

Use of Information and Communication Technologies for Teaching Mathematics

V. D. Polezhaev¹, L. N. Polezhaeva² and V. V. Kamenev³

¹Moscow University of Law and Finance (MFUA), Moscow, B. Cheremushkinskaya Str. 17A, 117447, Moscow, Russia

²Plekhanov Russian University of Economics, Stremyanny per, 36, 117997, Moscow, Russia

³Moscow Automobile and Road Construction University (MADI), Leningradsky prospect, 64, 125319, Moscow, Russia
vpolej@gmail.com

Abstract. The paper discusses the ways to improve methods and algorithms of the automated control of knowledge, approaches to the establishment and effective functioning of electronic teaching complexes, which include tests of a new generation, and their use is not limited control purpose only. Possibilities of computer-based Internet-testing system SCIENTIA are presented. This system is a tool to automate the control of knowledge that can be used for the assessment and monitoring of students' knowledge in different types of exams, self-control of students' knowledge, making test materials, creating a unified database of tests on a wide range of subjects etc. Successful operation of informational system is confirmed in practice during the study of the course of mathematics in the Technical University.

Keywords: Internet, information and communication technologies, assessment, quality control, education, the level of educational achievements, computer testing, monitoring, university.

1 Introduction

Building an effective education system that is capable to form a creative person who is ready to work in a fundamentally new information environment of the XXI century puts on the agenda the problem of the active introduction of information technology in the learning process, the development of a unified educational information environment. This environment will bring together educational and scientific potential of leading universities and other educational institutions into a unified system. Moreover, it is very important to use the latest smart achievements unhesitatingly spread into all spheres of life, as the application area of their use has become much more diverse. Recently, universities in Russia have paid great attention to the use of information and communication technologies (ICT) in teaching mathematical and other subjects. Using these technologies provides a number of advantages in the field of information technology.

Computerization is one of the main stages of modernization of modern education. This is quite justified, because the new information technology offer some significant

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advantages over the traditional methods. Using modern computer technology students have the opportunity to read the most recent teaching materials created in the departments, whereas the publication of the paper takes a long time and these texts could become obsolete or lose relevance. It should also be borne in mind that in many cases the number of textbooks in a library is insufficient or some books are not available.

Computerization is one of the bases of modernization of modern education. The use of information technologies in the educational process certainly has many advantages [1]. Modern technologies enable the diversification of the study of mathematics. Using presentations, animations and video material a professor can more clearly explain a new topic. Presentation slides significantly reduce the time that it takes to explain the material. Due to the use of information technologies in a classroom a teacher can show the fragments of educational and scientific films, tables, graphs and diagrams, animations of mathematical processes and phenomena, the work of technical devices and experimental setups, photos and so on.

The use of almost all types and forms of educational information resources in educational practice substantially improves the quality of visual and audio information, it becomes brighter, more colorful, more dynamic. Modern multimedia technologies have tremendous opportunities. In addition, the use of electronic educational resources and advantages of modern telecommunications in training radically changes the way of creating visual and audio information. The traditional visual learning means refer to a specific object. Now dynamic interpretation of the essential properties of not only real-world objects, but also scientific laws, theories, concepts and so on becomes possible with the computer and telecommunication technologies.

The use of modern technology enables one to make any activity more visible, work with various information, such as sound, text, photos and video. However, some teachers overuse these opportunities, justifying it by the fact that a modern student is not inspired by narration and lectures alone. It is important to remember that information technologies should complement the material rather than replace it. Technology has changed beyond recognition, but the core values remain the same in education.

Sometimes it seems that information technology brings to the educational process only positive things. Of course, in most cases it is true, but there are two sides of every coin. Probably there is no such a teacher who does not understand that the use of the computer in a classroom is not just a fad. Obviously, the use of modern equipment, software, electronic educational resources helps one to conduct lessons more easily and make them more interesting. But one should not forget that the information technology is not a cure-all, but a good learning tool in the hands of a wise teacher. Their use should be thoughtful, reasonable and competent. Only the talent and skill of a teacher will find a middle ground in the use of information technology.

The purpose of this study is to develop modern methods and new scientific and methodological approaches to learning mathematics, using innovative technologies of students by universities, as well as the experimental confirmation of the pedagogical usefulness of the proposed methods.

The analysis of modern scientific and methodical literature enables the selecting of the main areas of ICT use in education [2].

