SOME ASPECTS OF CREATING VIRTUAL LABORATORY APPLICATIONS

[1]Raxmonqulov R. [2]Manshurov Sh.T.
[1]Almalyk Branch of Tashkent State Technical University, Tashkent, Uzbekistan, PhD
[2]Almalyk Branch of Tashkent state technical university, Tashkent, Uzbekistan
E-mail: manshurov_sh@mail.ru
https://orcid.org/0000-0002-2654-6082

A B S T R A C T

In higher education, laboratory work is frequently used to illustrate mechanical processes in technical topics. It cannot be assumed, nonetheless, that these activities are carried out correctly everywhere. The utilization of virtual laboratory exercises is a useful substitute to improve this weakness. Furthermore, logical inferences about the processes are made possible by immediately transferring measured mechanical and physical parameters to computer memory. The global market offers a variety of reasonably priced chips made for monitoring mechanical and physical properties. By taking advantage of these features, measured parameter values can be sent straight to computer memory, doing away with the requirement for pricey measurement devices.

The process of recording and creating bootloader programs (applications) is the main topic of this article, which also shows how random numbers produced by the computer (randomizer) are used to replace data transmitted from chips.

K e y w o r d s: Virtual laboratory, application, bootloader, video lecture, electronic textbook, trainers (software), testing program, operating system, modulus of elasticity, absolute elongation, timer.

Analysis of literature

The groundwork for educating students for life, the workforce, and creativity is established in higher education institutions. Because of this, teachers now employ different teaching strategies than in the past, modifying their approaches to suit the needs of the modern classroom. Teaching methodology's organization, structure, and content should encourage students to be freely creative while providing a foundation for learning new information and successfully putting it into practice.

One of the promising avenues for efficiently structuring education is the incorporation of multimedia technology into the informatization of educational activities. There are opportunities for professors and educators to successfully use contemporary information technologies in education by enhancing educational procedures and restructuring professional development courses to partially replace the priceless technical foundation and educational materials with software and methodological support. [1].

Enhancing future specialists' creative activity and ensuring the development of their professional potential is currently one of the major challenges facing higher education. Teaching aspiring professionals how to engage with a professional, creative, and changing world on their own is the worldwide objective of educational reform.[2].

Most modern students are technically and psychologically prepared to use mobile technologies in the educational process. Exploring new opportunities to more effectively utilize information technologies, mobile devices, and applications in the learning process has become a pressing issue [2,3].

A mobile application is software designed for smartphones, tablets, and other mobile devices [6]. Mobile applications are specially developed programs that can be installed on specific platforms, allowing users to perform various tasks. These applications offer unlimited possibilities compared to traditional tools by providing opportunities to modify the subject of the educational process. Moreover, these capabilities create the most convenient conditions for implementing educational topics outside educational institutions by ensuring broad use of information resources [4,5].

For example, a virtual laboratory for natural sciences seminars developed at RUDN University has been introduced, installed on the local network of a computer classroom, and fully supports the educational process. The seminar is built on the principle of open architecture and has a flexible universal shell, making it easy to supplement with virtual and full-scale experiments, including the ability to control experiments remotely.

Main part

In the modern era, the penetration of information technologies into various fields, including the education system, has introduced numerous innovations. This naturally facilitates learners' comprehension of subjects and encourages a conscious approach to studying and acquiring knowledge. The modern teaching process poses various challenges for professors and educators.

It is well-known that no one has grounds to declare traditional teaching systems obsolete or ineffective. Regardless of the extent to which modern technologies evolve, they can never fully replace human involvement. However, this does not imply that new technologies should not be utilized. According to pedagogical principles, a person acquires the majority of their understanding through visual perception, while the rest is gained through hearing. Additionally, learners fully grasp the educator's thoughts during the first 20 minutes of a lecture. In the next 20 minutes, their ability to fully comprehend decreases, and they begin to feel bored. By the end of the lecture, this sense of boredom intensifies. Consequently, it becomes essential to enhance the amount of information received visually compared to that received audibly. For this purpose, numerous efforts have been made to utilize computer programs, which can be exemplified by the following:

- Using slides (PowerPoint);
- Subject-related video clips (visual aids);
- Video lectures;
- Electronic textbooks;
- Simulators (software-based);
- Test evaluators (interactive quizzes);
- Informational references (encyclopedias);
- Specialized software solutions, among others.

