Information Technologies in Professional Training of Medical University Graduates: Modelling Standard Interaction with Outpatients and Treatment Process

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Abstract – **The paper offers an architecture and a preliminary design of a special training computer program, which targets to improve analytical medical skills of graduate students. The article includes presenting computer programs for students to improve their medical skills. The program allows medical students to prepare for activities of outpatient clinics in practical health care: maintaining medical records, developing a diagnostic program, drawing up a treatment plan and monitoring a patient at home. Attention is paid to the discussion of the form of communication that can be used to transfer data between a patient and a doctor. The proposed interface is simple and includes crucial points from some other programs. The program can be applied for training a wide audience, from students to teachers.**

Keywords - information technologies, medical education, COVID-19 infections

I. INTRODUCTION

The COVID-19 pandemic has caused major changes in higher medical education in Russia [1]. The transition to distance learning has put many medical universities in need of rapid transformation of the educational process [2]. In the pedagogical aspect, the vector of development for a person-oriented approach to teaching students is adopted. Each student becomes a center of education with an individual approach to the process of acquiring knowledge, mastering skills [3]. In the new conditions, the requirements for the technology of the educational process itself have changed [4]. Teaching practical skills of the future profession in conditions of distance and limited opportunities for interaction with real patients has become a fundamental task of the educational process. There is no universal recipe for how to do this today.

One of the fastest growing areas of the educational process is the development of simulation techniques based on modern information and intelligent technologies. The use of different computerized and robotic simulators [5, 6], manikins certainly help the future specialist to master the skills of performing separate medical and diagnostic manipulations [7]. But this is not enough to create professional competencies of a medical specialist. The training of students should be comprehensive and based on interaction with real patients. It is important to find the optimal variant of decision for graduate students which can combine a high level of theoretical knowledges, the necessary number of practical skills for professional practice and the potential for self-improvement of the persona. One of the promising directions of development is the integration of information and intelligent technologies (IIT) in the teaching process of students of higher medical schools [8]. In the specialized literature, the "virtual patient" method is considered as an example of using information and intelligent technologies (IIT) for teaching medical students [9, 10]. The article describes the positive experience of using the "Alice" intelligent program in the training of doctors based on Miller's design [10]. The authors found that the system is not able to fully create the illusion of immersion in reality; students prescribed an excessive number of laboratory and instrumental tests; the program cannot provide an individual approach to the diagnosis and treatment of the patient. Another type of information and intelligent technologies is medical information systems (MIS). In the world literature, the equivalent of MIS is the EMR (electronic medical record) system. A modern multi-specialty hospital cannot operate without the use of network computer systems that provide communication between all parts of the treatment process [11-13]. Use of specialized computer programs for teaching of medical students how to organize treatment process and make an entry in the patient's electronic medical record is experimental yet. The results obtained by Russian and foreign authors indicate a positive effect of using MIS and EMR for training students of higher medical schools.

The purpose of our research is to create a training computer program that can reproduce the real conditions of a regional polyclinic and simulates the treatment process of

an outpatient. The main elements of the educational process are the examination of a real person as a patient, entering information into the patient's electronic medical record, creating a treatment plan and monitoring the patient at home [14]. One of the cases is intended for teaching by the algorithm for treating a patient with COVID-19 at home [15].

II. CONTENT

As a starting stage of research, we created an interface of a computer program that simulates the interaction of a doctor with an outpatient during a course of treatment in remote mode. Mandatory development of this technology is determined by temporary guidelines for the management of patients with suspected COVID-19 in the form of remote monitoring and treatment at the pre-hospital stage. According to this document, the initial examination of a patient with suspected COVID-19 infection should be carried out by medical specialist at patient's home or in a district polyclinic, and all further communication has to be distance. The doctor must fill out the patient's medical card, issue a disability certificate, and prescribe basic medical treatment after examining the patient in the form of an electronic document. Starting from the next day, remote contact with the patient involves using one of the generally accepted communication channels. There is no exact prescription for the preferred form of a remote communication channel. In everyday life, such communication channels are the standard urban telephone network and mobile telephone communication. From a long-term perspective, mobile communication has great potential. It allows to transfer data in the form of a face-to-face conversation, voice or text messages, photos and videos. Therefore, a patient who owns a smartphone was chosen as an example of the situation for the training computer program.

