

# Adaptive Mobile Application for the Cats Learning System

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**Abstract**— Using mobile devices around the world has already become commonplace. There are a huge number of applications that greatly simplify everyday life: from simple planning of actions and events to paying for goods by simply touching the terminal with a mobile device. That is why the problem of integration a mobile learning application into the educational process is quite relevant. The purpose of this study is to increase the efficiency of the learning process through using CATS adaptive mobile application. During the study, existing learning systems were examined, their advantages and disadvantages were determined, requirements for the development of a new mobile application for the adaptive training system CATS were developed. The implementation of the mobile application is made in the environment of Microsoft Visual Studio Community (Mac), the programming language is C#. The proposed development has been integrated into the educational process of the Belarusian National Technical University.

**Keywords**—adaptive learning system, LMS, mobile application, Xamarin, adaptive learning, knowledge control, electronic training complex.

## I. INTRODUCTION

In the information technology environment, the term “adaptive system” refers to a process in which an interactive system changes its behavior for specific users based on information received about users, circumstances of use, and the environment.

In our days one of the most popular types of adaptability is the adaptability of learning systems, which makes e-learning possible. The following types of adaptability of such systems are distinguished:

- adaptive navigation, leading to a change in the layout of the screen;
- learning-oriented adaptability: the learning method is dynamic and individualized for each student;
- content-oriented adaptation, which can lead to dynamic content changes. For example, course information is divided into three levels of detail, and the level is displayed based on the value of a certain coefficient;
- interactive support to solve a problem that helps students to find the right solution in the next step;
- flexible information filtering, which helps to provide students with only the information they need.

Therefore, we can say that the system adapts the level of presentation of educational material to the personal abilities and capabilities of the student.

Since mobile devices are currently gaining great popularity, it seems urgent to develop a mobile client for the adaptive learning system CATS, developed and used by the Belarusian National Technical University.

## II. ANALYTICAL LITERATURE REVIEW

The presence of demand for Learning Management Systems (LMS), naturally, gives rise to many offers, creating the problem of choosing the best. According to the Edutechnica team, the most common in the world are Blackboard, Moodle and Sakai [1]. Due to the specifics of the

educational system, which differs from the more individual western, as well as in terms of cost characteristics, in the higher educational institutions of the Republic of Belarus, the most widely used systems are Moodle, Prometheus, e-University (the current name is e-Uni) and SharePoint LMS.

Moodle (Modular Object-Oriented Dynamic Learning Environment), known as a virtual learning environment or as a tool of creating dynamic websites for students, is primarily focused on the organization of interaction between professor and students, suitable for organizing traditional distance learning courses and full-time support. Moodle LMS is a free, open source software product. This fact is both an advantage of this system and its disadvantage, since, on the one hand, it allows you to create any training courses and classes, and on the other hand, it requires special knowledge in their development. As a result, the system is quite difficult to configure, and for a professor who does not know the basics of programming, it's not easy to figure it out. There are even textbooks for learning how to work with Moodle, which once again emphasizes the difficulty in mastering it. It should also be noted the unfriendly system interface, overloaded links and a lot of unnecessary information [2].

Prometheus LMS is a Russian software allows you to organize learning courses, learning materials, tests with 10 types of questions, chat, forum, messages and much more. Unfortunately, the system does not provide for the possibility of supporting course and diploma design, and there is no learning adaptability to the student's current knowledge and its psychophysiological characteristics.

E-University LMS was created by Belarusian developers and used at several faculties of the Belarussian State University. The system provides the possibility of learning courses creation and tests creation for them. However, due to the fact that the system is no longer supported by the developer, its interface and set of functionalities is significantly outdated. Currently, the e-Uni system, which is more focused on the corporate sector, has replaced this software product.

SharePoint is a collection of software products and components from Microsoft for website development. Thus, the development of LMS using these products requires separate skills that are unlikely for professors. Some website developers have taken advantage of this moment and offer their services using SharePoint. Therefore, the completeness of the functionality of the LMS designed in this way will depend on the developer's imagination, and the ease of configuration will depend on his skill.

It should also be added that the Prometheus, e-University and SharePoint systems described above are paid developments and have the same disadvantages: high cost and lack of flexibility, i.e. the purchased product is a "thing in itself" and cannot be modified by other developers, but only for an additional payment.

