Immersive E-Learning Resources: Design Methods

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ABSTRACT

Proper design is the basis for the success of any application development, regardless of industry and field of application. This fully applies to both software design and learning design. Designing e-learning resources is a hybrid activity that significantly increases risks due to the speed of technological change. The risks are even greater when it comes to technologies of increased attention - immersive. In this regard, it is important to develop design methods for immersive e-learning resources – educational, scientific, informational, reference materials and tools used in an immersive environment, reproduced by immersive technical tools, and necessary for effective organization of the educational process.

CCS CONCEPTS

• **Applied computing** → **E-learning**; • **Human-centered computing** → **Mixed / augmented reality**.

KEYWORDS

immersion, e-learning resources, design methods

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1 INTRODUCTION

Proper design is the basis for the success of any application development, regardless of industry and field of application. This fully applies to both software design and learning design.

Designing e-learning resources is a hybrid activity that significantly increases risks due to the speed of technological change. A vivid example is the work of 2017 by Rybalko [17], the technological component of which cannot be used in 2021 due to the completion of its support cycle by the manufacturer. The risks are even greater when it comes to technologies of increased attention – immersive.

In this regard, it is important to develop design methods for immersive e-learning resources – educational, scientific, informational, reference materials and tools used in an immersive environment, reproduced by immersive technical tools, and necessary for effective organization of the educational process.

2 THEORETICAL FUNDAMENTALS

2.1 Electronic Educational Resources: Interpretation, Types, Requirements

"Regulations on electronic educational resources" [15] defines an electronic educational resource (EER) as a learning tools on digital media of any type or placed in information and telecommunication systems that are reproduced with electronic technical means and used in the education process.

The purpose of EER is to ensure the modernization of the educational process, the content of the educational space, providing equal access to participants of the educational process regardless of their place of residence and form of education in accordance with quality educational and methodological materials based on information and communication technologies [15].

"Regulations on electronic educational resources" defines the following types of EER:

- electronic version of the printed edition;
- electronic chrestomathy;
- electronic edition;
- electronic reference book;
- electronic laboratory workshop;
- electronic tutorial;
- electronic educational game resource;
- electronic textbook;
- electronic workshop;
- electronic workbook;
- electronic dictionary;
- electronic didactic demonstration materials;
- electronic methodical recommendations.

General requirements for EER are defined in [15]:

- functionality;
- security;
- reliability of operation;
- ease of use for the user;
- cross-platform;
- conformity with the grounds of implementation of the principles of state policy of digital development;
- conformity with the legislation of Ukraine on copyright protection;
- conformity with international standards (Experience API [16], etc.).

Synonyms are used Electronic Educational Resource (EER) and E-Learning Resource (ELR) – educational resource, presented in digital form and includes structure, subject content and metadata about them. EER may include data, information and software necessary for its use in the learning process [12, 13].

A systematic study of scientific and methodological, organizational principles of assessing the quality of EER for general secondary education was conducted at the Institute for Digitalisation of Education of the NAES of Ukraine in 2009–2011. The final report on the implementation of this research work [27] identifies the main types of parameters that can be used to assess the quality of EER:

- psychological and pedagogical parameters (didactic and methodological; substantiation of the choice of the subject of the training course; check for pedagogical expediency of use and efficiency of application);
- technical parameters;
- ergonomic parameters (characteristics of EER compliance of methodological material, accompanying documentation; compliance with the sequence of actions required to configure EER; ease of starting EER; compliance with the main technical characteristics of EER documentation; stability of EER operation) [27, p. 25–26];
- aesthetic parameters;
- sanitary and hygienic parameters.

In the process of examination, experts must assess the degree of compliance with the EER such didactic and methodological requirements: scientific, accessible, problematic, visual, learning awareness, independence and activation of activities, systematic and consistent learning, the strength of knowledge acquisition, unity of educational, developmental and upbringing functions, adaptability, interactivity, the realization of possibilities of computer visualization of educational information, development of the intellectual potential of student, system and structural-functional coherence of presentation of educational material, completeness (integrity) and continuity of the didactic cycle of training, taking into account originality and features of concrete academic discipline, the reflection of the system of scientific concepts of the discipline, providing the possibility of controlled training activities [27, p. 28-29].

An integrated system of psychological and pedagogical requirements for EER was developed at the Institute for Digitalisation of Education of the NAES of Ukraine in 2012–2014. In particular, Bykov and Lapinskyi [8] provided a general classification of EER by direction of use, the form of existence, physical habitat and limited space (figure 1). The report on the implementation of the first stage of research work "System of psychological and pedagogical requirements of information and communication technologies for educational purposes" emphasizes that EER reflects the content and technological components of educational methodological systems, form subject-information components of the educational environment (closed and open), form the content of educational electronic information systems, designed for versatile purposeful use of participants in the educational process to provide informational and

procedural support for educational, scientific and managerial activities, information support for the functioning and development of educational systems [28, p. 16-17].

