Experience of the distance testing system development and operation

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Abstract. The article discusses the original remote testing system of students BonTest, created on the basis of the Department of Safety for Life and Activity of the St. Petersburg State Electrotechnical University ETU “LETI”. As part of the “digital economy” formation, the education system faces new challenges. Electronic and distance learning of students requires the creation of new software products integrated into the digital educational environment of the educational institution. The BonTest testing system provides the ability to automatically generate options and upload test results in MS Office Word, MS Office Excel formats, as well as provide statistical data on student progress by academic semesters, groups, types of classes and course topics. The teacher's interface allows you to control access to testing, customize the parameters for passing the test and displaying the results, including the errors of each student. The test is available both in the classroom from computers (Microsoft Windows operating system) or smartphones (iOS or Android operating systems), and in a remote format. The program has a two-stage protection against unauthorized access; its database contains more than 3 thousand test questions. Currently, the BonTest system is widely used in the educational process at the department. Its main advantages are simplicity and efficiency of administration when solving technical issues; no failures or reduced response time of the system as a result of increased load on the server, the ability to promptly refine the program toolkit for emerging requests, as well as the ability to store an extensive database of test questions.

1. Introduction
In his Address to the Federal Assembly in December 2016, the President of the Russian Federation set the task of launching a large-scale systemic program for the development of the economy of a new technological generation, the so-called “digital economy” [1,2]. By order of the Government of the Russian Federation dated July 28, 2017 No. 1632-r, the Program “Digital Economy of the Russian Federation” was approved, in which the segment “Personnel and Education” became one of the basic directions of a new type of economy development [3,2]. The new version of the program was approved by the Decree of the President of the Russian Federation dated 07.05.2018 No. 204 “On national goals and strategic objectives of the development of the Russian Federation for the period until 2024”, in which educational organizations, among other objectives, were tasked with creating a “modern and safe digital educational environment that ensures high quality and accessibility of education of all types and levels” [4].

By the Decree of the President of the Russian Federation dated July 21, 2020 No. 474 “On the national development goals of the Russian Federation for the period up to 2030”, which replaced [4],
the achievement of “digital maturity” of key sectors of the economy and social sphere, including healthcare and education, was set as one of the main national development goals of the Russian Federation. Along with this, the task was set to increase the share of households that are provided with the possibility of broadband access to the information and telecommunications network of the Internet, up to 97 percent, as well as to increase investments in domestic solutions in the field of information technology four times compared with the indicator of 2019 [5]. The first goal, concerning educational sphere, means the increase of learners with remote access to educational content. The second goal determines the focus on the development and implementation of domestic software products. In this regard, it seems important to develop, implement and improve software solutions developed within the Russian university communities.

In the context of the formation of the digital economy, one of the most important tasks of educational institutions has become the transformation of the system of pedagogical practices in the implementation of educational programs in order to organize and implement e-learning (EE), as well as the use of distance learning technologies (DLT). As part of this task, the St. Petersburg State Electrotechnical University (hereinafter - ETU “LETI”) has developed and implemented a strategy for the development of EE and DLT from 2018 to 2020. The strategy is a formalized set of principles that underlie the action plan to saturate the educational process with information and communication technologies [6].

One of the prerequisites for the introduction of EE and DLT in the educational process is the appropriateness of their use. This practice should lead to qualitative improvements in mastering the material, or, while maintaining the level of knowledge, to reduce material costs [6]. Within the framework of this principle, the staff of the Department of Safety for Life and Activity of ETU “LETI” analysed the feasibility of introducing DLT into the educational environment of the department [7]. Within the framework of this study, the question of a complete transition to distance learning within the framework of the disciplines implemented by the department was questioned, mainly due to the lack of practical skills formation among students during distance learning (including working with measuring instruments, familiarization with means of individual and collective protection). The introduction of DLT only partially with reasonable integration into existing practice seemed reasonable.

Under these conditions, the department developed, tested and put into operation a project of the remote testing system BonTest, the initial version of which meant passing tests by students on stationary computers at the department. Further development of the system made it possible to organize the passing of tests using personal smartphones as part of a training session. The undoubted advantages of using the system were a significant reduction in the teacher's labour costs for checking the work, the possibility of forming a large number of original options for assignments, as well as reducing material costs for paper media [8]. Currently, the system also allows remote testing outside of classrooms.

2. The BonTest testing program features

The BonTest testing system is a secure software product based on components, the main purpose of which is storage and processing of confidential data.

The implementation of the main components of the product is presented in table 1.

| Component | Implementation |
|-----------|----------------|
| Storing student credentials, a question-and-answer database | SQL Server Enterprise Database Management System |
| Processing of test results, algorithms for assigning questions | NSG Framework (designed to build a management accounting system) |
| Teacher interface | NSG Framework (Windows Forms Application) |
| Student interface | AngularJS framework |
At the moment, the program works with closed questions (4 answer options, 1 correct answer), with the ability to upload pictures and assign a question category according to the degree of difficulty. The database of questions on the disciplines implemented at the Department of Safety for Life and Activity of ETU “LETI” currently comprises 3096 questions. Questions are grouped by topic and type of training, there is also the possibility of compiling a database of questions for an individual teacher. The program allows you to set a time limit for passing the test on a particular topic and the maximum number of attempts.

The teacher works with the program installed on the work computer and protected by an individual password. The intuitive interface is a list of the main features of the program in the form of opening tabs.

Key features of the program for the teacher:
1. **Access to the test.** The instructor opens access to the test through the "Test Permissions" tab. The date of the beginning and the end of testing, the study groups admitted to testing, and the topics of testing are established.