1. Information and methodological support. This area provides a qualitatively new level of access to a virtually unlimited volume of scientific and methodological information.
2. The means of organization and management of the educational process, which consists in determining the content and sequence of the presentation of learning content, record keeping and evaluation of students' work.
3. The means of improving the psychological and pedagogical conditions of educational activity, which creates opportunities of independent choice of the priorities, forms and learning pace for students.
4. The means of communication, which gives students opportunities to communicate with teachers, other members of the educational process regardless of location.
5. The means of modeling, automation of the experiment and analyzing the results. Modelling of processes and phenomena, especially fleeting and inaccessible ones to direct observation, makes it possible to study them. Automation accelerates experimental studies of mathematical parameters measurement processes, accumulation and processing of information and frees up time for other learning activities.
6. Means of automation control and correction processes of learning outcomes, testing and diagnostics. Obtaining timely information about each student enables the use of a differentiated approach to the learning process and ensures the provision of necessary methodological assistance.
7. The means for teaching and scientific and research activities of students and teachers. Information technologies provide the performance of training and research projects.

Quality training of highly qualified specialists in modern conditions requires from students not only basic knowledge, but also fundamental knowledge for understanding principles of advanced technologies. This implies an increase of the actual volume of educational material and reducing the number of classroom hours. To solve such a complex problem is possible only with the use of modern information technology. Different training systems with using information and communication technologies, including distance learning, have become part of life. With many similar features and capabilities they, nevertheless, have their own characteristics depending on the specifics of subjects and requirements for learning outcomes.

The implementation of competence-based approach in accordance with the requirements of the federal state educational standards of higher professional education provides the widespread use of active and interactive technologies of lessons, contributing to the accumulation of professional skills of students, and a significant increase of the volume of students' self-study in the learning process.

Improving the quality of teaching, the quality of training is one of the main problems of the functioning of any educational system. In order to work effectively to improve the quality of training a teacher must have reliable information about students' achievement level. In the context of mass education in the modern university and the increasing volume of work, especially increasing number of students per teacher, regular receiving such information about each student becomes problematic. To objectively assess the knowledge and skills of students in one group during one lesson is difficult even for

experienced teachers. Recently, due to the significant decline in hours for the study of natural sciences, it becomes relevant to improve methods and forms of control of students' knowledge.

In connection with the requirements of the new federal state educational standards of higher professional education it is very important to create new electronic teaching materials. They should contain tests of a new generation (competency test, practical skills, and others). Moreover, their use should not be limited only by assessment. Increasing the potential of test technologies for training, creating special thematic and other training test systems would be beneficial for a more productive organization of independent work of students.

Testing has extensive experience of applying in education system. The use of information technology in the learning process leads to the search for new opportunities in diagnostic activities. One important area in this respect is the general approbation and implementation of computer-based testing. Problems of computer control of knowledge are usually considered in two aspects: technical and methodical. Methodical aspects include planning and organization of the controls, definition of the types of issues in tasks, making a set of questions and tasks for exam, the definition of evaluation criteria for each task and variant. Technical aspects include sample control tasks on the basis of the chosen approach, the choice and use of the system parameters of knowledge control, the choice of algorithms for the assessment of students' knowledge etc.

The assessment of educational achievements of students is a part of quality assessment in university. Automation control is closely related to the automation of the entire educational process and provides feedback to the automated control systems of educational process.

The types of automated control are described further.

- Input control is designed to determine the initial level of students in order to select candidates for further training, to define a learning style, the best one for a student for maintaining a high level of cognitive interest, to compile an individual learning trajectory.
- Current control is designed to test the degree of mastering learning content and learning readiness of students to the study of the subsequent material, to correct an individual learning trajectory, to perform a regulatory function.
- Periodic monitoring is designed to verify the degree of learning content assimilation by students. It performs less than the current control and covers entire sections of the curriculum. The basic form of periodic monitoring is a mastery test. In addition, coursework, control tasks and so on are used. For periodic monitoring the same tests as for the final control are usually used.
- The final control is designed to test the quality of students' performance of the curriculum and is held in the form of the examination of a discipline, to make a decision about the assignment of degree.
- Self-control is designed to determine the success of learning, to find gaps in the study of a discipline, to adjust an individual style of learning.

- Mutual control is designed to set up evaluation algorithms and qualities, to increase the objectivity of assessment by a student's participating in this process himself or herself.

Automation can significantly increase the role of all forms of control, particularly self-control and mutual control; discover new aspects of their application. Not all methods of control may equally be the subject of automation, but with the development of information technologies new possibilities open for it.

2 Online testing system SCIENTIA and its features

Creating a model of web-based technology testing system is a highly promising and urgent scientific challenge. Moscow State Automobile and Road Technical University is actively involved in the integration of testing information and communication technology. The department of information and technical training instruments developed and put into operation the system of computer online testing of students SCIENTIA (Internet address – <http://scientia-test.com/>).