In modern times, in addition to full-time education, distance learning, part-time, and evening education methods are being widely implemented. For students enrolled in these forms of education, the opportunities to conduct practical sessions directly on laboratory equipment are often limited. This challenge is not new, as it is evident how it is addressed in the educational systems of other countries. However, these issues have not been completely resolved everywhere. Due to insufficient classroom hours allocated for laboratory work in universities, it is often impossible for students to perform all laboratory tasks in the classroom. As a result, integrating the use of computer software into the teaching process has become one of the pressing issues of modern higher education. This article focuses on this issue, emphasizing the need to significantly increase the development of software applications in the Uzbek language for educational purposes in the country's universities.

From the above, it is evident that there is a need to encourage the widespread development of mobile applications aimed at the educational system and integrate them into the learning process. The software applications developed for this purpose must meet the following requirements:

- Independence from specific operating systems;
- Comprehensive coverage of the topic;
- Availability of diverse materials for testing (while many materials can be found online, in practice, the range of materials in manufacturing industries is limited);
- Provision of ample opportunities for students to perform laboratory work;
- Capability to perform mathematical calculations of results quickly and accurately;
- Ability to draw scientific conclusions based on the obtained results;
- Minimization of measurement errors in experimental parameters;
- Capability to modify parameters in a separate window or using a visual scale during laboratory work;
- Providing sufficient information based on the results obtained for scientific or practical purposes;

•Ensuring that users can analyze how solutions to a given problem vary under different parameters.

To achieve this, it is essential to divide the process into manageable segments and ensure control through specific buttons in the software. To maintain continuity in the process, it is necessary to use a “**timer**” to track its progress. Furthermore, the appearance of the testing equipment should be as natural as possible. Special attention should be paid to ensuring that the range of test samples is sufficient, which will undoubtedly make the application more comprehensible. To enhance understanding and simplify management, the purposeful use of multiple query buttons for specific tasks is advisable.

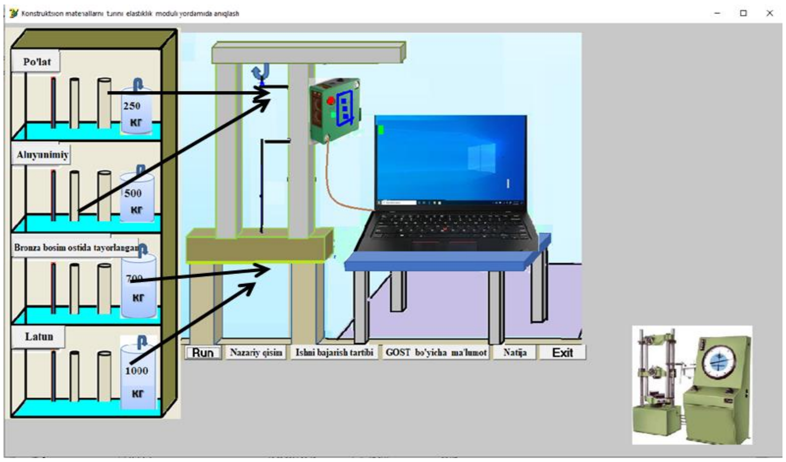

Figure 1. Screenshot of the window displayed when the application is launched (arrows indicate the movement of the tested material and the suspended loads).

Based on the provided ideas, let us consider an example of conducting the laboratory work titled *"Determining the Elastic Modulus of Materials"* from the course on the resistance of materials using a modular application. The key variable parameters include:

•The type of material being tested;

•The diameter of the sample (a rod with a length of 10 cm is typically chosen for testing);

•The load suspended on the material being tested.

The load and the type of material to be tested are sequentially arranged in a cabinet of the experimental setup. The sequence of conducting the experiment is provided in the questionnaire. During testing, the placement of the material and the load is depicted in Figure 1.

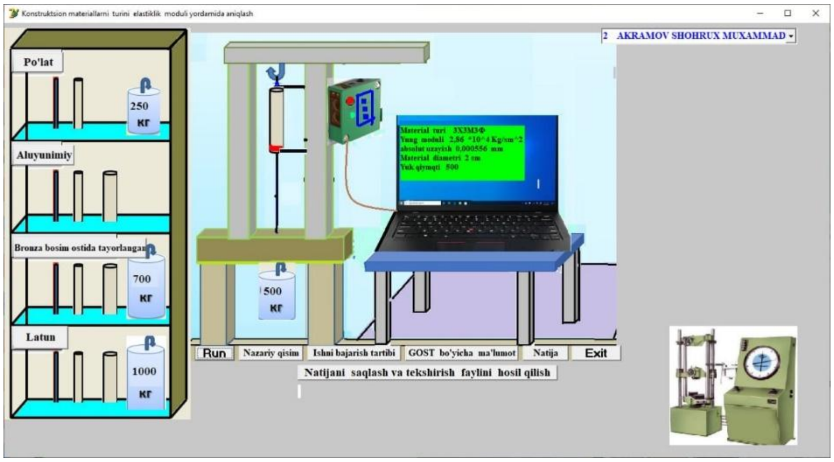

Figure 2. Screenshot of the window generated during the application loading process. (The movements of the tested materials and suspended loads are indicated with arrows.)