Face-to-face medical examination of the patient is preceded by working with a training computer program. An actor plays the role of a patient who comes to a district polyclinic for medical consultation. The student, as a polyclinic doctor, has to ask about complaints, medical history of the patient, make a standard clinical examination of the patient's body systems. The student will use this information for working with the training program. At the beginning, the student has to put the information into the database and create a personal electronic medical card of the outpatient (Fig. 1).
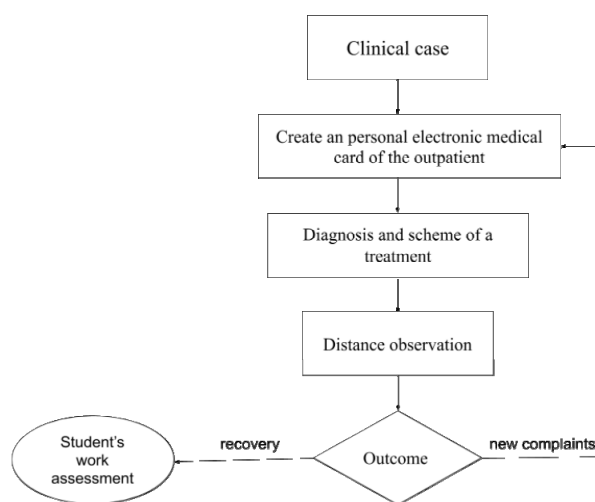

Fig. 1. An algorithm of a student's activities within the application.

The program opens free fields in the corresponding sections for the student and allows of manually entering text information. All fields should have been closed and only then student can move forward on to the next section of the task. For a correct diagnosis, the patient needs in laboratory and instrumental tests. On a separate page, present a list of a possible studies and there is an interactive button that allow for the student to mark the selected ones. The program, in a role of polyclinic laboratory, opens the requested information. All diagnostic tests, as in real life, are presented in a standard form, which require to perform analytical work to identify deviations from the norm. The next step is creating patient's clinical diagnosis and prescribe the treatment. The special corresponding fields are provided for entering this information. After filling in the patient's electronic medical record, the program performs automatic interim control, demonstrates the result of the work. Color indicators (red, yellow and green) are used for clarity. The green background of the key indicates a correctly performed action, yellow – there are deviations from the accepted standards, and red - an error was made. The student has the opportunity to make analysis these mistakes. Special interactive buttons appear in the fields with red and yellow colors. By activating each of them, the student can visit a database containing hints in the form of literature's material, guidebooks and current regulatory documents. At the next stage of work, the student will have to organize monitoring of the patient's condition and treatment at home. This stage of interaction with the training program can be carried out remotely. Entrance in to the case using the standard operating environment (Microsoft Windows) and a Web-browser. In the root page of the patient's electronic medical record, the student can view all the information collected earlier. Students will start their daily work in the "Diary" section. This field is used to save the main parameters of the patient who is being monitored remotely (Fig. 4). Students will start their daily work in the "Diary" section. In this field, you will use for saving the main parameters of the patient who is being monitored remotely (Fig. 2).

Fig. 2. Example of diary.

As a first step, the program offers to find out about changes in the patient's condition over the past day. The program allows you to do this by sending an active message to the patient's phone. Questions that can be asked to the patient are presented in the form of a list, from which the student selects those that are significant in his opinion (Fig. 3).

Fig. 3. Choose one or more complaints.

The student sends a list with questions to the patient. It is important, from the point of the effectiveness of the pedagogical process, to keep in the student's mind the image of the real patient, familiar by the doctor and examined in the day before. From this point on, the computer assumes the role of the patient also. The program will communicate with the student on behalf of the patient. List with answers for the questions appears in 5 minutes after sending a request. In the patient's response, along with the answers to questions, there are two free fields: "Other complaints" and "Photos" (Fig. 4).

Fig. 4. Information about the patient.

In the "Other complaints" section, the patient can inform the doctor about other complaints that are not included in the survey list. In the "Photos" section, patient can post a photo for discussion with the doctor (Fig. 5).

