaluate work according to the configured gradation, and set deadlines for work. Students, on the other hand, can keep track of the latest learning information, complete the necessary tasks, and receive feedback from course authors.

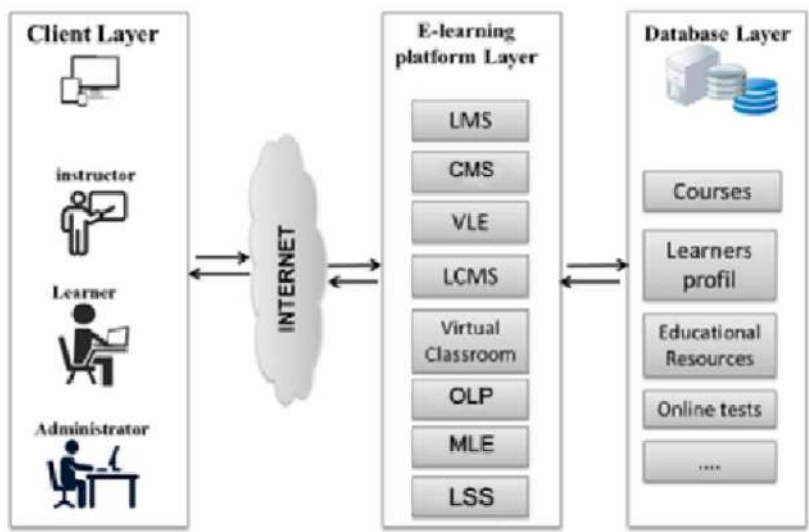


Figure 1. E-learning systems

Source: Developed by the Authors

Thus, LMSs are online platforms for posting, sharing, and mastering educational material, as well as for further tracking the progress and achievements of those who are directly involved in the educational process.

A **CMS** [17] is a set of software tools that provide an online environment for interacting with a training course. The CMS usually integrates with other databases at the university so that students enrolled in a particular course are automatically enrolled in the CMS as participants in that course. CMS is an enterprise software system designed to automate logistics and resource management, planning, administration, finance, reporting, etc. It may also include sales for for-profit training companies. Course management software is specifically

designed for learning organizations, whether corporate training departments, for-profit training companies, or associations. In higher education institutions, this system is used in advanced training courses in various production areas.

**LCMS** shares the same basic functionality as an LMS, but LCMS can create and manage content [18]. LCMS provides a common environment for content writers and those who directly use the system: teachers, administrators, and applicants. That is, it is a system for managing educational content and, above all, a platform used to manage the development of educational content. LCMS allows you to play content, not just use it. The tools of such systems allow you to manage the accounts of students or teachers, create and manage new courses, and reproduce smart analytics based on the success of participants in educational activities. Examples of systems for controlling educational content are Blackboard Content System, ATutor, OpenCms, etc.

**VLE** is an online platform (virtual learning environment) that offers students and educators digital solutions that enhance the learning process, aimed at creating an interactive, active learning environment. Virtual learning environments are often part of an LMS used by HEIs. Unlike Virtual classrooms, which are designed to copy and replace the physical classroom environment for distance learners, VLE uses technology to Complement classroom experiences, such as through digital communication, interaction, and testing, surveys are conducted through VLEs.

**The virtual classroom** is a video conferencing tool where teachers and students interact with each other and study educational material. The difference from other video conferencing tools is that virtual classrooms offer an additional set of features that are essential to the learning environment. An added benefit of virtual classrooms is that they can be scaled to more students. Physical classrooms often limit the maximum number of seats, Virtual classrooms use virtual meeting solutions that have a larger number of participants, allowing more students to attend engaging classes at the same time. This ensures better and higher participation rates and ensures that knowledge is much more accessible. A virtual classroom platform helps to make the learning process interactive by providing an effective, controlled environment. Attendees can connect to virtual classroom platforms from any device that has access to the internet. This type of flexibility allows members to consume content regardless of their location. Another great advantage of the virtual classroom is that it makes it easier to track users' progress through online surveys and analytics, identify complex

areas of discipline topics, and generally help the participant learn complex subjects using visual tools.

Finally, many virtual classroom platforms can be integrated into a university's learning management system (LMS). Advanced platforms support Learning Tools Interoperability (LTI) so that the virtual classroom system and LMS can communicate with each other, making the whole greater than the sum of its parts [19].

