Application of augmented reality technologies for education projects preparation

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Abstract. After analysis of scientific literature, we defined that concept of "augmented reality" has following synonyms: "advanced reality", "improved reality", "enriched reality", "mixed reality" and "hybrid reality". Analysis of scientific literature and own practical experience of the use of augmented reality technologies application in educational practices allowed to state next: augmented reality technologies have a great potential for application in education; there are some cases of augmented reality use for school education; positive aspects of augmented reality technologies application in higher education institutions are confirmed by experiments (isolated cases); only few universities in Ukraine apply augmented reality technologies to educate students; only few universities in Ukraine have special subjects or modules in schedule to teach students to develop augmented reality technologies; various scientific events, mass events, competitions are held in Ukraine, and specialized training on the augmentation of augmented reality technologies is carried out, but this is non-systematic and does not have special state orientation and support. Features of introduction of virtual and augmented reality technologies at Sumy State University (Ukraine) are identified: "e-learning ecosystems" was created; in 2019, augmented and virtual reality research laboratory was established. Advantages and disadvantages of project activity in education are described: project activity is one of the most important components of educational process; it promotes creative self-development and self-realization of project implementers and forms various life competencies. It is determined that augmented reality application for implementation of educational projects will help: to increase students' interest for educational material; formation of new

competences; increase of students' motivation for independent educational and cognitive activity; activation of educational activities; formation of positive motivation for personal and professional growth; conditions creation for development of personal qualities (creativity, teamwork, etc.). Current trends in implementation of educational projects were identified: most of the winner projects were implemented using augmented reality technology; augmented reality technologies were used in projects to teach different disciplines in higher education institutions. Augmented reality technology application for project activity has positive impact on learning outcomes and competitiveness of the national workforce; it will enhance the country's position in the global economic space.

Keywords: augmented reality, project activity, method of educational projects, preparation of students, preparation of postgraduate students, institutions of higher education.

1 Introduction

1.1 The problem statement

Increasing digitalization of society cannot bypass sphere of education. It actualizes research of opportunities and prospects for use of digital technologies in higher and secondary schools. Didactic capabilities of modern digital technologies and their application in education is one of the topical areas of scientific research. Augmented reality (AR) technology application in educational practices is now promising [75]. We agree with the paper [10] that virtual (VR) and AR technologies occupy an important place in new stage of innovative development of society (it is called Industry 4.0). These technologies have both common and distinctive features, which are reflected in specifics of their application by companies in the process of relevant products creation. VR and AR technologies include creation of themed visual content that can be used by target audience to meet specific needs with modern electronic devices. The presented technologies are implemented in production processes, in marketing companies [40], in medical sphere, in educational processes, etc. [10]. Users have the opportunity to receive additional product information that is presented as animated 3D models, videos, graphics, audio content, or text messages using AR.

One of the directions of modern state policy of Ukraine in the field of education is infrastructure improvement of information educational space. Necessary condition and priority for development of education system in Ukraine is its digitization. It is important to create appropriate IT resources for higher education institutions (HEIs) [71]. AR technologies have significant potential for implementation in educational process of Ukraine, since visualization of teaching materials during classes allows to increase level of communication with students, enhance their activity and promotes better material learning. There is an urgent need for comprehensive study of possibilities available for introduction of AR technologies for teaching in the HEIs of Ukraine [10].

Modern students are focused on global trends, which is why educational institutions

in Ukraine need to address issue of innovation in educational process. It is advisable to adapt advanced teaching methods and techniques to specificities of the country. It will stimulate student activity during their studies and motivate them to self-study which will eventually contribute to raising level of national higher education. Main problems of modern education in the universities of Ukraine are following:

- low level of student interest. Presence of the Internet in combination with large assortment of gadgets, psychological features and value system of modern youth require bringing educational process in a methodological, technical and pedagogical direction in accordance with modern realities;
- insufficient level of provision of modern methodological materials and technical means;
- level of lecturers' qualifications. It is necessary to increase number of specialized professional development programs to increase the level of knowledge of lecturers. Also, lecturers should be involved in cooperation with public and private companies and international organizations in the framework of grant programs;
- impossibility of all real processes realization in educational audiences. Practical implementation of certain processes during practical training is impossible because of their considerable cost, considerable time investment or health hazard [10].

AR technology is one of the effective tools that will help solve outlined above problems. It does not require significant financial resources to be introduced into educational process in higher education. A lot of training materials and video tutorials can be used to learn technology. There are AR constructors that can be used to create necessary visualizations over a short period of time. Presence of smartphones and tablets in most students makes it easy to learn using AR technology [10].

New evolutionary stage of society is called technological. It is important to train specialists who will be competitive and able to quickly master professions of the future. We believe that the use of digital technologies, in particular VR and AR, is important in preparing new technology professionals. Therefore, it is important to encourage HEI teachers to develop their own digital competence [44] and to use digital technologies in training, in particular AR technologies.

1.2 Literature review

Application of information and communication technologies (ICT) for various industries is a relevant topic of researches [18; 32; 77; 78; 81]. Various aspects of AR technologies application were explored in publications [2; 3; 13; 14; 16; 21; 22; 24; 27; 34; 41; 47; 48; 51; 56; 57; 58; 59; 61; 65; 67; 68; 80]. Preparation of students and teaching of students using digital technologies were subject of research [6; 8; 20; 17; 22; 28; 35; 42; 43; 50; 64; 66; 71; 72]. It remains important topic for further scientific research. There is an important desire to meet educational purposes needs of society which does not require large financial costs and do not harm the environment [19; 45; 46; 53; 54; 52; 63]. There is a need to continue research of AR technologies application to train specialists in various specialties. At present, application of AR technology is modern trend, and therefore research in this area is relevant and timely.

1.3 The aim of the research

Research aim is to analyze features of augmented reality technologies for preparation of educational projects.

