Digitalization of the educational process for the training of the pre-service teachers

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Abstract

According to the Development Concept of the Digital Economy and Society in Ukraine, the priority of this area is to develop a substantial national policy on digitalization of education, as this is the key part of the education reform in Ukraine. For this reason, universities should firstly take into account the particularities of teaching the current generation of students and the needs of the digital society as a whole. This paper considers the process of transition from informatization to digitalization in society, implementation of digital support for the educational process in the university, development of the digital educational environment for the training university teachers, and proposes the digital tools for such an environment. The authors propose several ways to improve the development level of digitalization of the educational environment in the university. This is to take into account the needs of the digital society and the modern generation of students, provide a high level of the digital literacy formation of university graduates and support the development of a new digital security system of the modern university. Aiming to design the digital educational environment for increasing the of educators' digital literacy level, the authors propose to develop and implement the following computer, multimedia and computer-based learning tools and equipment, which includes blended and distance learning classes, cloud technologies, tools of virtual and augmented reality, tools for gamification of the educational process, educational robotics, tools for learning 3D technologies, MOOCs.

Keywords

digitalization of the educational process, digital educational environment, training, future teachers, pre-service teachers

1. Introduction

According to the main development priorities adopted by the European Commission for 2019-2024 (6 Commission priorities for 2019–2024), one of the key priorities is "A Europe fit for the digital age", which includes empowering people with a new generation of technologies [1].

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At the same time, innovative and modernized education and trainings are strong parts of the Europe 2020 strategy [2]. This process relates not only to the European countries, but seems very important for Ukraine.

The Ukrainian government has approved (in 2018) the Concept of development of the digital economy and society of Ukraine for 2018-2020 years and the Plan for its implementation [3]. The main purpose of the concept is to implement the Digital Agenda 2020 (Digital Strategy) initiatives to remove barriers on the way the Ukrainian digital transformation in the most promising areas. This is planned to be achieved by stimulating the economy and attracting investments, overcoming digital inequalities, deepening cooperation with the EU in the digital area, and building up the country's innovation infrastructure and digital transformation.

Meanwhile, the recommendations from the EU Parliament and the Council [4] (dated 2006 and updated in 2018 [5]) state that digital competence is one of eight key competences considered as fundamental to each individual in a knowledge-based society. According to the Development Concept of the Digital Economy and Society of Ukraine, the priorities of this area are [3]:

- to develop a substantial national policy on digitalization of education, as this is the key part of the education reform in Ukraine;
- to identify specific initiatives for connecting the classes to the broadband Internet;
- to design and implement modern computer models, institutions, and tools;
- to prepare, adapt and organize access to multimedia technologies and create appropriate digital education platforms for use in the learning process and management of education.

Therefore, digital literacy is an indispensable requirement of the present, which is gradually beginning to be implemented in Ukraine. Another powerful step on this way was setting up of the Ministry of Digital Transformation of Ukraine in September 2019. Under the guidance of the Ministry, since January 21, 2020, the Ukrainian National Digital Literacy Education Platform Action: "Digital Education" has been launched [6]. On the National Digital Literacy Platform, the Ukrainians are free to take three online courses: Basic Digital Literacy, Digital Literacy for Teachers and Parents' course on Online Safety for Kids.

"We are taking another important step, which is a step towards overcoming digital inequality in Ukraine. The necessary digital skills should be accessible to all. To this end, a national digital literacy program will be launched on 21 January 2020. I will mention this as the best, most effective course in the world", – said the head of the government.

Burov et al. [7], Fedorenko et al. [8], Gergei and Mashbits [9], Glazunova and Shyshkina [10], Kalogiannakis et al. [11], Morze and Kucherovska [12], Papadakis et al. [13], Spivakovsky et al. [14], Tryus and Herasymenko [15], Vakaliuk et al. [16], Vidakis et al. [17], Zhaldak et al. [18] and others have addressed the digitalization of education issues.

