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DEVELOPMENT OF AUGMENTED REALITY TECHNOLOGIES FOR ACADEMIC LIBRARIES AS AN EXPERIENCE OF SYNERGETIC LEARNING

Abstract. The purpose of the study is to identify the features of the use of augmented reality technologies in the training of specialists in information, library and archival studies, who can solve specialized problems in the professional field, characterized by the complexity and uncertainty of the conditions and provide for the application of the provisions and methods of information, library and archival affairs. Work in project student groups to develop library augmented reality is a synergistic educational model that combines different pedagogical strategy: problem-based (PBL), innovative learning (IBL), project-based (PjBL), active learning (AL), deeper learning and game-based learning (GBL). The study proposes an interdisciplinary approach to teaching student librarians: a combination of applied augmented reality research for academic libraries and problem-oriented student learning, learning in the development process for innovations. The method of infographics comparative analysis was used. The article raises the issues of convergence of traditional forms of theoretical and practical training and the organization of innovative activities of students in the space of the academic library on the example of the development of AR-technologies. Peculiarities of development and implementation of augmented reality information technologies in work with documentary funds of academic libraries in the process of problem-based learning focused on innovations are determined. AR-marker technology has been intuitive for humanities students and facilitates the annotation and indexing of library documents. AR-technologies allow playfully to delve into documentary and library science aspects of creating the content of an AR document to master the skills of compiling thematic references. In the concepts of PBL and IBL, the primary emphasis is placed on the applied solution of problems and implementing innovations that meet the needs of a particular organization. This undermines the value of fundamental theoretical learning. We show the value of theoretical lecture material, on the example of the development of augmented reality for academic libraries by student librarians. We prove the importance of correlating lecture material as a starting point for student innovations to the actual needs of the academic library. The results of the research will be an impetus for implementing PBL & IBL in higher education in developing innovations by students in new learning environments (internships, information industry), such as academic libraries. Also initiate the work on implementing AR information technologies in the activities of university libraries. AR is a significant addition to the tools that university and libraries can use to engage their audiences to information literacy training. This should promote the librarianship and increase the status of the university. The students' work with AR library technology is characterized by complexity, interdisciplinary nature, the collaboration of students of humanities and technical profiles. All this develops in students important competencies: creativity, ability to apply theory, work in a team, learn, developer responsibility, systematic thinking, involvement, focusing on innovation. The paper proposes to consider AR information technologies not only in the perspective of programming but also as a tool for PBL-AL-PjBL-GBL-IBL of student librarians, and as a subject of library and document researches (new tools of documentation). We emphasize fundamental learning and its constant testing in practice. The starting point in the development of innovations by students is the educational material, not the needs of the organization for which the innovations are developed. Because the process of innovation is a learning experience designed to show the applied power of theoretical knowledge. A multifactor model for evaluating student innovations is proposed.

Keywords: majoring in information, library, and archival science; augmented reality technologies; academic libraries; problem-based learning; innovation-based learning; game-based learning; project-based learning; synergistic educational model

Statement and substantiation of the urgency of the problem. In the conditions of rapid development of information technologies and at the same time crisis of library and archival services in Ukraine, there is an urgent need not only to popularize the work of libraries, but also deep transformation of means of work with library and archival funds, use new forms of interaction with readers. New vistas for development Librarianship is opened by the implementation of information technology in virtual environments with full (3D, VR), augmented (AR) and mixed reality (MR). These tools used to attract, motivate, route, inform and educate library visitors. However, these technologies should be used in the work of librarians (fund formation, monitoring the safety of the library fund, interaction between libraries), and for teaching students in the field of library service as well. All this is a step to bring Ukrainian libraries to the world level.

Given the fast-evolving of youth culture, virtualization and gamification could become an effective way of developing, transferring and accumulating knowledge. D. Roberts rightly observes: «Humans have entered the most visual epoch in human history, and this and near future generations of university students have been exposed to visual learning for most of their lives» (Roberts, 2019, p. 64). Today it is no longer enough to perceive visuality as a method of pedagogical influence, teaching visibility. It is important to involve students in the process of constructing visual environments based on fundamental knowledge. Therefore, it is advisable to study the educational potential of augmented reality technologies within the framework of the model of problem-oriented teaching of students, in the specialty of information, library and archival science.

The relevance of research is determined by the value given to academic libraries as structural units of universities. Because the ability to use intellectual resources and create new knowledge is the key to integrating higher education and librarianship into the modern information space. Ukrainian libraries as conservative social institutions usually do not have time and budget to implement software innovations. An analysis of the experience of using virtual reality technologies in Ukrainian libraries shows the lack of a clear understanding of the essence of augmented reality technologies. In particular, this concept mistakenly includes related but not identical forms of library activity: websites and social accounts of libraries, mobile applications of libraries, electronic catalogs, electronic libraries, electronic library tours and events in spherical videos, QR codes embedded in catalog with bibliographic information, virtual reference on a mobile phone or geolocation of libraries. Therefore, it is necessary to explore the possibility of implementation innovations at the stage of teaching students-librarians.

In an era of rapid change and reassessment of knowledge, in the context of «the outstripping education» paradigm, we consider it appropriate to shift the focus from problem-based education to learning oriented on innovative discoveries. And we suggest to understand the term «Innovation-based learning» (IBL) as a logical continuation of PBL and Active learning. This will help to bridge the information and pedagogical gap between «the content lectured to the real life application» (Ismail, 2018, p. 1706).

Literature Review. The complexity of the historiographic base of the research lies in the interdisciplinary approach, becauseit raises the issues of applying of problem-based learning in high school, the implementation of innovations into the activities of academic libraries, the peculiarities of the development of augmented reality technologies. Each of these named areas (new-education, librarianship, computer technology) has a well-established rich scientific base.

The scientific relevance explained to the high level of disclosure of the article topic in foreign works, but a small number of domestic scientific works. The scientific platform Google Scholar is indicative (Table 1).

