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Methodology of preparing future computer science teachers to create electronic educational resources

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Abstract

Modern society stands in need of a next-generation teacher, in the light of which this study acquires particular relevance. The paper investigates the urgent issue of modern pedagogy – the study of the scientific foundations of the methodology for preparing future computer sciences teachers for the development of electronic educational resources. In the study, the following general scientific methods were used: logical-historical method, pedagogical observation, analysis, synthesis, systematisation and generalisation, methods of pedagogical experiment, methods of mathematical statistics. The authors propose criteria and indicators of the readiness of future informatics teachers to develop electronic educational resources, as well as levels to identify the readiness of future informatics teachers to create electronic educational resources. In the paper, the authors share the results of an experiment to determine the suitability of their proposed methodology, describe the ways of forming the skills of future teachers to develop EER.

Keywords: learning process, informatisation of education, structure, aptitude of future teachers, criteria, indicators.

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1. Introduction

Modern society stands in need of a next-generation teacher. The strategic documents adopted in recent years in Kazakhstan (State programs Digital Kazakhstan, and Information Kazakhstan 2020) and in Kyrgyzstan (Concept and Strategy for the Development of Education until 2020, the Taza Koom Program) determine a change in the narrative of the teacher who is ready to perform professional activities in the context of new socio-economic relations. Teachers should not only shape the personality of students, but they themselves must be highly professional specialists, possess pedagogical skills. The study shows those schools where the best teachers work, achieve high results, whereas schools with weak teachers leave much to be desired in terms of quality. Consequently, the quality of education in a school depends on the quality of teachers working therein (Kaldybaev et al., 2016). This means that the role of the teacher of the modern school must be enhanced. The teachers must work ahead of schedule, being engaged in upbringing and training, they must work for the future result, see the near and distant perspective. These tasks present new requirements for teacher training. Today, digital technologies are used in almost all areas of public life, performing a wide scope of tasks. Consequently, the most important result of training is information competence, in the formation of which the information educational environment plays an important role, and electronic educational resources (EER) constitute a part of it (Condruz-Bacescu, 2020; Fediv et al., 2021).

New challenges require comprehensive training of computer sciences teachers for new digital technologies. Information and communication technologies lead to a new level of learning with the use of electronic educational resources. There are great opportunities for the qualitative assimilation of subjects through the use of EER (Cheung, 2019). Many teacher functions are transferred to electronic educational resources. EER becomes the main source of learning, the organiser of student's learning activities, monitors student's performance and growth dynamics.

The problem of creating and using electronic educational resources in the educational process is considered in the studies of E.V. Artykbaeva (2010), N. Grijalva-Borja et al. (2020), J.Zh. Karbozova (2017), G.O. Kasymalieva and E.S. Seitalieva (2016), Sh.Kh. Kurmanalina (2002), etc. The works of N. Grijalva-Borja et al. (2020) and others (Grinshkun et al., 2011; Huang et al., 2020; Nipa et al., 2020) discuss the issues of technology for creating electronic publications at different educational levels. Researcher Zh.Zh. Karbozova (2017) studied the issues of preparing future teachers for the development of EER, but she emphasized the definition of pedagogical conditions for the design of EER, the search for features of competences that reflect the design process of EER. The works of I.V. Morozova (2014) investigate the issue of the methodology for the development of universal educational actions in the process of constructing EER within the framework of the formation of general cultural competences of future computer sciences teachers.

In her doctorate thesis, E.V. Artykbaeva (2010) investigated the pedagogical technology of e-learning, with EER acting as a materialised form of e-learning. G.O. Kasymalieva and E.S. Seitalieva (2016) studied the features of the use of electronic educational resources in teaching primary school students. With that, issues of preparing future informatics teachers for the creation of electronic educational resources in universities are not raised. It can be assumed that the study of the problem of the formation of the readiness of future computer sciences teachers to create electronic educational resources is conditioned by both strategic directions in digital technologies and situations of the practice of using computers in education. Thus, there is a need for a methodological framework for future teachers to create EER, but at the same time, the content of the EER development is clearly understudied in the theory and methodology of teaching computer sciences, and the developed methodological recommendations are general in nature. Nowadays, there is the widespread use of EER in the educational process. However, the issues of training future computer science teachers in the creation and use of EER have not yet been resolved.

