Teaching of Discrete Mathematics Using the Dynamic Learning Environment

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Abstract. In the paper describes the use of the distance learning system based on a modular object-oriented dynamic learning environment for teaching of discrete mathematics, discusses the advantages and disadvantages of this system. The methodological features of teaching a technical specialties students to the main sections of discrete mathematics (elements of combinatorics, theory of sets and relations, elements of modern abstract algebra, graph theory, classical concepts of the theory of Boolean functions, as well as the foundations of the theory of formal languages) are considered. Examples of applications of discrete mathematics in the analysis of the computer algorithms effectiveness, working with expert systems, solving routing problems, classifying ordered data and searching in them, checking the correctness of algorithms, creating functional diagrams, etc. are given. The work can be useful to teachers, both reading a course in discrete mathematics and introducing modern technologies of distance learning into the educational process.

Keywords: Learning Environment, Teaching Methodology, Discrete Mathematics, Information Technology.

1   Introduction

Now, not only the temporal, but also the spatial scope of obtaining education is being erased, digital technologies make it possible to receive education anywhere in the world. At the same time, in March – April of this year, higher education institutions faced the problem of a quick transition from traditional models of work to the large-scale use of "contactless" technologies in the framework of full-time education. Such a transition was supposed to ensure the minimization of face to face interactions while unconditionally maintaining the quality of the educational process. Due to the prevailing unfavorable epidemiological situation, as well as in order to improve the content and forms of the educational process on modern digital platforms, distance learning methods are actively used. The use of information technology should become the basis for the creation and application of new pedagogical methods and technologies [1]. This article describes how to integrate a dynamic learning environment with a web interface into the learning process for discrete mathematics.

2 Teaching of discrete mathematics using the modular object–oriented dynamic learning environment

In the course "Discrete Mathematics" (reading in the second semester for students of the specialty "Software of Information Technologies") elements of combinatorics, set theory and relations, elements of modern abstract algebra, graph theory, classical concepts of the theory of Boolean functions, as well as the foundations of formal language theory were studied with the aim of providing students with the tools and techniques necessary to understand and design computer systems. Discrete mathematics is used to solve problems on a computer in terms of hardware and software, including organizing symbols and manipulating data. Without knowledge of discrete mathematics it is impossible to successfully engage in computer science and programming, however, this course is often taught purely academic, without not often demonstrating possible applications.

In the spring semester 2020, the main material of this discipline was studied in the distance learning system based on the Modular Object Oriented Dynamic Learning Environment (Moodle). One of its advantages is the availability of simple, efficient, cross-browser compatible web interface. The training of students was carried out at a place of residence, remote from the university, using information and communication technologies for training, with the provision of access to educational resources under the supervision and control of a teacher. Learning Management System (LMS) Moodle supports the use of video conferencing, virtual programming laboratories, contains elements in the form of a glossary, task, lecture, interactive content, provides feedback, conducts polls, seminars, tests, the use of forums and chats, and also allows you to add hyperlinks, books, folders, explanations, pages and individual files in various formats (see Fig. 1).
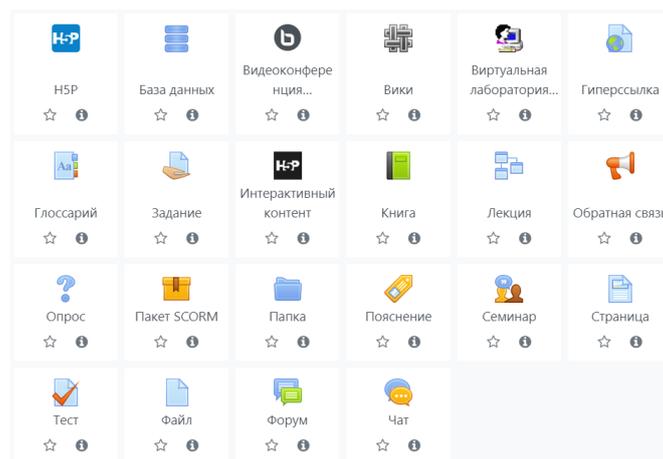
Fig. 1. Creating an item or resource