Table 1.
Comparative quantitative analysis of research interest on the topic of the article

Relevant research issues as of 07.03.2021	Scientific papers in English (about)	Scientific papers in Ukrainian	General research focus
Problem-based learning	4 480 000	212 000	Medical education; language majoring.
Active learning	5 530 000	77 500	Theory; methods; strategies; classroom cooperation; psychological and pedagogical problems; higher education; primary education.
Innovation-based learning	43 000	0	Theory.
Game-based learning	178 000	6 660	Design effective learning.
Synergetic learning	41 000	15 900	Synergetic learning systems. Most relevant to our study (Hauptman, 2011, pp. 2106-2117)
AR technologies in education	2 510 000	5 860	General usage issues; training of specialists in radio electronics, mechanical engineering, logistics, chemistry, museum business, marketing, projects; primary education.
Augmented reality in libraries	88 800	5 260	Design, methodology, ethical and legal issues; school libraries; medical education.
Augmented reality in university libraries	163 000	1 840	Customer service systems; mobile applications; computer vision; medical libraries
Using AR technologies to teach librarians	31 700	1	the experience of implementing augmented reality in school libraries.

In pedagogical science, the topics of PBL and active learning are currently one of the most discussed. A significant historiographic base has been accumulated in the implementation of augmented reality technologies in education. It should be noted that all areas of new-learning (IBL, PBL, active learning, Deeper learning, IGL, Flipped learning et al.) closely related to each other, constitute a complex unified system, which can be a separate topic for research. This is confirmed by the theses: «learners are motivated to be autonomous agents of discovery who can identify new knowledge, use it to build on their existing knowledge structures and apply it to solve problems» (Edelson, 1999, 391–450); «problem must stimulate a response and an activity» 0 . In the context of this study, it is important to emphasize the complexity of the approach, attention to the synergistic effects of learning.

Studies of Ukrainian scientists in the field of educational content in the specialty «Information, library and archival science» have shown the relevance of the introduction of forms and methods of problem, project and active learning, the importance of developing creativity and computer competencies (Sydorenko, 2019, pp. 215-218). There is already successful experience in implementing methods of active learning for designing library

instruction at California State UniversitySan Bernardino: informal, in-class, small-group work; cooperative student projects; simulations, such as role-playing and computer modeling; and case studies exercise focusing on the library's online (Dabbour, 1997, pp. 299-308). At the same time, scientists formulate the theoretical foundations of learning based on innovation (Vasylyshyna, 2007, pp. 15-17), discoveries (Bicknell, 2000) as ways to form a new generation of researchers-librarians. Scientists develop theoretical foundations of innovation-based learning (Ismail, 2018, pp. 1697-1706). However there are no works on the training of student librarians in the process of their innovative activities with the development of augmented reality for academic libraries.

The topic of using AR technologies to teach librarians is considered in only one Ukrainian paper (Vasylyshyna, 2007, pp. 15-17), and 32 800 papers in English. Many of these articles focus on the experience of implementing augmented reality in school libraries (Green, 2014, p. 28.). The most interesting are explores librarians' and students' reactions to metasearch technologies from a reference and information literacy perspective (Lampert, 2007, pp. 253-278). Despite the fact that AR is much less widespread in ARL-member libraries (Greene, 2019), scientists state that the technology of augmented reality is gaining more ground, and their uses in libraries and for educational purposes are expanding (Oyelude, 2017, pp. 1-4).

Heretofore the issues of implementation augmented reality technologies for training and increasing the productivity of librarians (in particular, for annotating, indexing books, collecting library funds, accounting and monitoring the issuance of books, etc.) are remained open. Need to study the possibilitys of using augmented reality technologies in academic libraries to train librarian students. We propose to implement the AR- technology as a tool for problem-based learning (Castelan, 2018, pp. 131-142) and a way of integrating academic work and library needs.

Scientists are actively investigating the use of library sites, text messaging services, e-books, mobile access to databases and the catalogue, chat/IM services, social media accounts and apps (Liu, 2015, pp. 133-146), and the implementation of augmented reality with interaction with geolocation, mapping and library fund (Harkema, 2012) as well. Library programs and related implementation processes have already been developed in the library of the Universitat Politècnica de València.

Especially useful are developments by scientists at the University of Illinois on the ways to use augmenting physical book stacks browsing, library navigation, optical character recognition, facial recognition, and building identification mobile software for compelling library experiences (Hahn, 2012, pp. 429-438); research of mobile augmented reality based on context oriented to the library management system (Shatte, 2014, pp. 2174-2185). The experience of the University of Oulu has demonstrated location-aware mobile library service SmartLibrary. This application facilitates the search for books in large libraries for novice library users (Aittola, 2003, pp. 411-416). The most common technologies offered in libraries were the Oculus Rift and HTC Vive (Green, 2014, p. 28), (www.oculus.com).

Augmented reality technologies for rare books or manuscripts of special collections in the libraries are being developed. Scientists point out that the use of augmented reality will be able to model these valuable manuscripts and rare books and appear as augmented reality to ensure that the collection can be better maintained. Users will be able to open the augmented rare book, and flip the pages, as well as read the contents of the rare books and manuscripts using the peripheral equipment such as the HMD or the Marker (Parhizkar, 2009, pp. 344-355).

An analysis of the experience of use the AR and VR technologies in Ukrainian libraries shows the lack of a clear understanding of the essence of augmented reality technologies. In particular, this concept mistakenly includes related but not identical forms of library activities:

websites and social accounts of libraries, mobile applications of libraries, electronic catalogues, digital libraries, library electronic tours and events in spherical videos, QR-codes embedded in the catalogue with bibliographic information, virtual help via mobile phone or geolocation of libraries.

Ukrainian research focuses on the informatization of scientific academic libraries. Scientists emphasize the great role of the academic library in the design of integrated information electronic environments (Solovianenko, 2011, pp. 8-24), creation of a scientific continuum of electronic science, founding of a discourse of academic library science in the knowledge society (Kopanieva, 2016, pp. 4-10), emphasizes the importance of the ability of librarians of scientific (academic) libraries to take an active part in the implementation of digital science technologies (Lobuzin, 2019, pp. 18-24).

The feature of academic libraries are close connection with the scientific and educational heritage of the university, the fulfilment of the function of preservation, dissemination and development of education and science, the formation of a scientific publishing model (Nazarieva, 2017).

Identifying aspects of the problem that are still studied. It is advisable to consider the possibilities of using augmented reality technologies of students as future librarians, as authors of AR educational projects to optimize the library, and concurrently library users. Understand augmented reality technology as a tool for teaching, designing and optimizing the library's work.

