Improvement of Teaching Higher Mathematics to Technical Students on the Basis Of the Application of Interactive Learning Tools

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A B S T R A C T

As part of the study, the article pays special attention to the combination of distance learning through the use of interactive learning tools, with the traditional form of education. Based on the analysis, the advantages of using interactive simulators and test generators are noted: accessibility, convenience, modularity in structure, ease of use, etc. The authors show that the use of interactive teaching aids is one of the successfully developing innovations in the organization of the educational process, and is also a new high-quality and progressive type of knowledge acquisition by students through modern information and communication educational technologies at a distance from the educational institution. As a result of the study, it was determined that due to the use of information technologies, the real workload of the teacher is reduced. It was found that the process of professional training of university students through the introduction of interactive teaching aids is carried out more efficiently.

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Back in the 60s of the last century, at the dawn of the development of information technology, theories about the creation and use of computer programs in education began to be developed. However, then the mass introduction of these technologies into the learning process was impossible. The rapid development of information technology in recent years has opened up new possibilities for using computers in the learning process. At present, almost every family has personal computers, and there is also a process of equipping not only schools, but even kindergartens with the latest computer equipment and software. Therefore, today's school graduates have an increase in the level of computer culture, compared with school graduates of past years [1].

Modern society makes high demands on the level of training of university graduates. Considering the need of all sciences for elements of mathematical culture, the growing role of mathematical methods in all research and in the process of teaching students of all levels is quite obvious. Traditionally, mathematics is a discipline of increased complexity for both school and university students. It is worth considering the steady trend in recent years towards a decrease in the quality of mathematical training of school graduates, the inability of most first-year students to operate with a large amount of information and highlight the main thing, as well as their undeveloped skills of independent work. In addition, the reduction in the number of classroom hours for basic education in mathematics introduces additional problems in the organization of the educational process. It becomes obvious that at the moment it is possible to improve the quality of education only through new forms and methods of organizing the pedagogical process and structuring the material.

In the study of mathematical disciplines, training during the first semester occupies a special place, since during this period the process of intensive adaptation of first-year students takes place. However, in the first semester, students at TSTU are supposed to study the material in sections: linear algebra, vector algebra, analytic geometry, and also begin to study mathematical analysis. The amount of time allocated by the program for this purpose in all specialties of the Faculty of Mechanics is only 36 hours of lectures, and the same number of hours of practical training.

Now there is a growing interest in those technologies and teaching models that take into account the individual characteristics of students. This seems to be especially important in the process of teaching higher mathematics in the technical specialties of TSTU in the first semester, since the students will be able to get involved in work so quickly and effectively, it affects not only their academic performance in this subject, but also on successful educational activities in subsequent courses.

Thus, we can single out the following principles and factors that formed the basis of our work:

1) low level of mathematical culture of school graduates;
2) the practical absence and the need to develop independent work skills among first-year students;
3) increasing the user level of personal computer proficiency among school graduates;
4) building an individual trajectory for the formation of mathematical culture by interactive teaching aids;
5) Individualization and unification of the current and intermediate certification.

We have formulated the following tasks:

- ✓ development of interactive teaching aids to improve the quality of assimilation of educational material;
- ✓ development of software that simplifies and makes more efficient the process of current and intermediate certification of students;
- ✓ Conducting experimental studies aimed at identifying the effectiveness of the use of these software products in the learning process.

To this end, taking into account the principles and factors noted above, we have created two types of programs: interactive simulators and test generators, in three sections of higher mathematics (linear algebra, vector algebra, analytical geometry). All programs were developed in accordance with the state standard for the course of higher mathematics for technical specialties of TSTU.

Interactive simulators and test generators developed in the Adobe environment Captivate [2]. Simulators allow students to independently improve their skills in solving problems in these sections at any time. In each such simulator, the most typical tasks of this section of mathematics are selected, and they are also structured by difficulty levels. There are only three levels of difficulty.

The first level of difficulty is low. The tasks at this level are the simplest; they are the minimum necessary to obtain a satisfactory mark on this topic. For example, tasks of the first level of complexity in the linear algebra simulator are actions with matrices of dimensions 2x2, 1x3, 3x1, calculation of second-order determinants, solving systems of two linear equations with two unknowns that have a unique solution.

