Computer Appliance for Remote Simulation Training in Ophthalmology

Valery V. Bakutkin, Ilya V. Bakutkin, Vladimir A. Zelenov

For citation:
Bakutkin V. V., Bakutkin I. V., Zelenov V. A. Computer Appliance for Remote Simulation Training in Ophthalmology.
Scientific Research and Innovation. 2020;1(2):91-98
DOI:10.34986/MAKAO.2020.2.2.003

Authors' credentials:
Valery V. Bakutkin, Professor, Doctor of Medicine, Principal Research Scientist, MAKAO LLC;

Ilya V. Bakutkin, Candidate of Medicine, Research Scientist, MAKAO LLC
(bakutkiniv@ya.ru)

Vladimir A. Zelenov, Director, MAKAO LLC, International Consulting, Audit and Education Academy (MAKAO LLC), Kraevaya, 85a, of. 307, Saratov, RF, 410012

Competing interests:
The authors declare no competing interests.

Acknowledgments:
The publication was prepared in accordance with the agreement with the Russian Fundamental Research Foundation No. 18-29-02008 "Intelligent Laser System for Eye Surgery".

Received: 30 May 2020
Revised: 29 June 2020
Published: 15 July 2020

Abstract: With development of information technology, and in connection with the threat of pandemics, the requirements for medical personnel training are changing substantially as well. For theoretical and practical training, assessment of professional skills, simulation technologies based on realistic modeling of clinical situations have great potential [1].

Keywords: simulation training in medicine, simulation technologies, simulation center, practical skills in ophthalmology, practical competence development.

Introduction

The new generation training systems are in high demand within the framework of implementing Russian Federal educational standards of the third generation. In 2012, the Russian Society for Simulation Training in Medicine (RSSTMED) was established to coordinate medical personnel training *via* using innovative technologies [2].

In 2013, the Committee on Continuing Medical Education was organized at the Russian Federation Ministry of Healthcare. International standards for simulation training were developed, as well as classifications of necessary equipment and of simulation and certification centers [3,4,5]. The creation of a pan-European space for higher education and science after the signing of the Bologna Declaration by Russia was aimed at improving education quality. Organization of simulation training was carried out at specialized centers [6,7], which provided methodological and technological support. The effectiveness and practical importance of simulation training has been confirmed by many studies [8,9,10]. As a result, simulation training methods have been officially approved by the National Board of Medical Examiners for use in medical training courses.

Such training system has been an integral part of the Federal licensing program in the United States since 2004. At present, the requirements for distance learning technologies of simulation training have changed significantly, their importance has increased due to socio-economic reasons and epidemiological restrictions. The most significant advantage is the possibility of using the remote learning system of simulation training and electronic educational technologies in distance learning. It is the use of novel technologies that ensures the availability of education, creating the opportunity for a trainee to maintain and improve his

or her professional level and improve professional skills at convenient time, regardless of location. As an outcome result of our research, the concept was developed for remote use of simulation training in ophthalmology by means of computer appliance.

In accordance with the requirements applied to all medical specialists with higher education, advanced training in ophthalmology must be attended by specialists with a higher medical education in pediatrics or medical practice, as well as by those who have been trained in the residency in ophthalmology. The need to create distance learning methods in ophthalmology is caused by increasing need for the continuous nature of education, as well as epidemiological and economic factors [5,11,12].

In accordance with regulatory documents, programs of simulation training courses should consist of training modules that include several practical exercises. Duration of training ranges from 6–24 hours, depending on the official credit-hours requirements of training specialists in a particular field of study. For each practical session of a simulation training course, we developed the teaching methodology aimed at the effective advance of practical skills and abilities, bringing them to automatism, and at the formation of clinical thinking and professional competences among the students. A standard simulation module is a unit of the educational process of a training course, equal to three academic hours of student working time with teaching aids, accompanied by pedagogical control. This is necessary to organize the educational process and structure the list of novel practical skills.