Thus, Andrushchenko [19], Bykov and Shyshkina [20], Semerikov et al. [21], Spivakovsky et al. [22], Yashanov [23] and Zhaldak and Franchuk [24] have considered the informatization of the teaching-learning process in whole; Mashbits [25], Varina et al. [26] has explored psychological aspects of using digital technology in education; Bondarenko et al. [27], Lavrentieva et al. [28], Morze and Strutynska [29], Glazunova et al. [30], Pererva et al. [31], Vlasenko et al. [32], Zelinska et al. [33] have developed digital environments for higher educational institutions; Bondarenko et al. [34], Kiv et al. [35], Kholoshyn et al. [36], Korotun et al. [37], Lovianova

et al. [38], Merzlykin et al. [39], Nechypurenko et al. [40], Popel et al. [41], Vakaliuk et al. [42], Velychko et al. [43], Vlasenko et al. [44], Volikova et al. [45] has studied the use of cloud technology for educational needs; Kalogiannakis et al. [11], Papadakis et al. [46], Vidakis et al. [17] have examined the ways of evaluating the learning process in the current educational environment.

Paper goal: to analyze the process of digitalization of educational environment and to develop the model of Digital educational environment for the pedagogical university.

Below we will consider the process of transition from informatization to digitalization in society, implementation of digital support for the educational process in the university, development of the digital educational environment for the training teacher university, propose of the digital tools for such an environment.

2. Theoretical backgrounds

The rapid development of digital technologies and, as a consequence, the digitalization of many sectors of society, led to the introducing such terms as "digitization", "digitalization", "digital transformation", which, in its turn, has led later to the so-called of digital transformation concept.

Bimber et al. [47], Brennen and Kreiss [48], Bumann and Peter [49], Bykova et al. [50], Dannikov and Sichkarenko [51], Knorr Cetina and Bruegger [52], [53], Castells [54], Kravchenko et al. [55], Kucherova et al. [56], Dijk [57], Pikilnyak et al. [58], Verhulst [59], Vyshnevskyi et al. [60] pay their attention to the issue of defining the concept of "digitalization". Following on the analysis and synthesis of experience and research, we define digitalization as a process of transformation and/or improvement of enterprise activities, business models, business functions, communications, use of online platforms, training and retraining of staff to work in new conditions, etc. based on the widespread use of digital technologies and digitized data.

One of the areas, in which fundamental changes take place due to the digitalization and digital transformation, is education.

In accordance with the Draft Law of Ukraine "On the Digital Agenda of Ukraine" (figure 1), there is a process of transition from informatization to digitalization in society [61].

The Development Concept of the Digital Economy and Society in Ukraine for 2018–2020 Cabinet of Ministers of Ukraine [3] identifies the main goals of digital development of Ukraine and eight principles of digitalization:

1. Digitalization has to provide every citizen with equal access to services, information and knowledge through ICT and digital technologies.
2. Digitalization should be aimed at creating benefits in various areas of daily life.
3. Digitalization is achieved through the economic growth mechanism by improving the efficiency, productivity and competitiveness of digital technologies.
4. Digitalization should promote the development of the information society and media.
5. Digitalization has to focus on international, national and regional cooperation to integrate Ukraine into the EU entering the European and world market.
6. Standardization is the basis of digitalization, one of the main factors for its successful implementation.