In particular, the BigBlueButton Video Conferencing module allows you to create links in Moodle to virtual online meetings in BigBlueButton – an open source web conferencing system for distance learning, with a webcam, presentations, screen sharing, online chat and many other necessary functions (see Fig. 2).
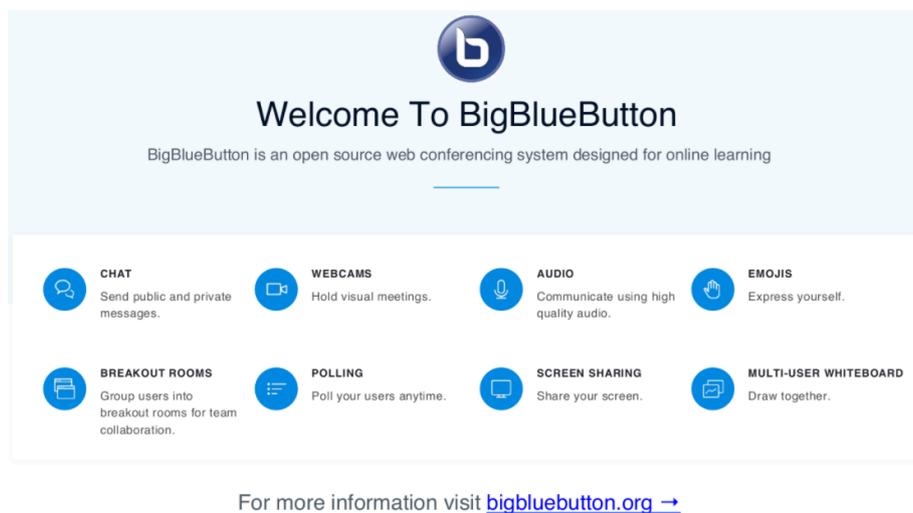
Fig. 2. Module "Videoconference BigBlueButton»

The BigBlueButton system is focused on educational activities, integrated with LMS Moodle, implemented directly as a separate customizable element, i.e. does not require additional actions from the teacher to organize a virtual seminar / lecture, unlike third-party conferencing systems such as Zoom, does not require the installation of any special software at the user's workplace, which allows access to it from any type of device, both stationary and mobile. All students are automatically registered in the system under their real surname, first name and patronymic (which saves the teacher from messages that are not related to the material being studied, as in the case of conditional anonymity during self-registration, as well as from access to the system by unauthorized persons interfering in the educational process), with an email address to send notifications of new chat messages, personal correspondence, verified jobs, received assignments and other new information. When conducting lectures, its name, description, binding to a specific schedule are indicated, groups and parameters for recording an online session are selected, in the future, the records can be viewed, the availability of viewing records for students remains at the discretion of the teacher (if students do not expect to be able to view them later, they will be more attentive to the material read online, however, for example, access may be open to prepare for an exam). During the lecture, the teacher sees all connected students who can ask questions using both a microphone and a group chat, all information is available right on

the screen online; the teacher broadcasts his presentation, highlighting and adding the necessary information during the lecture using the built-in editing tools, if necessary, allowing students to do this, and also conducts surveys right during the lecture, immediately receiving feedback and all the necessary statistics, however, some questions are more convenient to explain and perceive in person. It is also possible to broadcast the desktop to demonstrate the progress of work with various applications.

The Moodle and BigBlueButton systems implement mechanisms for monitoring the academic activities of students and teachers, in particular, accounting for the attendance of online events and working with various elements of the course. Using the virtual programming laboratory (VPL) allows you to edit the source code in the browser, students can interactively run programs in the browser, tests to check programs, that module allows you to search for similarities in the responses sent, supports setting restrictions on editing and prohibiting pasting text from external sources.