The purpose of the study is to develop a methodology for preparing future informatics teachers to create electronic educational resources and introduce it into the process of teaching in higher education institutions. Achievement of this goal implies the implementation of the following tasks: to develop indicators of the readiness of future teachers to develop an ESM; to conduct an experimental study to determine the suitability of the proposed methodology.

2. Methods

2.1. Research Design

Research materials, books, publications, theses, and electronic resources served as materials for research on the issue of preparing future computer sciences teachers for the creation of EER. In this study, the process of forming the aptitude of future teachers to develop and use electronic educational resources in the educational process is designated as the object of study, while the process of developing a methodology for the formation of the said aptitude of future computer sciences teachers to develop electronic educational resources constituted the subject of research. In the study, the following general scientific methods were used: logical-historical method, pedagogical observation, analysis, synthesis, systematisation and generalisation, methods of pedagogical experiment, methods of mathematical statistics.

In accordance with the objective of the study, an educational experiment was conducted from 2015 to 2018. The purpose of the experiment was to verify the effectiveness of used methodology for preparing future computer sciences teachers to create electronic educational resources, to determine the levels of readiness of future computer sciences teachers to develop EER. The educational experiment was carried out during 2016-2017 and 2017-2018 academic years at Zhetysu State University named after I. Zhansugurova (Kazakhstan), at the Kyrgyz State University named after I. Arabaev, and at the Osh Humanitarian Pedagogical Institute (Kyrgyzstan).

2.2. Participants

In total, 266 students took part in the experiment, of which 193 students were in the experimental group, 73 students were in the control group.

2.3. Data Analysis

In the 2016/17 academic year, before the experiment, conversations were held with students and teachers who took part in the experiment, they were explained the goals and objectives of the experiment. Prior to the experiment, preliminary diagnostics of the aptitude of future computer sciences teachers to compile EER was performed with the use of questions, practical works, and surveys. Diagnostics showed that the aptitude of the experimental and control groups at large is low, the starting aptitude of the groups is identical. According to the proposed methodology, the formation of aptitude was performed according to the selected components: motivationally purposeful, informative, activity, and evaluative-reflective. To form *the motivationally purposeful component* of training future teachers, the following work was performed.

1) First of all, it was necessary to instigate future teachers to formulate the purpose of training. In the classroom, they were asked the question: "For what purpose is it necessary to learn how to develop electronic educational resources?". To formulate the answer, a discussion was organised, where students realised the importance of setting learning goals, the aims of developing EER for training purposes.

2) To form a positive motivation, the structure and content of ready-made EERs were analysed. A meeting between students and teachers from the cities of Taldykorgan and Bishkek was organised, with the use of EER in computer science lessons. During the meeting, teachers talked about the features of the development of EER. Interactive work was carried out on the topic: “What gives the teacher the ability to develop EER? What are your ideas and suggestions?”.

To form *the informative component* of the training of future computer sciences teachers in the development of EER, a discussion was held on the content of the course “Development of Electronic Educational Resources”. Future teachers were explained the knowledge and skills that future teachers should have, as well as the experience with skills during the study of this course. The reasoning was provided that the future computer sciences teacher, as a result of studying this course, must know the role, purpose, types, and structures of the EER in computer sciences; EER development requirements. Teachers must be capable of using information and communication technologies to create EER, use the software and capabilities of the Internet to design the structural blocks of EER, analyse existing EERs and evaluate their quality. All this should lead them to mastering the experience of creating an EER in computer sciences, analysis, and examination of existing EER. Modern forms and teaching methods were applied in the implementation of *the technological*

component. To study the course, an electronic textbook was created with the use of SunRav BookEditor package. Students analysed the capabilities of existing EER in computer sciences that are posted at the educational portals of universities and the websites of educational centres. Students learned how to create presentation packages for organising training sessions: training presentations, interactive posters, exercise machines, and computer tests. To design fragments of audio and video materials, students solved examples with the use of Adobe Primer Pro and 3D Studio MAX programs. Thanks to such technical support, students received an excellent opportunity to demonstrate their presentations, conduct trainings and seminars (Bodnar, 2021).