Fig. 5. Example of a clinical case.

After receiving information from the patient and studying it, the student should fill out a follow-up diary following certain rules: recording the date of remote consultation, patient complaints, and changes to the treatment plan. The remote monitoring process will continue next day. One of directions of the training program is training of students to create complex decisions. To do this, the program can add new circumstances into the original conditions of the task. In this example, the patient, together with answers for the questions, reports about the appearance of red spots on the skin, itching and swelling. As confirmation, the patient sends several photos with skin changes in the corresponding areas. For the student, this information means that the patient has developed an allergic reaction while taking medication. Urgent measures are needed to help the patient. By clicking on the appropriate

button, the student is taken to a page where available options for patient care are listed (Fig. 6).
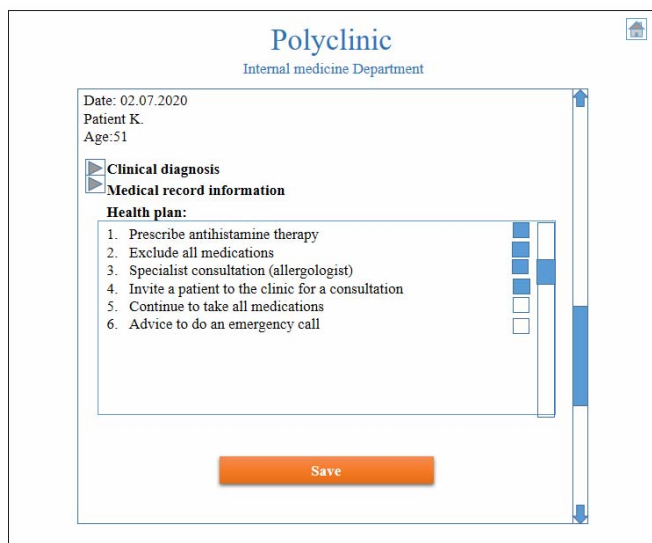

Fig. 6. Steps of the patient examination.

The student has the opportunity to choose a treatment method for the patient. The list offers correct solutions, erroneous and incomplete in this situation. This is done in order to eliminate random choice, and make the decision conscious. Suppose a student intuitively guessed the correct decision by prescribing antihistamines (anti-allergic) drugs. On the next page, the program will offer several different drugs from different groups. The student should make a choice and know the correct dosage and type of injection. After prescribing anti-allergic medications, the student returns to the list of measures to help the patient with allergies. A complete treatment program should be continued. As a next step, the student can cancel the medication prescribed to the patient the day before. The computer program asks the student to specify what exactly should be canceled: all drugs or only antibiotics or reduce the dose of drugs. In a similar form, the program asks the student to clarify all the steps for conducting an allergist consultation for the patient. Detailing each of the treatment elements allows the teacher to make sure that the student has solid knowledge of this problem and avoid accidental decisions. After completing all adjustments to the patient's treatment plan, the student receives an assessment of their performance. The result is shown in the form of different colors of indicators, and interactive icons allow the student to get acquainted with the correct algorithm of treatment in this situation (Fig. 7).
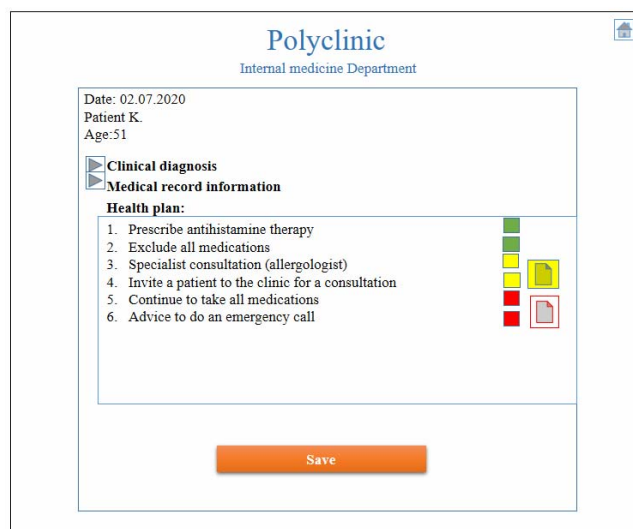

Fig. 7. Student's decision.