Interaction with the teacher and other students at consultations and seminars is carried out both through video conferencing and through forums and chats, knowledge control is carried out using tasks and tests. In particular, in the testing system, when creating a test, the start and end times of testing are fixed, a time limit is set for testing, the assessment format and the passing score are selected, if desired, the number of attempts is indicated (and a forced time interval between attempts, so that the student tries to understand the reasons for unsuccessful answers), the method of setting according to the final grade results of each attempts is also chosen, you can demand to answer the questions sequentially or use free navigation, give answers in random order (or in a certain sequence), give feedback on the answered question immediately or at the end of testing (or in an interactive form), base (or not) subsequent attempts on the results of previous ones. Depending on the purpose of testing (self-control, intermediate or final control), it is possible to report (or not report) information about the correctness of the answer, the scores received for it (which may also differ depending on the complexity of the question), give the correct answer itself, give feedback to individual questions and to the entire test (depending on the results obtained). Accordingly, the test can be hidden from students, and also become available from the specified moment, be available to students of a certain group (groups) or under certain conditions. For example, when studying some materials, passing control (laboratory) works or tests on previous material, all conditions for the test are indicated in advance (so that students can prepare). Setting of the final grade automatically (see Fig. 3) according to predetermined rules allows to relieve the teacher from the mechanical work of checking (but increases the load on him when compiling the tests themselves), as well as to analyze the assimilation of various sections and the material in general by students (see Fig. 4). Since the questions and answer choices are most often given in random order, even students taking the same test at the same time do not have the opportunity to "duplicate" answers.

Фамилия / Имя / Отчество	Адрес электронной почты	Состояние	Тест начат	Завершено	Затраченное время	Оценка/10,00
Ступин Владимир Александрович Просмотр попытки	stupin.alexander@qip.ru	Завершенные	1 June 2020 08:00	1 June 2020 09:30	1 ч. 30 мин.	4,14
Едунов Алексей Юрьевич Просмотр попытки	yury.e74@gmail.com	Завершенные	1 June 2020 08:00	1 June 2020 09:30	1 ч. 30 мин.	6,29
Шпригов Герман Глебович Просмотр попытки	herman.shpryhau@gmail.com	Завершенные	1 June 2020 08:00	1 June 2020 09:30	1 ч. 30 мин.	5,14
Ролевич Савва Ильич Просмотр попытки	savva.roll@gmail.com	Завершенные	1 June 2020 08:00	1 June 2020 09:29	1 ч. 29 мин.	6,43

Fig. 3. Test results
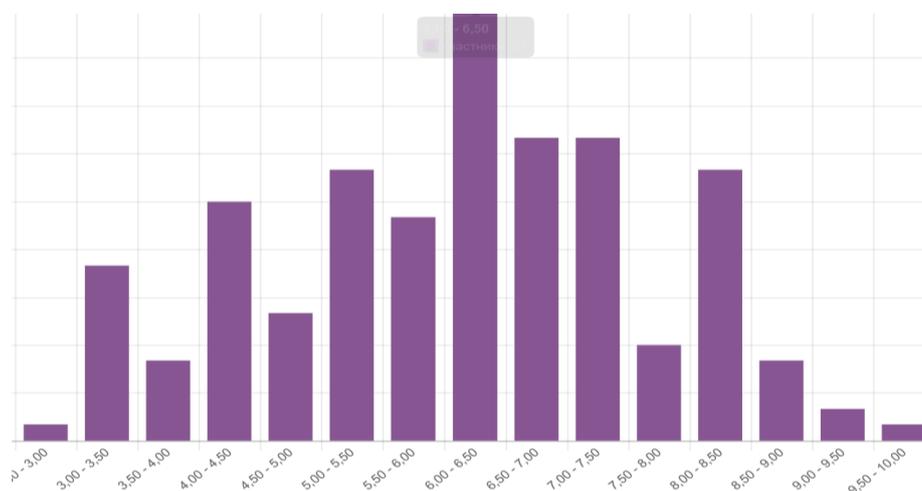
Fig. 4. Analysis of the assimilation of the material

Thus, both teachers and students actively and creatively interact, conduct a dialogue in the digital environment.