The second level of difficulty is medium. By learning how to perform tasks at this level, a student can get a mark of “good”. This level includes tasks that are similar to the tasks of the first level, but require more calculations. In the same linear algebra simulator, this level of complexity is represented by the following tasks: actions with matrices of dimensions 2x3, 3x2, 3x3, calculation of 3rd order determinants, solving systems of three linear equations with three unknowns that have a unique solution or no solution. It should be noted that all numerical characteristics in the conditions of these tasks, although determined randomly, are integer and range from -5 to 5.

The third level of difficulty is high. This level contains tasks that will allow the student to master the material "good" and "excellent". The essential difference between tasks of this level and tasks of the previous level is that numerical characteristics in the conditions of tasks are taken in the range from -9 to

9, but also remain integer. This fact greatly complicates the computational process. And also this level may contain more complex tasks that require better knowledge of theoretical material on this topic. The linear algebra simulator has tasks in this level of complexity: actions with matrices of dimensions 2x3, 3x2, 3x3, calculation of determinants of the 3rd and 4th orders, solution of systems of three linear equations with three unknowns, having any set of solutions.

Thus, thanks to the division of tasks into levels of complexity, each student can choose an individual trajectory for learning and consolidating the material, based on their own knowledge. The teacher can make adjustments to the learning path chosen by the student or, if necessary, it can be initially determined by the teacher. For example, if a student feels insecure about a given topic, then he can begin to solve problems of the first level. Then, having acquired the necessary problem-solving skills, move on to the second level. And finally, when he masters the second level, start solving problems of the third level of complexity. There is another option for student learning. If a student feels capable of solving problems of the third level immediately after the classroom lesson, then he does not need to solve problems of the first level first, he can immediately consolidate and at the same time test his skills at the third level of complexity. Then if he copes with these tasks, then we can assume that he has mastered this topic, and if he does not cope, then he always has the opportunity to go down to solving problems of a lower level.

Since at each launch of the simulator task all the numerical characteristics in its condition are determined randomly (using a random number generator), a large number of tasks of the same type are obtained. For example, if we take the problem of adding two 2x2 matrices, then there are 8 numerical parameters in the condition of this problem. If each of them is given randomly in the range from -5 to 5, then we will get 11^8 =214358881 different options for this task. Moreover, during the initial development of the mathematical model of these problems, undesirable options in the data of the problem are deliberately excluded, for example, so that division by zero does not result in the solution process. The previously used printed textbooks and teaching aids have a small number of tasks, do not allow each student to be given an individual task, and even more so to rank them according to the level of complexity. Therefore, such simulators are more effective for students to acquire independent work skills.

Another significant advantage of simulators is that when solving problems, the student immediately sees at what stage of the solution he made a mistake. Therefore, he can, having corrected the error, continue the solution correctly. This is important, because when solving a problem in the traditional way, if a student makes a mistake in the first step, then the wrong solution will follow. At best, he will understand that he made a mistake only when he receives the wrong answer, but he will not be shown exactly where he made a mistake [4]. In the simulator, a check is carried out after performing each action, while an incorrectly performed action is highlighted with a red frame. Only after the error has been corrected will the simulator check that the following actions have been performed correctly. Thus, with the help of these simulators, students not only improve their mathematical culture, but also have the opportunity to exercise self-control. For example, on the eve of writing a test or passing an exam, a student can check for himself, with the help of a simulator, how correctly he performs certain tasks.

The target nature of the described simulator is associated with the formation of primary knowledge and counting skills, as well as the consolidation of the studied material by students on the topics described above.

We also note that these simulators can be used both separately and in conjunction with interactive workshops, depending on the amount of time available to study the subject, the computer equipment of the classrooms, the level of students' preparation and the expected learning outcome [3] .

To simplify the process of current and intermediate certification, special computer programs (test generators) were developed. These programs allow you to create a large number of different options for tasks for conducting tests in the traditional form. This form of examinations remains relevant and widely used, despite the introduction of an electronic form. However, when conducting tests, it is very convenient when each student has his own unique version of the task. In this case, the knowledge of each student is checked more qualitatively and with greater individuality, since the student performs the proposed tasks on his own, relying solely on his own strength, and not hoping for outside help. But then a large amount of work falls on the teacher, but compiling the required number of options and getting the

correct answers to them, and this is not counting the direct verification of student work. Therefore, we can say that these programs are created to help the teacher.

