Teaching Algorithms and Programming First Year University students on Base of Distance Learning System DL.GSU.BY

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Abstract. This article describes the technology of teaching text programming to first-year students based on the DL.GSU.BY website. The main advantages of the technology include “zero entry threshold”, training adapted to the student, many years of experience in practical application, effectiveness, and scalability. The following issues are consistently considered in the article: idealized goal setting, students' use of a programming language of their choice from a variety of modern programming languages when performing practical tasks in the subject, clear verification of goal achievement, blended learning, effective personalization of the educational process, non-standard organizational and technical solutions, learning effectiveness. The idealized goal setting includes the need to teach students to algorithmic reformulation of the problem condition; possession of a set of basic language constructs, as well as basic built-in procedures and functions; ability to use basic algorithms on one-dimensional and two-dimensional arrays, sets of plane points, lines, queue; ability to develop and debug new algorithms. Effective personalization of the educational process is ensured by using the following methods: each lesson the student is offered a choice of activities that correspond to his current level of training; automatic verification of solutions is provided with the service "assignment of tests"; the system of automatic differentiated learning is used.

Keywords: Remote programming training, website DL.GSU.BY, Gomel State University

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1 Introduction

One of the global trends in higher education is the transition to blended learning, when a significant part of the educational process is transferred from the classroom to the Internet. With the help of a computer network, students receive tasks and the necessary theoretical information in a wide variety of forms (text, graphics, audio and video materials), complete tasks and send them for verification to tutors or automatic solution verification systems. The literature studied by the authors in preparing this article can be divided into four areas: review materials, proposals for the transition to blended learning, a variety of systems used in training, a presentation of work experience.

The first direction, review materials, includes works [1] and [2].

The work [1] is devoted to an overview of strategies and means of implementing blended learning. The work [2] is a review and analysis of computer education in Japanese universities. The authors of the work identified the following types of computer education:

- In faculties specializing in computer disciplines
- In faculties that do not specialize in computer disciplines, but have computer disciplines as an important part of their education
- General computer education for students of all faculties, usually in the first or second years of study
- Computer education for students who wish to obtain a license to teach computer science in schools.

The second direction - approaches to the transition to blended learning - includes works [3-4]. The paper [3] postulates the need for the digital transformation of education and explains in detail what is meant by the digital transformation of education. The paper [4] offers an overview of the directions for the development of blended learning in Asian universities.

The third direction is a variety of languages and systems used in teaching. Among the proposed systems are mentioned “GeoGebra”[5],Google Classroom[6], Moodle[7,8].

The fourth direction combines works that represent the real experience of learning with the help of computer technologies in universities: programming [9], computer thinking [10], chemistry[11], basic medical knowledge[12], earth sciences[13], anatomy [14] ,WEB design[15], neuroanatomy [16], English language [17], new educational technologies [18].

2 Problem Formulation

This article describes the experience of the author's implementation of blended education at F. Skorina Gomel State University in teaching programming to first-year students in the first semester. The authors have been actively involved in preparing schoolchildren for Olympiads in computer science and programming for many years [19]. The experience of this work formed the basis of classes with students [20]. However, it should be noted that work with schoolchildren is carried out within the framework of circles of interest, and therefore it is not necessary to spend significant efforts on teaching those who do not want to - they simply stop going to the circle. The situation with students is fundamentally different. It is necessary to work with everyone. It has become especially difficult since about 2005, when the enrollment for paid education increased significantly (up to 50% of the enrollment), as a result, the average level of preparation of first-year students has fallen sharply, not only in special (in computer science and programming), but also in general (for example, in mathematics, Russian language and oral speech). When at the Faculty Council teachers began to complain about this situation to the dean, he replied, "Teach these, there will be no others." Some help in such a situation is that students have an exam in the subject. Thus, the teaching methodology should develop in three directions: the learning process should be feasible, interesting, forcing (for those for whom the ability and interest is not enough). Some help in such a situation is that students have an exam in the subject.