In the experiment, special attention was also paid to the formation of *the evaluative-reflective component* of training. The actions taken in the experiment were aimed at the development of the reflective activity of students, their abilities for self-assessment. Upon studying the course, current, mid-term, and final control of students' academic achievements was performed. To ensure the objectivity of the assessment, a system of control tasks and assessment criteria were developed. Students were familiarised with the evaluation criteria, which helped to ensure the objectivity of the assessment. With the help of the criteria, students were able to conduct mutual assessment and self-assessment. During the semester, students prepared independent work on various types of EER: the capabilities of instrumental systems for developing EER; analysis of the experience in developing EER for secondary schools; development of electronic simulators in school subjects; development of electronic reference books on school subjects; Internet resources and collections used in the development of electronic learning tools; development of a computer test in specific school subjects (Kochisov et al., 2015; Kostiuk, 2020). Upon completion of the course and teaching practice, the degree of preparedness of students for the development and application of EER was checked. Assessment of the theoretical knowledge of future teachers on the development of EER was carried out according to the following indicators:

- knowledge of the purposes and effectiveness of EER in the educational process;
- knowledge on capabilities of information and communication technologies for creating EER;
- knowledge of the capabilities of programs for creating EER.

The formation of the experience of future teachers was determined with the use of the following indicators:

- analysis and demonstration of existing EERs;
- comparative analysis between different EERs and assessment of their effectiveness;
- ability to work with tool programs and software for creating EER.

The following indicators were used to determine motivation:

- desire and aspiration to create an EER;
- awareness of the need to create an EER;
- awareness of the new role of teachers in the development of EER.

3. Results

In the study of the essence of EER, the investigation of their structure is of the greatest interest. It is useful to know what components do electronic educational resources comprise and how many elements are offered by researchers. For this, the works of V.V. Grinshkun (2011), G.V. Ivshin, A. Abuloum et al. (2019) and others were analysed. Analysis showed that researchers offer various components and in this they proceed from their subject matter. Russian researcher G.V. Ivshina (2008) identifies the following components of an electronic educational resource:

A. Didactic component (material content, interactive teaching methods and techniques, multimedia tools).

B. Information technology component (information and communication technology to represent the content of the EER).

C. Regulatory component (compliance with regulatory documents, the requirements of the educational process, state standard).

Specialists in the development and use of electronic learning tools W. Huang (2020) propose two components of EER (Allred and Murphy, 2019; Shterenberg et al., 2015):

1. The content part includes a curriculum, structured study texts, illustrative materials, literature, a glossary, complementary materials, guidelines for studying the course and organising independent work (Kaldybaev, 2007).

2. The technological part includes the provision of support for practical and laboratory classes, evaluation of learning outcomes, reference material for teachers and students.

As is evident from the analysis of the work, the researchers offer a different number of constituent components of the EER. The authors believe that the proposed blocks should be filled with the corresponding elements proposed in the works of G.V. Ivshina (2008) and M.S. Nikabadi and A. Sepehrnia (2019). This, in authors` opinion, ensures the completeness and quality of the presentation of materials. Furthermore, it should be noted that technological components and information tools should appear in all EER units.

The methodology is defined as a kind of ready-made “recipe”, algorithm, the procedure for carrying out any targeted actions. With regard to education, in this case, the methodology is characterised as a description of specific techniques, methods, means of pedagogical activity in individual educational processes. Therefore, the methodology of preparing future computer sciences teachers to create electronic educational resources, on the one hand, provides an algorithm, techniques, and methods of activity that computer science teachers should have. With regard to the education system, training constitutes part of the learning and education process. Training can also be understood in a broad meaning – as the process of obtaining a profession, a specialty that covers the entire training cycle (Osmond-Johnson and Campbell, 2018). Preparation is also understood in the narrow meaning, this is the process of the student completing assignments in various subjects in the form of homework. This may be a review, or preparation for the next classes, etc.

All this significantly affects the entire procedure of preparing for an activity, its organisation, content, and methodology. Therefore, the training of specialists, teachers, in particular, lines in development and improvement of the conditions and qualities necessary for them, factoring in their personal features and the features of their activities. As a procedure, it is considered as a focused work on the formation, first of all, of aptitude for successful activity. The methodology answers the questions: "Why should I teach?", "What should be taught?", "How to teach?". The term “methodology” is often used to refer to a combination of methods of practical action. As a rule, in the process of preparation, purposeful, substantive, and procedural components are distinguished, the tasks of which are as follows:

- determination of the purpose of the training;
- development of the content and structure of training;
- selection of appropriate teaching methods and forms;
- selection of teaching aids;
- organisation of independent work of students;
- organisation of assessment and self-assessment.

