

# Experience of Blended Learning the Fundamentals of Digital Electronics for First/Second Year University students On Base of Distance Learning System DL.GSU.BY

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*Abstract.* The article discusses the practical experience of blended teaching students the fundamentals of digital electronics using the instrumental distance learning system DL.GSU.BY, developed at the Gomel F. Skaryna State University under the guidance of the author. The article also describes specially designed tools for teaching the basics of digital electronics: design, modeling and analysis of functionally complex digital systems (HLCCAD); writing and debugging assembly programs (WINTER), and their integration with DL, providing automatic verification of circuits and programs developed by students; constructor of interactive tasks for interaction with students of different levels of training.

*Keywords:* blended learning; fundamentals of digital electronics; distance learning instrumental system  
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## 1. Introduction

The papers [1,2] convincingly substantiate the need for a transition to new forms of education in universities, including, and above all, blended learning, which integrates traditional approaches with online learning and, accordingly, makes the most of both the teacher's opportunities in the classroom and means of modern information technologies in the classroom and during independent work of students.

The works [3-9] describe examples of the successful use of blended learning in university education in a variety of specialties: mathematics[3], English language [4], earth sciences [5], basic medical knowledge[6], anatomy [7], chemistry[8], new educational technologies [9].

The paper [10] presents the author's experience of blended teaching of first-year students the basics of programming.

## 2 Problem Formulation

The author teaches the basics of digital electronics to students of the Faculty of Mathematics and Programming Technologies of the Gomel State University named after F. Skorina, specializing in Applied Informatics (1st year, 2nd semester), Information Technology Software, Computer Science and Programming Technologies (2nd year, 1 semester in both cases). Significant problems that arise during training lie in three planes:

- minimal prior training (or even lack of it) for studying digital electronics of most students
- a significant difference in the ability to master new material among different students
- the presence of students who do not want to study in the absence of "means of coercion".

Therefore, it is required to organize the learning process in a differentiated way (feasible for everyone), interesting (in form and content) and coercive for those who lack the feasibility and interest.

### 3 Problem Solution

#### 3.1 Common Learning Technology

This article presents a long-term experience of blended learning in the basics of digital electronics for students of the Faculty of Mathematics and Programming Technologies of the Gomel State University named after F. Skorina (Belarus), who are studying in the specialties "Information Technology Software", "Informatics and Programming Technologies", "Applied Informatics" in within the framework of studying the discipline "Organization and functioning of computers". The technical basis of the proposed teaching methodology is the instrumental distance learning system DL developed since 1999 under the guidance of the author (<http://dl.gsu.by>) [11,12].

Having a common technical basis, the methods of blended learning in the basics of digital electronics and the basics of programming [10] have much in common in learning technology, including:

**Lectures:** conducting lectures using a computer, multimedia equipment, personal computers of students and wireless access to the university network, providing individual work with theory, individual transition to practice, re-explanation of the material to individual groups of students, activation of work at a lecture, automated personalized learning, use of a subject forum during the lecture.

**Workshops:** weekly tests with automatic verification of solutions, automated training in the basics of digital electronics based on a system of interactive tasks, control tests (fundamentally affecting the assessment in the subject).

**Independent work:** individual and training tasks in a wide range of complexity.

**Assessment automation:** an automatically generated assessment sheet is available to students permanently from the first to the last day of classes. It includes the following evaluated components of educational activities: theory control, practice control, training, individual assignments, new tasks, absenteeism.

**Automated system for recording passes and their working off:** providing the opportunity for students to work off missed classes remotely, with

the performance of useful training or monitoring tasks.

All this is described in much more detail in [10]. The purpose of this work is to present the features of blended teaching of students in the basics of digital electronics, caused by the content of the subject and the presence of special computer learning tools developed under the guidance of the author.

#### 3.2 Specialized computer training tools

**HLCCAD software system** (High Level Chip Computer-Aided Design), which is designed for the efficient development of hardware circuits for functionally complex digital systems. [13].