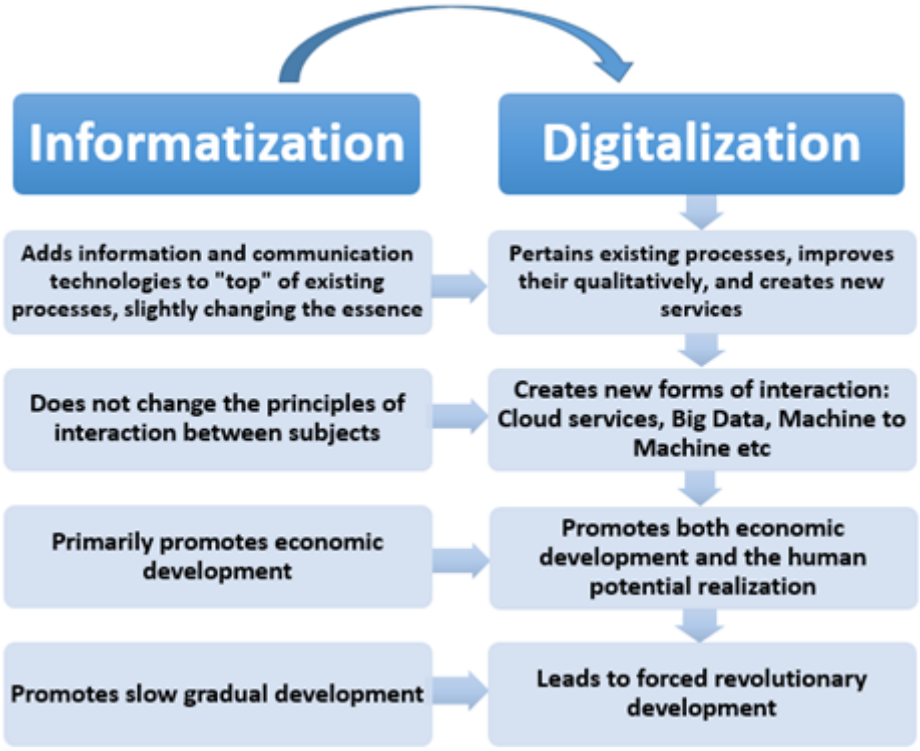

Figure 1: Process of transition from informatization to digitalization in society (based on [61])

7. Digitalization should be accompanied by increased confidence and security.
8. Digitalization is an object of focal and integrated governance.

Digital competencies are described as the knowledge, skills, and experience of using end-to-end and multi-platform digital technologies in professional activities. Besides that, this is for self-education, knowledge, skills and competencies in many other fields (e.g., for learning of languages, mastering new professions, etc.).

Digital competence of the Ukrainian teachers is not considered in the Concept, but there is a process of establishing the digital competence.

However, according to the European Framework for the Digital Competence of Educators [62], Digital Competence can be broadly defined as confident, critical and creative use of ICTs to achieve goals related to work, employability, learning, leisure, inclusion and/or participation in society. Digital Competence provides not only the ability to use digital technologies. It has also become increasingly necessary for the formation of creativity and critical thinking that is so meaningful in the 21st century.

On the way to digital development of the Education Concept [63], it is very important to harmoniously combine new digital technologies with traditional ones. Digital technologies make the learning process mobile, differentiated and individual. At the same time, the technologies do not replace the teacher, but complement him/her. Such lessons are adaptive, manageable, interactive, combining individual work with group one and time-limited learning.

3. Results

In order to improve the students' knowledge quality, to develop the digital competence of all participants in the learning process, create favorable conditions for self-development and self-studying, ensure access to education in 7×24 format (i.e., 7 days a week, 24 hours per day), and also raising of the national and international rating of National Pedagogical Dragomanov University, there is effective implementation of digital support for the educational process in the university. That's why the priority areas for educational institutions are:

- digitalization and innovation;
- globalization (establishing of an intercultural environment);
- mobility of students, pupils, teachers, lecturers;
- distance and online learning;
- informal learning and MOOC technologies.

The conditions of the pandemic put the heads of educational institutions up to reconsidering and changing approaches to the educational process. Accordingly, the digital educational environment of educational institutions were changed and adapted, i.e., a digital analogue of physical institutions. Specialists with different success rates try to model the digital environment of all structural and learning components of educational institutions. Virtual classes, remote personal accounts, online lectures, etc. have appeared. The problem of placement and full functioning of all elements of the educational process in the distance and blended learning modes has become extremely acute. An example of such adaptation is the following model of distance learning, which describes the features of the educational process organization during the quarantine in the National Pedagogical Dragomanov University (figure 2).