2 Research results

2.1 Analysis of main terms and definitions

Let's consider and analyze basic terms and concepts of this research, namely "augmented reality", "project method", "design", "educational project" and others.

The work [31] defines concept of "augmented reality" as group of technologies that allow to supplement real-world images with different objects of virtual environment. VR provides fully artificial synthesized world (video series) while AR involves the integration of virtual objects into natural video scenes.

Internet sources also state that AR is a term referred to all projects aimed to augment reality with any virtual element. AR is considered as a component of mixed reality, which also includes "augmented virtuality" (when real objects are integrated into virtual environment). There are different interpretations of this term, particularly researcher Ronald T. Azuma defined AR as a system that: combines virtual and real, interacts in real time, works in 3D [4].

In [39] AR is described as a kind of virtual environment. Unlike virtual reality AR allows user to see the real world with virtual objects added to real world. Therefore, AR complements reality not completely replaces it.

Authors of [23] define concept of AR as technology that allows to combine layer of virtual reality with physical environment in real time with a computer to face 3D world. This technology is necessary for the visualization of objects or the visual augmentation of printed matter – newspapers, booklets, magazines, maps and more. Supplementary information can be in form of text, images, videos, sounds, three-dimensional objects. Labels are scanned by special browsers of tablets or smartphones to get augmented content.

The publication [14] describes that concept of AR was introduced in 1992 by Tom Caudell, who collaborated with engineers of the Boeing Corporation over a simple headset. It assisted aircraft engineers in complex wiring diagrams. Purpose of AR is to reduce costs and improve efficiency in many human-aircraft operations. Terms "advanced reality", "improved reality", "enriched reality" are used as synonyms for AR. In recent years AR technology was often used. AR-based applications developed by various companies becomes popular in marketing, medicine, aviation, tourism, design, shopping and gaming. All you need is a smartphone (or another device connected to the Internet). Some classification of AR technologies for training are: AR applications; AR cubes; AR magazines; AR books; AR tutorials; AR textbooks; 3D coloring; maps, globes with AR, etc.

Blurring of terminological boundaries is showed in the work [11]. Therefore, such concepts as "mixed reality", "hybrid reality", "virtual reality with immersive VR", "programmed reality" are often synonymous. It indicates need for further theoretical

study of AR technology application. Also it proves practical importance of these technologies, as it is predicted that significant growth in revenues from the use of AR in various sectors of the economy. Implementation of AR technology required to improve user interface of 3D rendering using hardware and software. Computer-aided real-time digital data is added to observable reality to supplement our knowledge of our environment [11].

The term "project" is borrowed from Latin. It means "thrown forward". "Project" means intention that will be implemented in future. It is an idea, idea, image, purposeful change of certain systems with established requirements for quality of results, costs of means and resources. "Project" is embodied in the form of description, justification, calculations, drawings that reveal essence of concept and possibility of its practical realization. Modern understanding of "project" concept is considered as a complete cycle of productive (innovative) activity: as activities of an individual, group, organization, region or country as a whole, or group of countries (international projects). There is a separate area of knowledge – project management [15; 38].

The publication [38] states that basis of project method is idea which reflects essence of "project" concept and its pragmatic focus on result that can be obtained when solving a particular problem. Project method is related to direct activity of its implementation - design. "Design" is understood as a purposeful activity that involves finding ways to solve problems and make changes in the environment.

Design in competence-oriented education is didactic mean of creation of certain prerequisites for development of key competencies (social, information, digital, communication, etc.) and student's independence in achieving new one, stimulating its natural curiosity and creative potential. Educational design involves clear statement of purpose – result of student solving a particular problem. Efficient mastery of students' basic life and professionally-oriented competences will be more successful if they ensure transition from search to step-by-step validation of received information and implementation of main goal of project. Project provides an opportunity to interest future specialist not only in specific subject of study, but to large extent process of mastering knowledge [38].

2.2 Experience of AR technologies application in domestic and foreign practices

We consider it expedient to analyze existing experience of AR technologies application in foreign and Ukrainian educational practices, as well as scientific publications on this issue in order to further implement the best results in the work of the HEIs and activities of scientific institutions of Ukraine.

The team of authors [3] analyzed scientific publications and revealed major trends in recent years regarding AR application in educational goals. The analysis revealed that the most common keywords in the articles are mobile learning and e-learning. The most used words in the abstracts of the articles were: education, knowledge, scientific education, experiment and efficiency. The most cited journals are Computers & Education, Journal of Science Education & Technology, Educational Technology and Society, Computers in Human Behavior, and British Journal of Educational

Technology. These are the most famous journals on use of different technologies in education. Mobile markers and paper-based applications were found to be the most convenient type of AR materials, as they can be easily and practically developed and easy to use.

The work [21] reviewed literature on AR technology application to support education and science. Following conclusions were made: most AR applications for STEM training offer research simulation activities; programs under consideration offered number of similar functions; most studies evaluated effect of AR technology on student learning outcomes; little research with recommendations for assisting students in learning with AR [21].

AR application in training games was conducted at the Massachusetts Institute of Technology in 2006 and 2007 is described in publications [25; 60].

In a collective study [68] historical and technological analysis of experience of AR tools application for development of interactive educational materials was carried out. Software for designing of AR educational tools was characterized. Technological requirements for optional "Development of virtual and augmented reality software" were determined and separate components of educational methodological complex for designing VR and AR systems for future computer science teachers were developed.

We agree with the publication [10] that AR technology has significant potential for implementation, in particular in educational process. Visualization of teaching materials during the classes allows to increase level of communication with students, enhance their activity and promotes better learning of the material [30]. At present, there is a need for comprehensive study of possibilities available for introduction of AR technologies for teaching in the HEIs of Ukraine.