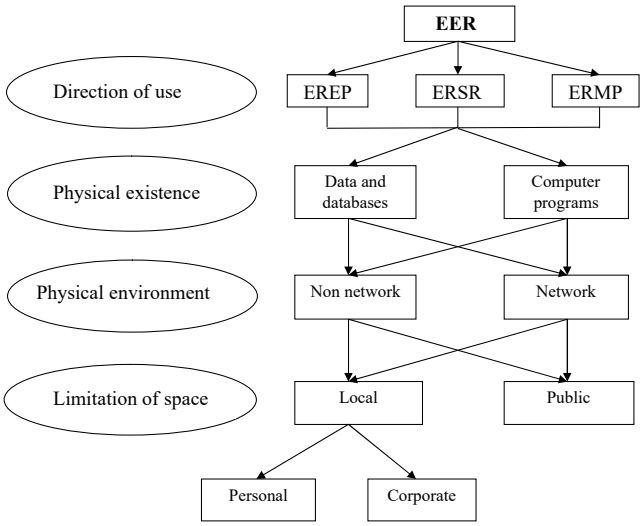

Figure 1: EER classification (according to [8]).

In [28, p. 32-37] the following system of EER requirements is proposed:

1) general didactic requirements:
   - *scientific teaching using EER* means sufficient depth, correctness and scientific reliability of the content of educational material in accordance with modern methods of scientific knowledge;
   - *accessibility of learning using EER* means the need to determine the degree of theoretical complexity and depth of learning material according to age and individual characteristics of students;
   - *problem-based learning using EER* means the need to stimulate educational and cognitive activities through specially created learning problem situations;
   - *clarity of learning using EER* means the need to take into account the sensory perception of the studied objects, their models and their personal observation by a student;
   - *awareness of learning using EER, independence and activation of the learner*, means the need to provide educational material for independent activities of students with the use of educational information, a clear understanding of the ultimate goals and objectives of the educational activities based on modelling their activities;
   - *systematic and consistent learning using EER* means the need to ensure consistent learning by students of a certain system of knowledge in the research subject area;
   - *unity of educational, developmental and upbringing functions of learning while using EER*;
2) specific didactic requirements:
   - *adaptability in the use of EER* means the need to ensure the adaptability of EER to the individual capabilities (level of knowledge and skills, psychological and other characteristics) of a learner;
   - *interactivity of learning while using EER* means that in the learning process there should be "interaction" of a student with EER: components and subsystems of EER should provide dialogue and feedback;
   - *the development of the intellectual potential of a learner using EER* is that there is a formation of thinking styles (algorithmic, visual, theoretical), the ability to make optimal decisions in difficult situations, the ability to process data;
   - *the systematic and structural-functional combination of the presentation of educational material in the components of EER*;
   - *completeness (integrity) and continuity of the didactic cycle of learning while using EER* means that EER should be able to perform all parts of the didactic cycle within one session with ICT tools;
3) psychological requirements:
   - compliance with verbal-logical and sensory-perceptual levels of the cognitive process;
   - focus on the peculiarities of perception (mainly visual, as well as auditory, tactile);
   - taking into account the features of attention (stability, concentration, ability to switch, distribution and amount);
   - development of thinking (visual and action, figurative, verbal and logical, concrete and conceptual, abstract and conceptual);
   - development of imagination (involuntary, voluntary, reproductive, creative);
   - development of memory (instant, long-term, short-term, operational);
   - vocabulary orientation, verbal and linguistic possibilities of a certain level of knowledge and training of children, availability of teaching according to age;
   - taking into account the "zone of proximal development";
4) ergonomic requirements:
   - requirements for the organization of dialogue;
   - suitability for communication purposes;
   - suitability for perception and understanding;
   - suitability for study;
   - attractiveness.

As a result of the second stage of research work "System of psychological and pedagogical requirements for information and communication technologies for educational purposes" the decomposition of the system "electronic educational resources" (figure 2) was performed and a typical structure of EER was identified, which provides effective learning educational purpose and depending on the functional purpose includes: content, program part, guidelines for teachers, guidelines for students, user manual for the administrator of the local network computer class or system administrator of the educational institution.