SCIENTIA is a versatile tool for the automatization of the control of students' knowledge. It can be used for a wide range of tasks [3]. The system works on the basis of a website for testing, it has proven its effectiveness in a number of successful tests in the learning process.

It provides:

- the efficient automation of testing and assessment with broad functionality;
- user-friendliness with a modern user interface;
- elimination of mathematical and time-consuming works due to the automated processing of the results;
- the creation of a stand-alone test by teachers and the autonomous operation of the program by students (at self-control).

To run the system SCIENTIA there is no need to install a special testing program on each computer, as in many other products, a modern web-browser for passing tests and to creating them is enough. Information security is provided by creating accounts with limited access and other means of protection.

The test constructor has a built-in text editor, which enables one to format a text in an arbitrary manner, to carry out the insert of graphics and tables, to insert the data in various formats, for example, from the document OpenOffice. In addition, the testing system supports the standard Unicode character encoding.

During work the analysis of the functioning of various systems of online testing was carried out, their features, advantages and disadvantages were studied and considered in the development of SCIENTIA software. The developed system satisfies the majority (but not yet all) of the requirements put forward at the stage of formulation of the problem. The department of information and technical training instruments is constantly developing, improving and complementing SCIENTIA. With the help of this system, it is possible to effectively determine the compliance of student's knowledge in the subjects with the requirements of the federal state educational standards of higher professional education. Test materials are widely used by teachers of for monitoring

and interim assessment of students and for the assessment of students during examinations and tests as well. The legal basis of exams in the test form is fixed in local regulations of the University. The challenge for developers is to bring the system to the point in which it meets all the needs of users and consistent with the present level of informatization of education.

3 Computer testing – an effective tool for monitoring and evaluation of students' knowledge

Achieving high quality of education makes it necessary to use different methods of monitoring and assessment of knowledge and skills of students. Knowledge control is carried out in the traditional manner in the form of tests, examinations, written papers, reports, presentations, abstracts, computer presentations, etc. The measured results is a powerful stimulus to revise positions in the educational process, both for a student and a teacher. Test results make it possible for a teacher to quickly identify and resolve emerging students' difficulties and shortcomings in their own teaching.

However, students sometimes do not agree with the assessment that a teacher has exposed. At the same time students adequately respond to the objective, reasonable and transparent evaluation results obtained by the machine control. Therefore, computer testing can be identified specifically as one of the most effective forms of control of students' knowledge. The complexity of this process makes it relevant to computerize it. With the appropriate material-technical base (network computer classes) it is easy to organize preliminary (input) and the current test. The input testing of first-year students enables the determination of their residual after passing school exam. Subsequent testing makes it possible for a teacher to assess students' knowledge obtained after visiting lectures, carrying out practical and laboratory studies.

At mathematical departments computer testing based on SCIENTIA system is widely used as a mean of monitoring and assessment. It is carried out at different stages of training in mathematics from the input to the final. This testing is not the only method of assessment; it is used together with other conventional methods, such as oral and written interviews, examinations, practical work, and exam.

Getting to the study of mathematical course students take the entrance test, in which a teacher and a student get an objective picture of the residual post-school knowledge of mathematics. Ever since the time of the entrance examination in mathematics teachers of the department have created an extensive bank of tasks of varying complexity, which in recent years has been transferred into computer input testing. Students begin studying a mathematical course with different levels of knowledge; their Unified State Exam scores show it. In one group there are often students who have significantly different scores: from the lowest possible to enter a University to the maximum possible on the scale of the Unified State Exam.

The entrance testing held by mathematical departments allows to compare results of the Unified State Exam for each student to the result of assessment of his residual knowledge of mathematics several months later after leaving school. Tasks of the Mathematics Department entrance test have only the first (easy) difficulty level, they have

been designed for the recognition and playback of the basic mathematical concepts, skills, application of the basic laws from memory. Test contains 10 items from all areas. Maximum score, as well as in the Unified State Exam, is 100. The received results demonstrate that correlation between knowledge which is shown by graduates of schools on the Unified State Exam and their basic knowledge with which they come to the university is traced. There is a certain correlation of residual school knowledge of students with the points received on the Unified State Examination in mathematics.

On average, in recent years the percentage of students who showed the lack of preparation to perform tasks that require basic school knowledge, has remained the same – 20%. This suggests the lack of proficiency of the subject in high school and the need for a propaedeutic course of mathematics for this group of students. At the beginning of the study of the mathematical course every teacher develops their strategy of individual work with these students [4].

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Thus, the computer testing provides information not only to teachers who determine the level of each student but to the group as a whole. The results of testing let students objectively assess their level of basic knowledge on the subject and try to improve it, be actively involved into the learning process [5]. These statistics can be accumulated further on intermediate and final tests.