The purpose of the study is to identify the features of the use of augmented reality technologies in the training of specialists in information, library and archival studies, who able to solve specialized problems in the professional field, characterized by the complexity and uncertainty of the conditions and provide for the application of the provisions and methods of information, library and archival affairs. Work in project student groups to develop library augmented reality is seen as a synergistic educational model that logically combines different pedagogical strategy: problem-based (PBL), innovative learning (IBL), project-based (PjBL), active learning (AL), deeper learning and game-based learning (GBL).

The research objectives: identify the features of augmented reality technology and reveal its potential for professional training of librarian students in the process of optimizing the work of the academic library (specification aspect: what do we implement?); describe the procedure for applying AR-technology to teach students the initial examination of a library document (methodology aspect: how do we implement?); compare the organizational features of students' work with AR technology and PBL-IBL-GBL models (organization aspect: how and why implement?).

The methodological basis for a pedagogical experiment is concepts of problem-based learning (Castelan, 2018, pp. 131-142); active and deeper learnin (Blazhko, 2017, pp. 18-21); innovation-based learning (Ismail, 2018, pp. 1697-1706); the canva-oriented game design (Blazhko, 2018, pp. 66-77); game design for the development of academic disciplines (Luhova, 2021, pp. 235-254); AR as a didactic support of the educational process (Bielchev, 2014, pp. 36-43). For the implementation of AR in the activities of university libraries: standards (DSTU HOST 7.51:2003; DSTU 2395-2000), and technology (Hahn, 2012, pp. 429-438), (Uzun, 2018, pp. 62-64).

The following methods were used to solve the tasks: analysis of literature and sources; comparative analysis; information modeling and generalization.

Presentation of the main material with justification of the obtained results. There are several different technologies used to work with AR: marker, markerless, augmented reality based on projection, and AR based on VIO. Marker AR called image recognition. This type of technology uses a camera and a special passive visual marker, such as a QR code (quick response code), which shows the programmed result only when the sensor reads it

(Kravchuk, 2017). In the conditions of Ukrainian libraries the most budgetary expedient and simple to use is the market technology of AR. There is a wide range of augmented reality tools, but we are interested in those that can be used in the libraries of Ukrainian universities, and work with texts and multimedia. These programs include Google Translate, Google Expeditions, Wikitude, Roar, ARLOOPA, Metaverse, Vuforia. The most relevant to the needs of library activities are Roar (free, intuitive) and Vuforia (licensed, professional).

Roar is an augmented reality constructor platform. This application helps to create, scan, use and share markers: labels, advertisements, posters, postcards, business cards and other visual markers. These can be images, videos, audio, texts, animated 3D models using notifications based on geolocation (https://theroar.io).

Vuforia is an augmented reality framework for mobile devices developed by Qualcomm. Vuforia uses computer vision technology and the tracking of flat images and simple three-dimensional real-time objects. From version 2.5 Vuforia recognizes text, and from 2.6 - has the ability to recognize cylindrical markers. Image recognition allows developers to locate and orient virtual objects, such as 3D models and media content, in conjunction with real-world images when viewed through mobile. Scientists and programmer students (Uzun, 2018, pp. 62-64) examined Vuforia markers to test the operability of AR according to the criteria: image brightness, contrast, saturation and resolution, marker resolution, marker contrast, ambient brightness, marker distance, camera rotation angle and marker overlap. The marker was loaded into the program database and checked for the quality of its recognition in Vuforia. They tested various types of markers and have found that the most effective for recognition are markers such as Theatre (large-scale object with many angles and contrasting elements) and VuMark (graphics, corner logos). The least effective is the target Blot (monochrome single object with many angles). Targets such as Ace, Circle, and Text were never recognized. To create augmented reality markers the authors recommend choosing the most complex photos or drawings with lots of contrasting elements and angles. Therefore, AR markers in the library space can not be the texts of catalogue cards or catalogue boxes. Sticker images similar Theatre (photo) and VuMark should be created. Each of them can be assigned a value (relevant hint text, index text, image, audio commentary, etc.) by compiling a correspondence table.

These programs allow not only create own markers, but also share them on social networks, including Facebook, Instagram. Markers have a geolocation function, can be located in a selected location, such as an academic library, and are already operational. New generations prefers to know the world through direct interaction and gamification. The Morgan Library & Museum in New York has a virtual tour developed in partnership with Google and GuidiGo. The virtual tour used video and animation to help visitors uncover hidden objects: secret stairs behind bookshelves; large interior details (www.themorgan.org/programs/virtual-talks-and-tours). Therefore, it is advisable to use educational games based on AR: quests on search of books, competitions on the correct indexing of books, etc. All of this help students navigate library resources and services, increase the level of mastering the material, master with innovative library consulting services, increase the opportunity to communicate with the librarian and library visitors.

AR technologies open up many opportunities for library visitors, for librarians, and student education in information, library and archiva studies as well (Table 2).

Table 2.

Educational functions of AR technologies in the library space

Functions of AR documents	**For library visitors**	**For librarians**	**For student education**
Index function	direct attention, indicate the direction of movement (guidebook, electronic guide)	identify indexes, codes, classifiers, which optimizes the search and replenishment of the fund	direct attention, indicate the direction of movement, promote memorization, get hints
Reference and information	provide information about the real object, tips, puzzles	facilitate work with annotation, bibliography	deepen and detail knowledge
Hedonic function	create a positive mood, entertain, gamification	visualize the structure of funds, it makes possible to optimize work	involve in the learning process, allow to communicate by shareing markers, gamification

According to DSTU HOST 7.51:2003 «System of standards for information, library and publishing. Cards for catalogs and card files. Cataloging in the publication. Composition, data structure and publishing design» catalogs can be realized in various forms: card, book editions, micro-media, machine-readable. In Ukrainian libraries, the most common catalogs with separate cards placed in catalog boxes. The augmented reality marker technology should help library visitors to imagine the content and type of publication (Figure 1).

Fig. 1. Transforming a catalog card with augmented reality

Librarian students have the opportunity to create additional content for AR markers: select photos, comments, tips, instructions. The advantage of such educational work is its low standardization, creativity and playfulness. This creates a positive attitude and at the same time deepens into the world of document identification.

Nowadays in the conditions of informatization and automation in libraries create electronic catalogues with high speed of search, multifaceted search, i.e. possibility to carry out search on any sign (author, branch of knowledge, time of publication, keywords). We see the potential of AR technology in the augmented materialization of the book on the electronic catalogue. When hover the mobile application and scan the code of the book, users can see the book, its annotation, location, commentary by a librarian or an expert reader.