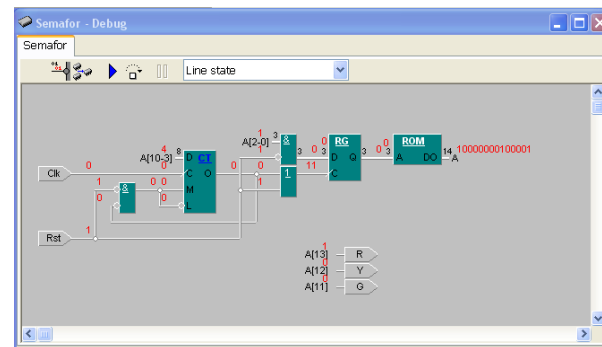


Figure 1. Debugging digital circuits

System HLCCAD allows you to draw a functional diagram of a digital device, consisting of standard digital elements: logical elements AND, OR, XOR, NOT; decoders, encoders, multiplexers, adders, flip-flops, registers, RAM and ROM, as well as previously created in HLCCAD schemes of digital devices. And then one can start the simulation in order to find and eliminate errors in the developed functional scheme. Input actions on the circuit can be set both interactively and from a file.

**Testing system integrated with the DL.GSU.BY website,** which provides: acceptance for verification of files with functional schemes of digital devices developed and debugged by students; verification within a few minutes of the received schemes on tests prepared by the author of the problem; delivery of test results to the student; and, if an error is found, the corresponding test that found the error in the schema. The use of secret tests for verification, which are not given to students to exclude the possibility of deceiving the automated verification

system with schemes like "if the input is like this, the answer is like that."

**WEB-system for deep check of students knowledge** on the algorithms of functioning of digital systems (Fig. 2).

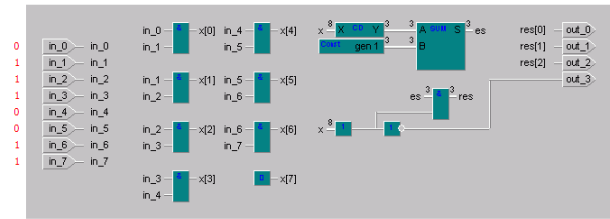


Figure 2. Check of students knowledge of digital circuits

The student is presented with a scheme and a random sequence of input actions. He must, having understood how the circuit works, calculate the values at the outputs for the given inputs. Such test actions are applied 10 times. According to the received data, a test file is formed, sent to the server, where it is modeled by the HLCCAD system together with the presented scheme. If all the student's answers matched the answers that were received by the modeling system, the task is considered completed, otherwise, the task is not accepted, and the student is informed about his errors for further analysis.

**Winter software system** [13], which is intended for the development and debugging of assembler programs (Fig. 3).

The Winter system allows you to type, edit, execute and debug assembly programs by observing the values in registers and variables during execution. It is possible to change the values of variables and registers. The possibility of reading input data from pre-prepared test files is provided.

**A testing system integrated with the DL.GSU.BY website, which provides:** acceptance for testing of files with assembler programs developed and debugged by students; verification of the received programs on tests prepared by the author of the problem, within a few minutes; issuance of test results to the student; and, if an error is found, the corresponding test that found the error in that program. The use of secret tests for verification, which are not given to students to exclude the possibility of deceiving the automated verification system with programs like "if the input is like this, the answer is like that."