Materials and Methods

Training on computer appliance simulators consists of several stages. Theoretical training (20 % of the training time) has traditional forms of lectures and presentations, including a description and instructions for working with computer appliance training simulators. Practical training takes up to 70 % of the training time, it is designed for acquiring manipulation skills on computer appliance simulators and computational human phantoms with a possibility of remote monitoring by a professor. This can be done both through video surveillance and by means of viewing recorded videos, which are sent to a professor by email. A professor can give an evaluation and recommendations, watching videos at a convenient time for him(her)self. Video recording of acquired skills is standardized by technical conditions.

The final analysis of acquired knowledge takes 10 % of the training time. It is carried out under the supervision of a professor in the form of completing control tasks on computer appliance simulators. These tasks are also recorded as a video of performed practical skills.

An analysis of recorded practical skills is archived; it can be used in the future as an indicator of the correctness of the manipulations and confirmation of the employee's qualification level. Thus, a training procedure is comprised of the following blocks:

1. Entrance control of the preparedness level, instructions, setting goals and objectives of the training (up to 20 % of the time);

2. Direct execution of the training task:

- Debriefing, discussion of implementation (at least 70 % of the training time is allocated);

- Exit control of knowledge and skills (up to 10 % of the training time).

Tasks for Remote Use of Computer Appliances for Simulation Training in Ophthalmology

The main goal is to provide an independent solution of professional problems in practical activities on the basis of maximum approximation of teaching methods to practical activities and performed manipulations. Whether a student performs manipulations and exercises skills correctly is controlled remotely by a professor both at the training stage and at final examination stage. The hardware and software of training simulator sin ophthalmology provides options for situational tasks and approaches actual activities of a practicing physician.

In practical training on computer appliance simulators, students develop manual skills necessary for further implementation of manipulations. First of all, such training provides correct setting of hands for performing manipulations, and ensures correct use of tools and equipment. An essential requirement is the use of standard medical instruments and equipment in the learning process. In accordance with requirements to the course in ophthalmology, it is necessary to have various types of computer appliances.