Taking into account the shortcomings of the available paid and free learning management systems, as well as wishing to take into account their own specifics, many educational institutions resort to the independent development of such automated systems or make an individual order for development. This was done, for example, at Harvard University and the Massachusetts Institute of Technology (USA), at the Russian Economic University named after G.V. Plekhanov, at the Higher School of Economics (HSE, Russia), at St. Petersburg State Medical University named after I.P. Pavlova and in many others. It can be noted that recently there has been a tendency for such orders, since the finished systems, although they claim the term "universality", do not always implement it [2].

It should be noted that recently there has been a shift from LMS to intelligent or adaptive learning systems (ALS) [3]. Adaptive learning systems analyze the student's knowledge at each stage of the study of the material and allow you to build an individual learning path. The psychophysical characteristics of individuals can also be considered. It should be noted the complexity of developing such systems and not always high accuracy. This is primarily due to

the difficulties of formalizing knowledge. In this case, the student acts as a control object (CO), and the ALS acts as a control device (CD). In Figure 1, the following notation is adopted:  $\Psi$  - state of the environment;  $Y$  is the state of the student;  $I_\Psi, I_Y$  - corresponding meters;  $\Psi', Y'$  - measurement results for  $\Psi, Y$ ;  $X$  - control actions;  $D_X$  - resources (control restrictions);  $Z^*$  is the control goal, which consists in transferring the student to the required state  $Y^*$  [1].

In the designations introduced, the general rule for the functioning of ALS is presented in the following form: ALS, receiving information on the state of the environment  $\Psi'$  and the state of the student  $Y'$ , as well as information on the purpose  $Z^*$  and resources  $D_X$ , gives out an acceptable control:

$$X=A(\Psi', Y', Z^*) \in D_X,$$

transferring the student from the current state to a state close to  $Y^*$ . Here  $A$  is the learning management algorithm. It is assumed that the student model connecting the observed inputs and outputs has the form  $Y'=M_L(\Psi', X)$ . The synthesis task of the optimal control  $X^*$  taking into account  $\mu(^*)$ , as a symbol of some measure of proximity, is written as:

$$\text{Min}_X \mu(Y - M_L(\Psi', X)) = \mu(Y - M_L(\Psi', X^*)), X \in D_X.$$

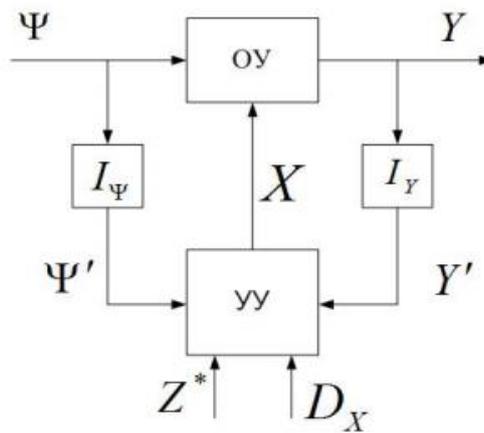


Fig. 1 General structure of ALS [1]

Despite the complexity of developing adaptive learning systems, this approach is extremely relevant in our days due to the development of continuing education. A person exists in this process throughout his life, he wants to study in any place convenient for him, in any free time for him, as soon as possible, without spending any extra money.

The adaptive learning system called CATS (Care About The Student) is developed and used at the Faculty of Information Technologies and Robotics of the Belarussian National Technical University [4]. As mobile devices are currently gaining popularity, a mobile client has been developed for this system. Thus, a student can receive all the necessary information for the educational process, including class schedules, news, assignments, track their performance and attendance in subjects, pass through tests, work with electronic educational and methodical complexes, and also use an adaptive learning module.

### III. OBJECT, SUBJECT AND METHODS OF THE STUDY

The object of the study is the adaptive mobile application of the CATS learning system.

The subject of the study is the adaptability of a mobile application and its impact on the learning process.

In the course of the study, the following theoretical and empirical methods were used:

- analysis of scientific publications;
- analysis of the basic concept of adaptability;
- methods of quantitative and qualitative processing of factual data;
- a method of secondary analysis of the study results;
- conducting experimental work on the implementation of adaptive mobile applications at the department of a higher educational institution;
- analysis of the received results.

