ЦИФРОВАЯ ОБРАЗОВАТЕЛЬНАЯ СРЕДА
DIGITAL EDUCATIONAL ENVIRONMENT

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Learning digital medical environment as a tool of teaching computer science to medical students

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Abstract. *Problem statement.* A future doctor should possess basic and professional theoretical knowledge, have certain practical medical skills as well as skills in working with information systems and digital programs. It is very important that medical students are prepared to work with the digital healthcare environment if they want to work effectively in modern medical institutions in their future professional activities. Using the digital healthcare environment in educational and subsequent professional activities of physicians contributes to improving the quality of medical care and medical services, accessibility of medical services, and reducing the number of medical mistakes. *Methodology.* Each digital healthcare environment is designed for a specific area of medicine, i.e. for solving a narrow range of problems. Therefore, the creation of a universal digital system for intelligent analysis of medical data obtained from different devices and different doctors is an important task of the performed research. *Results.* The learning digital medical environment was created aiming at integrating and analyzing medical data and electronically supporting future physicians in prescribing laboratory and instrumental examinations, making a diagnosis, and prescribing appropriate treatment. *Conclusion.* The main advantage of the developed learning digital medical environment is its universality, as it is suitable for a doctor of any specialty, providing continuous interaction between them. The digital environment will be used both in the process of training medical students and in their future professional activities.

Keywords: digital healthcare environment, digitalization of education, electronic health record, symptoms, objective examinations, medical history, preliminary diagnosis, final diagnosis, treatment

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Учебная цифровая медицинская среда как средство обучения информатике студентов-медиков

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Аннотация. *Постановка проблемы.* Будущий врач должен владеть базовыми и профессиональными теоретическими знаниями, иметь определенные практические медицинские навыки, а также навыки работы с информационными системами и цифровыми программами. Студентов медицинского вуза важно подготовить к работе в цифровой среде здравоохранения для эффективного функционирования в современных медицинских учреждениях в будущей профессиональной деятельности. Необходимо внедрение цифровой медицинской среды как в процесс обучения студентов-медиков, так и в их профессиональную деятельность, что значительно повысит качество лечебной и профилактической деятельности врачей, а также снизит количество врачебных ошибок. *Методология.* Каждая цифровая среда здравоохранения рассчитана на определенную область медицины, то есть для решения узкого круга задач. Поэтому создание и апробация универсальной цифровой системы интеллектуального анализа медицинских данных, полученных из разных приборов и от разных врачей, являются важными задачами и методами исследования. *Результаты.* Создана учебная цифровая медицинская среда, главной целью которой является интеграция и анализ медицинских данных и электронная поддержка будущих врачей при назначении лабораторных и инструментальных обследований, постановке диагноза и назначении соответствующего лечения. *Заключение.* Главным преимуществом разработанной учебной цифровой медицинской среды является ее универсальность, так как она подходит для врача любой специальности, обеспечивая непрерывное взаимодействие между ними. Цифровая среда будет использоваться как в процессе обучения студентов-медиков, так и в их будущей профессиональной деятельности.

Ключевые слова: электронная история болезни, симптомы, объективное исследование, предварительный диагноз, окончательный диагноз, лечение

Problem statement. The system of higher medical education in Russia is constantly changing related to the introduction of digital technologies into the educational process. A modern graduate of a medical university must possess a set of basic and professional theoretical knowledge, have the definite practical skills and of course skills in working with information resources, digital programs and analyzing the information received. Obviously, future doctors must be ready to work in a digital healthcare environment if they want to work effectively in modern medical institutions.

The digital healthcare environment is a combination of information systems that are necessary to achieve the goals of informatization, improving the quality of medical care and medical aid, including reducing the number of medical errors, the availability of medical services, as well as protecting personal and medical data.

Modern digital healthcare environments are computer programs that can help a doctor diagnose diseases based on clinical findings. The aim of such environments is to support future doctors, help them in prescribing treatment and examinations. Moreover, digital healthcare environments help doctors in making a diagnosis on the basis of a patient data, including full-age data, patient's complaints and symptoms, the results of objective examination, laboratory and instrumental methods of investigation [1; 2].

Nowadays all medical institutions need to use modern equipment, especially in situations related to emergency situations, when doctors must make decisions very quickly. Besides, improvement and introduction of new methods of treatment and investigation, using of medical environments or systems of medical care, medical emergency, one way or another, are connected with information technologies [3].