The EER content part includes: content, theoretical and practical parts, activity environment, including interactive models, drawings (diagrams, graphs, maps, tables), interactive diagrams, photographs, video clips, audio clips, 2D and 3D animations, dictionaries of terms

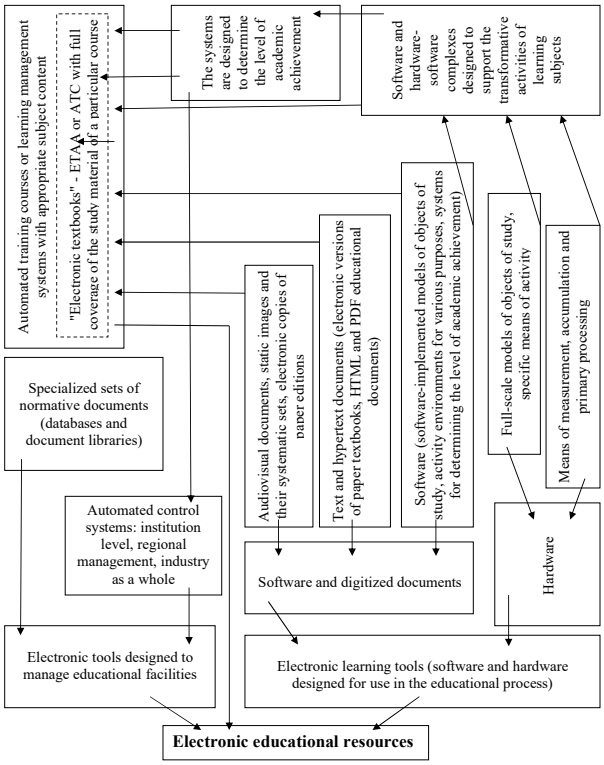

Figure 2: The result of the decomposition of the system "electronic educational resources" (according to [29, p. 29]).

and concepts (glossaries, thesaurus), historical references, list of sources of information, control questions and tasks, tests [29, p. 37].

The EER software part is a visualization of the content part by ICT tools which includes texts, media objects, tasks in text form, implementation of EER navigation, search of educational material, software for preparation, processing, transmission and visualization of statistical information on the level of academic achievement and student testing results [29, p. 38].

Guidelines for the teacher should contain a description of typical scenarios for different types of lessons and examples of their creation in the lesson designer, examples of using all modules and objects [29, p. 39].

Methodical recommendations for the student should contain a description of the basic methods of independent work [29, p. 39].

The user manual for the classroom LAN administrator or the school system administrator should contain a description of actions during installation, uninstallation, operation in various modes, EER settings for LAN operation, possible problems and ways to solve them, description of the collection (storing) methods and statistical processing of information on student performance [29, p. 40].

The final report on research work "System of psychological and pedagogical requirements for information and communication technologies for educational purposes" contains a table of evaluation of different types of EER [26, p. 26-27] – if it is sorted by weights (parameters that determine the significance, relative importance, advantages of this type of EER compared to other types), we obtain that among all EER distance learning course (e-learning course) has the highest weight.

2.2 Concept of Immersive E-Learning Resource

Immersion – "diving", deep involvement in certain activities. This concept is used in different contexts. Thus, Sokolyuk [30, p. 143-144] offers the following:

- a set of human sensations that is in an artificially created three-dimensional world, in which he/she can change the point of view, zoom in and out objects, etc.;
- creating the effect of "presence" due to a set of sensations of a person who is in an artificial environment;
- a group of teaching methods based on the unity of conscious and subconscious, two-way communication in the learning process, relaxation.

Under the immersiveness of the educational environment, Sokolyuk [30] understands such a property of the environment that reflects its ability to involve the subject in the system of relations, which is determined by its content: "immersion can be defined as a property of the technological part of the environment that provides the psychological state of a man, in which his/her own "I" perceives himself involved in the process and interacts with the environment that provides him/her with a continuous flow of stimuli and experience".

According to Sergeev [24], immersion of the subject in the learning environment (immersive environment) and navigation in it allow considering the processes of inclusion of the subject in the "world" of learning, which can live by their laws and not to correspond to the worlds of physical reality. The researcher distinguishes three types of immersion: immersion in the subjective world, immersion in the physical environment and immersion in the virtual environment [23, p. 96-98].

"The subject is immersed in learning environments that provide free forms of self-realization under the influence of environmental content, combined with didactic design and educational communication. Postclassical and post-nonclassical representations of learning environments provide more subtle and effective interpretations of learning and education processes, including synergetic and postclassical models of self-organization and evolution of artificial and natural systems of organized complexity. It is possible to include in the field of pedagogical knowledge technological advances in Internet communication, multimedia, virtual reality as a basis for creating integrated learning and education environments" [24, p. 38].