Augmented reality complements the main message in a certain way: illustrates, provides tips, details, shows links, additional terms. Augmented reality contains enormous potential as it transfers elements from the virtual world to the real one, complementing things that a person is able to see, hear or even feel. E.g. bibliographic indexes can be illustrated using this

technology, turning a list of data into a gallery of famous personalities, or illustrate systematic catalogues in accordance with the topic using scan-markers, which makes it easier to find books (Figure 2).

Fig. 2. Illustrative function of the added reality on the systematic catalogue

The technology for creating marker augmented reality for maintaining lists or databases is similar and summarized in a schema (Figure 3).

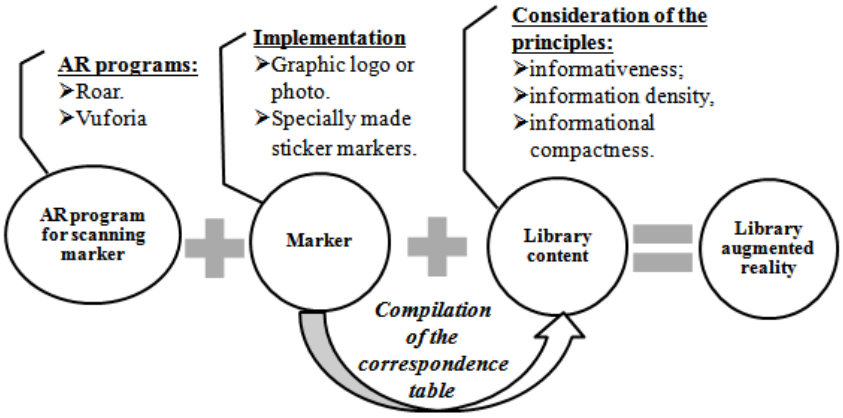

Fig. 3. Algorithm for creating marker AR

It is necessary to determine where the markers for camera scanning will be located, what they should be as objects of scanning, and what will be the content attached to the marker and informative for the user (relevant text-hint, text-index, image and audio commentary). All these questions are formalized in a table of correspondences compiled by a librarian and provided to the programmer for loading into the AR program (table 3).

Table 3

Matching of a AR-markers and library content

Marker AR		**AR content for the library**		
Location / geolocation	Scan object	Text (hint)	Picture	Media
Catalogue card	 1	title, abstract, table of contents, introduction, opening phrases of chapters and paragraphs, conclusion; and accompanying inscriptions; words or phrases	illustrations, charts, tables	audio commentary by the librarian

Catalog box	2	Generalized topic	illustrations	Gif- illustrations
Electronic resource	3	title, abstract, table of contents, introduction, opening phrases of chapters and paragraphs, conclusion; and accompanying inscriptions; words or phrases	illustrations, charts, tables	audio commentary by the librarian

For the fastest simple prototyping of library AR there is an intuitive program ARLOOPA (https://arloopa.com). Because it contains local targets (placed inside the application) and cloud (placed in the cloud storage), and ready-made visual templates for virtual content as well. This program can be used on the first attempts of students to create a library information product by means of augmented reality. The markers are on the catalog boxes, and the augmented reality image shows the area of knowledge in the systematic catalog. The results are presented in Figure 4.

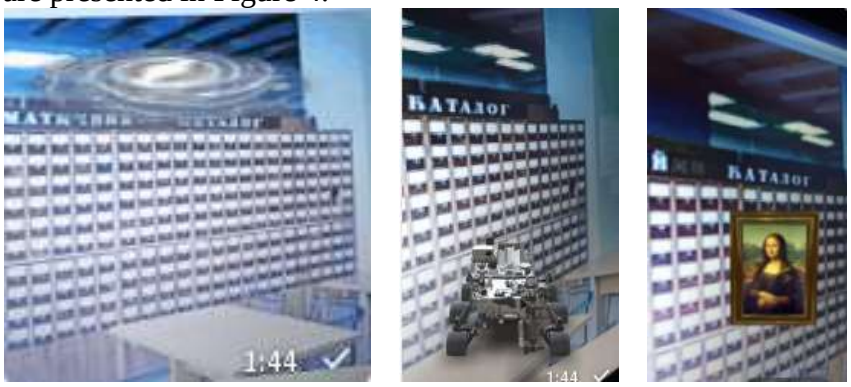

Fig. 4. Examples of augmented reality of a systematic catalog: space technology, mechanical engineering, art. Made with ARLOOPA

In document science it is accepted to understand the document as a complex information system, the volume of which can be measured on the physical (natural), syntactic (symbolic) and semantic levels. Each of these levels has its own quantitative parameters, ie they can help measure the amount of information. Therefore, it is important when developing an AR application to take into account the relationship of information content to the physical size of the mobile screen. In this case, as noted by researchers of augmented reality technology programs, the amount of textual or media information can be unlimited (www.oculus.com). But the ergonomics of the provided information for the user is important.

For the library service the parameter of informativeness of the document is extremely important. This is understood as the actual amount of information extracted by a particular consumer (Larkov, 2006, pp. 25-26). For the information presented in the form of AR the characteristic of information density which is equal to the ratio of informativeness (usefulness, value for the consumer) to information capacity (the real quantity of the information enclosed in any information volume) is obligatory. The information capacity and informativeness of the document depend on many factors: structure, degree of formalization, language (thesaurus and descriptors), etc.

Augmented reality objects (texts, multimedia) can be considered a specific electronic document that has its own details (markers) and special design requirements: information density and informativeness. Such documents perform certain functions in accordance with

the situation of documentary activity and communication.

This feature of the AR document requires special attention to students' study of the information levels of the document, understanding the terms of information compactness, informativeness and information density, the ability in practice to compile and compare lists of document descriptors; comply with the indexing procedure using a thesaurus according to DSTU 2395-2000 «Information and documentation. Examination of the document, establishment of its subject and selection of terms of indexing. General methodology».

Standard DSTU 2395-2000 is a methodological basis for the initial examination of the document: the establishment of its subject in order to further index it and create thematic references. In the future for prototyping a mobile application with augmented reality for academic libraries.