D.A. Mikov proves that the procedure of making a medical decision can be presented in the form of the following stages [4]:

– description of the patient's condition (conducting examinations, diagnosis);

– analysis of limitations (allergies, dysfunctions of body subsystems, etc.);

– selection of treatment method/drugs;

– prognosis of treatment outcome options (safety assessment, possibility of adverse reactions).

All these stages should be realized in the interaction between doctors and the digital healthcare environment is as follows [5]:

1. The patient undergoes an examination.

2. The image obtained from the diagnostic equipment is loaded into the system.

3. To clarify the diagnosis, the attending physician can contact a diagnostician.

4. The diagnostician uses an expert program for processing studies, make a diagnosis.

5. Diagnostic results are posted to the digital system.

6. The attending physician prescribes treatment based on the data obtained.

The creation of a digital healthcare environment is a prerequisite for the training of a new type of personnel on local and international levels for the medicine of the future, who are able to solve professional problems using digital technologies [6; 7]. Sabitova N.G. proves that there should be serious requirements for the training of future physicians and their mastery of digital literacy and competencies to solve professional tasks in the digital healthcare environment, master software platforms in medical information systems and communication competencies in telemedicine technologies, carry out electronic document management, manage information and digital arrays in medical databases, etc. [8].

In developing digital healthcare environments, used in medicine, several goals are pursued. First, it is necessary to increase the efficiency of treatment. Secondly, it is necessary to minimize the number of medical errors. Third, it is necessary to optimize the cost of patient care. Next, it's crucial for medical universities to provide the country with doctors, who are highly qualified specialists with profound medical knowledge. Moreover, a digital healthcare environment helps doctors to work in changed epidemiological situation, for example, there was the epidemic of COVID-19 in 2020. The last aim is the introduction of the systems for monitoring patients' condition and preventive work [9–11].

To achieve the above goals, it is necessary to provide real-time decision-making process of medical staff. It is a digital healthcare environment that allows to achieve proper automation of these goals.

As a rule, each digital healthcare environment is designed for a specific field of medicine: ophthalmology, oncology, pediatrics, cardiologist, surgery, etc., thus it can be argued that each system is designed to solve a narrow range of problems. In turn, it can be concluded that the data, collected for electronic health records, have different formats of both structured and unstructured records. Thus, there is an urgent *problem* of creating a system or an environment, aimed at analysis of medical data of patients, the results of examinations, different doctors' notes and diagnosis with different types of data (graphical, numerical, textual) [12–14].

The development of such digital healthcare environments is an important task, because when doctors try to make diagnoses, they can make mistakes. The main reasons are a lack of knowledge, little time, inexperienced doctors and incomplete medical information about patients' conditions [15–17].

Methodology. The performed analysis of the used means of informatization in the educational process of a medical university allowed to conclude that it is necessary to develop a universal digital platform, which implies the use of information technologies and tools to improve the quality of decisions made by doctors. Such a platform will be used by teachers and students while studying at university, and then by doctors in their professional work and will be an important part of an information educational environment of a medical university [18].

As part of the research, a Learning Digital Medical Environment was created, the objectives of which are as follows:

– electronic document management (electronic health records of patients, information about patients, their laboratory and instrumental examinations, medical diagnosis of different doctors);

– analyzing large amounts of medical data;

– electronic support for physicians in prescribing laboratory and instrumental examinations, making a diagnosis and prescribing appropriate treatment;

– unification of the medical environment (doctors of any specialty work in the digital environment);

– medical data integration (collection and integration of all laboratory and instrumental tests and doctors' conclusions on a particular patient for qualitative assessment of the patient's current condition, giving diagnosis and prescribing effective treatment).

Results and discussion. The design and interface of the created Learning Digital Medical Environment was developed in the Figma program, which is a collaborative graphic editor. The interactive prototype of the learning digital environment created in the ProtoPie program was tested by students and teachers, as a result of which changes were made to the prototype after analyzing the results obtained. The finished learning digital environment was created using the Python programming language. Python is a high-level, interpreted programming language that supports several programming paradigms, including procedural, object-oriented and functional programming.

The Learning Digital Medical Environment is both a database of electronic health records of patients and the system which a doctor uses during an appointment at a medical institution. The main idea of the system is that it helps students in learning process and doctors in making professional decisions.