This model of distance university work has arisen by force and, for the greater part, it was a swift response to the quarantine conditions, in which the whole world found itself. As part of the digital transformation of the educational process, NPU develops and implements innovative computer, multimedia and computer-aided learning tools and equipment to create a digital educational environment, such as:

- Blended and distance learning classes;
- Cloud technologies;
- Tools of virtual and augmented reality;
- Tools for gamification of the educational process;
- Educational robotics;
- Tools for learning 3D technologies;
- MOOCs.

3.1. Distance learning

According to the concept of digital economy and society development [3] one of the main areas of digitalization of education is "the development of distance learning using cognitive and multimedia technologies". Therefore, the introduction of distance and blended learning at pedagogical universities is an extremely urgent requirement of our times [64]. In addition to

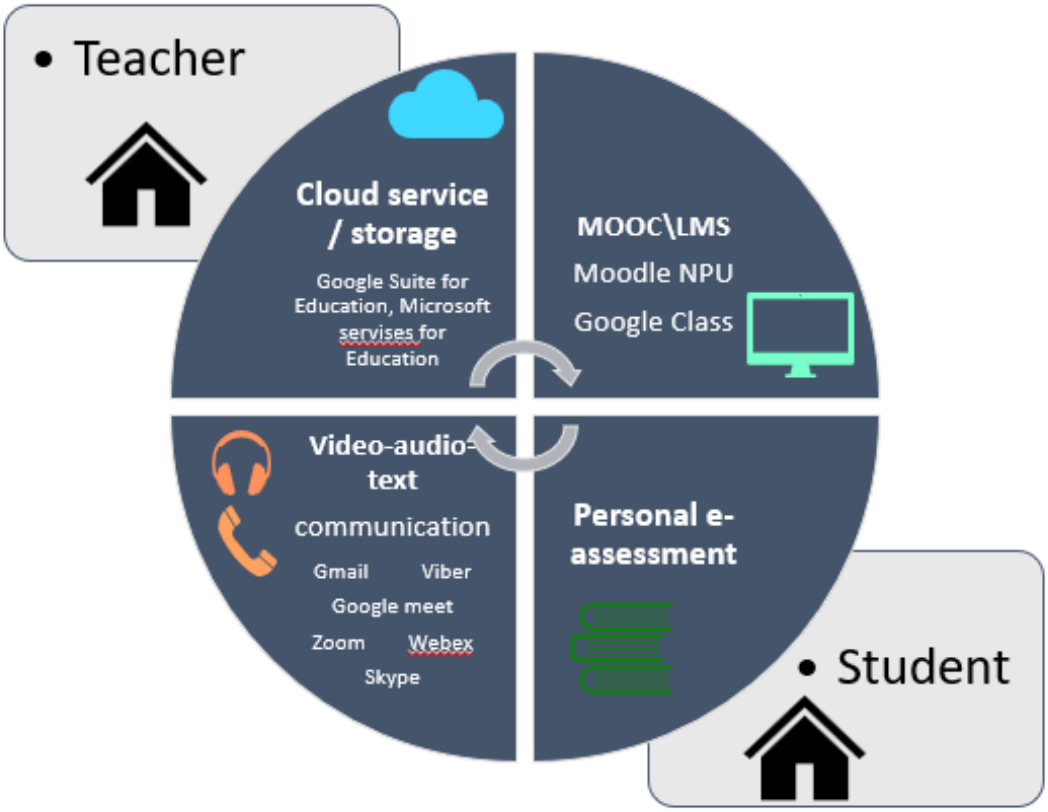

Figure 2: Digital educational environment of the National Pedagogical Dragomanov University (NPU).

traditional opportunities and aiming to improve the quality of providing educational services to students, there is an implementation of a full-featured IT space of the university with the use of remote educational technologies that have proven themselves at the leading universities in the world and have the most powerful potential within the educational process.