Systems are also used to support learning processes: OLP – Online Learning Platform (portal for educational content and resources); MLE – Managed Learning Environment; LSS – Learning Support System.

General advantages of e-learning platforms:

- flexibility – the ability to study regardless of time and place;
- diversity – the presence of a large number of tools for presenting information;
- certification – the possibility of obtaining a certificate of completion of training courses;
- monitoring is the ability to control the dynamics of success during training courses.

## 6. IoT Technologies

The Internet of Things (IoT) is an integrated part of the Internet of the future and can represent a dynamic global network with adaptive capabilities based on standard and interoperable communication protocols, where physical and virtual objects have matches, physical attributes, and virtual objects use intelligent interfaces and are seamlessly integrated into the information network [20]. IoT is a network of physical objects that have built-in technologies that allow them to interact with the external environment, transmit information about their state, and receive data from the outside. In the book *Designing the Internet of Things*, the elements of IoT are reduced to a simple formula:

***Physical Objects + Controllers, Sensors, Actuators + Internet = IoT***

This formula clearly describes the very essence of the Internet of Things. An IoT instance consists of a set of physical objects, each of which contains: a microcontroller that provides intelligence; a sensor that measures any physical parameter, and/or an actuator triggered by any physical parameter; it can communicate via the Internet or any other network. For example, a smart room installation consists of a set of things in the room that exchange information via Wi-Fi or Bluetooth with a central controller. Whether or not there is an Internet connection,

a set of «smart» elements, combined with any other computing and storage devices, can be described as a «network of things» or IoT. In these architectural definitions, it is interesting to understand that a device with the Internet of Things (network of things) means a piece of equipment that has mandatory communication capabilities and additional capabilities for measuring, triggering, as well as input, storage, and processing of data. According to Recommendation Y.2060, IoT is characterized by adding the dimension of «communication between any THINGS» to information and communication technologies that already enable communication «at any TIME» and «at any PLACE» (Fig. 2) and an IoT reference model by Recommendations Y.2060[21] (Fig. 3).

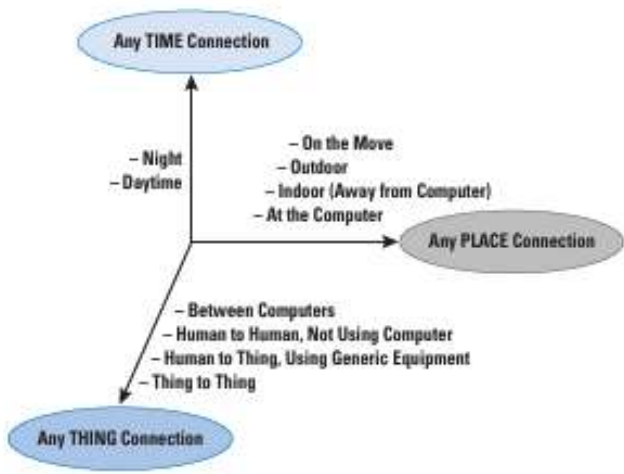


Figure 2. A New Dimension in the Internet of Things

Source [21]

The IoT reference model according to Recommendation Y.2060 (Fig. 3) consists of four layers plus management and security capabilities operating between the layers. Recommendation Y.2060 lists as examples of common management capabilities the functions of

- **Device Management:** Examples include device discovery, authentication, remote device activation and deactivation, configuration, diagnostics, device operational status management;
- **LAN Topology Management:** An example is network configuration management;

▪ Traffic and congestion management: for example, identifying network congestion conditions and implementing resource reservations for urgent and/or vital traffic flows.

The Internet of Things should not only replace traditional teaching methods but also bring changes to the infrastructure of educational institutions. The Internet of Things environment promotes the learning of academic disciplines through the use of images, objects, and videos in the classroom, and this contributes to the addition of new cultures. Aspirants can access resources using their devices, including mobile phones, laptops, and tablets, to create a dynamic learning environment. The learning process is automated with the help of e-learning platform software, by recording the data received from students, tracking courses, and managing reports.

Examples of the use of IoT technology in the educational process can be:

- automation of attendance accounting;
- security improvements;
- adaptive lighting systems;
- climate control systems;
- automation of material and technical support accounting;
- control of power consumption.