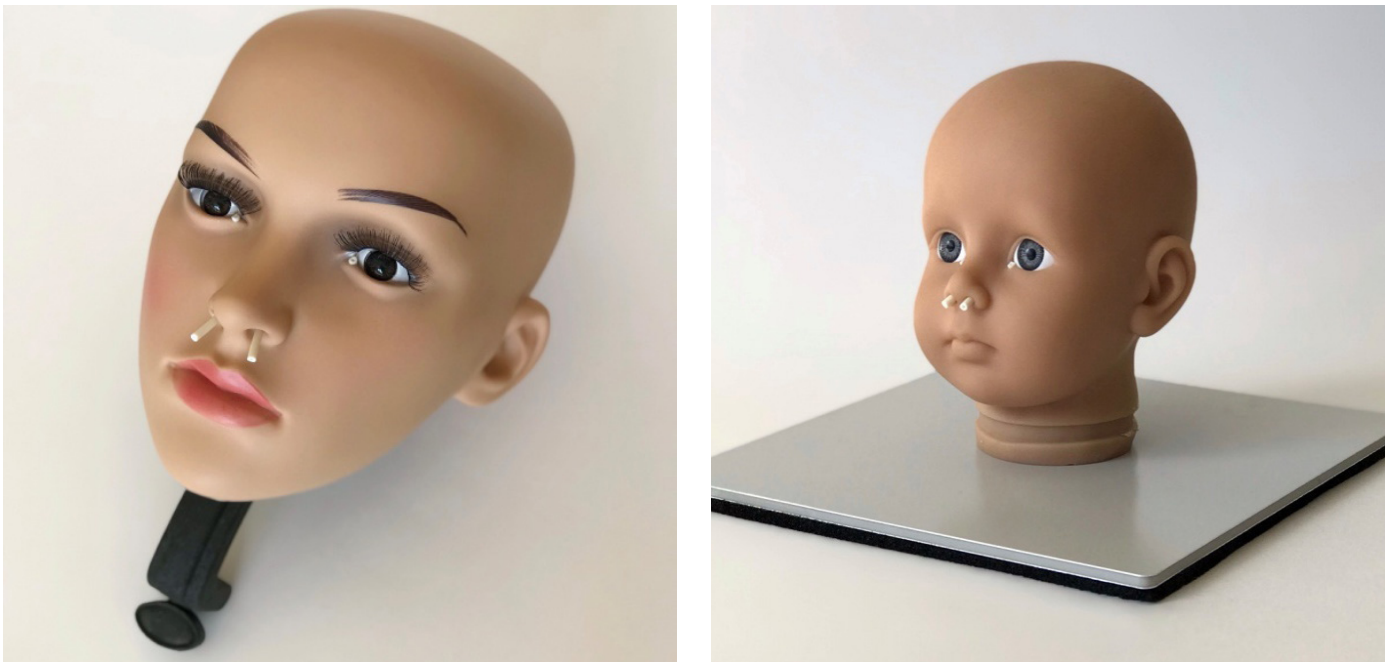

Figure 1. Computer appliance for teaching the methods of lacrimal apparatus examination

Methodological Tasks of Simulation Training

For effective use of remote simulation training, it is necessary to observe some basic methodological and organizational principles. Among these principles, we should mention the presence of computer appliance simulators for teaching practical skills in accordance with the requirements for the ophthalmology course. The appliances should be able to simulate various clinical conditions and diagnosis. Finally, the list of compulsory competences is determined both by the total time allocated to teaching ophthalmology (i.e., residency courses), and by continuing professional education courses. Simulation training includes the development of practical skills.

The most optimal form is the use of training modules. The module has a specific volume of theoretical and practical skills that are fully mastered. When working on simulators, the execution of manipulations is brought to automatism. The main requirement for training is the approximation of simulation training to actual work conditions with a high degree of reliability.

The modular training system defines the requirements to simulators. In addition to realism, they should have an optimal number of various clinical cases occurring in the practice of a physician. This adds clinical thinking and medical decision making to a learning process. Thus, the interpretation of clinical results and the acquisition of medical decision-making skills constitute the priority competences.

In accordance with the levels of realism, simulators can be represented by specialized computer programs. In this case, solely visual simulation training is used. Such programs are employed at the stage of theoretical and illustrative training; there are no practical training sessions in this case.

The authors developed the manual: "Computer atlas of ophthalmic diseases". It is intended for individual distance learning and has eight main sections. They correspond to a standard training course and have a large number of illustrations in the form of animated and graphic material. An addendum to the atlas of ophthalmic diseases is the video film "Practical skills in ophthalmology".

Tactile simulators are designed for practical skills and have high realism. These are primarily the skills of various medical examination techniques and surgical methods. It is the acquisition of practical skills on the simulators that provides a sufficient level of professional training with the possibility of a remote video monitoring, both for the student and the

teacher. Am on such simulators, we should mention the simulator of skills necessary for examining and washing the lacrimal passages in children and adults, developed by the authors.

Results

Computer Appliance for Teaching the Techniques of Examining the Lacrimal Apparatus of the Human Eye

Examination of lacrimal apparatus is among compulsory practical skills for ophthalmologists. Evaluation of the condition of the lacrimal gland and its secretory ducts is conducted by medical examination and use of specific techniques: tubular and nasolacrimal tests, and irrigation of tear ducts. Probing of lacrimal ducts is often done by manipulation. The computer appliance for teaching the methods of examining the lacrimal apparatus of the eye is designed to develop practical skills with the possibility of video recording and subsequent analysis by a professor and a student.

There are two options: simulators for examining adults and children. To master research skills, standard tools are used. There is the possibility of modeling various clinical situations and options. The computer program provides an opportunity for video recording of the learning process. At the same time, it is possible to save a video file directly on the hard drive, or to send it by e-mail for archiving. In this mode, distance learning *via* the Internet is feasible. A professor can monitor the learning process remotely, giving recommendations in the chat mode with a student.