Test generators are used by the teacher to create the required number of options for control tasks on the selected topic. Since, as in the case of simulators, every time the program is started, all the numerical characteristics in the tasks are determined anew using a random number generator, this practically excludes the possibility of tasks matching for some two students in a group (if we take an average group of 30 person) or further on the course. These programs allow you to issue options for work of various levels of complexity and designed for a different amount of time for their implementation, which means that they can be used for current and intermediate certification of students.

In addition, control tasks created in this way contain answers and intermediate results in a special column, which allows the teacher to check the work more efficiently and quickly.

In the control groups, students studied according to the usual scheme for this university: attending lectures and practical classes; doing homework after each practical session (usually quite large, about 15 tasks); upon completion of the study of each section, writing an classroom control work (usually 4-6 different options per group). An exam is held at the end of the semester.

In the experimental groups, training took place according to a different scheme. Students also attended lectures and practical classes, which were held in a traditional way. After each practical lesson, the students completed their homework similar to the tasks in the control groups, but of a smaller volume (3-5 tasks). In addition to homework, students worked with simulators. Each practical lesson began with a small test work, and at the end of the study of each section of mathematics, a control work was carried out (tasks for these works were obtained using test generators). A colloquium was held in the middle of the semester, and an exam was held at the end of the semester.

The simulators were not used in the classroom, because the university does not have enough computer classes to be able to conduct mathematics classes, providing each student with a personal computer place. However, now almost every student has a personal computer at home, and even students living in dormitories most often have a computer in their room, that is, one computer for three to four people. Therefore, the use of such simulators seems to be possible for independent work of students.

Before the start of work, a survey was conducted in the experimental groups. Its results show that interest in the use of interactive learning tools is increasing every year. This is also due to the fact that now it is possible to solve trial options in the Online mode when preparing for the DTM .

For clarity, we present some results of the surveys in 2019 and 2020. The survey involved 57 people in 2019 and 68 people in 2020.

Before starting work in the experimental groups, a survey was conducted to find out the attitude of students to interactive teaching aids (ISL). The results of this survey are reflected in diagrams 1 and 2.