3 Problem Solution

3.1. Idealized Goal Setting

As part of teaching in the first semester of first-year students the subject "Fundamentals of Algorithms and Programming", the authors set themselves the goal of teaching students the following:

a) Algorithmic reformulation of the problem statement
The original problem statement usually contains some kind of legend or "custom" explanation of the work the program is supposed to do. The student must reformulate the condition of the problem, retaining its essence, in terms of processing numbers, symbols, strings, points (given by X and Y coordinates on the plane) or their one-dimensional/two-dimensional arrays.

b) Possession of a set of basic language constructs, which we include declarations of variables and arrays, assignment operators, FOR and WHILE conditions and loops, as well as built-in procedures and functions:
Number processing: abs, sqr, sqrt, odd
String processing: length, delete, insert, copy, pos
Character handling: chr, ord
Type conversions: val, str
I/O: readln, writeln, assign, reset, rewrite, close

c) Possession of a set of basic algorithms, such as:

Basic algorithms for processing one-dimensional arrays: summation; counting elements with specified properties; maximum/minimum element; search for an element that has the specified properties. Sorting by exchange, bubble, count. Sorting with numbers.

Transferring basic algorithms to two-dimensional arrays and their components (rows, columns, diagonals).

Algorithms for finding distances on a plane: between two points, from one point to several ones, between adjacent points of a set of points, from each point to each in one set of points, between all pairs of points of two sets.

Basic string algorithms: splitting a sentence into words, forming all the different characters of a string, linear counting the number of characters in a string, reversing a string.

Queue: the problem of the horse (the minimum number of moves the knight can make from one cell of the chessboard to another) and the problem of pieces (the number of pieces into which a piece of paper will fall apart after cutting out some cells).

d) Ability to apply basic algorithms when solving problems, their modifications, compositions and super positions.

e) Ability to develop new algorithms and programs, perform manual scrolling of algorithms and debugging programs in the development environment using debugger commands: put variables

and arrays in the view window, conveniently position the source text and data view windows on the screen, execute a line, execute to the cursor, enter the procedure, execute to the end.

3.2 Multilingualism when Studying the Subject

The student has the right to submit solutions to the proposed problems in any of the programming languages installed in the verification system, including Pascal, C++, Java, Python, C#. If necessary, new language versions and new languages are installed in the system. Training for beginners is conducted in Pascal due to the presence of a powerful automatic learning system that has been developed, operated and developed for more than 20 years. However, there are lecture notes for the above programming languages, which are also developed by interested students as needed.

3.3 Clear Verification of Goal Achievement

The examination score for a semester for a student is actually determined by the number of tasks that he solves in 1.5 hours - from 0 to 10 on the following topics:

1. Introduction to programming
2. One dimensional array
3. Two-dimensional array
4. Geometry
5. Strings
6. One dimensional array
7. Two-dimensional array
8. Geometry
9. Strings
10. Queue

As you can see, the topics of problems 2-5 are exactly same as the topics of problems 6-9. The difference is in the level of difficulty. The tasks in topics 2-5 are chosen in such a way that any student who has more or less conscientiously studied during the semester can cope with them, even with a zero level of preliminary readiness. Tasks 6-9 actually check the quality of the student's skills in developing algorithms and debugging programs. Many years of practice and adaptation of the use of the approach has shown its effectiveness in assessment (showing a range from 6 to 9 adequate to the skills of students). The ability to solve the 10-th problem shows the readiness of the student to learn algorithms that are more complex.

3.4 Blended Learning

The educational process is conducted using the appropriate course in the distance learning system DL.GSU.BY, which since 2005 has the historical name "Computers, programming, algorithms - 20nn". The course provides access to theory; issuing tasks; automatic verification of solutions; differentiated learning that implements an individual educational trajectory that adapts to the student; motivating display of learning outcomes in a variety of contexts. All this guarantees the possibility of effective independent work of students in classrooms and outside them.