It should be noted that the main advantages of distance and blended learning are independence from the place of study, individual pace, time of study, rapid adaptation of the content of learning to the educational needs of students, etc.

Distance learning is an independent activity of the learner that is realized in a specific didactic system, in which both (the one who is teaching and the one who is learning) are independent in space and time and can interact with each other [65, 66, 67, 68, 69].

Since 2010, the system of distance learning based on Moodle [70] was implemented in National Pedagogical Dragomanov University [71] (figure 3).

Moodle is a learning platform designed to bring teachers, administrators and students together in a reliable and integrated system for creating personalized distance learning environment. For now, Moodle platform has over 500 e-courses.

The distance learning environment at the university is used both to support full-time and

Figure 3: Home page of the university's distance learning environment.

part-time students (blended learning), as well as to organize independent distance learning in the local centers of the university for professional training and retraining (Lubny, Lviv).

3.2. Blended learning

According to the Concept of development of digital economy and society [3] the priority area in digitalization of education is development and introduction of innovative computer, multimedia and computer-based learning tools and equipment for creating a digital learning environment (multimedia classes, lab STEM research centers, inclusive classes, blended learning classes).

The steps of introducing distance learning at university are briefly described above. Let us focus on the other areas of digitalization, which are the development and implementation of innovative computer, multimedia and computer-aided learning tools and equipment to create a digital learning environment for pedagogical universities.

Therefore, organizing blended learning in the university has to be considered.

This pedagogical technology is very important for the formation of high-quality education.

Blended learning provides flexibility in relation to traditional learning, and enables teachers to offer training in different variations of presentation on training material. Thus, a harmonious combination of traditional and distance learning is carried out [72]. Blended learning is implemented at the university by using Moodle platform [64] and MOOC elements (Massive Open Online Courses) within in-person training (figure 4).

3.3. Massive Open Online Courses

MOOC is an acronym for Massive Open Online Courses. MOOC students watch video lectures and participate in online discussions with professors and other students. Some MOOCs require students to complete test assignments that allow them to choose the answer from the suggested ones, and some tests require the completion of assignments that are assessed by several people, including the students themselves.

National Pedagogical Dragomanov University suggests using of MOOC to support students' full-time study [73]:

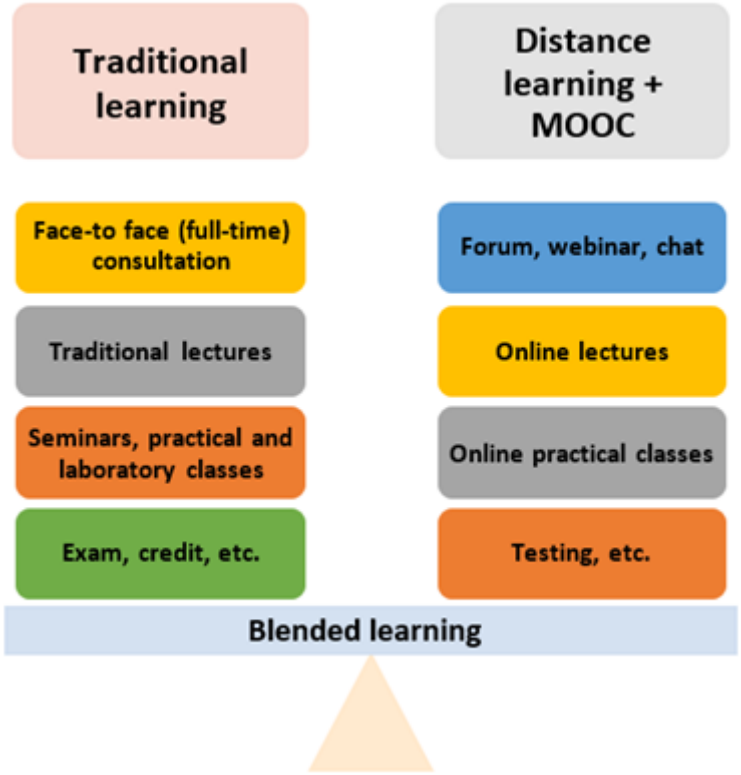

Figure 4: Organization of blended learning in the university.