According to Sergeev [22], immersive educational environment is a dynamic systemic psychological construct that is self-organizing and has the properties of deep immersion, the presence of the subject, interactivity, extra subjective spatial localization, redundancy, observability, accessibility to cognitive experience, saturation, plasticity, integrity, motivation. The main types of immersive environments that arise in professional and educational activities are divided according to the types of immersion into psychological environments (complete immersion in the subjective world); physical environments (complete immersion in the real world); environments with variable realism.

Chupina [9, p. 492] identifies the following pedagogical aspects of learning in immersive environments:

- *the purpose of learning* in an immersive environment is to create conditions for practical experience and its transfer to professional activities, as "learning environment models specialized professional niches for the organization of learning with practice";
- *goals of activities* in the immersive environment are not strictly defined, but reflected in the form of a general strategy, mission, which determines the direction of the student's activities in the learning environment: "motivation is not generated by commitment but by understanding and division of mission";
- *pedagogical communication* is subject-subject in nature and is to coordinate the meanings of the participants in communication in the educational environment: "the learner is an active subject, and the teacher is an observer, organizer and active participant in communication, which changes the conditions and parameters of learning and uses his experience and authority for the semantic orientation of the learner";
- *the organization of the learning system* is not determined by strict rules, has a flexible structure that takes into account the individuality and variability of the subject, decision-making methods are not predetermined, but depend on the specific learning situation and experience;
- *learning assessment is multidimensional*, has a qualitative and integral nature and reflects the fixation of the trajectory of practical experience for the possibility of full reflection and improvement.

Azevich [6, p. 358] defines the immersive approach in education as "a strategy of cognition, a set of techniques and methods of interactive interaction of the subjects of the educational process to develop and self-develop the learner's personality in an artificial virtual environment capable of effectively influencing his/her mind and feelings". In his opinion, the main advantages of immersive educational environments are their clarity, dynamism and interactivity [6, p. 360], as well as the possibility of application in distance learning.

The latter establishes an interesting connection between such concepts as "Virtual Learning Environment" (VLE), a typical representative of which is the distance learning system Moodle, an "immersive environment" also known as a virtual/augmented/mixed reality (VR/AR/MR) – the corresponding technologies and tools will be called *immersive*.

This makes it possible to define *immersive e-learning resources* (IER) as educational, scientific, informational, reference materials and tools that are developed in electronic form, used in immersive environments, reproduced by immersive tools and necessary for effective organization of educational process in the part concerning its filling with qualitative educational and methodical materials. Then the IER includes both the relevant ICT tools (software component) and educational data (information component).

IERs are divided into:

- *immersive textbooks* – educational electronic publications that supplement the textbook and are intended for distribution in immersive environments;
- *immersive tools of assessment of educational achievements* – tools of an immersive environment, which provides the opportunity to automate the processes of determining the level of academic achievement of students, designed to support the processes of assessment and self-assessment in learning;
- *immersive training laboratories* – software IER that can be used in the laboratory and practical classes to conduct experimental research with computer models in immersive environments;
- *immersive electronic reference books* – electronic educational publications on immersive access models to short scientific and applied information of reference content;
- *immersive didactic demonstration materials* – IER, designed to visualize the objects and processes being studied;
- *immersive modelling environments* – immersive training laboratories designed to model objects, phenomena and processes that are the subject of study, or provide tools for building and researching models;
- *immersive simulators* – software and hardware IERs, designed for the formation and consolidation of skills and practical skills, mastering methods, procedures for certain types of educational or professional activities, as well as for self-training;
- *immersive workshops* – IER, designed to develop and consolidate skills and practical skills, use theoretical knowledge to solve practical problems and exercises;
- *immersive subject environments* – a set of interconnected IERs for solving problems of a certain class in the subject area under study, designed to automate actions that occur in this area;
- *immersive educational and methodical complexes* – a structured set of IERs containing educational materials intended for joint use in the learning process;
- *immersive program-methodical materials* – electronic educational publications in an immersive environment, which determine the content, scope, order of teaching a particular discipline, its section, topics (curricula, plans, lesson plans);
- *immersive educational and methodical materials* – immersive electronic educational publications that contain materials on teaching methods of a particular discipline (its section, part);
- *immersive additional scientific and educational materials* – information resources of the immersive environment, which contribute to the supplementation and expansion of ideas about objects and processes that are the subject of study;
- *immersive test systems* – tools of an immersive environment, which contain standardized test tasks and are designed to assess the level of academic achievement of students;
- *immersive learning management systems* – IER system to support all stages and components of the learning process, providing the ability to automate the organization of the learning process through the preservation and delivery of learning resources and organization of educational activities, learning management, accounting and control of various types of educational work, educational resources, administration of individual students and groups, organization of interaction with the teacher, reporting, etc.;