The study results were integrated into the educational process at the Software of Information Systems and Technologies department of the Faculty of Information Technologies and Robotics of the Belarusian National Technical University for the software engineers learning as part of the disciplines “Unit Testing”, “Software Testing and Debugging”, “Software Reliability”. There is an act of implementation.

Study results were reported at Republican scientific conferences. There are three publications.

#### IV. STUDY RESULTS

To implement the adaptability of the mobile application of the CATS learning system for various platforms, the Xamarin framework was chosen, which allows developing the application for two operating systems iOS and Android at once [5-6]. The mobile application was developed using the architectural pattern Model-View-ViewModel, the development environment is Microsoft Visual Studio Community (Mac), the programming language is C#. Currently, for free download on the Internet, an Android version of the mobile application is available at <https://educats.bntu.by> by selecting the appropriate link at the bottom of the welcome page. On the first application launch, user will have two main modules available: the authorization page (Figure 2) and the settings page (Figure 3).

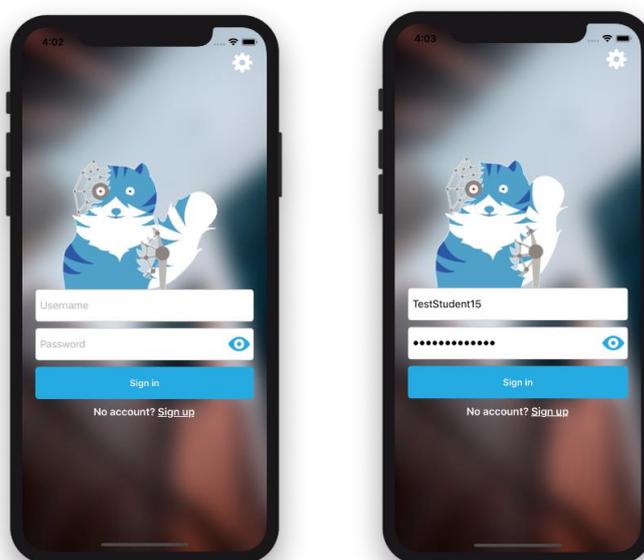


Fig. 2 Mobile app authorization page

The authorization page (Figure 2) assumes a student account in the CATS learning system. To test the application, six test entries were created with the logins TestStudent10, TestStudent11, TestStudent12, TestStudent13, TestStudent14, TestStudent15. Passwords for these credentials are the same as logins.

On the settings page, at the moment you can select the necessary server (stable, test and local university server), since the system is deployed on two servers. It is also possible to run the application on the university's local network via internal Wi-Fi without using Internet traffic.

The interface language is provided in English and Russian. By default, the system language of the device is set.

