Teaching Fundamental Mathematics for Students of IT-specialties in the Transition Period

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Abstract. We consider the problems of the first-year students' adaptation to the learning process at the university. The technique of intensive adaptation of the first-year students of IT-specialties to the development of the basic concepts and methods. These techniques are subsequently actively used both in fundamental mathematics and programming courses. Considerable attention is paid to development of the creativity and independence in the acquisition of competencies. The principle of the "Flipped class" ("Inverted class") is used as the basic pedagogical technology. At the same time, it is supplemented by a number of methodological, information, and technological tools that reduce the effect of the known negative aspects of this technology. The network computer platform Ulearn.me is used as the information and communication mean for student learning. It is like well-known open education platforms. But it has an expanded feature set for educators. The results of experimental teaching are presented. We consider them both from the point of view of students acquiring the necessary competencies and the psychological aspects of using this technique.

Keywords: Training Software Developers, Flipped Class, Computer Training Platforms.

1 Introduction

Today, the need for IT specialists significantly exceeds the capabilities of the university graduates who train such specialists. The deficit in the cluster of the high-level software developers is felt even more acute. The traditional way of their gradual "growth" in the process of working in an IT company is too slow. At least to partially accelerate the growth many large IT companies organize internships of both senior and junior courses for students. But this approach does not solve the problems that arise when students study the main sections of mathematics in terms of their preparation as the IT specialists.

Focusing on the training of high-level IT specialists, we note that, as a rule, it is conducted in universities. Especially, it is done in those areas where the contingent of applicants has a fairly high level of initial preparedness in computer science and programming and acquired outside of the school education. At the same time, their mathematical preparation and their readiness to perceive fundamental mathematics are on a very low level.

Also, we note that the initial stay of the yesterday's schoolchildren in student status does not immediately change their existing school stereotypes of learning. Moreover, the transition from the classroom-lesson system to the lecture-practical system is often accompanied by a relaxed attitude of students to study. This confronts with a much more intense and concentrated presentation of the training material often with very negative consequences. Therefore, the fundamental mathematics during this period is mastered by the yesterday's applicants with great difficulty and very superficially; and more attention is paid to subjects in the programming and information technology field.

Following [1], we called this period the "transition" from school to university. In [1], it was also shown that the adaptation of students in transition has two sides: socio-psychological and educational-professional. There is an extensive literature on the study of the socio-psychological aspects of adaptation of the first-year students. As for the educational and professional adaptation of students of mathematical specialties, here, the range of publications is very narrow. Moreover, they usually consider students' adaptation to the study of the regular mathematical disciplines: mathematical analysis, algebra and analytical geometry. In a generalized form, the main problems are described in [2, c. 138]. Their solution forms the basis of educational and professional adaptation of students of mathematical specialties. The following problems are noted:

• low level of general educational skills (*e.g.*, to provide lecture notes, independently study textbooks, work on defining a new concept and on proving a theorem, solving a problem, speaking in front of an audience);
• difficultness and abstractness of the educational material;
• increase in the share of self-dependent work;
• psychological difficulties of the transition from the school to the university curriculum;
• misunderstanding the essence of the studied material;
• insufficient level of the mathematical culture;
• frivolous attitude to study and irregular preparation for classes.

According to the author [3, p. 144] solution to these problems must be sought through the development of special training tools that ensure the organization of active cognitive activity of students and reflect the logic of studying the discipline.

In our study, we specialize these settings for students enrolled in IT specialties.

2 Objectives of the transition period for students of IT specialties

As already noted, students who enter the IT profession have a sufficient level of programmer training, often, but they are not motivated to study the fundamental mathematics. Therefore, from the point of view of IT companies that need the high-level software developers, it is necessary to bear in mind the following aspects in the fundamental mathematical training of students:

• increasing the orientation of fundamental mathematical courses (algebra, mathematical analysis, discrete mathematics, probability theory and mathematical statistics, *etc*.) to development of the digital resources;

• development of skills of the highly productive self-dependent work of students in obtaining and mastering new knowledge in the professional field of digital resources based on the fundamental mathematical disciplines.

Within the transition period, these aspects can be clarified as follows:

• it is important to demonstrate to students the conceptual unity of mathematics and programming as a field of scientific and industrial activity;

• a radical change in the style of educational activity of students is needed that will significantly increase the role of the self-dependent work in obtaining and mastering new knowledge;

• providing conditions for the development of individual abilities to perform creative tasks.

3 Pedagogical approaches to solving problems of the transition period

We have developed an intensive course that students get to know before they begin to study all the math and programming courses. In this course, we consider the basic concepts and constructions that will be further used and developed in the fundamental and applied mathematics and programming. They were grouped into 7 topics:

• sets and elements of the mathematical logic;
• graphs;
• relations;
• math mappings;
• math operations;
• mathematical induction method;
• basics of combinatorics.

As for changing the style of academic work, we applied pedagogical technology called the "Flipped class". In this, we rely on the basic research [4]. In addition, an important component of this technique is the use of digital technology. The basic principles of use of the digital technologies in education are set out in [5].

Implementation of the technology of the "inverted class" is based on the self-dependent study of theoretical material and implementation of a few tasks.