1. Pre-university education.
2. Adding MOOC training elements to traditional courses.
3. Advanced training and retraining of specialists.

The recommended MOOC's are shown in table 1 and table 2.

Table 1
MOOC recommended for pre-university education

Name of MOOC	Reference to MOOC
Ukrainian language and literature	http://courses.prometheus.org.ua/courses/OsvitaOnline/Ukr101/2015_T1
Mathematics	http://courses.prometheus.org.ua/courses/Prometheus/101/2015_T1
English language	http://courses.prometheus.org.ua/courses/OsvitaOnline/Eng101/2015_T1
Physics	http://courses.prometheus.org.ua/courses/Prometheus/102/2015_T1
Chemistry	http://courses.prometheus.org.ua/courses/Prometheus/103/2015_T1

Now NPU has personal subscriptions to MOOC-platforms Coursera and EdX. They are used as training elements for students within traditional courses and as advanced training and retraining for University teaching staff.

Table 2
MOOC recommended for in-depth study of individual ICT topics and programming of different difficulty levels for masters, pre-service (future) Computer Science teachers (in English)

Name of MOOC	Platform
Understanding IELTS: Techniques for English Language Tests course	FutureLearn
How to create a Windows 8 App	Independent
Codecademy	http://www.codecademy.com
Python For Informatics	Independent
Design and Development of Educational Technology	edX
Cloud Computing Concepts, Part 1	Coursera
Introduction to the Internet of Things and Embedded Systems	Coursera
Java for Android	Coursera
Beginning Game Programming with C#	Coursera
English for Teaching Purposes	Coursera
Fundamentals of Online Education: Planning and Application	Coursera
Teaching Math Through Problem-Solving K-12	Canvas.net
How to create MOOC (in Ukrainian)	Prometheus

3.4. Virtual and augmented reality

Virtual Reality (VR) is the world, which is artificially created with the help of special technical means that has the maximum impact on almost all human senses (sight, hearing, sense of smell and touch). Augmented Reality (AR) is a technology that enhances the user's imagination in the real world and is complemented by additional computer models while keeping the user connected to the real environment [74].

At the Digital Educational Technology Center of the National Pedagogical Dragomanov University, there is a working group aimed at creating educational materials based on virtual and augmented reality. Such development is a separate area of study for the field of distance learning and is used to organize virtual classes of the university's distance learning environment. The center plans to develop the training materials for both individual subjects in the school cycle and for use in the university's remote environment.

There are VR and AR examples for stereometry and astronomy (figure 5 and figure 6).

We have proposed to study VR/AR as the optional course for students from the Faculty of Informatics (NPU) within the last academic year. This course has got positive feedbacks from students (MSc and BSc) and administration of the Faculty and University. Therefore, we are extending this experience to other Faculties during the current academic year.

3.5. Gamification

Gamification is attracting to games where there is usually no place for play. Many experts consider gamification as one of the most important trends in the information technology industry [75, 46, 76, 77, 78, 79].

The elements of gamification are used to organize distance, blended and traditional learning in the university.