3 Discrete mathematics and its applications in the field of information technology

Discrete mathematics developed in connection with the study of the laws and rules of human thought; thinking is realized primarily in language. The theory of formal languages is the basis of the coding theory and cryptology, the theory of algorithms and mathematical logic. Coding literally permeates information technology and is central

question in solving a wide variety of programming problems. Context-free languages are the most important class of languages; their theoretical analysis underlies many information technologies, such as, in particular, the design of compilers or the development of linguistic support for databases.

The theory of formal languages is essentially based on the theory of graphs. Many problems in the theory of languages are reduced to the problem of paths in labeled directed graphs, where the set of labels has the algebraic structure of a semiring. The graph theory apparatus is widely used in various applications, in particular, in the mathematical support of computer-aided design systems. In the process of studying graph theory in the course "Discrete Mathematics", communication networks are also analyzed, whose vertices are computers, and arcs are communication lines connecting computers, and it is shown how to determine fixed paths for transferring information between nodes, and the dynamic routing procedure is also discussed. which allows students to better understand communication protocols. In the language of graph theory, many control problems are formulated and solved, including the problems of network planning, analysis and design of organizational structures, analysis of the processes of functioning of dynamic systems. Binary trees with root are useful for solving problems of choice, in particular, for classifying ordered data or searching in them, coding algorithms for arbitrary trees are also studied. A Boolean function [2] can also be represented by a binary code tree, illustrating the interconnection of various branches of discrete mathematics. Let us list some applications of typical graph theory problems: the shortest chain problem (replacement of equipment; scheduling the movement of vehicles; placement of ambulances; placement of telephone exchanges); the problem of the maximum flow (analysis of communication network bandwidth; organization of traffic in a dynamic network; optimal selection of work intensities; task of work distribution); the problem of packaging and coatings (placement of dispatch centers of the urban transport network); coloring in graphs (allocation of memory in a computer; design of television broadcasting networks); connectivity of graphs and networks (design of the shortest communication network; synthesis of a structurally reliable circulation communication network; analysis of the reliability of stochastic communication networks); isomorphism of graphs and networks (structural synthesis of linear electoral circuits; automation of control in the design of information networks), etc.

One of the important tasks of programming is the creation and analysis of the computer algorithms effectiveness. When studying combinatorics in the course "Discrete Mathematics", algorithms are compared in terms of efficiency using combinatorial formulas. Discrete mathematics also helps students understand the basic principles of working with database management systems using set and relationship theory. Expert systems can serve as an example of set theory applications, and answers to questions can be obtained from the knowledge base in a logical way. Haggarty's textbook [3] illustrates some examples and complexities of working with an expert system.

Predicate calculus is understood as a formal language for representing relations in a certain subject area. The main advantage of predicate calculus is a well-understood powerful inference engine that can be directly programmed. For example, to prove that the algorithm is correct (to make sure it works as expected), you need to check all

changes in the variables used before, during and after running the algorithm. These changes and conditions can be considered as small predicates; when studying the discipline, using the example of various algorithms, the correctness of the algorithms is checked using formal theory.

Also, with the help of Boolean algebra, various logical problems are solved, it finds the broadest application in technical fields, for example, the laws of Boolean algebra are used when constructing circuits from electronic elements, allowing you to minimize the circuit by simplifying the Boolean function, etc.

The main material of the discipline was studied using a distance learning system based on Moodle.

4   Conclusion

The concepts and methods of the theory of algorithms and Boolean algebra underlie the modern theory and practice of programming; knowledge of set theory, combinatorics, algebra, mathematical logic, graph theory and other areas of discrete mathematics are absolutely necessary for a clear formulation of concepts and the setting of various applied problems, their formalization and computerization. The paper discusses the advantages and disadvantages of using a modular object-oriented dynamic learning environment in teaching discrete mathematics, and also provides examples of discrete mathematics applications in the field of information technology.

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