The regular collection and analysis of the results of computer-based testing let a teacher evaluate the students' knowledge in general and identify issues that have caused difficulties. This makes it possible to improve learning. Certainly, the development of test items is a time consuming and methodically complicated process. However, computer testing, in addition to solving educational and pedagogical problems, enables the monitoring of students' independent work constantly. Experience in the use of computer testing in mathematics demonstrates high efficiency of the application of modern information technologies in the educational process.

In addition to information about the overall picture of academic progress, computer testing reveals the most difficult topics or the topics of the course which are the easiest to master, making it possible to optimize the learning process. The data obtained during the testing can be compared with the results of other control measures. At the same time, a periodic computer testing is useful not only as a tool to obtain data on the overall group academic progress for a teacher, but also as a means of self-examination and identification of "strong" and "weak" points in the structure of knowledge for a student.

This gives students an opportunity to work threads of various parts (modules) of the program not involving a teacher directly for this.

Students have unlimited access in the library. In the library there is a set of theoretical materials: basic theory; presentation of lectures; additional material for the expansion of knowledge, including a list of recommended information sources; laboratory practice – a list of laboratory works with links to their descriptions and worksheets; guidelines for solving tasks with the examples of solutions for each topic. All provided in the information system training materials (lectures, guidance, workshops, tasks etc.) has been scrutinized by teachers of the department. That guarantees high quality and proven sources of information on the subject. Thus, for each student a comfortable environment for studying mathematics is created. Each student studies theoretical material in the required amount and in such a form that is most appropriate.

The advantage of this information system is that it is a web-resource which a user can use with any modern browser on a laptop or desktop computer and a mobile device; a student can work in a computer lab at the university or at home, and even in public transport, at a convenient time, regardless of a teacher. Thus, the individualization of the learning process is achieved.

However, along with the advantages distance learning has disadvantages. First of all, there is a reduction of live communication of main participants in the educational process – a teacher and a student. It should be noted that the information system is not a rigid program; it is a growing, dynamic structure. All the materials in the library is constantly replenished, the bank of test items and tasks can vary at the discretion of a teacher, depending on the study program. Time of each level may vary depending on the complexity of the studied section, the level of students, etc.

Therefore, a useful tool for improving the quality of students' learning in the form of an information system has been designed, developed and implemented. The system contributes to the individualization of learning, providing each student with the access to the teacher's source of training materials. The information system provides all advantages of distance learning, but it still brings about losing live communication between a teacher and a student. Working with the information system teachers are able to see the details of each student's progress in each study group, to analyze the dynamics of students' academic progress. Test control is a mighty tool for monitoring. It does not only let a teacher to assess the knowledge and skills of students, check the level of assimilation of knowledge on the subject, but also contributes to positive motivation to learn, conscientious attitude to intellectual property, the desire for self-assertion, self-development and self-improvement, education readiness for active social activities.

4 Conclusion

The rapid development of informatization (computers, computer communications, and various electronic devices) creates new opportunities for the use of the computer in the learning process; it makes it more efficient, enables the efficient use of study time. It should be noted that similar information and communication technologies used by many of the leading universities of the world and their application in our universities

bring together a common approach to the education system. However, it is impossible not to highlight some features of the use of such technologies. All best ideas can be ruined by low-quality implementation.

First of all, there should be a lot of good quality tests. Test items should provide a comprehensive review of the essence of the assimilation of information, ability to apply it to solve practical problems. Hence, the main requirement for a testing system is the flexibility of the program and sufficient coverage of the subject by items. Answers to items should have a clear unambiguous interpretation. Level of tests must meet the relevant requirements.

Solving such problems is possible only in the universities with a highly professional staff. Computer software system of the university must be sufficiently developed and work without failures. It is preferably to carry out the control of the key elements in the classroom under the supervision of several teachers. Electronic database of students and testing should not be overloaded, otherwise the work on the lesson can be converted into control of filling of the database and it takes most of the time allotted to practice. At the end of the course it is advisable to test students for admission to the subsequent oral or written exam with the possibility of appeal to the competent committee. After the final assessment of the subject is put taking into account all the indicators.

The quality of education in general and mathematical education in particular is a multidimensional and multifaceted property of the result of training activities. It is determined by the variety of teaching and educational factors. Education system requires the creation of a unified information and educational and technological resource in the Internet based on resource integration and networking of various educational institutions. It will provide users with a wide range of different educational services, from access to materials of the distributed e-library to the opportunity to get education in any educational institution with virtual representation in the information educational environment. That may ultimately improve the quality of engineer training.

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