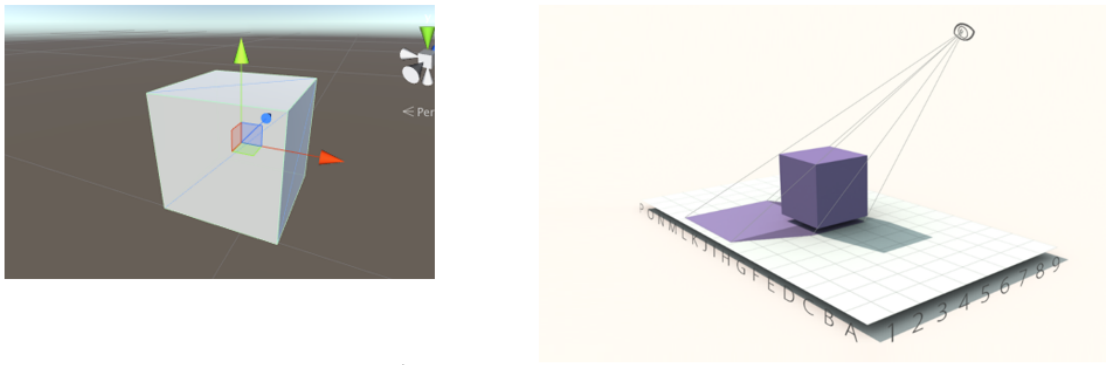

Figure 5: Virtual geometric shapes for stereometry designed by students of the Faculty of Informatics.

Figure 6: Virtual and augmented reality model of the solar system in the Unity environment designed by students of the Faculty of Informatics.

As an example of using gamification in carrying out research quest on the modern programming languages for pre-service Computer Science teachers we are using encrypted QR codes [80].

Gamification is widely used in remote courses to create VR and AR applications (figure 7).

We use the elements of the gamification within every course on the Faculty of Informatics. This requirement is stated in the courses' curriculum.

3.6. Educational robotics and 3D technology

The laboratory of Robotics and 3D Technologies operates at the Faculty of Informatics in National Pedagogical Dragomanov University (starting from 2017).

Robotics and 3D technologies are powerful learning tools that are suitable for all ages (from elementary students to professors). Educational robotics education and 3D technologies are in line with the ideas of advanced learning (learning the technologies that will be needed in the

Figure 7: Designing virtual reality of "7 Wonders of the World" within the university distance learning courses.

future) and allow students of all ages to be involved in the process of innovative and scientific and technical creativity [81, 82, 83, 84, 85, 86, 87, 88].

Examples of students' works developed based on Arduino robotic platforms and 3D technologies are presented below (figure 8 and figure 9).

Figure 8: 3D printed robot arm based on Arduino robotic platform.

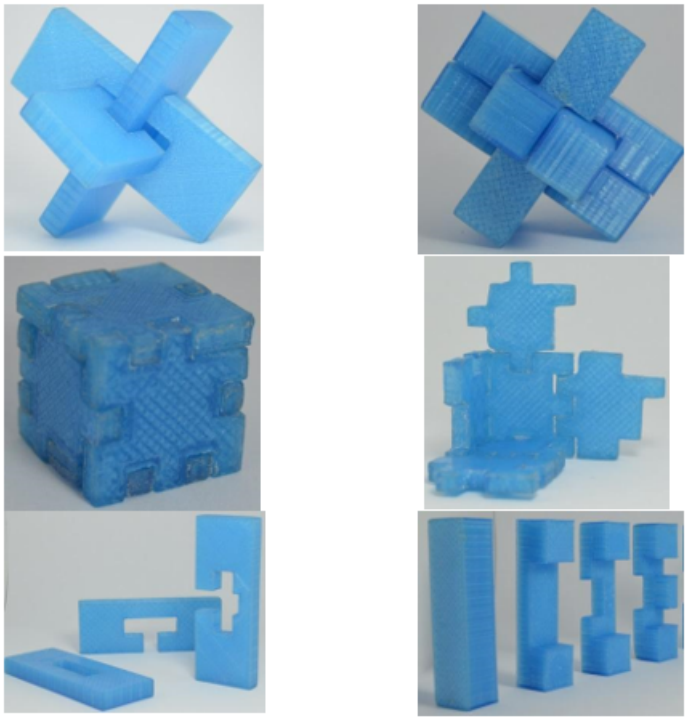

Figure 9: Prototype model of 3D puzzles designed by students of the Faculty of Informatics.