Equipment

The required equipment includes:

- Aluminum case for transportation and storage;
- Set of tools;
- Training apparatus;
- Digital video recorder;
- Tablet PC [13].

The reactive type of simulators allows controlling a student's actions and notifying about his/her errors or incorrect actions. To control the performed actions, special sensors and controllers are used. This is a variant of interactive simulators that record all manipulations that are performed, which can be repeatedly viewed in the video.

The most complex computer appliances for simulation training reproduce various clinical conditions and the use of standard medical instruments. These are highly realistic computerized simulation complexes. They improve clinical decision-making in trainees rather than their psychomotor skills, sensorimotor skills, and technical skills alone. In this case, it is possible to simulate clinical situations using a multifunctional computerized simulator.

The computer appliance simulator for teaching ophthalmoscopy in infants was developed by the authors of this publication. The software part for teaching ophthalmoscopy consists of the following components:

- User's personal account;
- Databases on eye diseases;
- Test files related to the educational process;
- Test tasks with the possibility of self-control;
- Systems of working with the interface;
- Possibility of on-going updates of the training image database; including *via* the Internet;
- Software for making medical decisions in accordance with the standards of diagnostic and treatment;
- Possibility of mid-term and final acquired knowledge level control.

It is possible to use both standard and individual programs in accordance with the level of a student-knowledge. The difficulty level of the tasks is determined by a professor. The medical decision-making program is based on comparing patient data with similar data in the archive and selecting the closest analogies. To develop the software part, we selected the data on actual patients with descriptions of the clinical picture and high-quality images of the fund us.

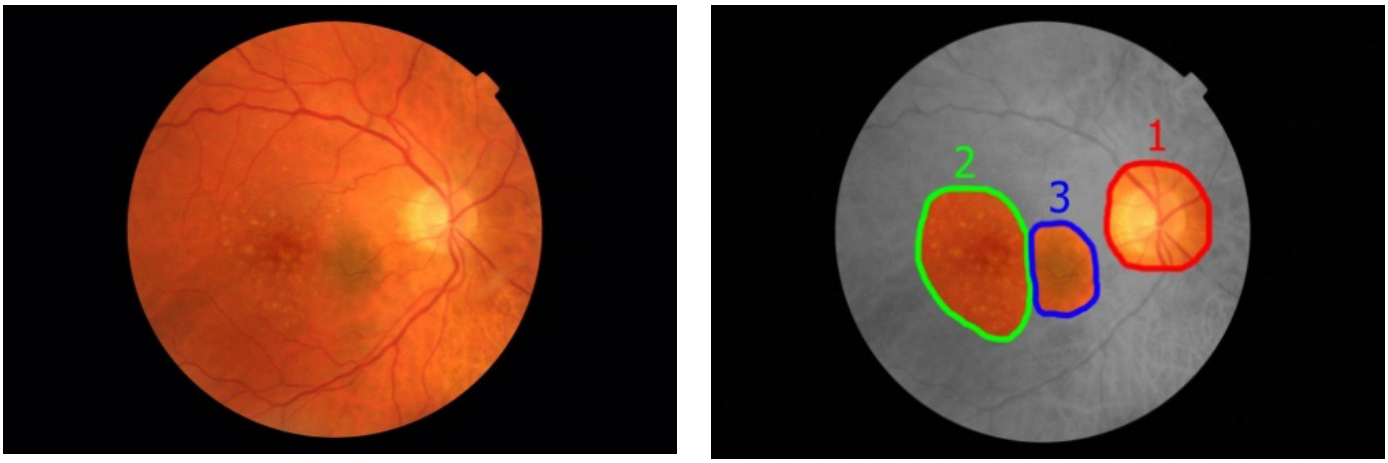

Figure 2. **Allocation of zones with the most diagnostically significant changes**

We implemented the technique of identifying pathological zones for subsequent analysis and use in the learning process, monitoring of student knowledge, and making medical decisions. This allowed highlighting the areas that were most important for diagnostic, and optimizing the data processing. The allocation of zones with the most significant changes for making a diagnosis is presented in Figure 2.