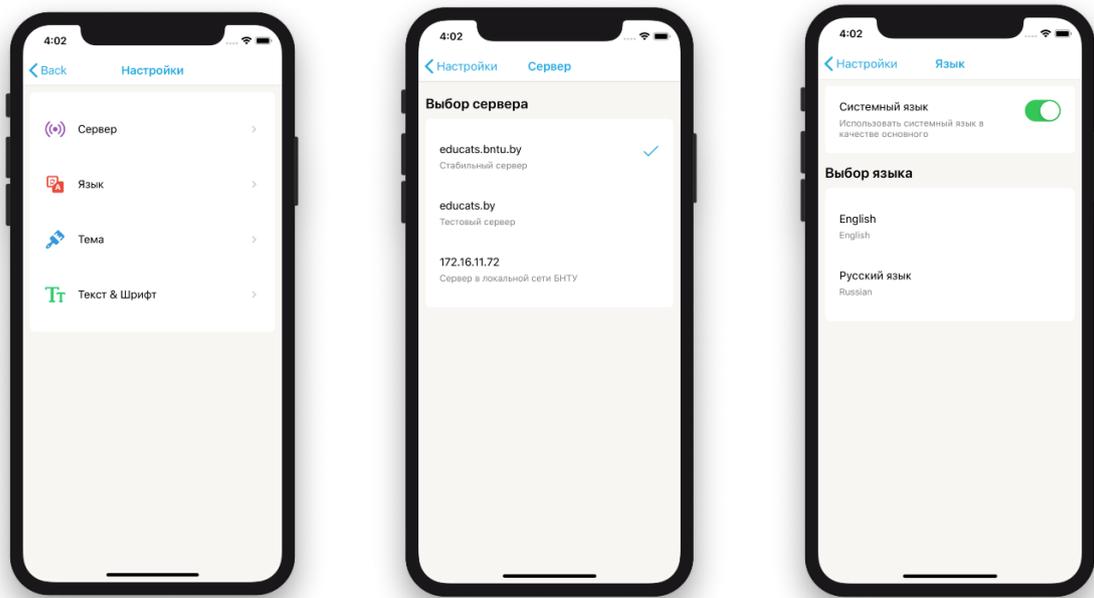


Fig. 3 Mobile app settings page

After authorization in the mobile application of the CATS learning system, you can see the main page, which is called Today (Figure 4). At the top of the screen is a calendar with the current date highlighted. In the middle part of the screen are the news, as well as the names of subjects, if there are learning sessions on them on the current day (Figure 5). At the bottom of the screen is a menu of a mobile application, consisting of four items: Today, Learning, Statistics and Settings. By clicking on each of the proposed menu items, a transition to them will occur.

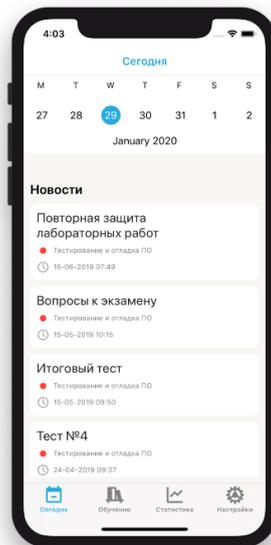


Fig. 4 Mobile app home page

As indicated above, the Today page (Figure 5) includes a horizontal calendar of classes and the latest news on subjects studied. The calendar is interactive and updates the news and the list of items for the selected date (Figure 6).

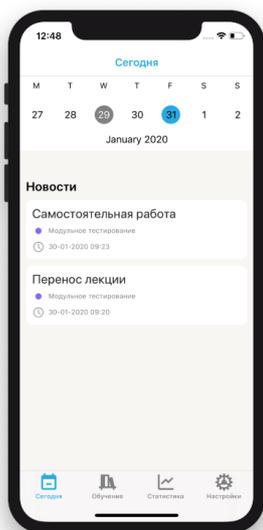


Fig. 5 Today page with a selected date without subjects

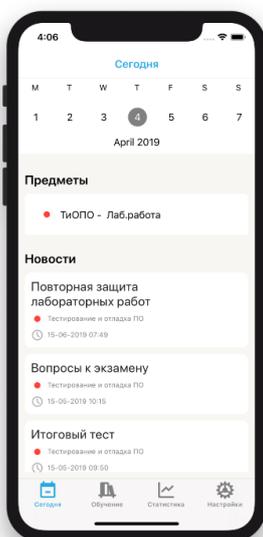


Fig. 6 List of subjects by a given date

The Learning page contains four modules: Tests, EEMC (electronic educational-methodical complex), Files and Adaptive learning (Figure 7).

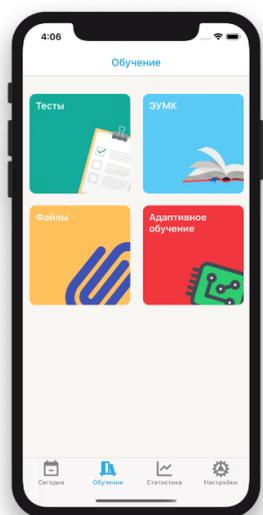


Fig. 7 Screen of the Learning page

When choosing the Tests module, the student has a list of tests that he can pass (Figure 8). It can be both tests for self-study, which can be taken many times and the rating is not counted for them, and tests for the control of knowledge used by professors to control the student's knowledge [7].

