KNITU-KAI educational cluster: teaching mathematics

Z Ya Yakupov, R K Galimova, S I Dorofeeva, S V Nikiforova and N T Valishin
A. N. Tupolev Kazan National Research Technical University - KAI, 10 Karl Marx street, Kazan, 420111, Russia

E-mail: zymat@bk.ru; RKGalimova@kai.ru; drf-svetlana@yandex.ru; svetlana1605@yandex.ru; 5.vnaitl@yandex.ru

Abstract. The system of mathematical education at the A.N. Tupolev Kazan National Research Technical University (KNITU-KAI) is described. It is suggested that the mathematics course at a technical university should be diversified. This should be ensured for different areas by the difference in the selection of material, the placement of emphasis on the relevance of the studied sections of mathematics in the specialized disciplines. It is proposed that the development of interest in mathematics for future engineers can be provided by solving professionally oriented problems, showing the use of mathematical sections using specific examples from the disciplines of the professional cycle, and thus drawing the attention of junior students to the need to have solid mathematical knowledge. The author points out the significant role of online training courses at KNITU-KAI. It is assumed that e-courses allow a deeper study of the material presented by the teacher in lectures and practical classes, and they also provide an opportunity to qualitatively prepare for control activities, for intermediate certification.

1. Introduction

An educational cluster is a system that works in a single direction of professional training, which, as a rule, includes two or more subsystems. They provide professional training at various levels to meet the needs of production and research.

Educational cluster of the A.N. Tupolev Kazan National Research Technical University (KNITU-KAI) includes the Engineering Lyceum-boarding school; 2 colleges of secondary vocational education: Technical College (TC) and the College of Information Technology (CIT); 5 institutes: the Institute of Aviation, Land Transport and Energy (IALTE), the Institute of Automation and Electronic Instrumentation (IAEI), the Institute of Computer Technologies and Information Security (IRES), the Institute of Radio Electronics and Telecommunications (IRET), the Institute of Engineering Economics and Entrepreneurship (IREE) and Faculty of Physics and Mathematics (FPM) (Faculty teachers conduct classes in all divisions of the educational cluster).

The level of mathematical training is determined by the content of the lectures, practical and laboratory classes, individual tasks of the corresponding specialties (areas of training) of students. KNITU-KAI conducts training in 40 bachelors’ degree courses, 5 - specializations, 21 – masters’ degree courses and 8 specialties in colleges. About 8000 students in various areas of training annually study at only one of the departments of FPM, the department of special mathematics.

Thus, in order to take into account, the priorities of individual sections of mathematics for the areas of training students, the mathematics course should be diversified:
• by content;
• by depth and rigor of presentation;
• by forms of study (full-time, part-time and distance learning);
• by qualification (bachelor's, specialty, master's degree).

Great importance is attached to the interaction of the subjects of the subsystems of the educational cluster at KNITU-KAI [1].

2. On the diversification of the content of the course "Mathematics"
Let us dwell separately on the diversification of the content of the course "Mathematics". Working with students of various directions and levels of training, even in conditions of standard work programs, it is necessary to diversify the content of the course, focusing on the sections of mathematics that are most in demand in future professional activities. For example, for students of IRET is an operational calculus, Fourier series, elements of field theory, for IEEE - methods of making managerial decisions, and so on. In our opinion, diversification of the standard (classical) mathematics course is possible as follows:

• depth of presentation of the lecture material (definitions, proofs of theorems) depends on the direction and qualifications of students;
• examples illustrating theoretical material are selected taking into account the professional orientation of students;
• in the conditions of limited time for classroom studies, competent distribution of the material is of great importance: the most complex material is studied in classroom lessons, the material, which is simpler or detailed in the methodological instructions, is allocated for independent study;
• individual assignments, settlement and graphic works correspond to the qualifications of students (bachelor's degree, specialist degree, secondary vocational education (SVE)) and future professional activities;
• theoretical material and practical examples are also formed in electronic form on the BlackBoard Learn platform, which allows you to place additional information, give explanations to the most difficult to understand sections.