Besides analysis of digital images, a standard description of the patient's condition (used routinely in medical histories) was introduced. This was necessary to match the graphic and descriptive parts of the program with each other (Figure 2). Management of all actions of the simulator, as well as monitoring and analysis of the actions of trainee physicians was carried out using an external computer.

A computerized simulator is used to objectively evaluate the performance of physician's clinical actions, since the outcome of treatment completely depends on the chosen tactics of action. To control training, the monitoring is carried out with archiving in user's account. The program controls both the time of studying each section and the duration of training. Both trainees and professors are shown what was learned, how much time was spent, and what were the mid-term test results. Training and control of acquired knowledge takes place after each section of the course, as well as at the end of each daily or final class. The variant of knowledge control in actual clinical conditions is presented in Figure 3.

In each section, there are options for clinical cases that are selected according to the principle of random generation. There are several operating modes: "Training", "Examination", and "Reporting". Actual images fund us of various clinical cases are reproduced with the possibility of mastering the skills of direct and indirect ophthalmoscopy. In the "Training" mode, are as of the fund us with pathological changes are shown. In accordance with national guidelines, there are eight sections for teaching ophthalmoscopy in adult patients. Real clinical cases are used, which permits mastering all basic teaching methods and stages of diagnosing diseases. Additionally, images are displayed on a monitor for professor's control and demonstration to other students [14].

Discussion

Analysis of a trainee's actions and discussion of his/her experience after the simulation training is called debriefing. In medical practice, this routine has been used for a long time, since the process of making medical decisions occurs after discussion, that is, after professional consultation, and takes into account opinions of various specialists. In this regard, debriefing is of great importance in medicine. We offer a wider use of this technique in the simulation training of ophthalmologists. In this process, several stages can be distinguished. The initial phase is acquired knowledge self-assessment by students. This can be defined as the initial level of professional training. An interview with a professor at this stage determines the needs of a trainee. They include required knowledge, which must be mastered based on the number of course credit hours, as well as individual requests focused on a specific practical activity. Evaluation of the outcome at the initial level stage would allow