This application has been implemented by the author in the process of conducting laboratory work as part of the *Applied Mechanics* course. The application is capable of distinguishing between 18 types of "Steel" materials, 13 types of aluminum alloys, 22 types of brass alloys, and 17 types of bronze alloys.

It is well known that such physical testing equipment is unavailable in some universities. In such cases, the practical sessions are limited to verbal explanations and sketches, which provide students with an opportunity to visualize the information. In universities where such testing equipment is available, only a limited number of students can complete the laboratory work within a single session.

However, since almost all universities now have computer laboratories, conducting laboratory work using virtual applications allows an entire group of students not only to complete the tasks but also to have sufficient time for discussions and question-and-answer sessions.

Figure 3 shows a list of material types for the above-mentioned laboratory tests presented via a questionnaire.

The application developed by the author is independent of the computer operating system and does not require special training for use. Additionally, making some modifications to the application to update it to modern standards is not complicated.

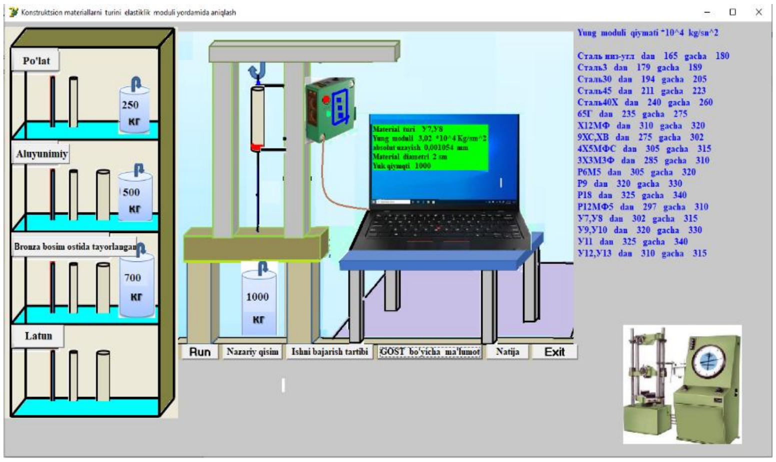

Figure 3. Screenshot of the window displayed during the use of the equipment.

Let’s focus on another application for conducting laboratory work. This application is dedicated to the study of gearboxes (reducers) in laboratory settings. It is well known that equipment designed for conducting such laboratory work is quite rare. Meanwhile, it is difficult to imagine modern mechanical engineering without such devices. In such cases, using virtual laboratory work is clearly the most appropriate solution.

The gearbox is a device adapted to transmit rotational motion by changing the kinematic parameters of the wheels within it. The rotational motion angular velocity of shafts in industrial electric motors is typically 3000, 1500, 100, or 750 rpm. It is impossible to transmit this motion to other devices without modification. For example, the speed of belt drives used in mining operations needs to be adjusted according to the working conditions. As a result, conducting laboratory work under the title “mining operations” becomes mandatory for students pursuing education in this field.

A software application developed with the participation of the author and registered with the Ministry of Justice of the Republic of Uzbekistan has been created for conducting such laboratory work. The application is launched via a computer and provides the following capabilities:

- Selection of the rotational speed of the electric motor shaft;
- Input of the output shaft rotation value of the gearbox (rpm);
- Input of the required power value at the output shaft (kW);
- Input of the efficiency value.

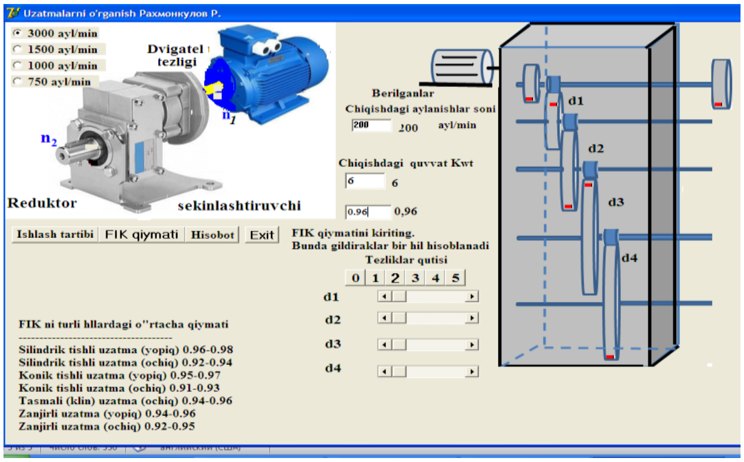

Figure 4. A screenshot of the application for studying the working processes of gearboxes

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•**Specifying the parameters of the resulting motion on the output shaft** (e.g., the type of motion after transmission—chain-driven, gear-driven, belt-driven, friction-driven, etc., each with its specific FIK value).