The main menu of the developed Learning Digital Medical Environment consists of six blocks: "Patient Data", "Symptoms and Complaints", "Examination and Tests", "Preliminary Diagnosis", "Final Diagnosis", "Complete an Appointment".

The "Patient Data" block contains information about a patient: date of birth, passport data, place of registration, actual residence address, phone number.

The "Symptoms and Complaints" block includes the following sub-blocks: "Symptoms and Complaints of a patient", "Medical History", "Objective Examinations of a Patient", which are filled in by a doctor at the first appointment of a patient (Figure 1).

The "Tests and Examinations" main menu block contains main menu all laboratory and instrumental examinations prescribed by a doctor and performed by a patient.
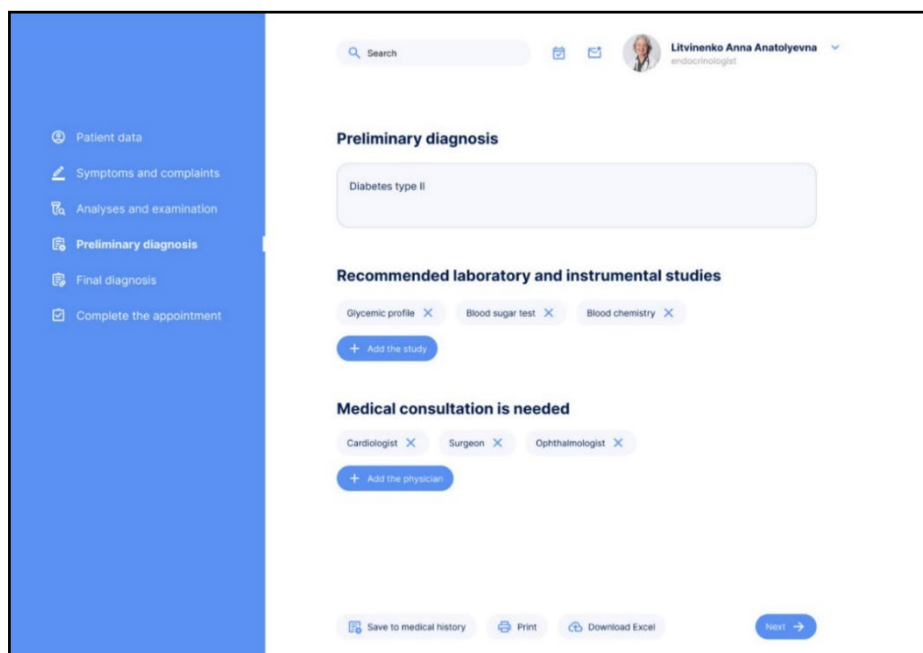
The "Preliminary Diagnosis" main menu block is a preliminary diagnosis offered by the system based on the analysis of patient's symptoms and complaints entered into the system by a doctor, patient's medical history and objective examination. The "Preliminary Diagnosis" block contains sub-blocks "Recommended

Laboratory and Instrumental Examination" and "Necessary Medical Consultations", which Learning Digital Medical Environment recommends to a doctor based on a preliminary diagnosis, which the doctor agrees with or modifies (Figure 2).
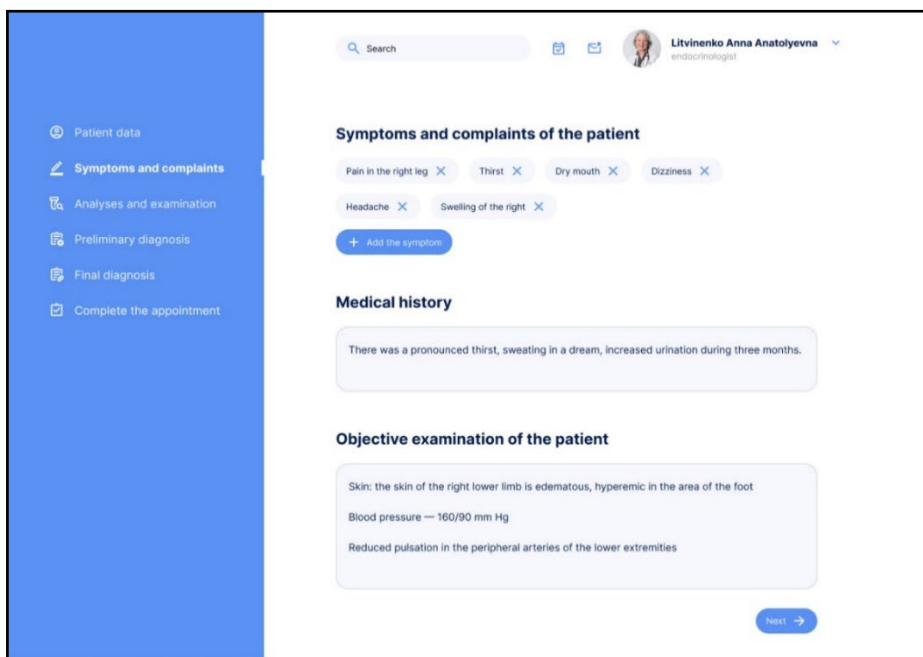
Figure 1. Determining the patient's symptoms and complaints, performing an objective examination of the patient as an important stage in making a preliminary diagnosis