2. **Display of test results.** Test results are generated automatically in the "Current assessments" tab with the ability to download as a report (supported formats: MS Office Word, NS Office Excel). The report can be generated by the number of the study group, full name, student or testing topic. The teacher sets the period for which the report must be generated, as well as the maximum number of points for the test. It is also possible to set time limits (the results of tests that took too little time are blocked), as well as the rule of two attempts (only the results of the first two attempts to pass the test are taken into account).

3. **Display of mistakes made by students.** The student's answers are displayed in the "Test execution" tab. The instructor sets the period in which the test was conducted. The program provides the ability to filter the results by the number of the study group, full name, student and the topic of testing. It is also possible to group the results presented in the form of individual documents for each test of each student, with the ability to save as a document (supported formats: MS Office Word). The test result shows not only the total test score, but also the list of questions received, the correct answer and the answer given by the student.

The student can be connected to the testing system both through a personal computer (Microsoft Windows operating system) and through a mobile device (iOS or Android operating systems).

Connection is made using the link given by the teacher. The student is invited to choose from the list the name of his faculty, the number of the study group, the full name, and also enter manually the number of the grade book. After entering the data, the program redirects the student to a personal page, which displays the tests available to him at the moment. The test results are generated automatically and are available to the teacher immediately after the student passes it.

If the student does not have a compatible device, the program allows you to generate and print a version of the task on a given topic.

The system provides two-stage software protection against unauthorized access to test questions. The learner frontend application does not have direct access to the database, as the AngularJS framework is connected to the database through a service built on the NSG Framework that constrains read / write to the database. At the level of the NSG Framework, there is regular encryption of credentials, in addition, access to the database server is limited [9].

There is currently no graphical display of testing statistics. However, there is access to statistical data, in connection with which the construction of graphs and diagrams is available in the programs provided for this. So, for example, it is possible to analyze the performance of study groups within the lecture stream in different academic years (figure 1). It is possible to specify the requested data and analyze student performance in one of the types of classes or in the development of a specific topic (figure 2). The data obtained allows you to effectively monitor the progress of students in each group and, if necessary, adjust the learning process.
Figure 1. Comparison of the performance of study groups of the same lecture cohort in different academic years (comparison by average score, %).

Figure 2. Comparison of the performance of study groups of one lecture cohort on the topic “Electrical safety” in different academic years (comparison by average score, %) as part of testing in practical classes.

3. Experience in using the program in the educational process

The BonTest program was launched into widespread use in the fall semester of the 2017-2018 academic year, when 356 students were tested with its help. The further number of students who interacted with the program varied depending on factors such as the number of students on the list in a particular semester (including those related to changes in the academic schedule), as well as the number of teachers who switched to full or partial use of the system (figure 3). However, in general, there is a tendency towards an increase in the use of this system in order to assess the knowledge of students. The largest number of test takers as expected, was observed in the framework of distance learning during the period of self-isolation (spring semester of the 2019-2020 academic year).

Figure 3. Number of students (people) who passed testing in the BonTest program in the last 6 semesters (A – autumn semester, S – spring semester).
Currently, the program is used at the Department of Safety for Life and Activity in the framework of the current assessment in laboratory work, during practical, lecture classes and interim assessment, as well as to check the degree of competence formation in the disciplines of the department among undergraduate and master's students of intramural, extramural and part-time forms of study. In addition, a procedure for the formation of impersonal printed forms of test and computational tasks was put into operation as part of the task to increase the objectivity of evaluating the results of current control when using open questions and computational problems [10].

The events related to the global pandemic of the coronavirus COVID-19 set new tasks and challenges for the educational community. The need to carry out educational activities in a distance format entailed urgent decisions on the transformation of existing practices and their integration into the electronic educational environment of the university. Along with the use of online platforms and a system of personal accounts, the department widely used the BonTest testing system. When comparing the system with online test constructors, as well as testing within the framework of public educational platforms, the following advantages and disadvantages of the BonTest program can be distinguished (table 2).

Table 2. Advantages and disadvantages of the BonTest testing system when compared with online test constructors and educational platforms.

| Advantages                                                                 | Disadvantages                                      |
|---------------------------------------------------------------------------|----------------------------------------------------|
| Simplicity and efficiency of administration when solving typical technical issues (issues are resolved within the department) | A separate system, not integrated into a single platform for working with students |
| No failures or reduced response time of the system as a result of increased load on the server (the load is limited by the number of students and can be organized within the framework of the chair's schedule) | Lack of graphical presentation of analytics data based on testing results and analysis of the quality of test items |
| Two-step protection against unauthorized access to the database           | A small number of types of test questions that the system works with |
| The ability to promptly refine the program toolkit for emerging requests   |                                                   |
| Capability to store an extensive database of test questions                |                                                   |

Practice has shown that the main advantage of the system during the period of distance learning on self-isolation was a lower load on the server than on other public educational resources, and therefore there were no failures in the program during the entire period of operation.

Prospective directions for the BonTest testing system development include:
1. integration of the platform with the MATLAB engineering analysis system using COM technology in order to reduce the laboriousness of checking works by a teacher [10];
2. introduction of a system for assessing the quality of test questions (for example, such statistical indicators of the quality of test items as the index of ease, standard deviation, index and coefficient of differentiation, etc. [11]);
3. introduction of statistical accounting of students' progress with graphical output;
4. introduction of additional types of questions (assignments to establish correspondence / sequence, questions with several correct answers).

4. Conclusion
As part of the digital educational environment of an educational institution, the BonTest testing program can be both integrated into the full-time educational process and be used as part of distance learning. The program does not imply restrictions on levels or types of training and can be applied in any areas and specialties, where a testing format is possible as an assessment of students' knowledge and
competencies. Additional functions of the program allow you to form task forms, including those with open questions.

The program has a wide range of functions, is protected against unauthorized access to the database, and is easy to use for both the teacher and the students.

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