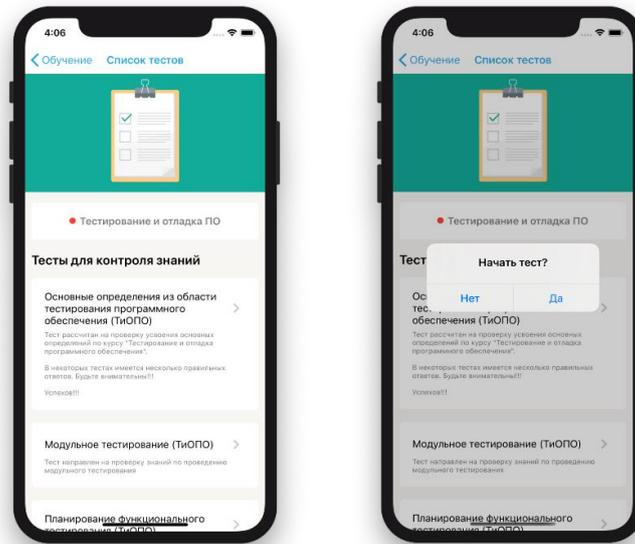


Fig. 8 Tests page

Each test can have several types of questions: with one correct answer, with the correct sequence of answers, with several correct answers, and also to enter the correct answer from the keyboard. Figure 9 shows the first three types of questions.

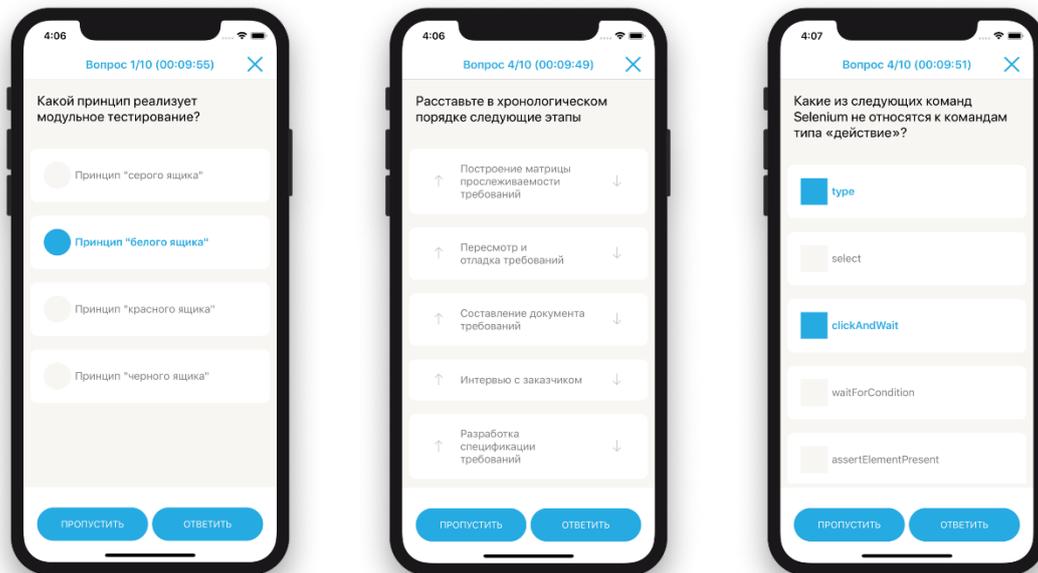


Fig. 9 Types of questions in the test

As a result of passing the test, the obtained mark is displayed for it indicating which questions were answered correctly and which are not (Figure 10).

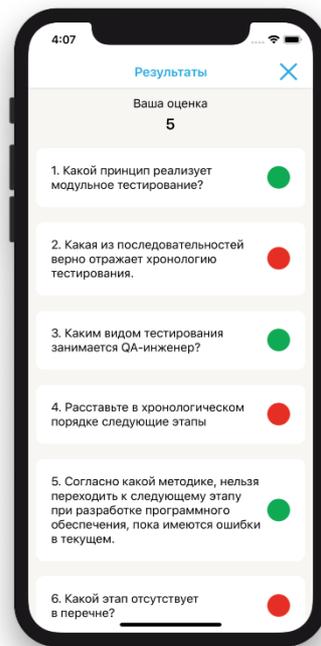


Fig. 10 Test results

The EEMC module is an interactive book (Figure 11). In the Republic of Belarus, electronic educational and methodological complexes are the main component of e-learning. The process of developing EEMC, its structural elements and sections are regulated by the relevant Regulation approved by the Ministry of Education of the Republic of Belarus [8]. According to paragraph 7 of the above document, EEMC, as a rule, includes sections: theoretical, practical, knowledge control and auxiliary. So, figure 11 shows the EEMC for the academic discipline "Software Testing and Debugging" with the required components and a cover page. Choosing the right section, information for reading will be opened, and when choosing a knowledge control unit, a transition to the test module will be implemented.