It is clear that the examination of the document is a complex time-consuming process that takes into account many criteria, the main of which are the physical form of the document and its information volume. The standard states that indexing based only on the title is not recommended, just as the abstract cannot display the text of the document. They cannot be considered reliable sources for indexing. The indexing of the document is multi-criteria, should be taken into account: title, abstract (if any), table of contents, introduction, initial phrases of chapters and paragraphs, conclusion; illustrations, diagrams, tables and accompanying inscriptions; words or phrases underlined or highlighted in any way (DSTU 2395-2000). Therefore, the content of the AR-application for indexing the book will be just these criteria. But the question arises, what amount of information can and should be presented on the screen of the mobile application.

Augmented reality technologies can be used in teaching students the work of reference and bibliographic services for library users. One of the first technological processes is the reception of a request. This involves a dialogue between the user and the bibliographer. Successful completion of this stage determines the degree of relevance of the answers. Library practitioners (Sashkova, 2014, 23 p.) note that the formulation of thematic requests by the reader is based on his subjective ideas about the topic, which often do not coincide with its actual content. The reader tends to formulate the subject in an expanded form, usually naming it approximately. In the process of dialogue, the topic can be narrowed. Augmented reality technologies can help the reader to narrow and detail search request with the help of hints, images, instructions, which will facilitate and automate this time-consuming work of the bibliographer. AR technology may contain markers for classifying documents, such as: structural (e.g. department, faculty), chronological (the time of appearance of documents); sectoral, functional, thematic; nominal (e.g. books, magazines, or plans, reports, orders); author's; geographical.

In addition, such features as the language of the documents, their format, originality or copying, material (paper, film, videotape, diskette) should be taken into account. In each case, determine the main and secondary features (Basic rules of work of the state archives of Ukraine, 2004). All this is studied by students in the process of documents analysis and compiling a table of markers and AR content. Moreover, students using AR technology can create game worlds that help identify library collections. Thus, the scientifically organized database of the university library becomes the basis for the creation of augmented reality databases: database of objects, database of images, database of indexes, database of annotations, database of abstracts, base of metaphors etc. The ratio of scientific gathering of library funds for the implementation of gamified augmented reality in libraries by students is shown in Table 4.

Table 4.

Matching library collecting methods and their AR-virtualization and gamification

Scientific collection of library funds	**AR-technology game databases**	**Game design canvas** (Blazhko, 2018, pp. 66-77)**Помилка! Джерело посилання не знайдено.**
Typological - replenishment of collections with typical items characteristic of a particular era.	Image base: subjects of the game world (game and non-game objects).	Game world canvas
Thematic - documenting processes and phenomena that reveal a specific topic, the collection of diverse items.	Base of narratives - events, milestones etc.	Narrative canvas
The complex method is obtained from two in front.	Base of game worlds: chronological, historical, alternative, fantastic etc.	Psychotypes of the player and components of the game aesthetics Canvas

Prototyping of the mobile application AR-library aims to formalize the basic functionality of the concept of augmented reality in the work of the librarian, so at the stage of prototyping with little effort students create the simplest system that already works. At the first stage it is expedient to prototype only a part of the general process of indexing of the document, namely: a stage of inspection of the document. In the future, this project can be developed for further, more complex indexing procedures using a thesaurus: identification of concepts, selection of indexing terms and quality control of indexing. Diagram of the indexing procedure using the thesaurus (DSTU 2395-2000. Information and documentation. Examination of the document, establishment of its subject and selection of terms of indexing. General methodology) serves as the main algorithm (methodology) for students to choose the content to be presented in augmented reality, and can also be a software basis for teaching students to index library documents (AR-tips).

Verification of a term / image / content for augmented reality implementation on a specific library material is based on the document indexing procedure diagram provided in the standard DSTU 2395-2000. We divided the presented process into three stages: 1) the choice of terms (meaningful images, comments, etc.) to define the content to create augmented reality; 2) verification of the relevance of the selected term (or AR content) to the denoted document; 3) approval of the choice.

The process of developing augmented reality for libraries by students can be gamified and be a specific game that has a learning purpose, game space, rules (defined by the standard for indexing documents), tasks, managerial decisions of the player as a storytelling (Luhova, 2020, pp. 42-59) (Figure 5).

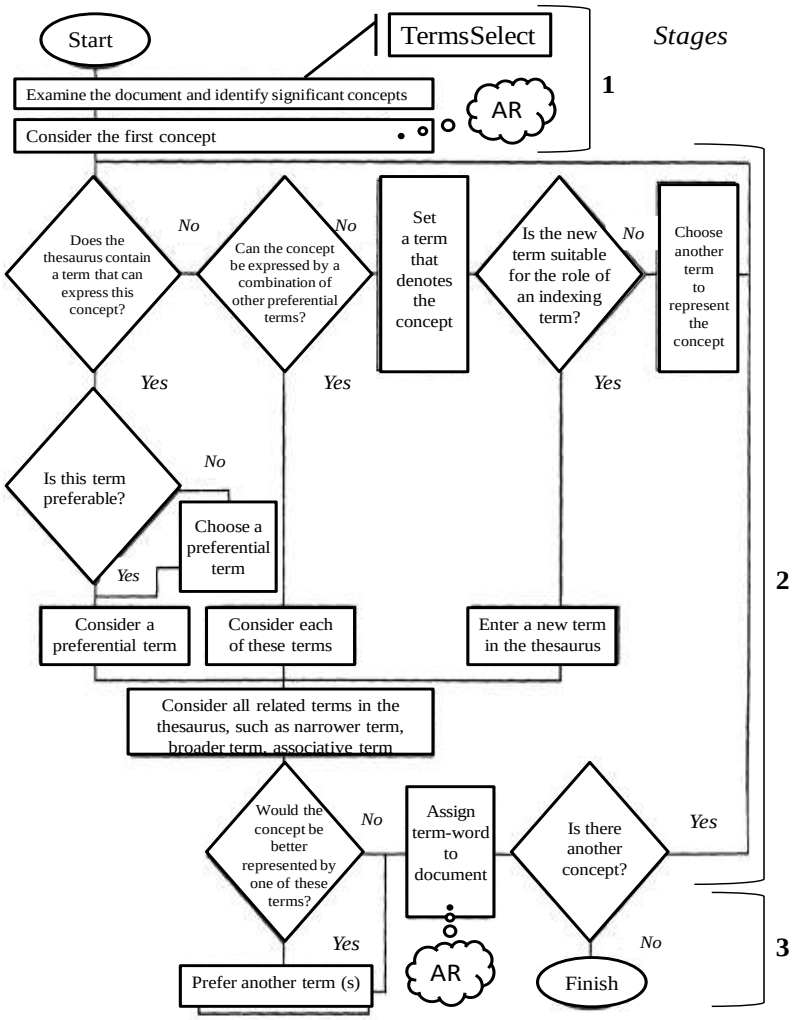

Fig. 5. AR-content distribution process based on diagram of the indexing procedure DSTU 2395-2000

The first stage can be automated. Undoubtedly, indexing books in AR is usually a painstaking task, so a software product should be implemented to automate the process of extracting terms from text documents. A model of such a program was developed and implemented (Kunhurtsev, 2018, pp. 202-208). The scheme of document processing is presented in Figure 6 and includes components: analyzer of possible phrases, text document in any format, document analysis, selection of abbreviations, dictionary adjustment, dictionary of terms and abbreviations.