To study the theoretical material, there are given video lectures (Vodcast) and the text versions of the lecture material. However, they are not matching verbatim. The definitions and formulations of the main statements are uniform in them. As for the proofs and the examples, which explain the concepts introduced, here, we strove for an enough technique.

The lecture material on each topic is divided into fragments that are close in meaning. The duration of each fragment is 15 to 20 minutes. Inside each passage, in the suitable places, the lecturer invites to pause and to complete some mini-task. This allows the student to evaluate whether everything in the listened part of the lecture is understood by him. Immediately after, the student starts continuation of reading the lecture, the lecturer explains how this task could be completed, and the student can compare this with his decision.

Practical exercises (conducted after this with the teacher) have the following structure:

• analysis of questions and difficulties encountered by the students in the self-dependent work (approximately, 25% of the total time is devoted to consideration of the topic in the practical classes);

• collective solving productive tasks on the topic (about 50% of the time of the practical lesson);

• fulfillment of the individual tasks (at the student's choice) of a creative nature (up to 25% of the time).

It is slightly different from the structure recommended in [4]. Firstly, 15% of the lesson time is allocated to the analysis of questions and difficulties, and secondly, the second and third components of the lesson are not divided. Our decision is dictated by the fact that we are considering the transitional period of student life.

4 Technological computer platform

The technological basis for implementation of the course is the network platform Ulearn developed by the SKB Kontur. For each topic of the course under study, this platform contains

• vodcast;

• text versions of the lecture material;

• tasks for self-fulfillment;

• tasks intended to be performed in the practical lesson on the topic.

Individual tasks of a creative nature were not placed on this platform.

For most tasks, an automatic check of correctness of the decisions is provided. For those tasks where automatic testing is not provided, the student himself notes whether he, in his opinion, coped with this task. All information about students completing assignments for independent decisions is available to the teacher conducting the practical classes in the group; and he takes it into account when planning the next lesson on this topic. If less than 70% of students completed the task, then it is considered in the practical lesson. The solution of the task is presented on the class-board by the student. who has marked it as resolved. This allows the teacher to accelerate the analysis of tasks intended for the self-solving before the practical training.

The Ulearn platform provides student the feedback with the teacher. This allows one to quickly respond to questions raised by their students, as well as, to provide on-line explanatory comments on the course materials.

Each student is registered in the Ulearn system, and all his actions are recorded. In particular, the teacher can find out not only about whether a student has solved or not solved a problem, but, also, how fully he has studied the theoretical material from the vodcast.

5 Organization of the experiment and its results

Experimental training was carried out in two groups of students (65 people) who entered the educational direction "Fundamental Informatics and Information Technologies" of the Department of Mathematics, Mechanics, and Computer Science of the Institute of Natural Sciences and Mathematics of Ural Federal University.

The intensive course that we developed was called the "Introduction to Mathematics". It is designed for 60 hours of the self-training (vodcast and independent problem solving) and 40 hours of the classroom instruction. Intensity of the course can be judged even by the fact that during this time students should master more than 130 new mathematical concepts and terms for them. The course itself was carried out over two training weeks.

According to the results obtained by means of objective measurement of learning outcomes, we note the following:

- more than 70% of students cope with at least 80% of the tasks (as part of the independent work before the laboratory and practical classes);
- from 50% to 65% of students independently cope with tasks of the productive level (in the laboratory and practical classes) depending on the topic;
- 15–17% of students independently cope with the individual tasks of the creative level.

Analysis of the use of materials to study the theory showed that, for the first acquaintance with the theory, 85.7% of students watched fully video lectures. Only 33.3% of students used the video lecture to repeat the material. For the text materials, these indicators were 45.2% and 73.8%, respectively.

As part of the objectives of our study, it is important for us to evaluate the significance of each component of the learning process both within the technology of the flipped class and other elements of the blended learning. The information obtained by the Ulearn platform is presented in Table 1.

Table 1. Preferences in choosing the presentation formats for the educational material.

Presentation format	Percentage of students browsing			
	more than 95% of lectures	70% to 95% of lectures	30% to 70% of lectures	less than 30% of lectures
Video format	63.1	24.6	9.2	3.1
Text format	24.6	23.1	38.5	13.8

As we can see, the most of students, when they first were getting acquainted with the theoretical material, have preferred video lectures, but more than 45% were getting with the material in the text format, too (some in the text format only). As the students showed, the appeal to the text format was motivated by the large presence in it of examples of the application of the studied methods. At the same time, the results of the laboratory and practical studies showed that students can and wish to independently convert the studied theoretical material into solving the practical problems.

Although 15 – 17% of students coped with the tasks of the creative orientation, more than 80% of students consider it useful to get to know them in the laboratory and practical classes. They were dissatisfied with the fact that, in their opinion, little time was devoted to solving such problems.

6 Discussion and conclusions

The results of the experiment show that the proposed method of the blended learning allows us to achieve our goals quite effectively. It develops among students the skills of the independent work with the educational material, capability to compare different versions of the presentation of the same educational material, to evaluate them critically, and to create problem-solving algorithms based on the methods studied.

We also observe that the pedagogical technology that we have proposed increases for most students their motivation to study methods of the fundamental algebra and geometry and the ability to critically evaluate their own academic achievements.

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