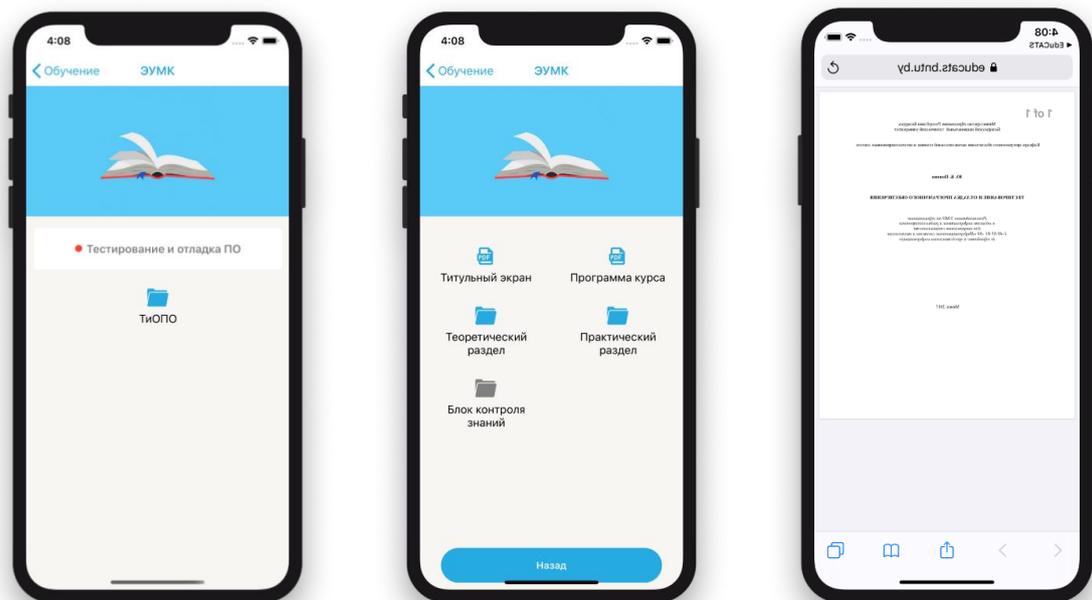


Fig. 11 Electronic educational-methodical complex

The Files module provides the ability to download files attached by the professor (Figure 12). For example, it can be questions for the exam, lecture notes, recommended list of literature,

guidelines for practical and laboratory works, course projects, task texts for these works and other information. Figure 12 shows the list of files for the discipline "Testing and debugging software", which can not only be downloaded, but also shared.

The Adaptive Learning module connects the EEMC and Tests modules. The idea behind this approach is to identify gaps in student knowledge. Each topic for study (or concept) is associated with a certain test. Passing the test, a list of questions is formed to which the student answered incorrectly, therefore he did not study a certain topic. Therefore, this topic should be offered for reading, and then a test to verify the material studied. The algorithm will continue its work until the correct answers are received to all questions of the required topics for study.

Adaptive learning begins with passing a pre-test throughout the course, the results of which will form the first list of materials for study (Figure 13).