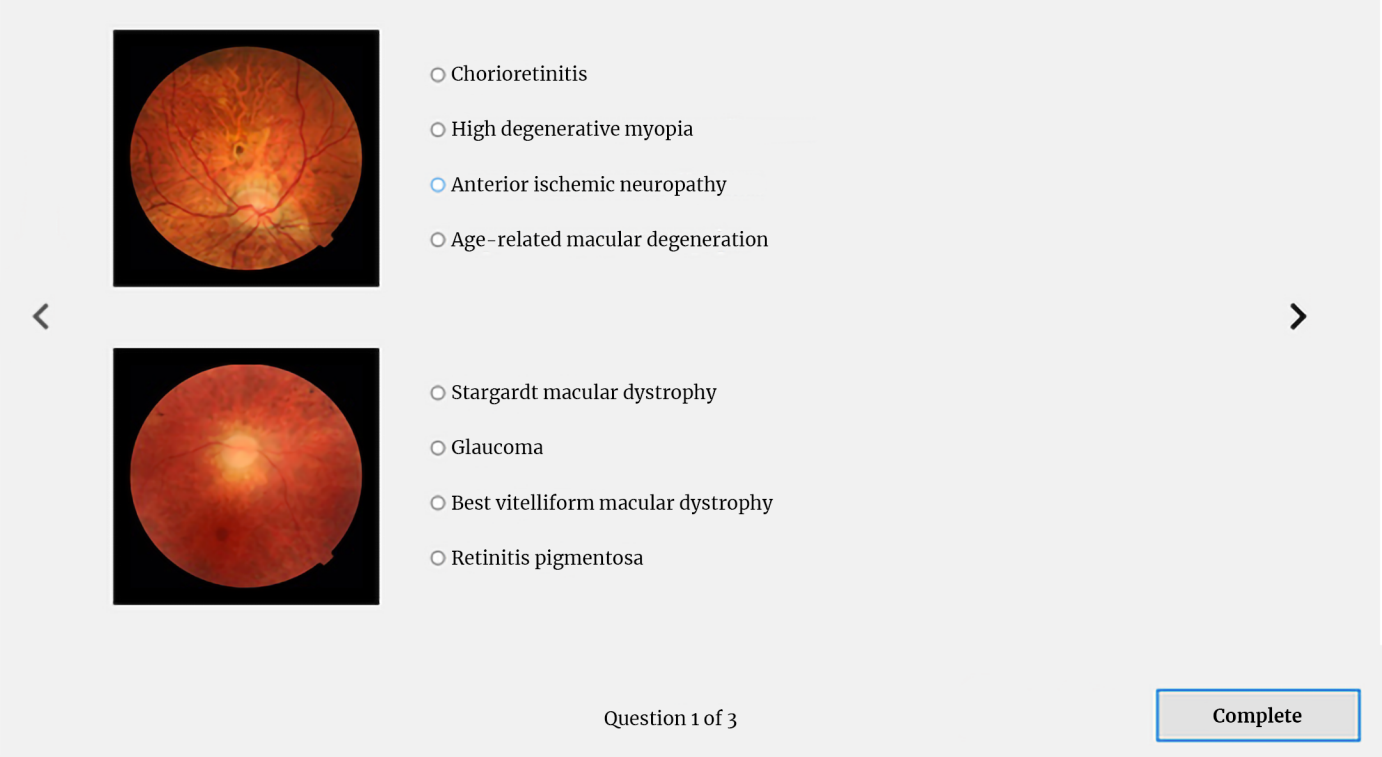

Figure 3. Variant of knowledge control via testing in actual clinical conditions

Figure 4. Mannequin polymer material resembling human skin in appearance

developing an individual training plan depending on existing knowledge and practical activities.

The system of continuing professional education involves consistent learning process in the form of separate specialized courses. As a result, debriefing, as a form of discussion with a professor, can be used to draw up a continuing education plan on an individual basis for each particular student. Course volume is determined based on professional standards and clinical recommendations. The learning process is objectified by use of certain methods, such as knowledge testing and video recording of the process of acquired skill application. Control of acquired practical skills includes a quantitative indicator–time spent on the simulator–as evaluation of the results. An intermediate learning outcome involves identification of errors and their elimination. The final result includes correctness of manipulations, self-evaluation, and use in the medical diagnostic process. In the relationship between a professor and a student, an additional information exchange in the form of mid-term tests is offered. The objectives of the learning process are to identify the level of acquired knowledge, to find errors and to eliminate them.

Debriefing is seen as a feedback process between a professor and a student. The socio-economic scope of specialist training is of significant interest to an employer. The choice of a specialist, as well as an employment contract with him/her are influenced by the level of qualification and quality of practical training. In this case, the conclusion of independent experts and the analysis of the outcomes of specialist training are of decisive importance [15,16]. Video recordings of practical skills should largely determine objective data on the training quality of a specialist. The remote nature of training and interaction with a professor provide the objectivity of certification on the basis of criteria approved for compliance, and of documentation and video recordings of the learning process.

Conclusion

The main advantage of the remote use of simulators in the process of ophthalmic training is the ability to produce specific practical manipulations. This concept also includes the practical development of individual methods and algorithms, which becomes possible in the course of practical work on simulators. A computer program allows changing the patient's parameters and recreate various clinical conditions, along with using acquired knowledge. The goal of remote simulation training is the diagnosis and making medical decisions rather than mastering technical skills alone. Thus, it is legally approved that the use of simulation training is mandatory for the programs of secondary, higher and postgraduate continuing medical education and should precede the licensing of physicians.