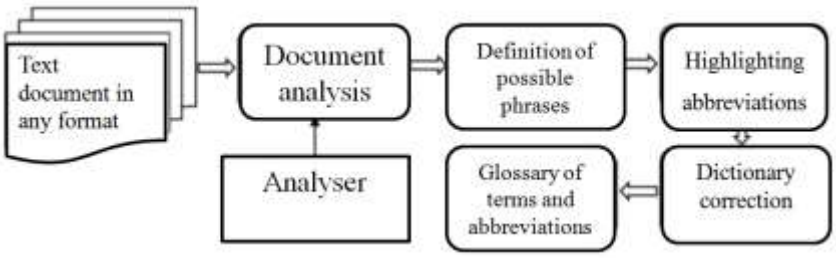

Fig. 6. Functional diagram of the program TermsSelect (Kunhurtsev, 2018, pp. 202-208)

Implementation of student work on the development of library AR technology in the educational process of universities within the framework of an PBL model. The development and implementation of augmented reality technologies in the work of academic libraries acts

as a synergetic educational model, it harmoniously combines the interaction of various new concepts of learning: PBL, AL, PjBL, GBL, IBL, STREAM-education etc.

This type of work corresponds to the PBL with rapid prototyping devices (Castelan, 2018, pp. 131-142) (Table 5), the concepts of learning in new spaces, and the principle of «Deeper Learning» as a set of interrelated competencies (Blazhko, 2017, pp.18-210): Critical thinking & Problem solving, Self-directed learning, Learning from Failure, Collaboration, Effective communication, Academic mindset, Content mastery. According to them students apply new knowledge and products in real situations (practice, case situations, simulation games, role-playing games, life situations).

Table 5.

Matching PBL Attributes and AR-library as Innovation-based learning

PBL Attributes by J. Castelan and R. D. Bard	**AR-library as Innovation-based learning**
1. The space and time needed: where PBL lessons occur and how long it takes to solve the problem.	Training of librarians in the process of developing augmented reality for the library takes place in the classroom (teamwork) to develop a general concept of library augmented reality) and in the space of the academic library (practical classes, internships, dual education) to implement their ideas. Such work should be limited to classroom time or internship time. Therefore, the development of augmented reality by students should be divided into micro-tasks.
2. The development of students' autonomy.	The training of students in the development of AR for university libraries is based on a balance of traditional learning (listening to lectures and resolving lists of exercises) and autonomous activities to implement innovations by project student teams. It is important to involve in the project team students of different specialties: humanities (librarians, culturologists, psychologists, historians, philosophers, marketers) and technical (programmers). Programmers customize augmented reality software for the needs of the library. Humanities students develop content, study the impact of content on users of library services and professional librarians. Such teamwork to create an information product at the intersection of technology and the humanities can take place within an educational approach to learning STEM/STEAM. Students act in two roles: as developers of innovations to optimize the work of the library, and as library visitors and interns who use innovations. This promotes the development of students' sense of responsibility for their information product, pushing them to improve their project.
3. The importance of teachers in the learning process and their role in the different levels.	The role of the teacher is not narrowed to tutoring, the teacher gives instructions (lecture material), helps (advice) and creates conditions for the development of students' independence, provides control over the educational process. Students' work on creating a AR for library requires an interdisciplinary approach. Therefore, the teacher should organize a complex communication between departments and faculties of the university, agree on curricula and study programs of different specialties for a single purpose - to optimize the work of the university library in the process of student innovation and educational work. This attribute

	requires re-evaluation by the teacher the learning theory on which their practice is based on and then promote their understanding of the need for changing as well as discussing principles of learning based on research.
4. The problem itself. The scope can be named as Academic, Structured, Simulated or Professional, according to domain of the problem, as problems can vary from well-defined to illdefined.	The structured educational material of lectures on document science and library technologies in the process of development and implementation of augmented reality in university libraries by the efforts of students are transformed into semi-structured creative tasks. For example, a learning topic about the information levels of a document becomes a creative task of choosing augmented content to play on a mobile phone. The concept of independent search in the funds of scientific publications with the help of augmented reality technology allows to shift the emphasis in the role of librarian and increase the effectiveness of search as a creative and poorly formalized process.

Based on the above, we described the stages of implementation of innovative student activities for the development of library augmented reality in the educational process.

For teachers:

1. Cooperation: teachers must agree on the curricula of humanities and technical specialties, in particular, specialties «information, library and archival affairs» and «programming». Identify common learning topics whose knowledge is required for student development. Form project teams of students.
2. Organization: to provide the educational process of students in the library space.
3. Methodology: to review lecture materials and practical tasks in order to reformat them into effective algorithms for student innovation.
4. Assessment: to provide pedagogical examination of innovative proposals of students. Re-evaluate the lecture material.

For students:

1. Study: to study specialized topics in document science, library and bibliographic technologies. Develop a concept of library augmented reality.
2. Cooperation: together with students-programmers to consider the possibilities and limitations of software platforms for creating augmented reality. Assign roles.
3. Content development: create sticker markers (photos, graphics, possibly a logo) that can be placed on catalog boxes for the AR systematic catalog in order to facilitate the search for the required literature by library visitors. Create and fill in the table of correspondences «marker - marker location – content» in accordance with the indexing algorithm given in the standard DSTU 2395-2000 «Information and documentation. Examination of the document, establishment of its subject and selection of terms of indexing. General methodology».
4. Prototyping and implementing the developed information product in the university library.
5. Test information product in different roles: as a developer, as a professional librarian and as a library visitor.
6. Improve the information product.