The work [61] emphasizes that one of conditions for successful scientific and pedagogical work is exchange of methodological materials, including AR application. This publication analyzes approaches to systematization of methodological materials using AR. It is suggested to use STEMUA platform to organize them. Teachers, lecturers, and methodologists are encouraged to add their developments and teaching materials using AR to the STEMUA platform.

Impact of teaching materials (developed with AR technology) on achievement of high school students was investigated in [58], and attitude of students to AR technologies was determined. Results of pedagogical experiment are described, where students were divided into experimental and control groups. The experimental group completed the "Solar System and Beyond" module of their training course using AR technology, while the control group completed the same module using traditional methods and textbooks. It was determined that the students in the experimental group had higher level of achievements and more positive attitude towards the course than in the control group; the students were pleased and wanted to continue using AR applications in the future.

Also, the teaching of students using AR technology is described in [14]. It is noted that in study of biology, anatomy, chemistry, astronomy, and integrated in the study of other subjects you can use AR-applications such as "Animals 4D", "Anatomy 4D +", "Planets 4D", "Elements 4D +", and more. Ukrainian encyclopedias AR IEXPLORE familiarize students with magical world of animals, insects, beetles, dinosaurs. It brings

animal world from the pages of the book into our reality. Also the author [14] proposed classification of AR technologies for teaching and provides examples of AR-cards, encyclopedias, fiction and textbooks, tutorials, coloring books that describe AR technology application for education in schools [13] analyzed impact of AR technologies on learning environment and the results of student assessment.

Prospects of AR application as a component of the cloud environment are discussed in [51]. There is experience in using AR tools in cloud technologies. Involvement of AR technologies for education requires development of new methodologies, didactic materials, and curriculum updates. Main features of AR application in educational process are described: design of flexible environment; correction of educational content for assimilation of material stipulated by curriculum; development of research methods that can be used in training with the elements of AR; development of adaptive materials, etc.

Theoretical substantiation of AR technology application and its features in technical universities is described in [16]. It is suggested to use AR objects during laboratory practical work on physics. It is determined that introduction of AR technology into educational process at technical universities increases efficiency of learning, promotes learning and cognitive activity of students, improves quality of learning, provokes interest to subject, promotes research skills and competencies of the future specialist.

Features of AR technologies application in higher education are described in [59]. Some students have difficulty understanding of mechanical systems, starting with two-dimensional design plan. Therefore, real system manipulations related to different perceptions were implemented, especially for students who do not have technological skills. AR can answer difficulty of establishing a connection between imagination and real system. Since AR technology is not yet fully used in mechanics of mechanical design, an assessment was made and relevance of AR technology application was determined to facilitate understanding of different mechanisms creation. AR script is implemented on electromechanical mechanism. It makes possible to identify components and their location, to study mechanism and to make it easier to identify, for example, kinematic circuit or flow of transmit power. Two different interfaces were used by students (tablet and HoloLens glasses), each with its own advantages. Also a pedagogical experiment is described. It was conducted with students of technical specialties. The results of the experiment showed that students using AR technologies had better learning outcomes [59].

Digital transformation of society led to the need for future professionals with ability to quickly adapt to changing activities, apply digital technologies and constantly increase their competency in order to be competitive. We support statement in [65] that different technologies can be used to support employees in different industries. Also, this paper explores potential of AR as an innovative learning environment that can be applied in variety of cases. The research outlined teaching and learning goals that can be achieved through AR technology application in learning [65].

The researchers [49] emphasized that the availability and convenience of technical devices used by students is very important during distance education, and degree of their involvement in educational process and its effectiveness depends on it. Interactive technologies that can be used in educational process include: computers, mobile devices

(smartphones, tablets), electronic devices (smart watches, fitness bracelets, etc.), VR and AR devices (HMD).

The preparation of future IT teachers for use of AR systems is described in the study [68]. The authors noted that it is advisable to use an integrated approach in professional training of future IT teachers to use AR systems for development of interactive teaching materials. Common use of "Unity" for visual design, "Visual Studio" or virtual (Google VR or similar) and augmented (Vuforia or similar) platforms is advisable. Content of optional course "Development of virtual and augmented reality software" for future computer science teachers consists of two content modules: "Development of virtual reality software" and "Development of augmented reality software" [68].

AR technology can be used for both leisure and professional activity. It helps to navigate in unfamiliar places and sometimes unknowingly change our appearance. AR technology makes possible to project digital information (images, videos, text, graphics) beyond screens of devices and integrate virtual objects with the real world. Device's processor, screen, and camera [62] will be used to combine virtual objects and elements with real objects.

Following means can be used for implementation of AR technology in educational process: 1) Textbooks and manuals that contain specialized objects with AR technology. With specialized mobile applications, printed illustrations are transformed into 3D animated objects that can perform certain movements and be accompanied by sound information; 2) Educational games. Best practice shows that in many cases information provided in the form of interactive games is positively perceived by students. It activates motivation to participate in the process and promotes the development of learning materials; 3) Modeling of objects and situations. Creating graphic objects and constructing certain situations that can be used to learn material saves considerable material and financial resources; 4) Skills training applications. During teaching of different disciplines it is possible to create content in AR format that can be used as a tool to acquire certain professional skills. It can be used by students to independently work out specific practical tasks outside the school [10].

Creation of specialized applications for the disciplines in order to modernize the educational process in HEI is advisable. It will represent training complexes by 3D stereoscopy. There is a need to develop educational and methodological complexes of disciplines using AR technology. It will raise quality of education to new level [10].

We agree with the paper [2] that in modern conditions, smart technologies should be one of the main topics of scientific research. AR technologies can be useful tools to help modernize higher education. Advantages of AR technology application in universities of Saudi Arabia in terms of its economic and environmental component are analyzed. It was identified that Saudi staff believe that AR application in higher education has positive environmental and economic benefits [2].