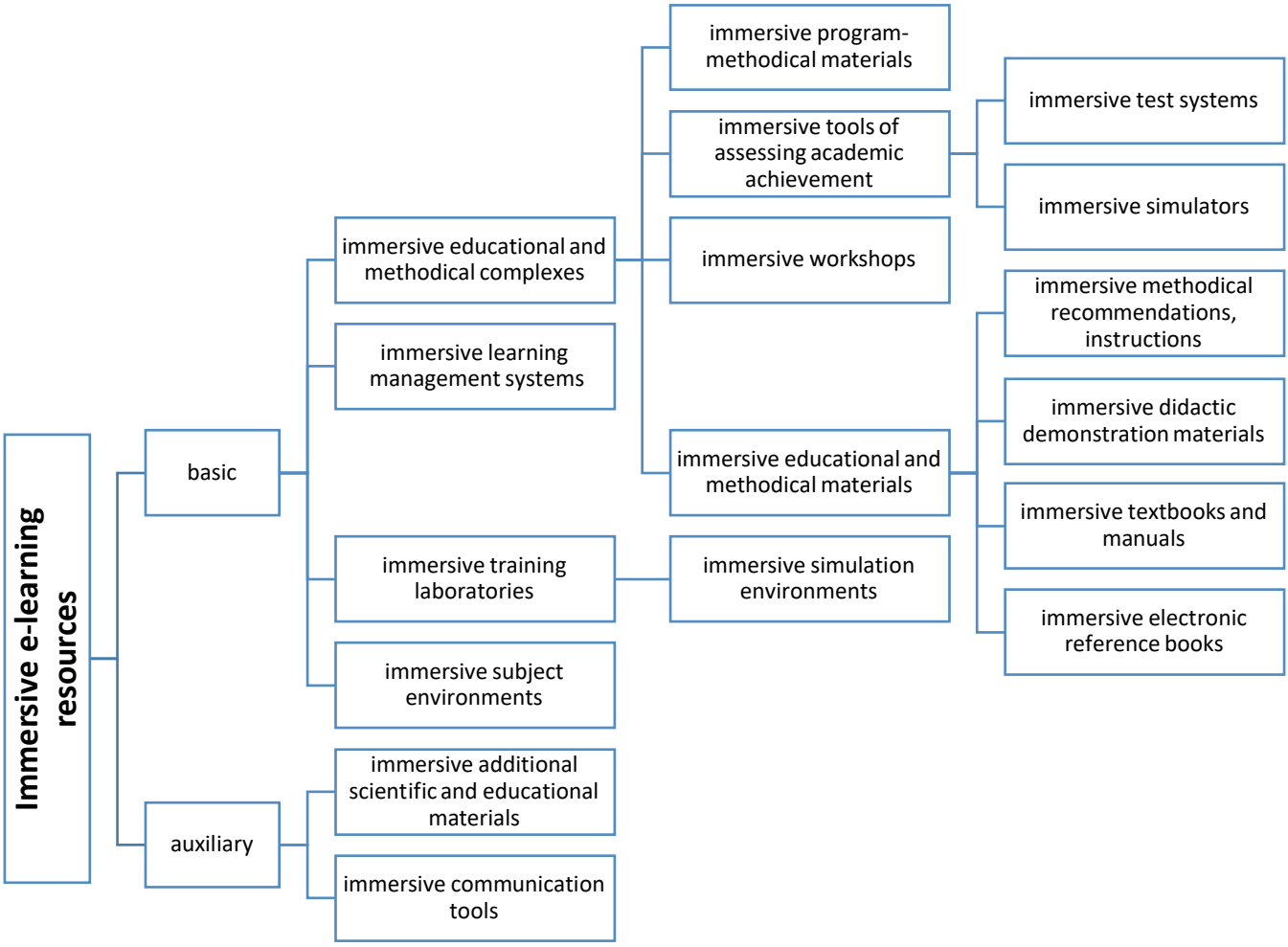

Figure 3: Classification of immersive e-learning resources.

- *immersive communication tools* – software for data exchange in an immersive environment.

To increase didactic efficiency, the tools of immersive learning technologies are used in the educational process together with other educational materials (for example, with traditional textbooks and manuals, guidelines for teachers and students, etc.), forming *immersive software and methodological complexes*.

Figure 3 presents the classification of immersive e-learning resources.

3 DESIGN METHODS

3.1 Model of Design Methods for Immersive E-Learning Resources

According to Boiko [7, p. 13], the process of development and implementation of EER (electronic educational resources) includes six interrelated components:

(1) analysis (the analysis of three aspects of learning using EER: the didactic component provides data on the content of educational material, didactic goals; the psychological and pedagogical component provides data on student's individual characteristics; the technical component consists of the analysis of information and learning environment);
(2) definition of requirements (the received data are specified);
(3) selection of software (market analysis and compliance);
(4) planning and development (the structure of the resource, stylistic design, methods of operation are determined, the preparation of the original multimedia components and their layout is carried out);
(5) deployment (practical usage of the developed software during the educational process);
(6) assessment (assessment of the EER functioning, students' learning activities and the user of the EER interface).