Before they can be used in working with real patients, clinical work skills should be acquired by the trainees in specialized centers equipped with high-tech computerized simulators that can model specific clinical situations. Such trainees are represented by students of a medical college or university, residents, and physicians. The concept of remote use of educational ophthalmic simulation computer appliance simulators is of interest to the government-owned and commercial training centers.

The appendix to this publication in the form of a computerized acquired knowledge test is available from the corresponding author on request.

References

1. Yudaeva Y. A., Snasapova D. M., Aksarova L. D., Solovich O. A., Svistunova V. A. Role and Place of Debriefing in Simulation training. *Modern problems of science and education.* 2020;2: (In Russ.). Available at: http://science-education.ru/ru/article/view?id=29729 (Last visit: 07.07.2020). DOI:10.17513/spno.29729

2. Order of the Ministry of Healthcare and Social Development of the Russian Federation dated 05.12.2011 No. 1475n "On approval of Federal requirements to the structure of the main professional educational program of postgraduate professional education (residency)". Available at: https://legalacts.ru/doc/prikaz-minzdravsotsrazvitija-rf-ot-05122011-n-1475n/ (In Russ.)

3. Vulvert V. Ya. Imitation methods of active learning: textbook. Novosibirsk State Agrarian University

Institute of Engineering. 2nd revised edition. Novosibirsk. 2011. 96 p. (In Russ.)

4. Pavlov V. N., Viktorov V. V., Sadritdinov M. A., Shripov R. A., Leshkova V. E. A four-stage system of simulation training at a medical university. In the book: II Congress of the Russian Society of Simulation Training in Medicine RSSTMED-2013. Moscow. 2013.

5. Savoldelli G. L., Naik V. N., Park J. et al. Value of debriefing during simulated crisis management: oral versus videoassisted oral feedback. *Anesthesiology.* 2006;105:279-285.

6. Zaripova Z. A., Lopatin Z. V., Chernova N. A. The concept of creating a single information space in the field of simulation training in the structure of medical education in the territory of the Russian Federation. In the book: II Congress of the Russian Society of Simulation Education in Medicine ROSOMED-2013. Moscow 2013.

7. Okuda Y., Bond W., Bonfante G. et al. National growth in simulation training within emergency medicine residency programs, 2003-2008. *Acad. Emerg. Med.* 2008;15:1113-1116.

8. Murin S., Stollenwerk N. S. Simulation in procedural Training: At the Tipping Point. Virtual Simulators in Medicine. 2010;1:7-10.(In Russ.). Available at: https://medsim.ru/file/2011-1/simulatory_v_obuchenii.pdf

9. Pakhomova Yu. V. On the role of virtual simulators in the educational process of training the physicians Medical education and simulation training: conf., Mainz, Germany, 26–27 November, 2011. Mainz, 2011.

10. Frank J. R., Mungroo R., Ahmand Y. The first comprehensive systematic review of the medical education literature related to Competency-Based Education definitions. *Medical Teacher.* 2010;32(8):631-638.

12. Zarukina E. V., Loginova N. A., Novik M. M. Active teaching methods: Recommendations for development and application: textbook. St. Petersburg State University of Engineering & Economics. 2010. 128 p. (In Russ.)

13. Frank J. R., Shell L. Competency-Based medical education theory of practice. *Medical Theacher.* 2010;32(8): P. 638-646.

14. Bakutkin V. V., Bakutkin I. V., Zelenov V. A., Nugaeva N. R. Simulator for examination of human lacrimal apparatus. *Virtual Simulators in Medicine*. 2020;1:30-31 (In Russ.). Available at: http://www.medsim.ru/file/2020-1/SIMULATOR_FOR_THE_STUDY_OF_HUMAN.pdf

15. Bakutkin V. V., Chichev O. V. Virtual technologies for teaching ophthalmoscopy in infants. *Virtual Simulators in Medicine*. 2017;2:12-15. (In Russ.). Available at: https://medsim.ru/lit/journal.html

16. Peters V. A. M., Vissers G. A. N. A Simple Classification Model for Debriefing Simulation Games. *Simulation Gaming March*. 2004;35(1):70-84.