The overall process of innovation-based learning (creation AR-liblrary) as part of PBL is summarized in Figure 7.

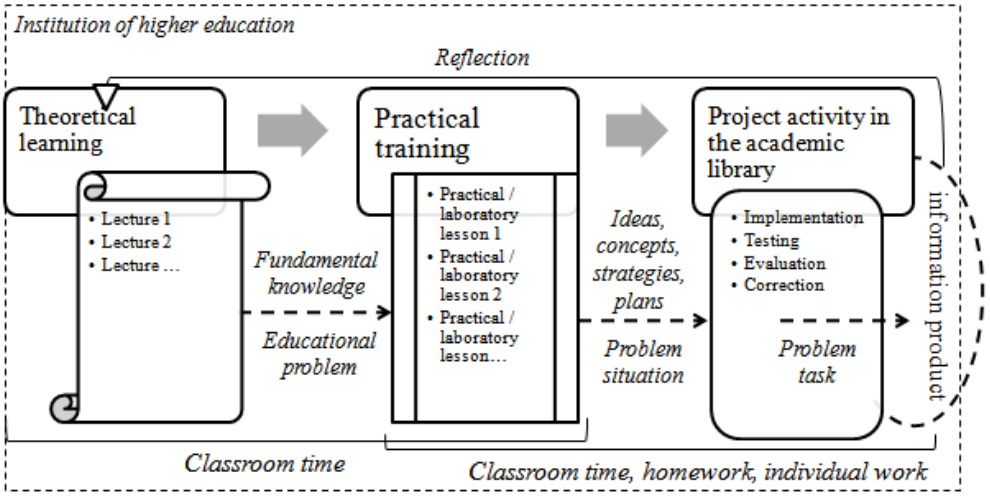

Fig. 7. Learning in the process of development AR for library

The role of triple examination is crucial in the development of an innovative product by students: pedagogical (correspondence of the student's innovative idea to the fundamental knowledge and tasks of the discipline), professional (compliance with professional standards, needs and realities of the academic library), pragmatic (alpha testing, usability testing, beta testing). An added value of pragmatic testing of an innovative product is that students experience different expert roles: as software product testers, as library users, and as librarians. This increases the importance of developer responsibility.

The purpose of the examination is to determine the value of the information product for the library institution and library users and to give a pedagogical assessment of the students' work. The system of examination of innovative activity of students is presented in figure 8.

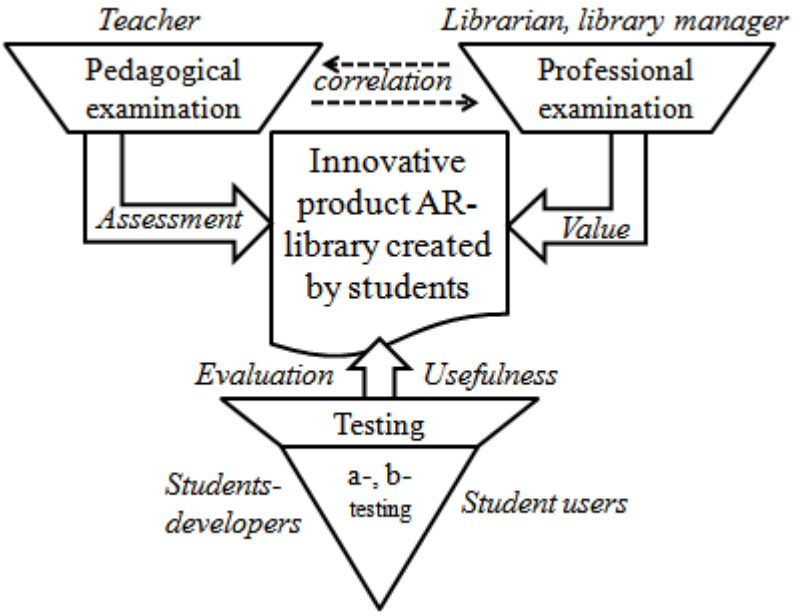

Fig. 8. Expertise system in innovation-based learning

Unlike (Ismail, 2018, pp. 1697-1706), the starting point in the development of innovations by students is the lecture material (fundamental knowledge), and not the needs of the organization itself, for which innovations are developed. Since the process of implementation innovations is a learning experience designed to show the applied power of theoretical knowledge. Our approach gives a good chance to establish a correlation between

lecture material and practical production activities. We agree that «by employing IBL teaching strategy students are forced to make critical analysis and think out of the box to solve the real problem of the society. <…> They are also experiencing learning process based on real life setting» (Ismail, 2018, p. 1706).

For universities, supporting student innovation work, in particular augmented reality for academic libraries, is an important step towards integrating academic work and the production needs of the library, which promotes the university's scientific and pedagogical achievements in national and world science (Figure 9).

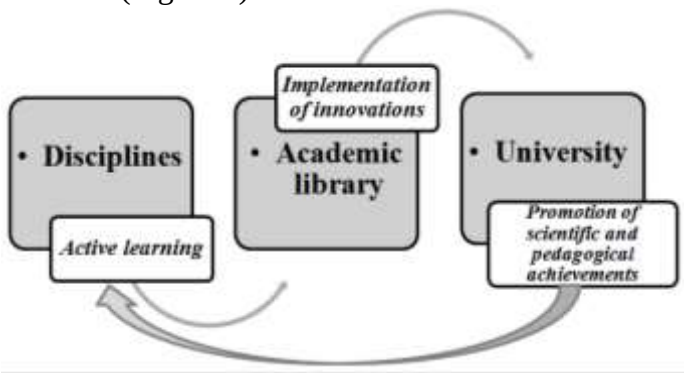

Fig. 9. Integration of the university and the library by innovative students activities

Conclusion.