Boiko [7, p. 14] showed the need to update approaches (methods and forms) during the teachers' training for the EER designing, in particular, usage of problem-based, project-based and research

learning, gamification, use of e-learning environments, virtual and augmented reality.

Semerikov et al. [20] indicate that the essential characteristic of a methodic is the interrelation of means and methods, which should be defined in a specific order of their application to carry out the work – the algorithm for achieving the goal. For teaching methods, the activity content is the content reflecting the core activity – the learning content. "A methodic is by definition a system, so we can talk about methodical systems in general and methodical training systems in particular, about the methodical training systems of a particular academic course" [20, p. 2].

The essence of EER design by Rybalko [17, p. 6] may be defined as intentional activity on creation of electronic learning tools and their introduction into educational process: "creation of EER, on the one hand, is a creative process that requires logical and algorithmic thinking, on the other hand, is the pedagogical process, as they are designed to improve the productivity of the educational process" [18, p. 26].

By means of this approach, the *design methods for immersive e-learning resources* can be determined as a training system aimed at acquiring competencies in the formation and development of immersive e-learning environment (in its tool part).

As for the main *principles of the design methods for immersive e-learning resources* by Hrytsenko [10, p. 253-254] we define:

- *validity* – the choice of methods, techniques, forms, methods and tools provided by the design method must be scientifically and pedagogically balanced and justified;
- *intelligibility* – understanding and unambiguous awareness of the developed design methods by the subjects of the methodic: by lecturers (teachers) and students (pupils), who must design, implement and apply immersive e-learning resources;
- *availability* – tools, the use of which is provided by the design methods, must be available, and techniques, forms and methods can be implemented with the help of the proposed or alternative technologies;
- *reproducibility* – the possibility of implementing into the educational process the proposed design methods by relevant specialists who are not developers of this methodology;
- *effectiveness* – involves achieving a predetermined design result by applying the proposed methodology.

The general model of IER design methods is given in figure 4.

The purpose of the *IER design methods* is to form a specialist capable of designing and using the IER in his or her professional activity. Accordingly, the *main purpose of training* is formation of competence in the IER design.

Defining the goal in the target block of the model requires determining who it is aimed at – *the subjects of the design methods*: future teachers.

Training should be implemented in three stages: theoretical stage should be related to mastering the theory of IER design and design methods, practical stage consists of the formation of competence in IER design, stage of approbation is related with experience in preparing and conducting training sessions using developed IER, self-assessment and expert assessment of the experience of implementing the results of design in the educational process.

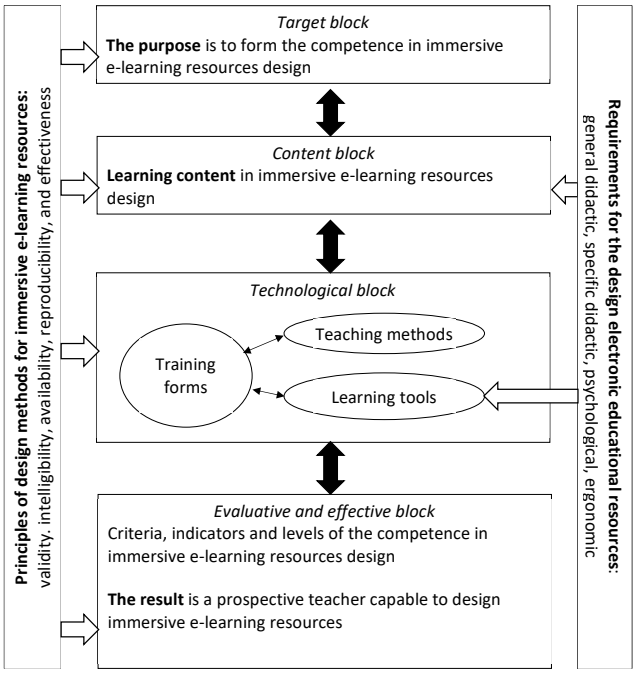

Figure 4: General model of design methods for immersive e-learning resources.

The selection of the *learning content* is important in the methodology. Therefor (immediately or after adaptation), previously developed author's training material on the design of autonomous [31] or web-based [19, 25] IER can be used. The content of training is reflected in the content block of the model, but it is not limited to it; it is also necessary to determine the content of *competence in immersive e-learning resources design*.