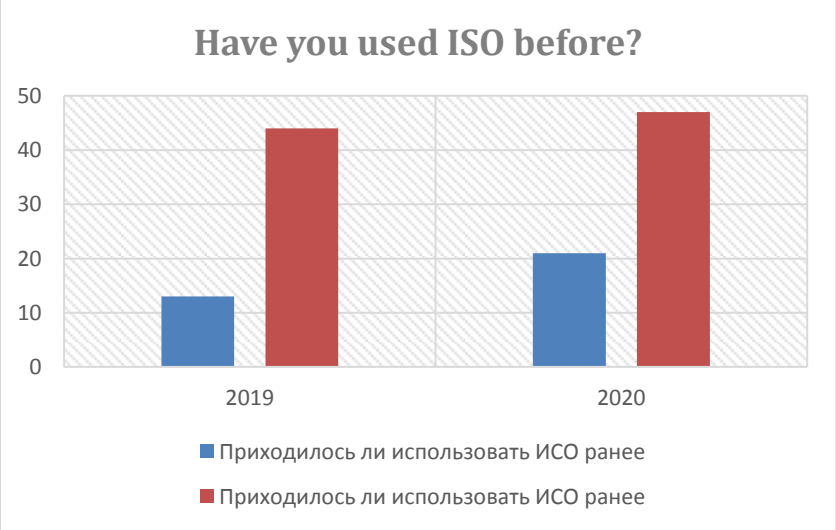


Diagram 1

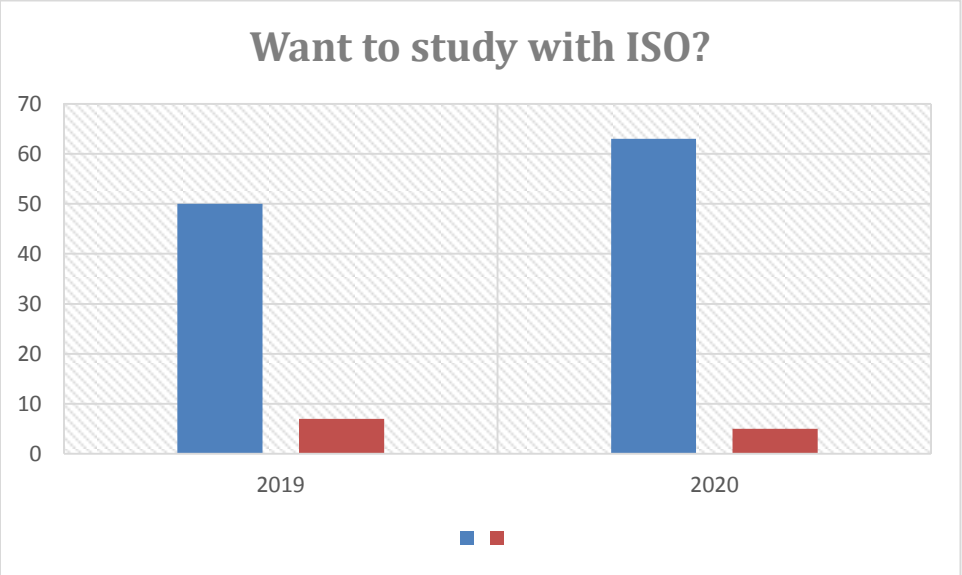


Diagram 2

At the end of the first and beginning of the second semester, a second survey was conducted in the experimental groups. The results of the survey of students of the 2020-2021 academic year at the beginning of the second semester are shown in diagrams 3 and 4.