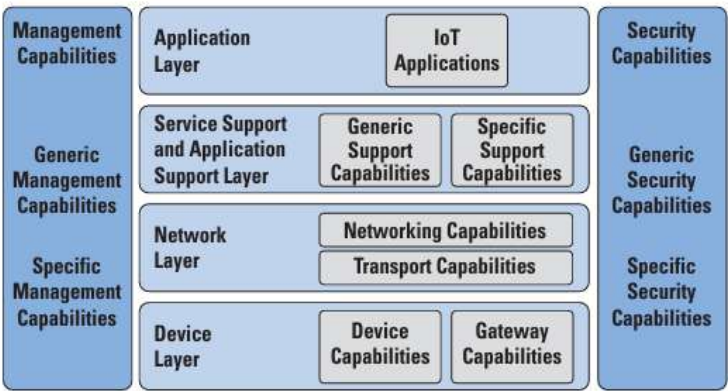


Figure 3. IoT Reference Model according to Recommendation Y.2060

Source: [21]

Based on the Internet of Things in education, a variety of «smart (smart)» systems can be implemented in various fields of student learning, these are «smart classrooms» for conducting lectures, «smart

laboratories» for laboratory research, «smart campuses» for creating a comfortable living and leisure environment.

**Smart classrooms.** Usually, in a traditional classroom, their activities are not recorded in any form, since they only contain display aids such as a whiteboard and a projector connected to a PC. Whiteboarding has become less common in use due to the use of newer alternatives such as interactive whiteboards and flipcharts, LCD projectors used to display given graphic, textual, and tabular information. Thus, using improved tools, a display system, and a system for finding the necessary information, the general audience turns into a smart class. Also, the smart classroom provides the necessary information for both lengthening and repeating the learning of the necessary material, as well as for novice students who, for some valid reason, missed the given topics.

IoT-controlled facilities are equipped in a smart classroom to provide remote functions, such as lighting, room temperature, parameters of technical devices for conducting lecture material, accumulation of necessary material from network platforms, and collection of information on the interaction between users [22]. After the lesson, the necessary information is stored for future use. A smart e-learning app can be used by downloading this data in the required learning format [23].

**Smart Labs.** In smart laboratories, classes are also held in various formats, both in distance and online forms of learning. Directly in smart laboratories, students perform experimental research using existing equipment, specialized computer equipment, and prototyping of various physical processes, and phenomena with IoT devices [24]. In distance learning, interactive experiments and software simulators are conducted that can reproduce a physical experiment and assess the adequacy of its mathematical model. In laboratories, IoT devices can be used in different ways. It allows students to remotely control and access IoT devices through a learning management system (LMS). To experiment remotely, students can log in to their account, perform the specific experiment that is needed, select the architecture of the required laboratory work, and select the required laboratory. Students can use the IoT module to collect the data needed for the experiment if the experiment requires external data, and then save it to the experiment profile.

The results of the evaluation of the conducted classes are carried out by the E-learning system for each lesson and/or experiment with the distribution of grades according to the rules of assessment using IoT. The time it takes for students to complete each task completely, the calculation of the number of errors, and the number of attempts for each task are also analyzed by IoT.

**Smart campuses**, as a rule, are implemented on the campuses of higher education institutions on the initiative of the governing bodies of student self-government and are designed to create a comfortable student environment for the living, leisure, and recreation of students.

The main advantages of using IoT technologies in education include:

- Improved communication and collaboration. IoT devices, such as smart whiteboards, tablets, and laptops, can facilitate real-time communication and collaboration between teachers and students, as well as between students themselves.
- Personalized learning. With the help of IoT devices, teachers and administrators can collect data on a student's «successful» learning style, progress, and difficulties that arise in the learning process. This information can be used to create customized training plans tailored to the individual needs of each applicant.
- Improved interaction in smart classrooms. With the help of IoT devices, such as interactive whiteboards and tablets, educators can create more engaging and interactive classes that keep applicants engaged and motivated.
- Improved resource management. Thanks to IoT systems, teachers and administrators can more effectively control and manage classroom resources, as well as accumulate the necessary e-textbooks and e-materials for each topic conducted.
- Improved safety and security. With the help of IoT devices, can you monitor and protect your buildings, grounds, specialized computer devices, and tools? helping to ensure the safety and well-being of applicants and staff.
- Increased efficiency. Educators and administrators can streamline many of the administrative and organizational tasks that take up their time each time using IoT systems, such as automating attendance tracking and grading after each class. This can free up more time for teaching and learning and allow educators to focus on the core learning functions of their work.