The Faculty of Informatics in National Pedagogical Dragomanov University has designed educational programs "Secondary education (Computer Science) and Robotics" (2018) for the preparation BSc and MSc students (specialty 014.09 "Secondary education (Computer Science)") [89, 90]. All students, who choose this specialty, will get qualification of the Computer Science and Robotics teachers. Now we provide the training of educational robotics for students of other NPU Faculties to involve them in research projects (also STEAM projects).

3.7. Cloud technologies in education

According to the Development Concept of the Digital Economy and Society in Ukraine [3], one of the main priorities of digitalization of education is the creation of educational resources and digital platforms with supporting of interactive and multimedia content for public access to educational institutions and students, including tools for automating the main processes of educational institutions.

Cloud technologies are used at National Pedagogical Dragomanov University to automate the basic processes in the university work and ensure universal access to educational resources and digital platforms.

Cloud is a model that allows you to scale data sources as needed. The more users use the system, the more sources will be involved. Cloud storage takes advantage of the computer network and applies them to e-learning (from digital university classes to small training modules

used for specific purposes).

Since 2016, the university staff and students have been using specialized cloud software and collaboration tools for G Suite for Education. The cloud contains a set of communication and collaboration tools, including Google Classroom, Gmail, Docs, and Drive, etc., allowing students, teachers and administrative staff to work and learn together regardless of time and place. The use of cloud services greatly increases the efficiency of the learning process.

4. Discussion

Thus, the paper addresses the following issues:

- analyzing the digitalization of the educational process in the EU and Ukraine;
- implementing the digital educational environment in National Pedagogical Dragomanov University and, as a result, increasing the digital competence of the future teachers.

According to the research conducted, the authors propose several ways to improve the development level of digitalization of the educational environment in the university. This is to take into account the needs of the digital society and the modern generation of students, provide a high level of digital literacy formation of university graduates and support the development of a new digital security system of the modern university:

- development of distance and blended learning;
- adaptive learning, which incorporates the benefits of distance, blended, MOOC learning and virtual / augmented reality technologies;
- widespread use of cloud technologies to automate the core processes of the university and ensure public access to educational resources and digital platforms;
- update of curricula for future teachers through the inclusion of the STEM approach and educational robotics (for students);
- involvement of the University teaching staff in retraining of the teachers for further development of their digital skills.

Recommendation for Researchers. The research gives us the opportunity not only to develop a model of the digital educational environment for pedagogical universities, but it also can be used as a roadmap for development of the model of digital educational environment for secondary institutions.

There is a controversial issue of creating a full-featured digital educational environment, which addresses the needs of the digital society and the current generation of students and ensures the highlevel of digital literacy of university graduates.

The digitalization of the educational process during the training of the future teachers will benefit within different levels:

- local level:
  - increase of awareness of the digitalization of the training process of the educators;
  - improvement of study skills;

  - participation in the collaboration on research activities with the use of different digital tools.

- regional / national level:
  - improvement of the national core curricula according to the article findings;
  - bringing together students, specialists and civil society to promote the digitalization of the educational process.

- overall expected impact is following:
  - increase of opportunities for academic staff;
  - support and promotion of young researchers and teaching staff;
  - enhance of employability, career prospective for students and young researchers;
  - integration of the best practices in the digital competency field into the Ukrainian universities learning process;
  - implementation of improved innovative curricula into educational process of universities;
  - collaboration with other organizations (the Ukrainian universities and public schools);
  - formation of more active citizenship with regard to the Digitalization of the educational process issues.

5. Conclusions

In the paper, the authors declare to introduce digitalization of the educational process by creating a developed digital educational environment.

Aiming to design the digital educational environment for increasing the of educators' digital literacy level, the authors propose to development and to implement of the following computer, multimedia and computer-based learning tools and equipment:

- Blended and distance learning classes;
- Cloud technologies;
- Tools of virtual and augmented reality;
- Tools for gamification of the educational process;
- Educational robotics;
- Tools for learning 3D technologies;
- MOOCs.

Our future work is finding the effective ways to develop the Ukrainian educators' digital literacy level and their digital competences for making them as fluency use of the digital educational tools and digital educational environments.

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