The tasks of the teacher are to present clearly and concisely the new theory in lectures, to organize and maintain a working atmosphere in the classroom. Particular attention should be paid to the development of independent work skills of first-year students. Very many of them in the first lessons try to demand constantly and unnecessarily the help of the teacher, instead of thinking and solving the problem on their own or with the help of a teaching system DL.GSU.BY.

3.5 Effective Personalization of the Educational Process

Our goal in organizing training sessions is formulated as follows:

Each student works every minute in every lesson

- Desirable - because he is interested
- At least, because the system and/or the teacher and/or "public opinion" forces him to.

How and due to what this goal is largely achieved in real practice?

At each lesson, the student is offered a choice of activities corresponding to his current level of training.

At the lectures (after reading the new theory, as it is correct for 20-30 minutes), tasks are offered on the topic of the lecture of DIFFERENT levels of complexity. In addition, during lectures, you can solve problems both on your own laptop alone, and in a team of two people who are close in terms of the current level of knowledge (determined by the current assessment of each).

In practice and during work at home, the student has a choice of both topics (from previously studied) and the level of complexity of the tasks being solved.

Automatic solution check (programs written by students in lectures and practice), performed in real time within a few seconds.

Service "Concession of tests", which allows the student to find out the test (input data and the

correct answer for them) on which his program does not work correctly.

Automatic differentiated learning system on each of the topics studied: introduction to programming, one-dimensional array, two-dimensional array, geometry, strings, all these five topics - at two levels of complexity (basic and simplified), queue. So that each student can study independently both in the classroom and at home.

Packages of tasks for the development of thinking integrated into thematic training which the student can skip if it is impossible or unwilling to perform such tasks.

Availability of the theory in lectures and practical classes.

Individual assignments. Problems are collected in the corresponding folder both by topic and by olympiads, for which there are no solutions or explanations in the course. For each task, its level of difficulty is displayed, described by two numbers: how many people solved this task and the average number of days per solving. That is, the number of days from the moment the task was set to the current day, divided by the number of people who solved this task. A student can choose any problem for himself, solve it in any programming language, and then describe his solution in the forum and post a readable self-documented source text of the solution. After checking the teacher, such a task is transferred to another place in the course - "Individual tasks with a description of solutions in the forum." The work itself is highly rated on the current academic record. Besides, links to all such descriptions of solutions are collected by topic, both regardless of the programming language, and separately for each of the programming languages. Thus, students get the opportunity for an additional self-developing type of learning: solve problems if possible, and finally read the solution on the forum.

Competitive elements introduced into the educational process:

- After each training session, an automatically generated result of the work performed by each student in this session is entered in a special topic “Who works how” on the course forum: in which topic he worked, how many tasks he solved, where he is in the topic. At the same time, higher in the table are students who have gone further in training.
- A weekly test is carried out, which contains about 30 tasks for developing programs of various levels of complexity from the simplest to the most complex. The tasks are both for topics covered and not yet studied in lectures. At the end of the table of results is presented to all students.
- Every week at the lecture, after reading the theory, it is proposed to solve about 30 tasks of varying complexity on the topic studied at the current lecture. At the end of the lesson, the results table is presented to the students.
- Permanently during the semester, students have access to the current grade sheet, which evaluates the results of students in the semester, including work in lectures, practice, at home, also showing the current examination grade of each.

3.6 Non-standard Organizational and Technical Solutions

Automated registration of absenteeism and their processing. One of the problems of modern education in our university is the absence of classes by students. The authors understand that there may be both real objective and subjective reasons for this, as well as "student's exploration of the boundaries of what is permitted." Therefore, omissions are introduced as a separate column in the academic record and negatively affect the assessment of work in the semester. After almost seven missed classes, the assessment becomes negative (for those who work best in lectures and practice), and for those who work worse, the assessment can become negative after five passes. Therefore, students are given the opportunity to WORK omissions. At any time convenient for him, he can go to the site, work for an hour and a half (from the first to the last sending according to the work protocol. Then choose the date of the omission, which was worked out and the system will generate a message in the special forum topic “Working out omissions - 20nn” of the following form: such student from such group worked on such date from such time to such time, solved so many tasks, total time. This message also includes a direct link to the log of this work.