**WEB-system for deep check of students knowledge** on the algorithms of functioning of assembler programs (Fig. 4).

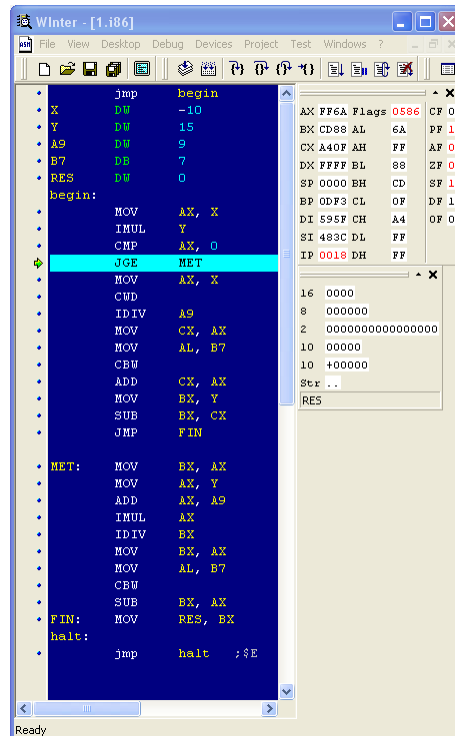


Figure 3. Debugging assembly programs

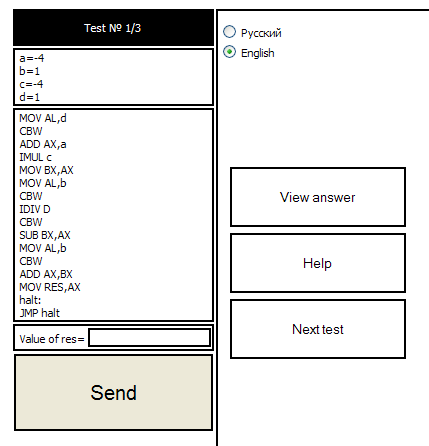


Figure 4. Control of knowledge of assembler programs

The student is presented with a program and random values of input variables. He must, having understood how the program works, calculate the values for the output variables. Such test actions are given 3 times. According to the received data, a test file is formed, sent to the server, where it is

simulated by the WINTER system together with the presented program. If all the student's answers matched the answers that were received by the modeling system, the task is considered completed, otherwise, the task is not accepted, and the student is informed about his errors for further analysis.

#### Constructor of interactive flash tasks[14].

There is a set of structural elements from which tasks are constructed. Structural elements are divided into two groups - active and passive. Active elements provide interaction with the student using the mouse and/or keyboard. Passive elements serve to design the task. To form a task, the developer uses the "Task Constructor". The result of creating a task is a text file that describes the task and is saved to disk. The Player is used to complete tasks. It reads the text file created in the "Constructor" and ensures that the task is displayed to the user and interacts with him in the process of completing the task. When the task is completed correctly, the "Player" notifies the user about it.

Figure 5 shows an example of an interactive task created using the Constructor. In this task, for the mnemonic minimization of the Boolean function, the unit values of which are transferred from the truth table to the Karnaugh map, it is required to cover all the ones with the minimum number of ships of the maximum area (equal to the power of two). In this case, it is necessary to take into account the "gluing of the Karnaugh Map" along the upper and lower, left and right borders. In the corresponding WEB-task, the student must select the desired rectangle (or its halves - top / bottom, left / right), rotate, if necessary, and overlay the Karnaugh map on the desired area. If the task is completed correctly by the students, a corresponding signal appears on the screen (a huge green checkmark).