## **7. The main trends and directions of research of the Research Institute «Institute of Information Systems in Economics» and the Department of Information Systems in Economics of KNEU named after Vadym Hetman in the field of education**

One of the main directions of the strategic objectives of the KNEU named after Vadym Hetman is provided in the «Development Strategy of KNEU named after Vadym Hetman» and «Program of Innovative

Development of KNEU named after Vadym Hetman» are dominated by the following provisions:

- digitalization of the scientific and educational process;
- introduction of the latest educational technologies to improve the quality of educational services and adaptation of the educational process to the requests and needs of higher education applicants;
- intensification of competition between universities for leadership in the world market of educational services;
- deepening international scientific cooperation.

### ***7.1. Trends and directions of research in educational activities:***

▪ Formation and implementation of applied and initiative research. The subject of scientific research is focused on the design, creation, and implementation of information control systems (ICS) for complex objects, in particular at enterprises, firms, banks, universities, and other organizations using modern information technologies, the results of which are implemented in the educational process of the Department of Information Systems in Economics;

▪ Research of the conceptual and methodological foundations of ICS design, the use of modern information and communication technologies, and applied artificial intelligence tools for the construction of universal and specialized computer systems and tools in various fields of science, economics, technology, and education, the results of which are implemented in the educational process of the specialty 122 «Computer Science»;

▪ Development, improvement, and implementation of universal electronic document management systems in banking systems, and IT companies using machine learning technologies to build a semantic search result based on large Amazon Kendra services, which will increase the efficiency of individual banks, large IT companies, and the banking system as a whole [25, 26];

▪ Development, improvement, and prototyping of the latest ICS, specialized computer «smart» systems and tools in the social and applied sphere and educational activities based on modern microcontroller elements based on the Arduino platform, in particular, the development of the Smart Laboratory ICS, which consists of the following modules: module for accounting for the material and technical support of the laboratory, module for monitoring climatic indicators in the room, a module for monitoring electricity consumption, etc.;

- Organizational and technological improvement and updating of the material and technical base of the leading Educational and Scientific Laboratory «Information Control Systems and Technologies» of the Department of Information Systems in Economics and the Research Institute «Institute of Information Systems in Economics» of specialized computer equipment and hardware and technical devices on the platforms Arduino Uno, Arduino Mega, Arduino Nano, ESP8266, Orange Pi and Raspberry Pi allows:

- to increase the scientific and practical efficiency of high-quality training of specialists of all levels in the specialty «Computer Science»;

- to implement the provisions of the concept of Industry 4.0 industrial platforms, the main role of which is played by such technologies and concepts as high-tech production systems and technologies, applied artificial intelligence systems, intelligent technical systems, knowledge bases, IoT technologies, mobile and cloud technologies, specialized digital information processing systems, remote device management systems, intelligent «smart» laboratories and classrooms in education:

- conduct various laboratory scientific research and educational processes in technical, industrial, social, domestic, financial, and economic systems;

- Carry out prototyping of the developed devices on a 3D printer to improve and produce experimental functional models and finished components of various technical objects and systems in the educational process

- train student teams and projects and participate in competitions, IDEAFESTs, and startups;

- Introduction and implementation of organizational and technical aspects of the development of educational activities of the latest information and communication technologies and modernization of educational products, in particular, video products from the cycle of presentation of educational and professional programs; innovative specialized disciplines of specialties; performance of individual and independent work of students; scientific and educational nature of student projects; educational and scientific circles and master classes of educational and professional programs; branded accessories;

- Attraction and cooperation with leading Ukrainian and foreign IT companies for joint scientific cooperation with IT employers, which should be understood as customers of potential scientific products, business partners in the training of modern specialists based on the introduction of a dual form of education of our graduates in the specialty «Computer Science», employment of graduates and

organization of scientific activities based on non-formal education of the OPP «Information Control Systems and technologies», expanding the participation of researchers in the implementation of international projects on the platforms of IT startups, grants, and programs, Industry 4.0 concepts;

- Implementation of real scientific projects at the University based on the development of qualifying master's theses of the OPP «Information Control Systems and Technologies» and initiative research work carried out at the Research Institute «IISE»;

- Introduction and development of new innovative educational products (systems) and technologies of distance education to provide relevant services to students, graduate students, and young scientists, including webinars, coaching, webcasts, lectures, and practices.