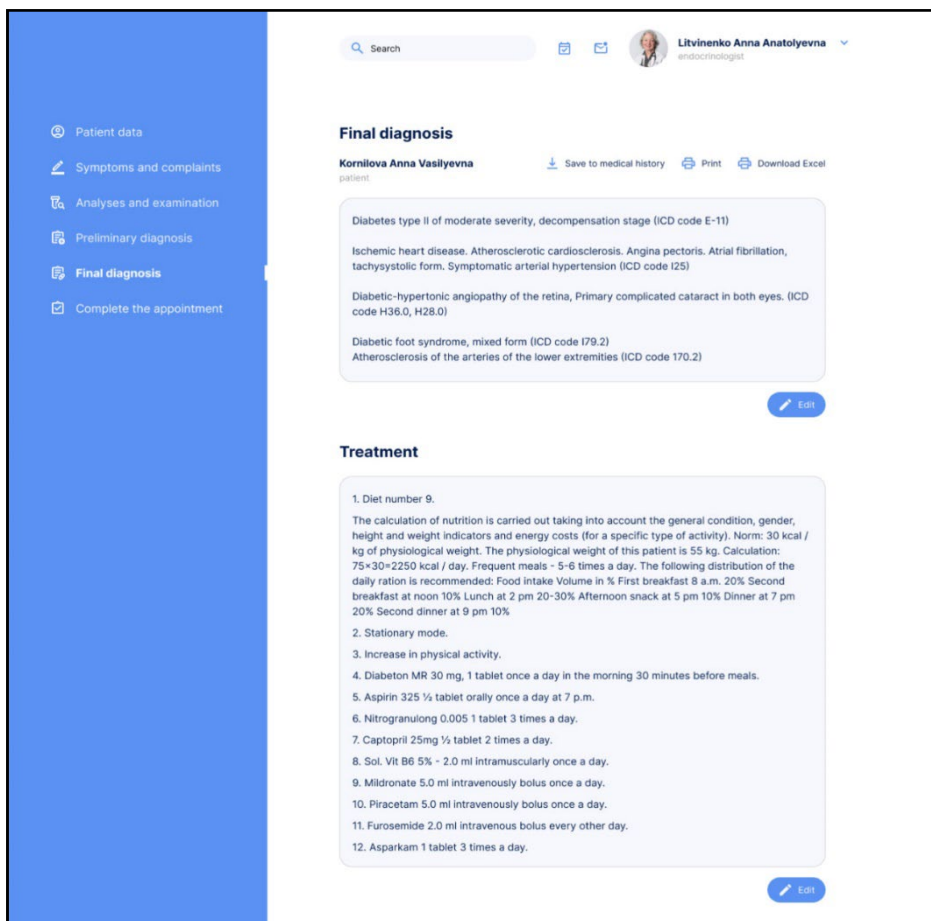*Source:* made by Vadim V. Grinshkun, Kristina S. Itinson.

Figure 2. Preliminary diagnosis, examinations and medical consultations to a patient offered by Learning Digital Medical Environment based on patient's symptoms and complaints, medical history, objective examinations entered into the system by a doctor

Source: made by Vadim V. Grinshkun, Kristina S. Itinson.

The "Final Diagnosis" main menu block involves downloading patient's medical data from an electronic health record, namely the results of medical consultations and laboratory and instrumental tests in xlsx format.

Learning digital medical system, having analyzed patient's medical examinations downloaded from an electronic health record, displays a final diagnosis and recommended treatment, which a doctor proves or makes adjustments (Figure 3).