•**Selecting the number of stages based on operational requirements.**

This application can be used not only for teaching students about laboratory work on gearbox topics but also for the broader purpose of designing gearboxes.

Below is a brief overview of gearboxes. A gearbox's type is determined by the composition of its transmissions and their arrangement, which governs the speed relationship between the input and output shafts.

For designation purposes, the following Russian alphabet letters are used:

Ц (Ts) – cylindrical, **П** (P) – planetary, **К** (K) – conical, **Ч** (Ch) – worm, **Г** (G) – globoid, **В** (V) – wave-shaped.

If there are two or more identical transmissions, a corresponding number is added after the letter. If all transmissions are located in the same vertical plane, they are given an index. If the transmission is intended to reduce the number of revolutions, a **Т** index is added; otherwise, a **Б1** index is assigned.

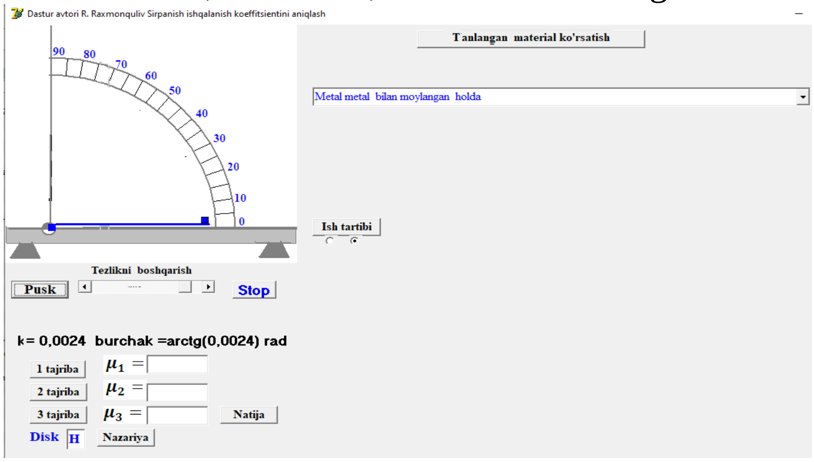

Figure 5. Screenshot of the application window for determining the coefficient of friction. "Title: Initial State"

Another virtual laboratory work developed by another author is dedicated to determining the friction coefficient that occurs between materials. The screenshots of the window produced during the application's use are shown in figure 5. The application provides the ability to visually determine the friction coefficient between over 60 different materials.

No special training is required to use the application. As shown in the figure on the monitor, the operation procedure of the application is presented by the "Operation Procedure" button.

In this process, the materials placed on the horizontal ruler should be lifted in relation to the ruler's horizontal line, ensuring that the test material does not slip off the ruler. The experiment is repeated three times, and the results are recorded in the μ coefficient window. To ensure the application works on any computer, the name of the downloaded hard disk is displayed.

The friction coefficient between materials is a critical factor to consider in manufacturing companies. From this perspective, it is essential for students studying mechanical engineering to learn and understand this laboratory work.

Conclusion

Based on the above points, the following can be concluded:

- Writing computer-based applications and implementing them can not only speed up the design process but also increase the accuracy of the project. An example of this is the "Determining the Elasticity Modulus of Materials" application. This problem occurs frequently in practice, and for this, there is no need to purchase expensive testing machines in enterprises. Especially in market economy conditions, such an offer is of significant importance.
- Through the second application, designers can modify project parameters and analyze and review the obtained results based on visual representation, thus improving the accuracy of the project without wasting time.

Based on the above points, it can be said that in engineering education, the use of application software can replace the laboratory equipment that is lacking in higher education:

- First, this provides an opportunity for students to gain knowledge while waiting for the purchase of equipment.
- Second, there is no need to purchase expensive equipment.

Furthermore, there are many chips available in the global market today, and they can be widely applied in technology. This creates the foundation to conduct virtual laboratory work and obtain results that are no different from those obtained on real laboratory equipment.

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