## **Conclusions**

The current stage of development of the educational sector in Ukraine is characterized by increased competition and the desire of higher education institutions for even greater integration into the global market of educational services. Under such conditions, in this work, a study of the introduction of innovative trends in the development of digital educational activities was carried out, the results of which include:

1. The study showed that innovations in digital educational activities allow: to reduce in the costs of the educational process through the use of digital technologies, tools, and educational materials on a free or inexpensive basis; increasing the effectiveness of the study of basic training courses; and reduce the need to retake these courses; use convenient and flexible forms of conducting training courses and programs with remote access provided by mobile devices and applications; to receive high-quality preparation of the developed courses and training at the level of individual and independent work of students.

2. One of the most common modern trends in the education system is the search for new forms of education. The most common were distance learning, continuing education, transnational learning, and virtual education using network information technologies. Virtualization of education opens up fundamentally new opportunities to overcome the two most important and urgent problems of modern society, it is an increase in accessibility to openness of quality education and the continuity of the learning process throughout human life, which is already a universally recognized need and requirement proclaimed in UNESCO documents. At the same time, it should be remembered that

the virtual education system cannot be recognized as full-fledged because of its fundamental inability to completely replace the personal contact between the student and the teacher, the processes of their communication and interaction. The development of virtual reality, the transformation of communicative processes carried out within its framework into everyday life, is an essential prerequisite for the development of distance learning.

3. In the context of external challenges and threats to the national security of Ukraine, there is a constant expansion of the educational infrastructure aimed at the development of innovative learning technologies, such as the latest flexible forms and approaches to adaptive distance learning, open education, gamification of learning, the use of artificial intelligence and the Internet of Things, which contributes to wide access to information resources, the study of academic disciplines through the use of means of images, objects and videos in the classroom and this contributes to the formation of a new information culture of promoting and accumulating knowledge. Applicants can access resources using their devices, including mobile phones, laptops, and tablets to create a dynamic learning environment and implement online courses. The learning process is automated with the help of E-learning platform software, by recording data from applicants, tracking courses, and managing reports. All innovative learning technologies are aimed at the introduction and implementation of competency-based and student-centered approaches, which allows you to build individual educational learning trajectories. Institutional implementation of innovations requires proper infrastructure, including economic, personnel, technical, information, and marketing. It is also necessary to treat organizational support properly. The introduction of digital technologies requires careful planning and implementation of innovative technologies in various specialties of educational and professional programs with implementation in the basic training courses of higher education institutions.

4. A significant number of HEIs and teachers have been innovating in digital learning for a long time. E-learning platforms and mobile devices are considered the main learning technologies in most institutions throughout Ukraine, as well as abroad, in particular, the MOODLE system is effectively used at KNEU named after Vadym Hetman to ensure a continuous learning process at all levels of educational activities. Thanks to advancements in mobile technology and the compatibility of learning tools, allowing for the integration of course software into an LMS. Students can learn from their devices regardless of location and time, according to this, the determining factor

is the implementation of personal and individual forms of learning. The introduction of these innovative technologies, although redundant, creates the effect of a spiral of development and implementation of the main learning technologies located on the following trends.

5. With the rise of innovation in digital learning, it is evident that institutions, educators, and researchers are confronted with large amounts of teaching and learning data that they previously could not cover on a large scale in traditional face-to-face courses. Therefore, big data, machine learning, artificial intelligence, and the Internet of Things are becoming major trends in the field of educational technology. Also, in recent years, distance learning has acquired a single privileged trend, which has radically changed the educational process. Students now have to get used to remote learning with E-learning platforms due to social distancing. The most promising forms are blended and hybrid learning. Blended learning involves alternating offline and online classes, which allows you to conduct online lectures and consolidate knowledge in practice during offline classes. Hybrid learning involves a simultaneous combination of offline and online classes, which creates the effect of direct presence. Thus, as the study showed, it is impossible to single out only one or several identified innovative trends, since each of them directly affects the quality of education. In general, it can be noted that the use of innovative technologies in digital educational activities can significantly increase the efficiency of the educational process and ensure the quality of education in difficult conditions of internal and external challenges and uncertainties. Priority in further research of this issue should be given to the development of effective approaches, methods, and models for assessing the effectiveness of digital educational activities and determining the degree of expediency of introducing appropriate digital technologies at the existing risk.

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