Algorithm of AR technology is described in [37]. It means that camcorder of mobile device reads image containing tags (markers) and transmits video signal to the computer (smartphone, tablet). Special program processes the received signal (recognizes markers) and overlays virtual object on the screen of real object. Texts, sitelinks, photos, three-dimensional elements, sounds, videos can be used as virtual objects. The most common ARs are QR codes, AR browsers, auras. All of these

technologies have the following characteristics: they complement real world with virtual elements; add-on happens in real time; complement must occur in three-dimensional space [37].

AR technology allows you to augment the real world with certain virtual objects that require users to use one of the electronic devices with screen, camera and specialized software to view relevant content. AR-based interactive visualizations can be placed on the walls of any building exterior and interior. You can also use VR glasses, special helmets, hologram technologies (such as Google's Magic Leap) for AR rendering. [10].

The author [14] describes various examples of AR applications. After downloading the "New Horizon AR +" program students required to point cursor to correct part of page in book and watch videos where characters speak English in different topics of life. "Livit Studios" company specializes in the development of VR and AR software and also develops books on AR and full-featured applications in various functions (visualization, animated 3D models and animated characters, audio and interactive 3D games). For example, there is a book on human body with AR. There you can explore all the organs and functions of the body with help of interactive objects AR [14]. Indeed, such a book can be useful for children and adults.

In the work [20] we briefly describe examples of AR application in various fields: social communication, leisure and games; education; sphere of tourism; sphere of purchase/sale and presentation. We agree that rapid development of AR and VR technologies and expansion of their scope led to demand for highly skilled professionals in the field. A number of studies began on development of AR technologies. However, it is important to increase competencies of teachers and to educate students to develop and apply AR technologies in various public sectors. It is also important to share best practices in this field and to prepare educational and methodological materials for HEI based on world best practices [20].

AR mobile applications designed for education use two main scenarios of user interaction with the environment: 1) using label attached to virtual object; 2) with layer of virtual objects over entire frame space of external camera of device. Classifications regarding use of AR in the educational field are given in foreign sources [76]. The authors refer to the following types: books with AR technology that form a bridge between the physical and digital worlds; educational games; educational programs; object modeling; skills training apps. Analyzing use of AR technology in education the researchers noted such positive characteristics as [36]: interactivity, ease of use, use of surprise effect and student motivation.

However, there are some limitations related to technical issues on AR technology application [79]. Lack of single methodology is important problem: AR technologies are developed so rapidly that research in education and pedagogy simply does not have time to provide theoretical understanding or develop a systematic methodology [7]. It also requires integration of applications into educational process. AR is interactive interactivity but it is not possible to establish student feedback that is necessary to control the acquisition of knowledge and skills. AR technology application also requires considerable resources and special training for teaching and research staff.

2.3 Features of implementation of virtual and augmented reality technologies at Sumy State University (Ukraine)

Information system of modern HEI is an integrated information system based on totality of subsystems providing basic types of HEI activities. Interaction of all subsystems at different levels of the hierarchy is clearly constructed in accordance with the methodology of organizing the university's business processes due to its structured architecture and multi-level integration. Organizing methodology of each business process in an integrated information system is determined by ultimate goal - to ensure quality of the university's educational activities. Operation of each of the subsystems is based on their own technological, software and technical solutions, which ensure the stable operation of the system as a whole [71].

Granted projects and research contracts provide access to up-to-date software. For example, access to mobile portal software development under the TEMPUS INURE project, DELCAM and LabView engineering products under TEMPUS ENGITEC, access to Unity Technologies (VR and AR) software [71].

Sumy State University develops technical and informational resources, regulatory framework to implement a model of multidisciplinary innovation-oriented university. This model provides harmonization of educational, research and active international activities, the generation and transfer of knowledge in business, socially significant projects, etc. [69]. The management of the university is determined to form such scientific and educational environment where scientific achievements of the university's scientists would significantly affect content of educational process and all spheres of activity. It is done with aim to continue taking a university model that adheres to ideology of research-type educational institution which has an inherent unity of scientific and educational processes and "portrait" of graduate who is able to perceive and implement innovation, to work in a multifunctional IT environment. In order to intensify student's scientific activity and deepen its interaction with the educational process the Target Comprehensive Program "Organization of Student Scientific Work in Organic Combination with the Educational Process" was created.

The university pays great attention to motivation system of students and teachers for engaging in scientific activities. System of internal grants was introduced, the competition for which is held annually to increase the level of interest in research activities. Main tasks of introducing grants for undergraduate and graduate students are:

- promotion and involvement of student youth in scientific and innovative activity;
- achievement of scientific result and/or creation of scientific and technical products, which will have continuation in preparation of commercial proposals for implementation of grant projects, creation of start-ups, etc.;
- acquisition of skills of preparation of scientific grant projects by students and graduate students;
- stimulation of scientific researches of students and graduate students;
- support and development of activity of student scientific associations (laboratories, centers);
- financial support for research and applied development of undergraduate and graduate students;

— identifying undergraduate and graduate students who are capable to deliver innovative developments that are commercially attractive, in particular on an outsourced basis [69].

Grants for undergraduate and graduate students are funded by funds determined by the University's Academic Council. Procedure for competitive selection of projects for grants is open and all information is published on the University's websites. Ability to find reliable information, critically analyze, create and disseminate own intellectual product is key competency of successful specialist. Comfortable information environment was formed at the university. It contributes to development of information and digital competences and introduction of innovations.

The university created an "online learning ecosystem" based on software that automates most of the university's business processes, including support of online training courses for various categories of learners (students, teachers), creation and management of electronic content, project management, quality assurance of training materials and the learning process. Basic idea of the developed software of the university is to create maximum number of multipurpose components. This has following advantages: 1) it is easy to launch service that offers different ways of learning: from mass open online courses to corporate online learning; 2) online content can be easily converted from HTML/JS learning objects to modern AR/VR elements. This technological solution allows the university to significantly reduce cost of study compared to individual implementation of each local learning task. Benefits of coherent solution include complete control of all inputs/outputs, easy integration of learning outcomes from one learning method (for example, through open online courses) [12].