Therefore, the subject of the methodology for preparing future computer sciences teachers for the development of EER is the system of goals, content, methods, tools, and forms of training, including the procedure of training. The way to actively search for a place in the educational process, which should be occupied by a test of knowledge, its forms and methods, as well as the supervisory function of the teacher. The theory of action, associated with knowledge about educational changes and building professional capacity, determined the thinking, values, and strategies, both developed and implemented ones. Proceeding from studies on the determination of the essence of the structure of the learning process, teaching methodology, the authors believe that the methodology for preparing future computer sciences teachers for the development of EER can also be represented as a combination of interconnected and interdependent components. The scientific methods of analysis, synthesis, and generalisation of work on the educational information system, electronic educational resource, educational information tools allow to determine the following components of the methodology for preparing future computer sciences teachers to develop electronic educational resources:

- motivationally purposeful component;
- informative component;
- activity component;
- evaluative-reflective component.

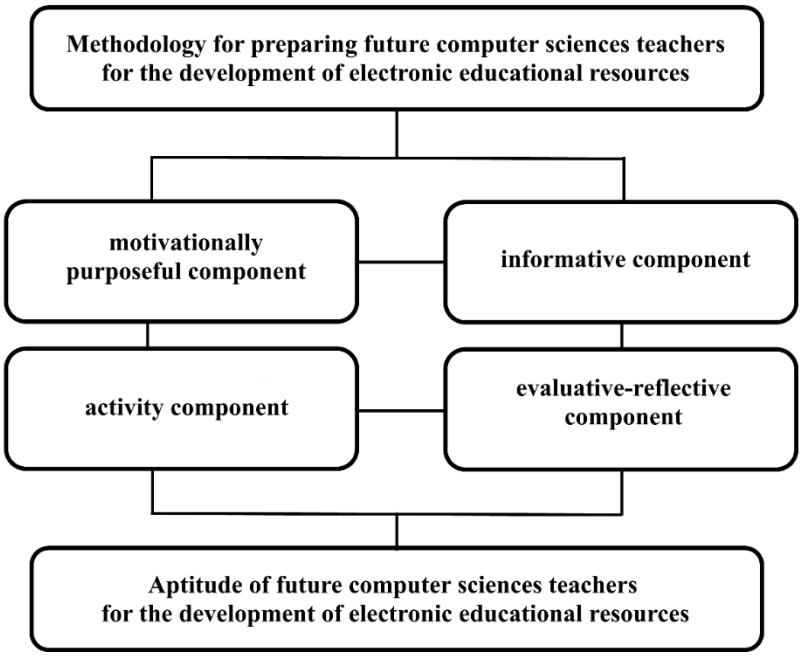

Figure 1. Methodology for preparing future computer sciences teachers to develop EER

The authors shall describe each of the components of the methodology reflected in Figure 1.

a) The motivationally purposeful component reflects the personal attitude towards future activities, which is expressed in goal-setting. The goal setting assumes a set of results upon the conclusion of the activity: the formation of knowledge, skills, and experience in the use of various information tools for the development of EER; development of interest in information technology; development of the need to create an EER. Motivation is, above all, a process that encourages a person to intensify activities aimed at achieving their goals. Before starting to prepare future teachers for the development of EER, students should be informed about the goal, purpose, and features of EER. It is advisable that teachers demonstrate ready-made EER to motivate students to work ahead. Meetings with teachers who use EER in their lessons can create positive motivation.

b) The informative component of preparing future computer sciences teachers for the creation of EER includes a combination of training content (knowledge, skills, abilities, creativity, value-based orientation, computer technologies, software, etc.). Furthermore, the content includes knowledge and skills in working with network technologies and services in the development of electronic educational resources. Students should be capable of making presentation packages that allow students to manage cognitive activities. The system of training students includes the formation of skills to create and use educational videos, the ability to post materials on the Internet

c) The activity component reflects the process of forming the readiness of future computer science teachers to develop electronic educational resources (active and interactive learning, teaching methods with the use of EER, actions, skills).

d) The evaluative-reflective component describes the formation of future teachers' skills of assessment and self-assessment. The teacher needs to correctly organise reflective and evaluative activity, which allows the learners to form an awareness of the task at hand, to trace the degree of their progress

towards the goal, timely adjust their actions and plan their future directions for solving the set educational tasks (Ongarbaeva, 2018).