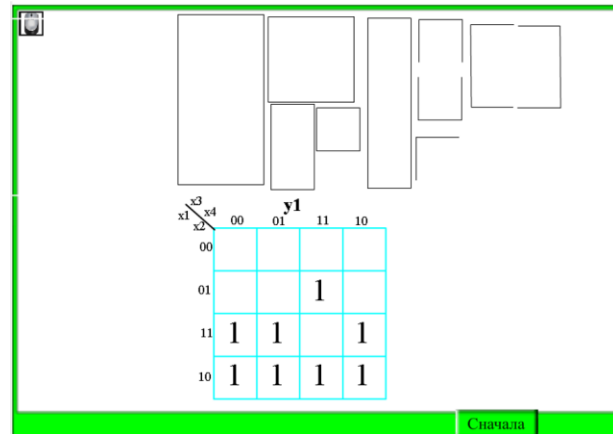


Figure 5. Coverage of Karnaugh maps

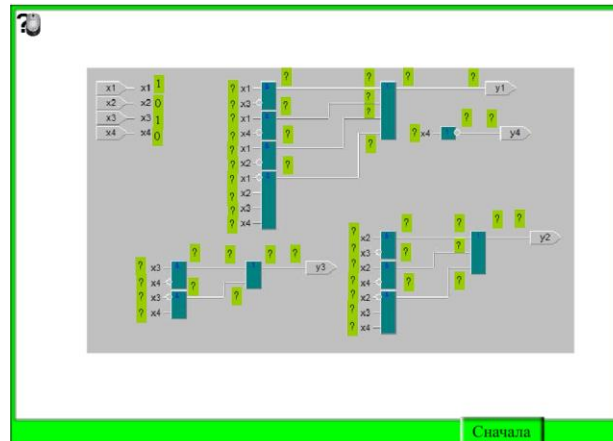


Figure 6. Calculate the values on all contacts of the circuit

Figure 6 presents a task that tests the ability of students to read and understand the functional diagram of a digital device. For it, one need to calculate the values on all contacts of the circuit for the given input values and replace all the questions with them.

Figure 7 shows task in which one need to find errors in the assembler program fragments and click on the place with the error. If the location is found correctly, the click point is circled.

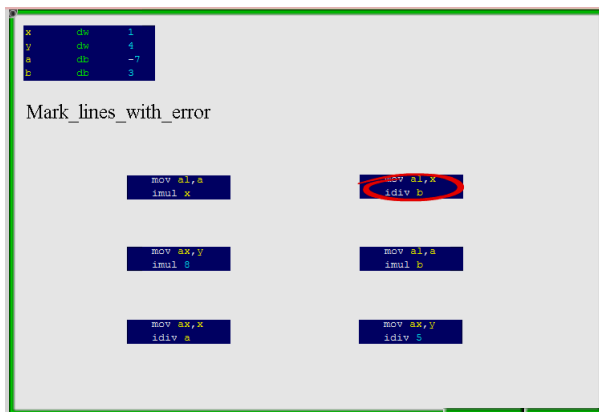


Figure 7. Point out errors

### 3.3 Organization of study tasks

With the help of the specialized tools described above, thousands of tasks of varying complexity have been created, teaching and controlling knowledge of the basics of digital electronics with automatic verification of the correctness of execution and integrated into the distance learning system DL.GSU.BY. In the process of learning (both in classrooms and during independent homework), the student can choose tasks that are feasible for himself in each topic. In the process of learning, the student can gradually increase the level of difficulty to the required one to obtain a positive mark on the exam.

We also note that all these tasks were created by the students themselves over the course of two decades. And the process of creating new tasks is also an effective differentiated form of learning. Since the student is compiling a task, for which he must and can make an author's decision.

## Conclusion

This article describes the experience of blended learning in the basics of digital electronics for students of the Faculty of Mathematics and Programming Technologies of the Gomel State University named after F. Skorina, who study in the specialties "Information Technology Software", "Computer Science and Programming Technologies", "Applied Informatics" as part of the study of disciplines "Organization and functioning of computers". The technical basis of the proposed teaching methodology is the development of an instrumental system of distance learning DL (<http://dl.gsu.by>), as well as specialized tools for designing, modeling,

debugging and researching devices and programs of digital electronics created under the guidance of the author.

Convenient interactive tools for the development of digital devices and programs provide effective consolidation in practice of the studied theoretical material. Fast automated verification of solutions, on the one hand, guarantees the objectivity of testing the knowledge, skills and abilities of the student, and on the other hand, intensifies the learning process.

The described flash task constructor made it possible to create visual training exercises on all topics of the subject being studied, providing productive training for students with different levels of training and motivation.

It should also be noted that in the tradition of blended learning, students use all these software packages and learning tasks both in classrooms and when working outside classrooms.

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