IER design training is carried out in the following basic *training forms*: training sessions (lectures, laboratory classes), independent work, control of learning outcomes. The main *teaching methods* for IER design are: explanatory-illustrative, reproductive and research learning method. Leading *learning tools*: traditional EOR and immersive electronic e-learning resources. The forms of organization, methods and teaching aids form together the basis of the technological block of the model.

The projected *result* of the application of the design methods is prospective teacher capable to design immersive e-learning resources. Diagnosis of the students' achievements is performed in the evaluation and performance block of the model, which requires the definition of criteria, indicators and levels of the competence in immersive e-learning resources design.

All the blocks of the model are influenced by certain principles of IER design, while the requirements are influenced by the content and technological block.

Each of the blocks of the model is interconnected with all the previous ones: it reflects the cyclical nature of the design process and the possibility of returning to any of its previous stages. The design and redesign of the methodology continues until the desired result is achieved.

This model does not reflect a number of important external factors that may initiate the redesign of the methodology namely regulatory changes due to changes in public procurement, and technological changes due to changes in immersive technologies.

Figure 5: Complex IER in the form of a distance course (extract).

3.2 Elements of the immersive e-learning resources design methods

Complex IER in the form of a distance course, the content of which is devoted to the IER design, is considered by Semerikov et al. [19]. Researchers emphasize that this course is designed for prospective STEM teachers, that provides a high level of variability in the definition of subjects of the methodology – future teachers of primary schools, gymnasiums and lyceums. The course is aimed at those specialists who have some experience in web-programming (figure 5).

For the design of *immersive textbooks* (figure 6) various tools, that provide the ability to programming and no-code design, can be used. The specific features of the design significantly depend on the hardware used. One example of prototyping an immersive textbook is given in [1].

Figure 6: Immersive textbook.

Immersive tools of assessing academic achievement are a relatively new IER class. In 2021, the EU launched the "Augmented Assessment" project [4] aims to address the gap that exists in assessing newly arrived migrant students' (age group of 9–15) prior knowledge in the fields of Science and Mathematics, by utilising augmented reality for assessment. This will be achieved by developing and piloting an innovative augmented toolkit in the form of an online library and a training course for teachers that will equip them with the necessary theoretical and practical knowledge for assessing newly arrived migrant students' prior knowledge. The authors of the project combine immersion in a language and virtual environment and point to the positive connection between augmented reality and the educational inclusion of special groups of students.

Immersive training laboratories (figure 7) are a classic type of IER, the design of which is widely represented in various sources (in particular, [11]).

Immersive electronic reference books can be designed using computer vision systems [21] and classical reference books (figure 8).

Immersive didactic demonstration materials design is the most common activity as they are visuals that can be combined in order to to create a lesson fragment.

The use of *immersive simulation environments* and *immersive simulators* requires specialized hardware to create an immersive

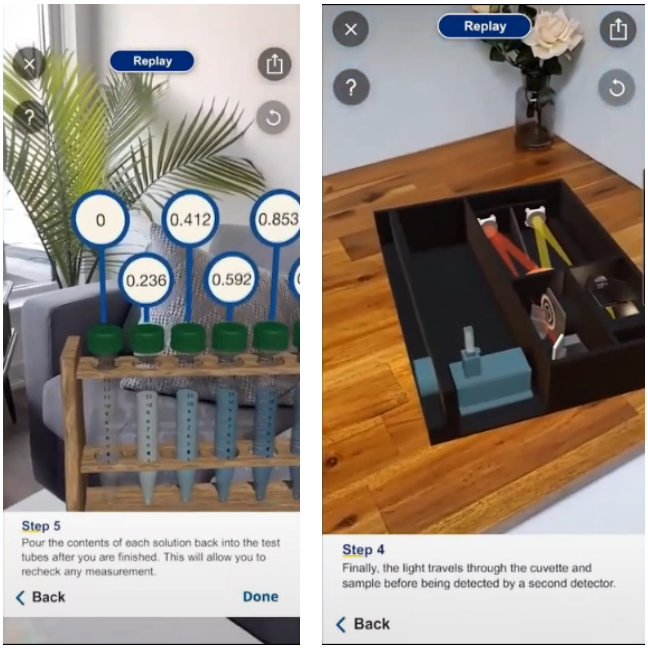

Figure 7: Immersive training laboratories.