Taking into account that more than 8000 students of various directions pass annually through the Department of Special Mathematics alone, teachers must have a bank of options for tests, individual assignments, a list of theoretical questions in all areas of study, in addition, examples must be selected that implement the formation of competencies in this direction of preparation in the process of studying mathematics. Moreover, when selecting illustrative examples, a mathematics teacher must have an idea of at least the basic concepts of the specialty (areas of training) in which the training is carried out. When calculating the load on the teacher, only the hours allocated for classroom lessons are taken into account. The rest of the work (checking homework, independent, control works, individual assignments, computational and graphic works (CGW), conducting colloquiums, forming and adjusting the fund of appraisal means, creating distance electronic courses, consulting on the implementation of the RGR and preparing for the test) is carried out at the expense of the teacher's personal time.

Note that in recent years there has been a need for additional, correcting, leveling courses of elementary mathematics for freshmen, since gaps in the knowledge of elementary mathematics make it impossible to consciously master higher mathematics, and later on special engineering disciplines, including special sections of higher mathematics.

Book "Thoughts on modern mathematics and its teaching" written by L.D. Kudryavtsev, reveals the secrets of teaching methods, generalizing the experience of teaching mathematics. It is the deskbook for mathematics teachers of technical universities. L. D. Kudryavtsev writes: "Unfortunately, there are no exact recipes for teaching various branches of mathematics. The method of teaching mathematics is not the science, but the art" [2]. A brilliant lecturer, a world known mathematician who lectured at the
world's leading universities, L.D. Kudryavtsev (1923-2012) drew the attention of teachers keen on mathematics to the following: “We must always remember that when we teach mathematics to students who, due to their natural inclination, have chosen not mathematics as their future specialty, then only the material that is useful to them, which is available to them and which can be assimilated by them for the period of time that is allotted for this, and finally, that material on which it is possible to instill in them the mathematical culture they need” [2].

Conclusion from the above: mathematics for different areas of training cannot be presented to students in the same way, the differences will be in the selection of material, the placement of emphasis on the relevance of the studied sections of mathematics when mastering specialized disciplines [3-7].

Teachers of the Department of Special Mathematics at KNITU-KAI devote a sufficient amount of time and pedagogical skills in order to take into account the professional interests of students and satisfy all formed competencies in the limited time for mastering mathematics (according to the approved curriculum of the discipline).

3. On the methodology of teaching mathematics at a technical university

Another important issue is the methodology of teaching mathematics at technical universities, in contrast to the formulation and content of mathematics courses at the mathematical faculties of classical universities, where there is a department of "Mathematical Analysis", "Probability Theory" and so on. Teachers of mathematics at technical universities are "multi-tool": they must be well versed in various areas of mathematics, not to mention pedagogy, psychology, and improving their own professional skills.

The methodology of teaching mathematics in technical universities should be aimed at the formation of engineering thinking, which implies:

- fundamental physical and mathematical training, which has always distinguished the Russian engineering school;
- interest in the studied disciplines, including mathematics;
- development of general cultural competence, which makes it possible to transfer the ideas of applying research from one field of science to another, which often leads to scientific discoveries;
- use of modern information and communication technologies [20-23].

We believe that the development of interest in the study of mathematics for students of non-mathematical specialties and areas of training is facilitated by:

- setting and solving professionally oriented tasks [10,14,16,24], demonstrating the role of mathematics in engineering disciplines, stimulating a responsible attitude to the study of mathematics;
- acquaintance with the facts related to the emergence of ideas, scientific discoveries.

For students of technical universities, mathematics is a convenient, generally accepted language for describing real phenomena, and mathematical methods are fruitful methods of studying them. Our goal is to show, using specific examples from the disciplines of the professional cycle, the application of the mathematical sections studied in the first and second years, and thus draw the attention of junior students to the need to have solid mathematical knowledge. The solution of professionally oriented problems is the propaedeutics of solving the problems of special courses.

4. On the use of information and communication technologies in the educational process

Modern students, who are usually called learners, actively use not only the classical form of education: lecture - classroom practical classes - independent work, but also distance learning methods [25-28]. The transition from the traditional (full-time) form of education to distance (part-time) requires painstaking work, large time expenditures for the creation of an accessible, complete methodological
support, testing methods when checking the level of knowledge assimilation. The teacher is faced with a difficult task - to find that fine line, the proportion "full-time - part-time", in which students receive the necessary amount of new knowledge using distance learning methods.

Creating a high-quality e-course is a difficult and time-consuming task that requires a lot of knowledge, effort, time from the developer, and has a good command of the subject of the course and teaching methods of the subject. Involved students in the creation of e-courses can be viewed as an independent task that helps to master mathematics, pay attention to difficult moments to learn, and motivates independent work. Participation in the creation of an electronic course together with a teacher can be regarded as a kind of well-known idea of "Learning by playing" [23].