What exactly is the aptitude of future computer sciences teachers to develop the EER that is presented in Figure 1? Aptitude can be described as a special state of preparedness, as a result of preparation. In the study, the following criteria for the readiness of future computer sciences teachers to create EER were identified:

- theoretical knowledge (knowledge of the content of electronic educational resources);
- experience (the ability to create EER, analyse the structure of EER);
- motivation (interest and need to create an EER, an explanation of the role of EER in education).

The study developed indicators of the willingness of future teachers to develop EER. Indicators of the formation of theoretical knowledge are knowledge of the purpose and effectiveness of EER, the capabilities of software for creating EER, knowledge of the content of the subject on which EER is created. Experience indicators may include: the ability to analyse the structures of existing EERs, the ability to work with software for creating EERs, and the experience of creating a pedagogical situation for creating EERs. The following indicators may motivate future teachers to develop EER: desire and aspiration to create EER, awareness of the necessity of creating EER, awareness of the new role of teachers in the development of EER. Determination of the criteria and readiness indicators of future computer sciences teachers allowed to determine their levels of readiness for the development of electronic educational resources (Aizstrauts et al., 2013).

Low level is typical for future teachers who have little knowledge of the purpose and effectiveness of EER; poor understanding of software capabilities for creating EER; they have no desire to create an EER; they are insufficiently motivated to design EER; they are insufficiently able to offer the right program for the development of EER; insufficient insight into the role of teachers in developing EER. *Average level* of aptitude describes an understanding of the need for EER preparation and awareness of the role of the teacher; they know the purpose and capabilities of programs for creating EER in computer sciences; they have a desire to create an EER and can offer the correct program; but they do not always have the need to develop an EER. *High level* of aptitude for future teachers to develop electronic educational resources is inherent in those who are highly motivated to develop EER; they know the subject of computer sciences at a fairly high level; quickly navigate in software analysis; can independently develop an EER in computer sciences; have sufficient insight into the role of teachers in the design and use of EER.

Based on the proposed assessment work and survey data, the levels of aptitude of future teachers for the development and use of EER in the educational process were identified. The generalised results were presented in a histogram.

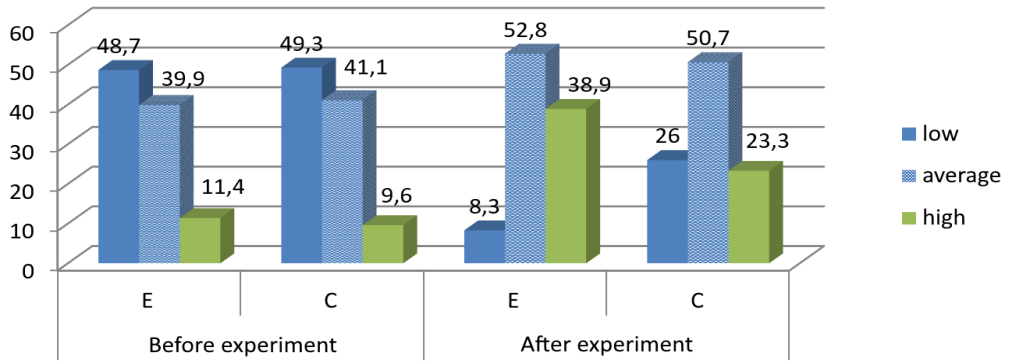

Figure 2. Generalised data from the educational experiment

A comparison of the data obtained before the experiment and the data after the experiment confirms the effectiveness of used methodology. If, at the beginning of the experiment, more than 50% of the students did not master the ability to develop EER, then after the experiment this proportion significantly decreased

to 8.3%. As is evident from Figure 2, after the experiment, 38.9% of students showcased a high level of aptitude to develop EER.

4. Discussion

The essence of electronic educational resources. The term "resource" is understood as a means and source. Proceeding from this, the meaning of EER should be understood as a source of knowledge and a learning tool. In the works of researchers, electronic educational resources are described differently. The difference in the understanding of the essence of electronic educational resources by scientists, in authors` opinion, is conditioned by the differences in their types (Alpizar-Chacon et al., 2020). In the analysis of the essence of EER, one can notice the hierarchies of EER, ranging from educational, audio and video materials to support training sessions, to massive electronic publications and electronic training packages, covering the contents of subjects, information, technical, software, various collections for further study.