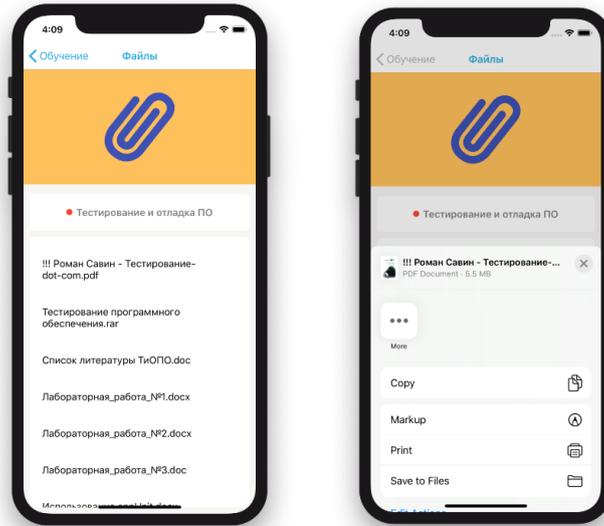


Fig. 12 Files to download from a mobile application

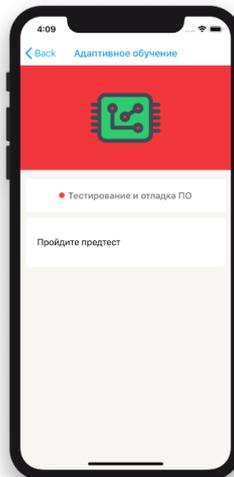


Fig. 13 Adaptive learning start

Figure 14 shows the first pre-test question for adaptive training in the discipline "Software Testing and Debugging". At the top of the screen you can see that this is the first question out of thirty-six. It displays the timer remaining time for passing the test. You can answer the question right away or skip it and return to it later. The figure shows a question with one correct answer.

After passing the pre-test on the Adaptive learning page there are two links Recommended reading material and Take the test (Figure 15).

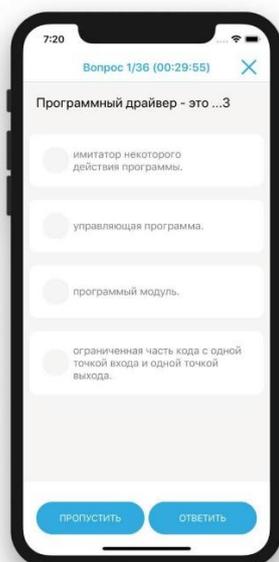


Fig. 14 Questions from the pre-test

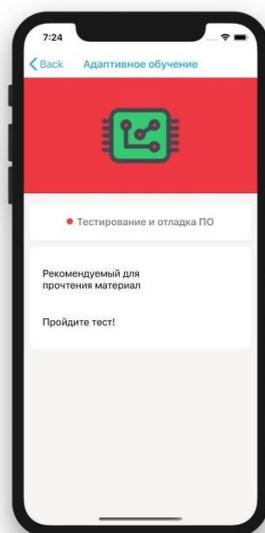


Fig. 15 Updated adaptive learning list

If you click on the Recommended Reading Material, the EEMC will open right on the necessary page of that topic, the questions to which were answered incorrectly (Figure 16). After reading the proposed material, you should pass a test on the topic.

The Statistics page contains information about the student's academic performance in laboratory studies, as well as about his omissions from laboratory work and lectures (Figure 17).

The student is only available information about his own grades and passes (Figure 18), while the professor can view information about all students in the groups in which he conducts classes (Figure 19).

The Settings page was described above, however, it is worth mentioning that after authorization the full name of the student and his group will be visible in a separate block. An exit button also appears, which redirects the user to the authorization page and clears all current authorization data (Figure 20).