It should be noted that the well-known fact that today's world does not stand still, but is developing rapidly. The educational segment is also changing. Today it is impossible to imagine modern education without information and communication technologies. Technology is changing all areas of our lives, but its impact is most tangible in education, which determines the future of any society. We are entering an era of connectedness - from Internet of Things to Internet of Everything [26]. Students of KNITU-KAI actively use distance learning courses. First, e-courses allow you to study more deeply the material presented by the teacher in lectures and practical sessions. Secondly, the electronic course is an opportunity to qualitatively prepare for control events, passing a test and an exam, as well as pass trial tests in the corresponding section in order to independently check the level of knowledge gained.

Of course, a distance course (especially in the disciplines of the mathematical cycle) cannot fully replace classroom lessons, "live" communication with the teacher. But in connection with the covid-19 coronavirus epidemic, distance learning is becoming more and more relevant. In the changed circumstances, the experience of distance learning in self-isolation tells us that a distance course in mathematics can in the future replace up to 25-30% of classroom lessons.

Distance courses at KNITU-KAI are created on the BlackBoard Learn platform [25] and are available to learners at any time of the day and from any electronic device with Internet access. By the way, many text files can be downloaded and used offline. For the convenience of users, it is possible to download the application to a mobile device and use the course materials in classrooms. Login to the BlackBoard system (bb.kai.ru) is carried out using a username and password (individual for each student), which are issued when an applicant enrolls in KNITU-KAI.

Electronic distance courses at KNITU-KAI, in particular at the Department of Special Mathematics, have been created since 2012. This work does not stop until now: the teachers of the department supplement, modify, build on existing courses and create new ones.

Of course, everything new does not always evoke a positive reaction. This was the case with the introduction of electronic educational resources (EER) into the educational process of KNRTU-KAI: the students were distrustful of this innovation, did not know how to navigate the course and all the capabilities of the BlackBoard Learn platform, find the required information, and pass the test correctly and on time. But as practice has shown, both the students and teachers very quickly got involved in this process. Today, every 3-4 classroom lesson is interactive.

Advanced training courses on the creation, implementation and application of electronic courses, were organized for teachers, on the basis of the Corporate Institute of KNITU-KAI Note that creating an e-course "from scratch" is a titanic work for a teacher, which must be done "on the job", that is, in parallel with the main classroom load. Teachers of the Department of Special Mathematics successfully cope with this task, continue to work on the modernization of the created electronic courses and improve their professional skills in the field of information and communication technologies, regularly take advanced training courses, retraining and internships.

5. Conclusion

Digitalization is a transition of information into digital form, digital transmission of information data. To remain competitive in the era of mobile technology and social media, organizations must find new techniques to attract customers. These techniques should match today's digital reality. Companies that want to be a few steps ahead of their competitors put their consumer sense at the center of their
technology strategy [27]. Digitalization processes include educational activities. The educational process can be based on the use of web-platforms and be implemented at any time, and the role of the teacher will be the role of a mentor, assisting students to navigate in the information galaxy [28].

Note that the problem of teaching mathematics also lies in the fact that it is necessary in a short time to lay the theoretical foundation, to give specific skills required in the further work [29]. Preparation for lectures, practical exercises require thinking through many details, adjusting the content of the corresponding section of mathematics, depending on the audience and the direction of training. The idea of unifying the mathematics course for all areas of study, in our opinion, will not have a positive impact on the quality of education [5,7].

Classical spectral analysis, based on the application of Fourier transforms, is included in the working programs of the bachelors’ program. It would be useful to return to this topic when studying mathematical statistics, since real signals are random or noisy. Fractals that are not included in any curriculum are used in the latest methods of image processing [17,30].

The teacher needs time to get acquainted with modern sections of mathematics, to consult with colleagues, exchange experiences, to improve their cultural level and professional skills, and, at last, time to communicate with friends, relatives and family.

It is believed that one of the goals of studying mathematics is to create mathematical models. They try to present the observation of the processes in the form of powerful (informative) models that are selected from the knowledge space, based on the criteria of adequacy and convenience. Our task, as teachers, is to expand the space of knowledge. In conditions of time pressure, a careful selection of material is required, including basic modules that give an idea of the development of mathematics and its use in technology.

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