In the study of the works of researchers, several groups of authors who described the essence of EER were identified. The first group of researchers represented by L.Kh. Zainutdinova (1999), A. Abuloum et al. (2019), A.V. Osin (2018) and others believe that electronic educational resources constitute educational materials that are reproduced through electronic devices (Rahdari et al., 2020). By this, the authors mean the types of training materials – these are educational videos and sound recordings, electronic textbooks (Kaldybaev and Ongarbaeva, 2016). For reproduction, a tape recorder, CD player, or computer is used. The second group of researchers (V.V. Grinshkun, E.V. Chernobay and others) tend to understand the meaning of EER more broadly, as an electronic publication that contains systematised material on the corresponding discipline. EER implements the didactic capabilities of information and communication technology in all parts of the learning process: presentation of the content of educational material; assurance of creative and vigorous activity on mastering knowledge, abilities, and skills by students; feedback, monitoring of students' activities (Suzdaltseva and Chernobay, 2012). Third authors suggest understanding the meaning of EER as a learning tool. For example, D.V. Chernilevsky (2002) notes that EER constitutes educational software that reflects a specific subject area, the technology of its study is implemented to a certain degree, and the conditions for the implementation of various types of educational activities are provided for. A similar meaning is proposed by the Russian researcher O.N. Belaya (2018). In her opinion, EER is a learning tool created with the use of computer information technologies. As Zh.Zh. Karbozova (2017) notes, electronic educational resources should be understood as educational software that contains systematic material of a specific subject area, providing students with creative and active mastery of knowledge, skills in this area. In recent years, attempts have been made to present an electronic educational resource as a pedagogical tool, reflecting an integrated approach to education and training and allowing to isolate both the main elements of the content and the interrelation between academic subjects (Kurmanalina, 2002).

The authors understand aptitude as a state or a feature, which means the individual’s ability to mobilise resources for the implementation of the intended activity. The most important components of future teachers' readiness for the development of EER include: knowledge, experience, and motivation. Indicators of knowledge features are knowledge of the purposes and effectiveness of EER in the educational process; knowledge of the capabilities and differences of software for creating EER; knowledge of the content on the subject for which the EER is created. Indicators of the formation of experience in the development of EER can include: analysis of the structure of existing EER; comparative analysis between different EERs and assessment of effectiveness; ability to work with software for creating EER; creating a pedagogical situation for developing an EER. Indicators of future teachers' motivation to develop EER can include: desire and aspiration to develop EER; awareness of the need to create an EER; awareness of the new role of teachers in the development of EER. The conducted experimental work proved the feasibility of the methodology of forming the preparedness of future teachers for the development of EER. The development and use of a special course on the development of EER in the educational process of higher education institutions, independent work on the development of EER on a specific subject allowed to form the aptitude of future computer sciences teachers to develop EER.

5. Conclusions

The results of the study on the development of the main provisions on the formation of readiness of future computer sciences teachers for the development and use of EER led to the following conclusions. The study allows to argue that it is possible to successfully shape the aptitude of future teachers to develop electronic educational resources in the educational process of higher education institutions. It is necessary to include a special course on the development of EER as a higher education component in the structure of the training of future computer sciences teachers. The methodology of preparing future computer sciences teachers to create electronic educational resources, on the one hand, provides an algorithm, techniques, and methods of activity for future computer sciences teachers. On the other hand, special emphasis is placed on the independence of the actions of future teachers so that they learn how to independently develop and apply EER of various levels and types. Based on studies to determine the components of the learning process, the components of the methodological system, the authors believe that the methodology for preparing future computer sciences teachers for the development of EER can also be defined as a combination of interconnected and interdependent components: motivationally purposeful; informative; active; evaluative-reflective. In authors` opinion, this study does not completely solve the problem of developing and using EER in training.

Recommendations

Based on the results of the study, several recommendations are drawn as follows:

1. Further study may include wider participants.
2. Further study may include EER development technology in other subjects.
3. The possibilities of using EER through mobile applications are also worthy of being explored further.

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