Developed own methodical model of online courses promotes high level of interactivity of educational content, in particular on widespread use of virtual simulators. Our own technological solutions to optimize work on creation of interactive learning content allowed to create more than 2,000 virtual simulators based on Java, JS, Flash, Unity3D (including using VR and AR). In 2019 the University established VR and AR research laboratory. It is part of the online learning ecosystem and allows us to reach a new level of VR/AR application in education in future [12].

The University's ecosystem development plan envisages complete transition of university's educational process to E-learning technology, active introduction of blended learning models, use of VR and AR for learning, development of its own VR online course concept, increase and active dissemination of non-academic, online courses transferring results to academic disciplines [12].

Digitalization of society requires universities to consistently develop and implement modern ICT trends, to demonstrate ability to solve digital transformation problems, enabling them to significantly enhance competitiveness, attract additional resources, including upgrading their facilities, and improving the quality of education. Important trends in education are: use of cloud technologies, access to virtual computing systems, business analytics and Internet of Things, virtual laboratories, AR technologies and more [69].

Nowadays, the university's educational process uses unique technical equipment obtained through active international cooperation: biomedical engineering laboratory,

modal analysis complex, multispiral tomography, electron microscopes, 3D printers, etc. The university's potential makes possible to make more intensive use of modern technologies and solutions, for example, not to be limited to support and development of traditional resources (computers, software, equipment, etc.), but also to implement virtual laboratory complexes, access to remote laboratories and educational and scientific activities [69].

At the university AR technologies are actively introduced into the courses "Essential Geometry", "Engineering Graphics", "Computer Graphics in Mechanical Engineering" and when studying other disciplines and for training in various specialties.

The staff and students of the university are involved in processes of IT development, since the university is a member of the Association of Industrial Automation Enterprises of Ukraine. In 2019 a Memorandum of Understanding was signed on establishment of Industry 4.0 Center at the University with the support of the Sumy City Council. Process of Industry 4.0 is primarily understood as complete automation of Ukraine's production with introduction of cutting-edge digital technologies: artificial intelligence, Internet of Things, robotics, AR. Such innovative transformation is needed to improve business models, accelerate state development, enhance scientific capacity and provide skilled creative workplaces with training at the university. First results of such cooperation are: 3D Innovation Group of the University became a member of the Fablab international network and is marked on its world map [1]. Currently, there are only 10 such centers in Ukraine [33].

Also, the university pays great attention to continuous professional development of scientific and pedagogical staff. Number of competitions was introduced to encourage teachers to study and apply modern technologies and teaching methods, to ensure quality of higher education, to disseminate better experiences. These are competitions: pedagogical innovations; "The best teacher by eyes of students"; for the best collection of educational materials published on OpenCourseWare; to choose content of mass open online courses; ICT Innovation for Contemporary Education ICT4EDU [55] by nomination: "Mobile Devices in the Learning Process", "Access to Remote Equipment and Virtual Laboratories", "Introduction of Artificial Intelligence Technologies into the Learning Process", "Developing Learning Resources Using VR and AR Technologie"; experiment on testing of blended learning model. Cumulative system of accounting for basic professional development results was developed and implemented in order to obtain competencies required for modern-day teachers. It enables to determine personalized indicators, including participation of employees in international internships, formalized certification programs, trainings, workshops and other types of professional development [69].

2.4 Project activity in education: advantages and drawbacks

Scientists define project activity as one of the most important components of educational process. It promotes creative self-development and self-realization of project implementers and forms various life competencies. Project technology combines theoretical knowledge and practical application to solve specific life or professional problems.

Project technologies are derived from the "project method" that emerged in the 1920s in the United States. Initially, it was called the "method of problems" and it was developed within humanistic direction in philosophy and education. William H. Kilpatrick called project organization a way of working with students [26]. Project at time meant purposeful act of activity based on the student's interest. Then first classification of projects was proposed (created projects, consumer projects, problem solving projects, exercise projects), as well as the main stages of the project [29].

In Ukraine theoretical and methodological principles of project application were laid by Hryhorii H. Vashchenko [70]. A prominent Ukrainian educator attributed project method to active teaching methods, characterized by "practical bias of learning and a connection with life". In course of project implementation one should pay attention to organic combination of theory and practice, since project task is not only to do some useful work but to broaden one's worldview, to acquire theoretical knowledge that enables one to understand better life [29].

Practical skills are formed in solving practical problems during the implementation of the project. There is a mastery of knowledge in the process of using information and assessing its importance and subsequent use. Project executor analyzes, performs certain actions, simultaneously learns techniques and methods of design and assesses its own experience in terms of readiness for life. Development of project thinking provides individuals with opportunity for sustainable development along their chosen trajectory of activity. Paradigm of project learning corresponds to personally oriented pedagogy: it is characterized by humanistic and psychotherapeutic orientation, aimed at the free, versatile and creative development of individual characteristics of cognition subject [73].

Educational project is one of the methods of educational project activity. The essence of educational project is to stimulate the students' interest in the problems, to find ways to solve them through project activity; provide opportunities for practical application of acquired knowledge and skills. It is assumed that during project implementation student must acquire some knowledge on the subject under study. Main characteristic of creative projects is that their content and structure depend on creativity and interests of the authors [73].