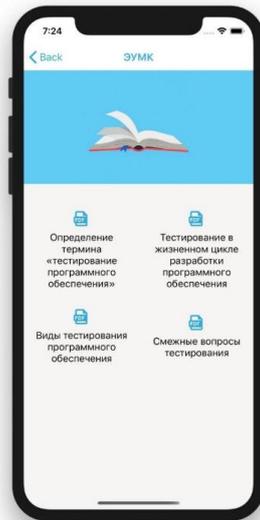


Fig. 16 Recommended reading material

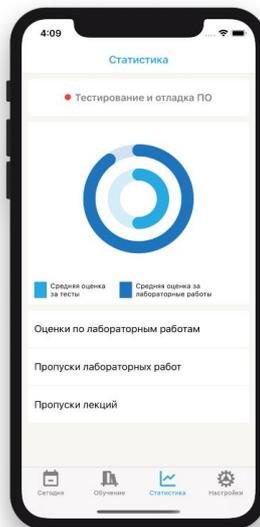


Fig. 17 Statistics page

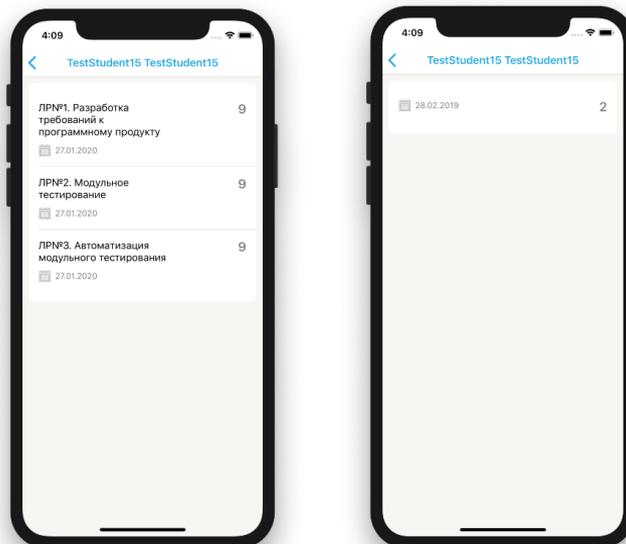


Fig. 18 Information about student's academic performance and skipping classes

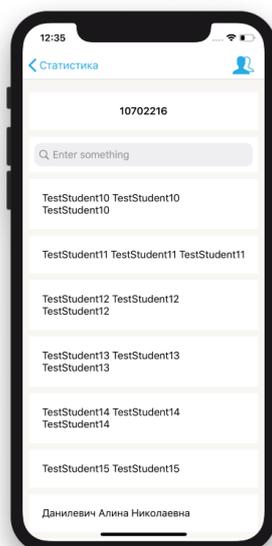


Fig. 19 List of students visible from the professor's role

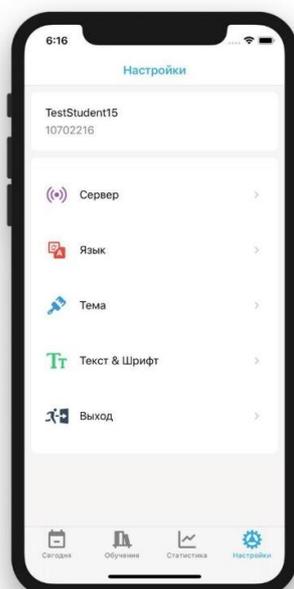


Fig. 20 Settings page after authorization

## CONCLUSION

The current trend towards lifelong education creates a promising environment for promoting the proposed mobile application of the CATS adaptive learning system.

The considered mobile application has the following features:

- covers all the main components of the learning process, including working with electronic educational and methodological complexes, passing tests, downloading the required information;
- informs participants of the educational process about their performance and absences;
- takes into account the characteristics of each student, realizing the possibility of adaptive learning;
- allows to adapt to various sizes of devices;
- implemented using modern technologies for the Android and iOS operating systems;
- available on the Internet, as well as on the local network of the Belarusian National Technical University via Wi-Fi;

- the proposed system has been tested on several academic disciplines of the university;
- the mobile application is constantly being improved, updated and is a platform for generating new ideas;
- the functionality of the CATS adaptive mobile application can significantly increase the efficiency of the learning process.

#### **REFERENCES**

- [1] LMS data from universities in the USA, Australia, Canada and the UK [Electronic resource]. – Access mode: <http://education-events.ru/2014/09/26/edutechnica-published-data-about-lms-usage/> – Access date: 10.02.2018.
- [2] Popova, J.B. Classification of Automated Learning Management Systems / J.B. Popova // System analysis and applied informatics. – 2016. – №3. – P. 51–58.
- [3] Popova, J.B. From LMS to adaptive learning systems / J.B. Popova // System analysis and applied informatics. – 2019. – №2. – P. 58-64.
- [4] Popova, J.B. Automated Learning Management System CATS (Care About The Students) / J.B. Popova // Science and technology. – 2019. – №4 (18). – P. 339-349.
- [5] Lehchylin I.V. Types of software adaptability / I.V. Lehchylin, J.B. Popova // Information technologies and systems: problems, methods, solutions: collection of materials of the Republican scientific and technical conference, BNTU, November, 2018 г. - P. 8-9.
- [6] Lehchylin I.V. Mobile application for LMS CATS using the Xamarin framework / I.V. Lehchylin, J.B. Popova // Informatization of technical systems and processes: materials of the student scientific-practical conference. E-learning material. Minsk, 2018. - P.13-15.
- [7] Lehchylin I.V. Testing student knowledge in the CATS mobile application / I.V. Lehchylin, J.B. Popova // Informatization of technical systems and processes: materials of the student scientific-practical conference. E-learning material. Minsk, 2019. - P.18-21.
- [8] Regulation on the educational complex at the level of higher education. – Approved by the Ministry of Education of the Republic of Belarus 26.07.2011. №167.