Figure 3. Final diagnosis and treatment offered by Learning Digital Medical Environment based on analysis of the patient's medical data

Source: made by Vadim V. Grinshkun, Kristina S. Itinson.

An important structural element of Learning Digital Medical Environment is the database of electronic health records. Any physician authorized in the digital system can search for a patient by name, date of admission, an attending physician, and department.

Let's consider an example of storing medical data about patients in the database of electronic health records of Digital Learning Medical Environment. So, a diagnostician writes a conclusion on a clinician generates a diagnosis in doc format, which are saved in an electronic health record. Digital Learning Medical Environment analyzes the received files and converts them into universal xlsx-files, which are further used by the system to make a final diagnosis
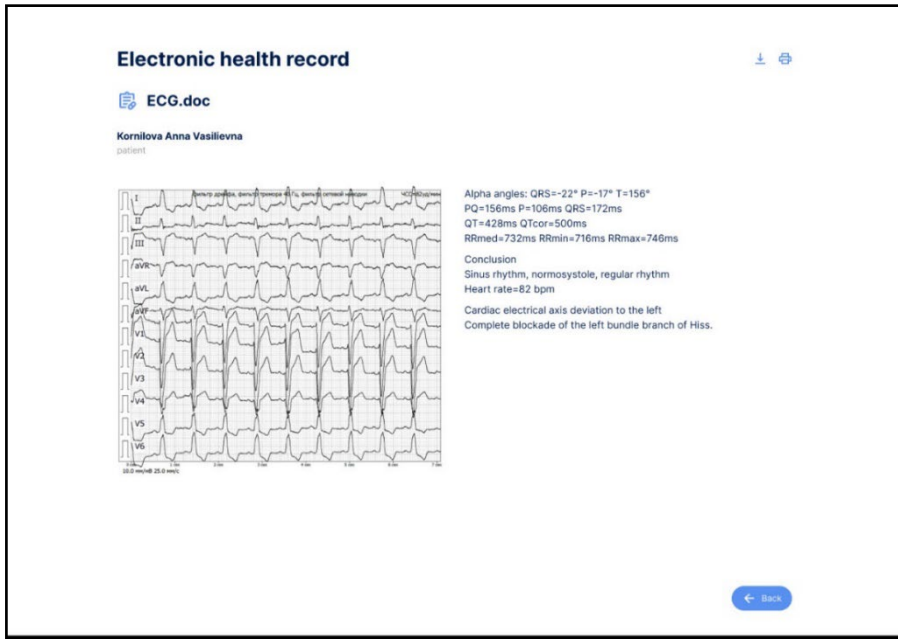
Figure 4. ECG transcription results used by Learning Digital Medical Environment for final diagnosis

Source: made by Vadim V. Grinshkun, Kristina S. Itinson.

Figure 5. ECG report converted by Learning Digital Medical Environment into the xlsx format required for diagnosis

Source: made by Vadim V. Grinshkun, Kristina S. Itinson.

Each electronic health record of a patient contains the following sections: "Patient Data", "Outpatient Visits", "Examination Results", "Hospitalization History", "Medical Examinations", "Referrals For Hospitalization", "Medical Consultations". The electronic health record stores all doctor's appointments,

consultations (in doc and xlsx formats), results of laboratory and instrumental examinations (also in doc and xlsx formats) and hospitalization histories.

For example, Figure 4 shows an ECG transcript written by a general practitioner (or a cardiologist) based on the results of an electrocardiogram performed on a patient, in doc format.

The ECG data transcription document converted by the Learning Digital Health Environment into xslx format is shown in Figure 5.

Conclusion. The main advantage of the Learning Digital Medical Environment is its universality, as it is suitable for a doctor of any specialty, ensuring interaction between them. Thus, the interface of the program is the same for all doctors, so a surgeon, as well as an endocrinologist, will fill in the blocks "Symptoms and Complaints", "Tests and Examinations", form a preliminary and then a final diagnosis.

The exchange of medical data between doctors takes place in the system using a specific data format (xlsx), which is used by the program to analyze the data and help the doctor to make a final diagnosis formed on the basis of diagnoses-consultations of the necessary doctors and the results of laboratory and instrumental examinations. All examinations performed by a patient, as well as their analyses, are stored in a format that is easy to recognize by the digital system.

The Learning Digital Medical Environment will be used in teaching medical students at university, and then by doctors in their professional work and career. Moreover, the Learning Digital Medical Environment will be an essential part of an information educational environment of a medical university.

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