The publication [29] states that project method (project technology) gives each participant of educational process an opportunity to develop their own cognitive interests and ability to independently construct their knowledge, to navigate information space. Educational design is always focused on independent activity of students – individual, paired, group, which they perform for certain period of time. Design technology provides successful solution of problem. It involves use of variety of different methods and learning tools and need to integrate knowledge and skills from different fields of science, technology and creativity. Students have opportunity to generalize, consolidate and practically apply theoretical knowledge in disciplines and professional methods, to improve the skills of independent research activity [29] during creation of teaching methodical project.

Project activity will be able to play leading role in the formation of positive motivation for personal and professional growth, readiness to find new, original methods of solving professional problems in students in process of their professional

formation in higher education. Designing, as a special type of activity, is characterized by ability and willingness of person to predict certain professionally-oriented tasks and to search necessary tools for their complete and speedy solution [38].

During project activity students acquire following skills: reflexive (task comprehension), research (ability to generate ideas independently, independently search for information, propose their own hypothesis, establish cause and effect relationships); managerial (ability to plan activities, time, resources; ability to make decisions, predict consequences); communicative (ability to engage in dialogue, discussion, defense of one's point of view, etc.); presentation (monologue, public speaking, artistic skills, etc.); self and mutual evaluation (adequate assessment of their work and those of other students); cooperation skills (collective planning of group work, interaction with various group members, mutual assistance, business partner communication skills, etc.) [29].

Decisive role in modern educational process is played by student ability to use information for realization of their tasks and goals. Analysis of theoretical and practical achievements makes possible to state that project is a special form of educational philosophy, which allows combining values and content foundations of culture and process of activity socialization. Designing is complex activity that characterized by: features of auto-didactics (participants of design seem to automatically learn without specific didactic task from organizers, new concepts, new ideas about different spheres of life, industrial, personal, socio-political relations between people, new understanding of content those changes that life requires); designing fundamentally different subjective rather than objective form of participation of each person in social activity; adoption of design as specific individual-creative process which requires each of original new decisions [38].

Rapid spread of computer technology led to dramatic changes affecting learning process itself. There is a widening gap between level of knowledge of those who have access to modern information technologies and those who do not have such access. There are changes in pedagogy as result of emergence of new technologies. Expansion of curricula is caused by technological changes. They have a direct impact on learning culture. Their competitiveness and activities of higher education institution as a whole is criterion that determines the quality of graduates' training in today's economic realities [12].

The publication [82] proposed to use special software "Salamstein Studio" to perform project activities (it was designed for developers of distance training courses, graduate students and doctoral students). Salamstein Studio's Project Management tools provide: implementation management of work set on planning, development and verification of training facilities; ability to monitor status of tasks; communication between all participants. Each started task in Studio has responsible executor and status that captures status of its completion. Status of the task and its responsible executor are changed automatically after each type of work at different stages of learning object development. Assignment status changes from "not started" to "completed" sequentially in absence of any comments from the Project participants. If necessary, the status of task may be repeatedly returned to previous stage. Moderator and Programmer are usually involved as part of the development of interactive practical tasks. Work on

these objects actually goes through two stages: developing of script and creating of software product based on it. Certain quantitative characteristics are used to manage and analyze the Project. Status of the task is determined in percentage and depends on the status of the task and the type of educational object [82].

Based on Ruby on Rails framework, Salamstein Studio is a module of the automated distance learning system of Sumy State University. It implements project approach to organize process of development of distance learning courses. Project at Salamstein Studio is set of all tasks for development of distance learning training objects. It requires certain sequence of work stages and corresponding performers. It provides monitoring of task performance by all project participants in automated mode. The authors of the Project are teacher, group of teachers, graduate students, doctoral students responsible for development of distance courses. Project Expert is selected from the most experienced teachers in the automated distance learning system. This person controls observance of Methodological requirements for distance learning courses. There are following participants in addition to the listed above: the Programmer provides software implementation of interactive learning objects, the Moderator performs complex structural and functional verification of distance learning materials, and the Tutor coordinates the students' educational process relevant direction. They are involved at different stages of the development of distance courses. training [82].

Introduction of AR technology into education is in its beginning. Taking into account prospects for their development, it is necessary to study and analyze experience of their application and to find opportunities to integrate them into educational practice, for example, through the project activities of students.

Information projects involve collection, analysis and formulation of conclusions about information and object under study. This type of project does not involve experimental work. It can be widely used in high school chemistry or physics, especially for 7th grade pupils. At this time pupils deal with science of chemistry, methods of handling chemical equipment, methods of conducting the simplest chemical experiments. Finding of additional information, analyzing it and being able to interpret it from a chemical scientific point of view, drawing up own (correct) conclusions in the form of an abstract (indicating the purpose, tasks, results of work, conclusion), part of the information stand, booklet are serious work, especially for students with humanitarian inclinations. Research projects are as close as possible to scientific research. They include writing of scientific essay and presentation in form of a report or a poster defense. According to requirements of the Minor Academy of Sciences the experiment should be present in the pupils works starting from the 10th grade. It is said that tenth graders work under scientific guidance and chose chemistry or physics as a subject to study in future [73].

Currently, there are following existing curricula: "Physics and Astronomy", Curricula for 10-11 classes of general secondary education institutions (standard level, profile level), approved by Ministry of Education and Science of Ukraine (Order No. 1539 in 2017); "Natural Sciences" Integrated Course for 10-11 classes of general secondary education institutions, approved by Ministry of Education and Science of Ukraine (Order No. 1407 in 2017), "Physics" 7-9 Grades Curriculum for secondary education institutions, approved by Ministry of Education and Science of Ukraine

(Order No. 804 in 2017). These programs include implementation of educational projects in physics: “Nuclear energy” (section “Quantum physics”, class 11), “Physical foundations of atomic energy” (section “Physics of atom and atomic nucleus”, grade 9), “Energy” (section “Technology course” Integrated Course, Class 11). These include advantages and disadvantages of using nuclear energy, development of Ukraine’s nuclear energy, ways to ensure safety of nuclear reactors and nuclear power plants, the Chernobyl problem, effects of nuclear energy on the environment, protection against radioactive radiation, and more.