The teacher from under his account can click on this link, check whether there was a work or its simulation and accept the work (omission is eliminated) or refuse the work - the omission will remain.

In order to ensure continuous work on the subject during the semester, practice without a teacher (at home) is allowed only during the week after the absence.

The fight against the indiscipline of students during classes. The manifestations of such indiscipline include being late for classes, “long”

breaks, the absence of a notebook and pen in class, distraction by mobile phones during class, using a laptop for other than class purposes, etc. For most students, an explanation of the rules is enough, in extreme cases, one-time remarks-reminders. However, there are also "active explorers of the boundaries of what is permitted" who do not respond to explanations for everyone and even personal comments. This is the pass of the current lesson with the student's right to "reset" it if the next same pair (exactly in a week) the student conducts without remarks and reminds the teacher of the desire to reset the pass set for a remark.

Using a subject forum to support independent learning. The authors try to provide students with the opportunity to work independently both in the classroom and outside of them.

In particular, the forum has a topic "Help, please - 20nn", in which a student can ask a question of interest to him including problems to be solved. If none of the students promptly answers, then the teacher does. It is very important that at the beginning of this topic, links to questions and answers to them systematically accumulated. Thus, often the student may not need to ask his own question, if such a question has already been asked and the answer to it is recorded.

In addition, at the initiative of one of the students (2009 year of study), a topic was created **"Teach each other, learn from each other - 20nn"**, in which student can write how he/she solved a difficult / individual problem or read how another managed to do it. The teacher manually constantly updates the table of contents of the topic.

Topic **"Students Opinion - 20nn"**designed to receive feedback from students both in the learning process and after its completion.

Topic **"Computer, programming, algorithms - 20nn"**at the beginning contains all organizational messages for new students, as well as links to materials on all topics studied. The last post in the topic contains links to materials on the last read topic.

Finally, the topic **"Bonuses - 20nn"**contains the marks of each student in "bonuses" for the last lecture; in addition, there appear, as necessary, messages about bonuses for one or another cognitive activity of students in a lecture, practice or in work at home.

Multiple retakes of the exam during the semester. If a student regularly studies, then in fact his mark on the exam is determined by the mark on the control cut. From about the middle of the semester, a student is allowed to apply for a control cut and write it once a week. In this case, the assessment is fixed only in the direction of increase.

3.7 Learning Effectiveness

At the first practical lesson, an entrance control section is held. It fixes the initial preparation of students before entering the university, with a slight adjustment for the fact that there are one or even two lecture weeks before the first practical lesson, and many students, motivated by the lectures and the opportunity to work at home, they are making good progress in knowledge during this initial period. However, on average, the assessment of each at the end of the semester increases by a value from 4 to 9. In addition, the authors consider the following "subjective" indicators of learning effectiveness to be important. Most students start studying immediately upon arrival, without waiting for a call about the beginning of the class, and "do not notice" the break between the hours of the class, continuing to work. During classes, there is almost perfect silence, and everyone is working actively and enthusiastically.

4 Conclusion

This paper presents many years of experience and methodology for teaching the basics of algorithms and programming in the first semester of the first year students of the Faculty of Mathematics and Programming Technologies of the F. Skoryna Gomel State University. Any university and teacher can use it. Either directly by subscribing their students to the appropriate course of the DL.GSU.BY distance learning system, or by borrowing the teaching methodology, but using other technical and software solutions. The authors refer to the important components of the methodology: the use of a personal computer and a projector by a lecturer, the use of laptops by students in lectures, direct consolidation of theoretical material by practice, operational verification of programs - solving problems, a table of results in real time at lectures and practices, solving problems in teams.

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