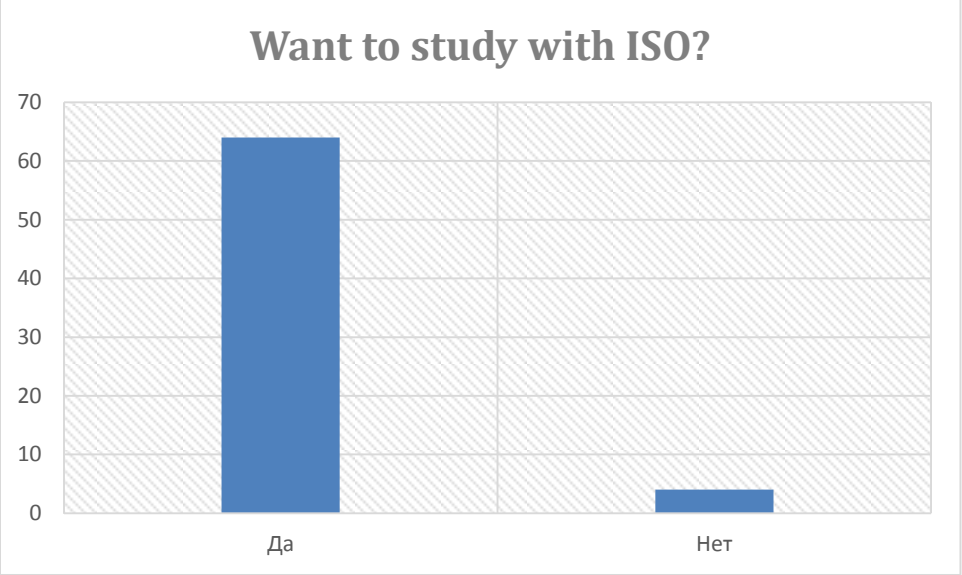


Diagram 3

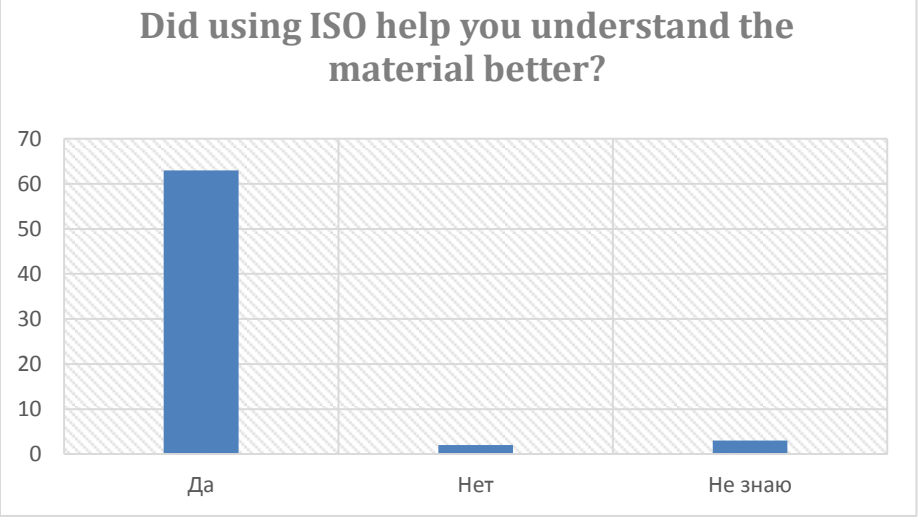


Diagram 4

Also, students noted the following positive aspects when working with simulators: a convenient form of work; the ability to correct errors; timely verification; no need to write with a pen; visibility of the task execution algorithm; interesting to work; saving time; replaces the teacher.

All test and examination results were recorded. Based on the results of work in the first semester of the 2020-2021 academic years, we can build the following graph for comparing student performance in the experimental and control groups (Diagram 5).

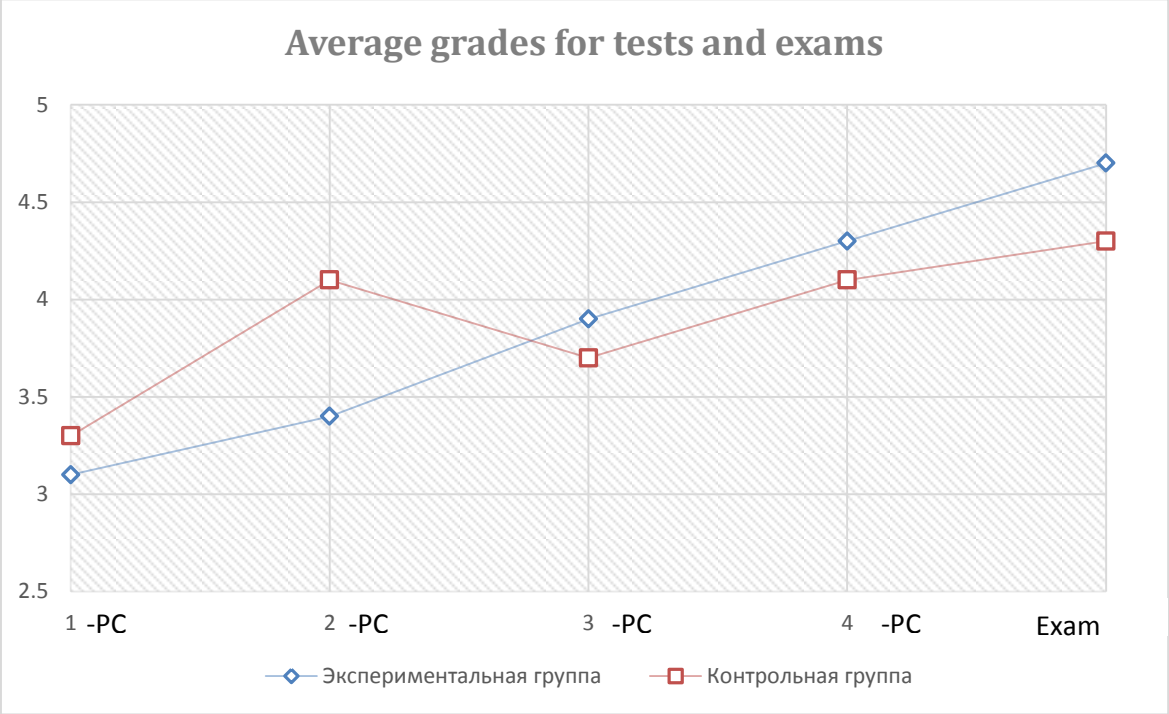


Diagram 5

The technology presented above can also be implemented in teaching other disciplines, for example, economics, physics, and also the humanities.

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