Application AR APP Chornobyl NPP ARCH AR [9] was officially launched in 2018. It can also be used for educational purposes (Fig. 1). According to the State Agency of Ukraine on Exclusion Zone Management this application helps to take closer look at the construction of the Arch and the Shelter object on a smartphone. You can look at the various details and get a real picture of the little things about the Shelter without risking human health. Its example is shown in fig. 1. It should be emphasized that in the such applications can be used to increase efficiency of emergency preparedness, response system and emergency situations on potentially hazardous sites. Such applications can be used to educate students in preparation of future specialists in the field of ecology and environmental protection. Also, new methods, algorithms and software need to be developed to address environmental security issues in areas of impact of potentially hazardous sites [5; 53; 54; 52; 63].

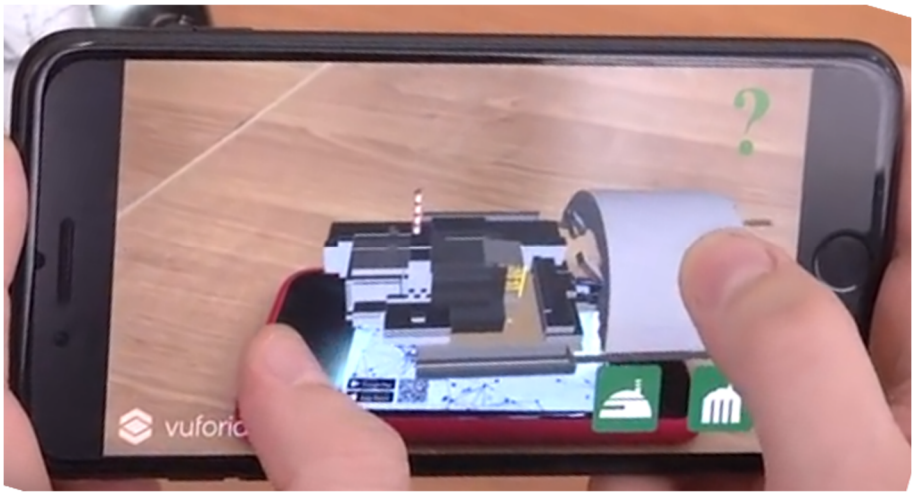

Fig. 1. Use example of application Chornobyl NPP ARCH AR

Results of educational and cognitive activity of students during implementation of educational projects on topic “Nuclear energy” should know: component knowledge (they know principle of nuclear reactor action, they know about impact of radioactive radiation on living organisms); activity component (they explain ionizing effect of radiation, use dosimeter (if available, use acquired knowledge for safe life); value component (aware of advantages, disadvantages and prospects of development of

nuclear energy, possibility of using fusion energy, efficiency of methods of protection against the effects of radioactive radiation).

AR is one of the most advanced learning information visualization technologies. Application of this technology will increase motivation for learning, will increase level of assimilation of information due to variety and interactivity of its visual representation and will allow transferring of part of research work in the field of distance learning [14].

Digital transformation of society influences changes that need to be made in higher education system to train new generation professionals. Future professionals in addition to professional skills should also be: creative, adaptive, with critical thinking, independent in decision-making, focused, capable of professional growth and use of digital technology in a variety of professional situations. That is why it is important to use design technologies to train specialists in new technological era.

2.5 Project activity in education: advantages and drawbacks

Nowadays the University's work on innovation is aimed to ensure sustainable functioning of internal quality assurance system of education, development and implementation of unique organizations-methodological solutions, flexible information technologies, creation of various information services, target databases and access to them through personal offices, implementation of IT-projects both regionally and nationally. Global trend of universities in the world is to extend their lifelong learning services. One of the important issues facing higher education institutions today is transformed demand of modern students. Young people want to build their individual learning trajectory by choosing both academic and non-academic courses; both offline and online [12]. Therefore, teachers often use method of education projects for further interest students in the university. Advantages of this method were described above. Also, the university management constantly introduces innovations, conducts various competitions among teachers and students.

We describe experience of implementing educational projects at Sumy State University, where for several years "All-Ukrainian competition on use of mobile devices in educational process" is held. Description of competition: competition for development of the best training (lectures, practicals, etc.), provided by curriculum, using students' mobile devices (laptops, netbooks, tablets, smartphones). The competition is based on study of current trends in technology implementation and understanding of educational space transformation. It is based on experience of implementing BYOE (bring your own everything) and "flipped learning" technologies. The peculiarity of the Competition is need to confirm in practice their own projects, real cooperation between students and teachers. Contest nominations: "Efficient use of existing software" and "Creation and using of own software development". Specialized competition site was created and maintained for implementation of this competition [74]. Its main page is shown in Fig. 2.

The main page of the competition contains following information: About the contest; Evaluation criteria; Tender Commission; Apply; Consultations; Useful materials; Social Network and Sitemap. Information about the winners of the contest and photos

is also available. For example, in 2018-2019, the first place in the nomination “Efficient use of existing software” held the project “Application of AR and VR technologies in the conditions of holding QR code of the quest for formation of English-speaking competence of future sailors” (the project implementation in practice is presented at https://tinyurl.com/ydef66jn). The nomination “Creation and using of own software development” was won by the project “Augmented reality – methodical tool for mathematics” (the project implementation in practice is presented at https://tinyurl.com/yavsrlte). Fig. 3 shows examples of use of AR technologies in competition works, and Fig. 4 – photos of winners and active participants of the competition 2016-2017.