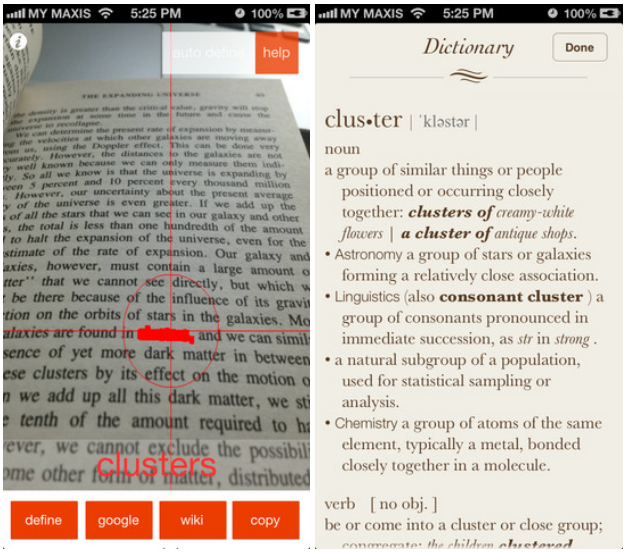

Figure 8: Meanings – immersive vocabulary.

environment with partial and complete immersion, in which a person moves with the required degree of freedom [32].

Immersive workshop can be developed, in particular, in the game form. In [5] there is an example of Qubit Arcade, a VR model of quantum computing. The arcade provides a hands-on sensory experience for students to manipulate qubits in a three-dimensional space, as well as see the qubit from the inside (figure 9). Such a workshop is a kind of *immersive subject environment.*

Figure 9: Immersive workshop Qubit Arcade.

Within the framework of ARETE project, a module and unit for the Moodle learning support system is developing, aimed at giving it a higher level of immersion [3] according to the IEEE 1589-2020 standard [2]. The ARETE ARLEM (Augmented Reality Learning Experience Models) combines Moodle with web-services and a user interface to create, store, retrieve, view and use of IER.

Immersive communication tools are standalone IERs or add-ons to existing ones, such as Skype. A promising direction for the development of this IER class is the metaverse – hypothetically next step in the Internet development, which provides the opportunity to present communicators as avatars that interact online in a 3D environment. As of 2021, the most famous project in the metaverse is Meta [14].

4 CONCLUSION

The following results were obtained in the process of solving the problem of preparing prospective teachers for the design of immersive e-learning resources:

1. The analysis of sources on the research problem provided an opportunity to summarize the definition of electronic educational resource as a structured educational resource, presented in digital form and includes structure, subject content and metadata about them. Requirements for the design of electronic educational resources are summarized in 4 categories: 1) general didactic requirements that correspond to the implementation of the principles of learning in electronic educational resources; 2) specific didactic requirements that reflect the peqularity of the learning process using electronic educational resources; 3) psychological requirements that must be taken into account in the process of electronic educational resources design; 4) ergonomic requirements that contribute to the full disclosure of the designed electronic educational resource potential.
2. Immersion is a "diving" (deep involvement) of the subject into the system of relations, which is determined by its content. Immersive educational environment is considered as a dynamic systemic psychological construct that is self-organizing and has the properties of deep immersion, the presence of the subject, interactivity, extra subjective spatial localization, redundancy, observability, accessibility to

cognitive experience, saturation, plasticity, integrity, motivation. Immersive educational environments are divided according to the types of immersion into psychological (complete immersion in the subjective world), physical (complete immersion in the real world) and environments with variable realism (partial and complete immersion in the virtual world). The study provided an opportunity to identify immersive e-learning resources as educational, scientific, informational, reference materials and tools that are developed in electronic form, used in immersive environments, reproduced by immersive tools and necessary for effective organization of educational process in the part concerning its filling with qualitative educational and methodical materials. Such types of immersive e-learning resources were identified and classified as immersive textbooks, immersive tools of assessment of educational achievements, immersive training laboratories, immersive electronic reference books, immersive didactic demonstration materials, immersive modelling environments, immersive simulators, immersive educational and methodical complexes, immersive program-methodical materials, immersive educational and methodical materials, immersive additional scientific and educational materials, immersive test systems, immersive learning management systems, immersive communication tools, and immersive software and methodical complexes.

3. Design methods for immersive e-learning resources is a training system aimed at acquiring competencies in the formation and development of immersive e-learning environment (in its tool part). The main principles of the immersive e-learning resources design method are validity, intelligibility, availability, reproducibility and effectiveness. The developed model of design methods for immersive e-learning resources consists of four interrelated blocks namely target block (learning purpose is is to form the competence in immersive e-learning resources design), content block (learning content in immersive e-learning resources design), technological block (training forms, teaching methods and learning tools), and evaluative and effective block (diagnostic tools and expected result).
4. The developed elements of the methodology include the learning, and examples of IER design: complex IER in the form of a distance course, immersive textbooks, immersive electronic reference books, etc. Among the undeveloped elements, the most important are the criteria, indicators and levels of the competence in immersive e-learning resources design – its theoretical justification is the direction of further research.

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