The proposed training program is built on the block principle of presentation of educational material, which allows for student to expand its database in accordance with the tasks set. As part of a single case, can be present several different problems that are of great practical importance for a polyclinic doctor. As an example, we continue to solve the presented case. During the initial examination of the patient and information obtained from communication with the patient remotely, the student diagnosed the main disease (acute viral respiratory infection) and its complications (allergic reaction to medication). On the next day of remote monitoring, the student receives new complaints from the patient about constant dry mouth, increased thirst and a sugar level of 11 mmol./l. (measured by a home glucose meter). This information indicates another problem of the patient. The patient's medical card contains information about available diseases. The student established in the medical history that the patient has diabetes, type II. Apparently, the use of different groups of drugs for the treatment of respiratory infection provoked an exacerbation of diabetes. The next task for the student is to make changes to the patient's treatment program, taking into account diabetes and high blood glucose levels. The general principle of work for the student repeats the previous scheme. In this block, the student has to demonstrate own competences in correcting high blood sugar level and treating diabetes on an outpatient basis. At the end of this part of the work, the student receives the result in the form of colored indicators. As an improvement his professional skills, the student has the opportunity to study practical recommendations on the joint treatment of diabetes and respiratory infection.

III. ASSESSMENT

At all stages of the student's work with the training program, the results are automatically monitored. The student is informed about the assessment using colored indicators. Visiting the database and reviewing regulatory documents does not affect the initial assessment. After each visit to the database, the program offers the student to go through this stage again. If the student agrees to repeat, the database will store the results of all attempts to complete

each part of the case. Upon completion of the case, the student can see the results on the screen or get them in print. The final rating (in points) is given to the student by the teacher after the interview (Fig. 8).
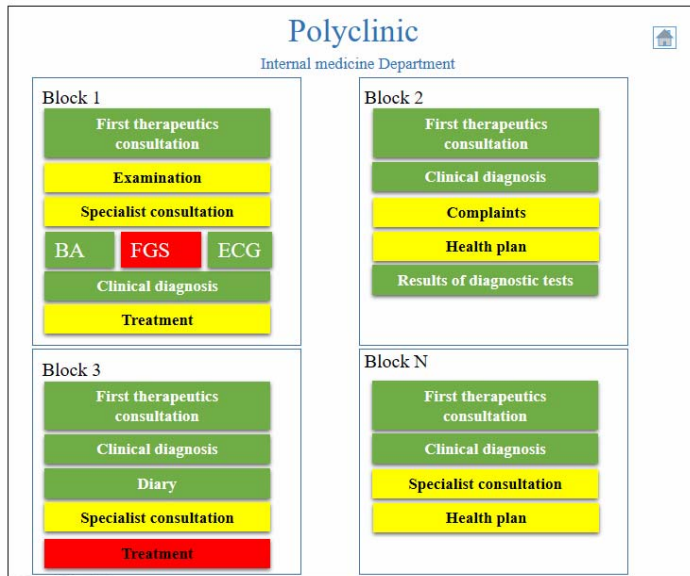

Fig. 8. Assessment of student's results.

IV. DISCUSSION

The proposed training computer program belongs to the section of intellectual and information technologies. The program is designed to improve the quality of training for medical students. In the form of a game, the program reveals to the student topical issues related to the activities of outpatient clinics in practical health care: maintaining medical records, developing a diagnostic program, drawing up a treatment plan and monitoring the patient at home. Attention is paid to the discussion of the form of communication that can be used to transfer data between the patient and the doctor. Proposed interface is an intermediate step to the whole program, what includes the first contact with patient, distance examination, diagnostic and treatment strategy with assessment of a student's work by computer and teacher. We are planning to expand the program with other medical cases, which consists of noninfectious disease (myocardial infarction, stroke, thromboembolism etc.), new variants of complications and comorbidities.

V. CONCLUSIONS

The proposed interface of the program is simple and concise, which makes it easier to use it as an intermediate link in the development of medical information systems. The program is intended for graduate courses of medical universities, residents of clinical departments of therapeutic profile and can be used as a training course for doctors of district clinics.

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