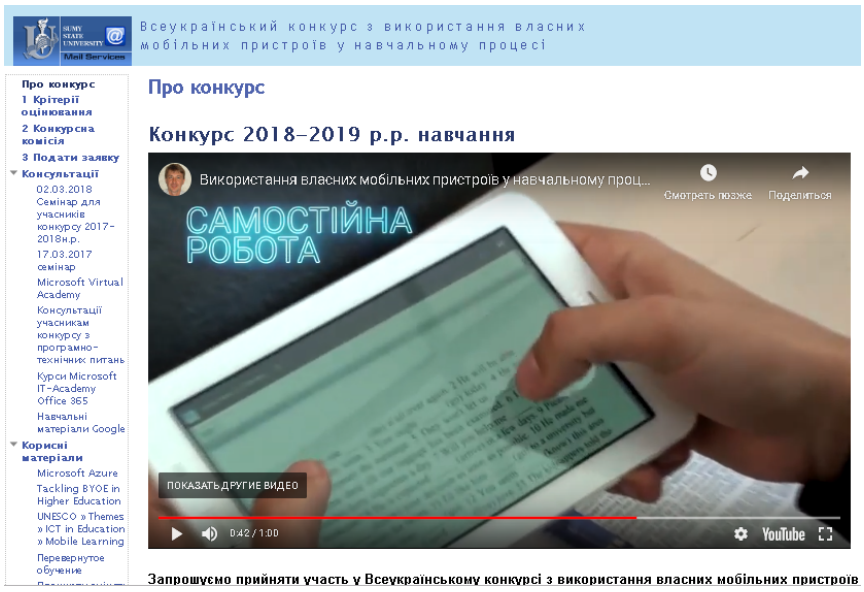

Fig. 2. Main page of the site “All-Ukrainian competition on the use of own mobile devices in the educational process” [74]

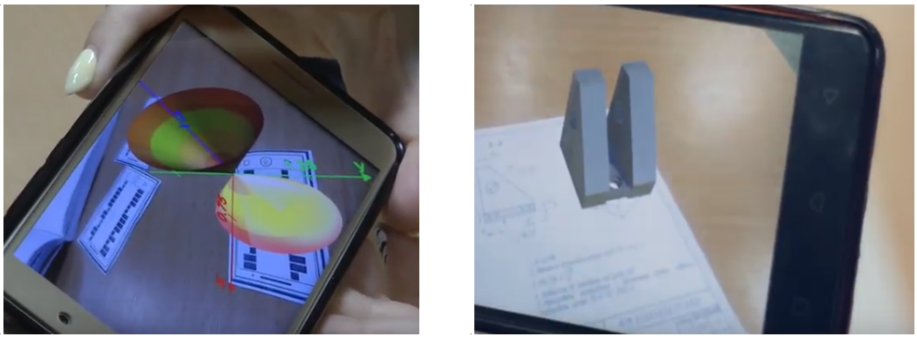

Fig. 3. Application of AR technologies application in the competition works

Fig. 4. Winners and active participants of the competition in 2016-2017

So, works with AR technologies were the best ones and won the competition. It happens because AR technology is a really up-to-date trend in educational projects.

3 Conclusions and prospects for further research

1. Basic terms and concepts are analyzed and determined: terms “advanced reality”, “improved reality”, “enriched reality”, “mixed reality” and “hybrid reality” are used as synonyms for “AR”; “AR” is term that refers to all projects aimed at augmenting physical reality with any virtual element.
2. Results of analysis of the scientific literature (Ukrainian and foreign) and our own practical experience of AR technologies application in educational practices allowed to state that: AR technologies have great potential in many application fields, in particular, for education; there are some difficulties with AR technologies application in educational institutions (financial, professional, methodological); there are some cases of AR application in schools; positive aspects of AR technologies application in higher education institutions are confirmed by experiments, however, these are isolated cases; only a few universities in Ukraine apply AR technology to educate students; only a few universities in Ukraine supplemented their curricula with special subjects or modules to educate students to develop AR technologies; various scientific events, mass events, competitions are held in Ukraine and specialized training is performed for promotion of AR technologies, but this is non-systematic and has no special state orientation and support.
3. Features of implementation of VR and AR technologies at Sumy State University (Ukraine) are identified: the “e-learning ecosystems” are created at the university. Its basis is software that automates most of the university’s business processes. These processes includes: support of online training courses for different categories of students (students, teachers); creation and management of electronic content, management procedures (project management, quality assurance training s materials and learning process). Advantages of the developed university software are following: 1) it is easy to run a service that offers different ways of learning: from mass open online courses to corporate online learning; 2) it is possible to convert

online content from standard HTML/JS training objects to modern AR/VR elements; 3) reducing the cost of training. Also in 2019 the University created VR and AR research laboratory. It is part of the online learning ecosystem.

4. Advantages and disadvantages of project activity in education are described: project activity is one of the most important components of educational process. It which promotes creative self-development and self-realization of project implementers and forms various life competencies. Project technology combines theoretical knowledge and practical application to solve specific life or professional problems. AR application for implementation of educational projects will help: to increase students' interest in learning material through interactive content; to form new competencies through augmented reality technology; to increase level of students' motivation for independent educational and cognitive activity through introduction of game, competitive incentives; to activate educational activities; to form positive motivation for personal and professional growth; to provide process of developing educational materials with a new organizational form that is attractive to students; to create conditions for development of personal qualities (creativity, teamwork, etc.). All listed above will increase students' self-esteem.
5. Current trends in implementation of educational projects were investigated and determined based on experience of Sumy State University. It is defined following: most of the projects that won the competition "All-Ukrainian competition on using mobile devices in the educational process" were implemented using AR technology; AR technologies used in projects to teach different disciplines for HEIs.

AR technology application for project activity has positive impact on learning outcomes and competitiveness of national workforce. It will enhance the country's position in the global economic space. It is important to carry out series of national and international events on promotion and application of AR technology – conferences, seminars, project competitions, etc.

Areas of further research can be: AR technology application in training of specialists of various specialties.

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