1. Features of augmented reality technology for implementation in vocational training are: the priority of the marker AR-technology as an intuitive, budgetary tool for rapid prototyping; the need to create and fill in tables of correspondence of markers and AR content; taking into account the principles of informativeness, information density and compactness of the document.
2. The procedure for using AR-technology to teach students the initial examination of a library document should be based on scientific and methodological algorithms, which are enshrined in the standard DSTU 2395-2000.
3. The use of augmented reality technologies in university libraries has great educational potential for all participants in the library process. For library visitors AR-technology serves as a hint (where to look for a book, book features), a guide (provides information to get acquainted with the structure and procedures of the library, creating a kind of tour of the library), informing in the context of the library's exposition event, when working with catalog boxes (instant orientation, saves visitor time search). For library staff, AR can help in working with readers (on the reader's cards shows the status of debt, deadlines for books, search interests, etc.), in the process of indexing documents and collecting of library funds. Great educational opportunities for AR technology open up for student librarians. AR-technologies allow in a playful way to delve into documentary and library science aspects of creating the content of an AR document, to master the skills of compiling thematic references. All this develops in students important competencies demanded by society and the labor market: creativity, ability to apply theory in practice, constantly learn, be responsible for their information product («Students will accept, prefer, and be committed to the value of using library resources for academic inquiry, and will know how to and will use those resources» (Dabbour, 1997, p. 302), systematic thinking and involvement, ability to work in a team of specialists, be focused on innovation. It can be stated that augmented reality technology should be considered an effective auxiliary tool for teaching students majoring in information, library and archival science to achieve a positive synergistic effect of combining the latest educational strategies.

4. The organizational features of students' work with AR library technology correspond to the synergistic model of PBL–AL–PjBL–GBL–IBL, are characterized by complexity, interdisciplinary nature, the requirement of collaboration of students of humanities and technical profiles.
5. It is appropriate to understand the term «Learning based on innovation» as a logical continuation of PBL and Active Learning. IBL is based on the practical development of innovative ideas, their prototyping and multilateral evaluation.

Prospects for further research: a gamified system for library augmented reality; the augmented reality design forms for the study of other disciplines of the library speciality; interaction of dual and synergetic education; the role of the students' innovative activity at the intellectual capital of the university.

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РОЗРОБКА ТЕХНОЛОГІЙ ДОПОВНЕНОЇ РЕАЛЬНОСТІ ДЛЯ АКАДЕМІЧНИХ БІБЛІОТЕК ЯК ДОСВІД СИНЕРГЕТИЧНОГО НАВЧАННЯ

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Анотація. Мета дослідження – виявити особливості застосування технологій доповненої реальності при підготовці фахівців з інформаційної, бібліотечної та архівної справи, здатних розв`язувати спеціалізовані завдання та практичні проблеми у професійній галузі, що характеризуються комплексністю та невизначеністю умов та передбачають застосування положень і методів інформаційної, бібліотечної та архівної справи. Робота у проектних студентських групах з розробки бібліотечної доповненої реальності розглядається як синергетична освітня модель, що логічно поєднує різні педагогічні напрями: проблемного та інноваційного навчання, проектного та глибинного навчання та навчання, заснованого на іграх. У статті порушено питання зближення традиційних форм теоретичного та практичного навчання на основі організації інноваційної діяльності студентів у просторі академічної бібліотеки на прикладі розробки AR-технологій. Визначено особливості розробки та впровадження інформаційних технологій доповненої реальності у роботі з документними фондами академічних бібліотек у процесі проблемного навчання, орієнтованого на інновації. Встановлено, що маркерна технологія створення доповненої реальності є інтуїтивно зрозумілою для студентів-гуманітаріїв і практичного засвоєння знань, набутих з дисциплін «Документознавство», «Стандартизація в інформаційній сфері», «Бібліотечні технології та бібліотекознавство», зокрема засвоєння знань інформаційних рівнів документів, стандартів в бібліотечній діяльності, анотування та індексування бібліотечних документів. AR-технології дозволяють в ігровій формі заглибитися в документалістику та бібліотекознавчі аспекти створення змісту документа AR, оволодіти навичками складання тематичних посилань. У новітніх освітніх концепціях проблемного (PBL), інноваційного (IBL), проектного (PjBL), ігрового (GBL) та активного (AL) навчання основний акцент робиться на прикладне вирішення проблем та впровадження інновацій, які відповідають потребам конкретної організації. Це нівелює цінність фундаментального теоретичного занння, що реалізується під час засвоєння теоретичного лекційного матеріалу як фундаментальної основи синергетичного навчання на прикладі студентської роботи з розробки доповненої реальності для академічних бібліотек. Ми доводимо важливість співвіднесення лекційного матеріалу як вихідної точки для студентських інновацій до реальних потреб академічної бібліотеки. Результати дослідження стануть поштовхом для

впровадження PBL, PjBL, AL, GBL та IBL у вищій освіті в процесі розробки інновацій студентами в нових навчальних середовищах, таких як академічні бібліотеки. Також ініціювати роботу із впровадження інформаційних технологій AR у діяльність університетських бібліотек. AR слід розглядати як важливе доповнення до інструментів, які університети та бібліотеки можуть використовувати для залучення своєї аудиторії до навчання цифрової культури та грамотності. Це має сприяти розвитку бібліотечної справи та підвищити статус університету. Робота студентів з бібліотечною технологією AR характеризується складністю, креативністю, міждисциплінарним характером, вимогою до співпраці студентів гуманітарних та технічних профілів. Все це розвиває у студентів важливі компетенції: творчість, вміння застосовувати теорію на практиці, працювати в команді, постійно вчитися, відповідальність розробника, систематичне мислення, залучення, орієнтація на суспільнозначимі інновації. Синергетична освітня модель сприяє також реалізації принципу вибірковості освітніх компонент та індивідуальної траєкторії навчання, адже під час розробки бібліотечних AR, студенти дізнаються про інші освітні програми, вибіркові освітні компоненти та можуть здійснити свідомий вибір. У статті пропонується розглядати інформаційні технології AR не лише в перспективі програмування, але і як інструмент синергетичного навчання, що гармонійно поєднує PBL–AL–PjBL–GBL–IBL, а також як предмет бібліотечних та документальних досліджень (нові інструменти документування). Ми наголошуємо на фундаментальному навчанні та його постійному тестуванні на практиці. Вихідним пунктом у розробці інновацій студентами є навчальний матеріал, а не потреби організації, для якої інновації розробляються. Оскільки інноваційний процес - це досвід навчання, покликаний показати прикладну силу теоретичних знань. Запропоновано багатофакторну модель оцінки студентських інновацій в процесі їх фахової підготовки.

Ключові слова: навчання студентів за спеціальністю 092 Інформаційна, бібліотечна та архівознавна справа; проблемне навчання; технології доповненої реальності; академічні бібліотеки; навчання на основі інновацій; ігрове навчання; проектне навчання; синергетична освітня модель.