Training Simulators for Support of Inductive Method in Teaching

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Abstract – **This article is devoted to training simulators aimed to support inductive methods in teaching applied mathematical disciplines in the higher education system. Such training simulators not only implement traditional functions by presenting ready knowledge and ensuring opportunities for obtaining skills in problems solving, but they also enable students to organize their own experimental research, to process and analyze the obtained results in order to generate a new generalized knowledge. The article summarizes some requirements to simulators, and describes one of the variants of the basic structure of the simulator and its functions. The article also gives examples of simulators applicable to the following disciplines: Optimization Methods, and Simulation Modeling, elaborated in the framework of the concept of inductive teaching.**

Index Terms – **Inductive teaching, training simulator, structure of the training simulator, requirements to the training simulator.**

I. INTRODUCTION. PROBLEM DEFINITION

THE INDUCTIVE method of teaching is a teaching method intended to provide possibilities for students to organize and carry out experiments and observations followed by the analysis of the results obtained, so that students can themselves make generalizations and generate conclusions, see, for example [1-2]. Inductive teaching methods implement the logic from particulars to generals in the presentation of teaching materials. The inductive method is increasingly used in teaching applied mathematical disciplines in the higher education system. The first stage of the inductive teaching method implies the collection of experimental results obtained by observations and experiments. The second stage expects that the obtained results and inductive arguments are analyzed, and notions, generalizations are formulated as classifications, scientific hypotheses and conclusion.

The steady development of information technologies leads to appearance of new educational technologies based on computer-based means of information processing and transfer. Nowadays, different types of e-learning are developed and used to support all forms of education, one of them are training (teaching) computer programs, or programs/simulators.

In studying applied mathematical disciplines, sometimes programs/simulators designed for teaching to solve problems of a certain type using a given set of techniques are applied. The functions of the simulator are traditionally reduced to a provision of ready knowledge (for example, reference and theoretical information on methods of solving problems) and ensuring opportunities to acquire skills to solve problems (for example, step-by-step solving of problems included in the database with the detailed explanations of the solving process interactive with the user).

However, in order to implement inductive teaching, a radically different simulator is needed, which besides traditional functions can also support the process of analytical investigation. This simulator should let students organize their own investigations, offer opportunities to carry out experiments, to store, process and analyze the results obtained, in order to gain skills to generate a new generalized knowledge on the basis of the experimental data.

In view of the above, the elaboration of training simulators in the framework of the concept of inductive teaching is considered to be of the utmost importance.

The present article summarizes requirements to the simulator aimed to support inductive methods of teaching applied mathematical disciplines; describes a possible basic structure of the simulator and its functions, and also gives examples of simulators for the following disciplines: Optimization Methods, and Simulation Modeling.

II. REQUIREMENTS TO THE TRAINING SIMULATOR

It is obvious that in order to fulfill the abovementioned functions the simulator supporting the inductive methods of teaching should meet a certain set of requirements.

1. Provision of learning and teaching reference information (description of a problem formulation, methods and algorithms of solving problems, and user's manual).

2. Provision of different scenarios of teaching, i.e. students can study educational materials by different trajectories depending on the initial background of students.

3. Support to the process of solving problems at different modes of operation (*demo mode* – solving of problems step-by-step with different input data; *training mode* – solving of problems when the user enters the necessary data or chooses the next step; *control and evaluation mode* – a personal problem solving, and evaluation of the results obtained; *research mode* – the performance of experiments).

4. Feedback from students, including outlining of possible mistakes made in the process of problems solving, and information for correcting the mistakes.

5. The dialogue with the students, thus promoting better understanding of the study material, and involving students into the process of discussion and team work.

6. Visualization (animating) of the process of problems solving, and presentation of the work results in the form of text reports and diagrams.

Besides, it is recommended that the simulators implementing the inductive education should include the following techniques:

- simulation modeling of experimental data (obtaining of the test data) for research carrying out and problems solving;
- carrying out joint experiments and exchange of the experimental results between the researchers, for example, on the basis of cloud technologies;
- tracing the experiment “history” and saving the experimental results;
- implementation of several methods and algorithms of problems solving, as well as comparison of the results obtained, and formation of the final conclusions using a set of methods.

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Such a program/simulator ensures the implementation of traditional functions (provision of reference knowledge and training in problems solving using the given methods), and also makes it possible to support the process of inductive teaching and formation of skills of inductive arguments, and carrying out research work in general.

III. STRUCTURE AND FUNCTIONS OF THE TRAINING SIMULATOR

Basing on the requirements formulated above, the structure of the simulator should contain the following basic modules: *reference and training* module, *analytical and experimental* module, *history of experiment* module, and module *of the formation and assessment of the final knowledge*. All the modules should be interrelated and have intuitive navigation aids in between. Fig. 1 shows a diagram of the navigation between the interfaces of the modules of the simulator. According to the elaborated diagram the user starts the work with the main primary window, which ensures a quick access to all modules of the simulator.

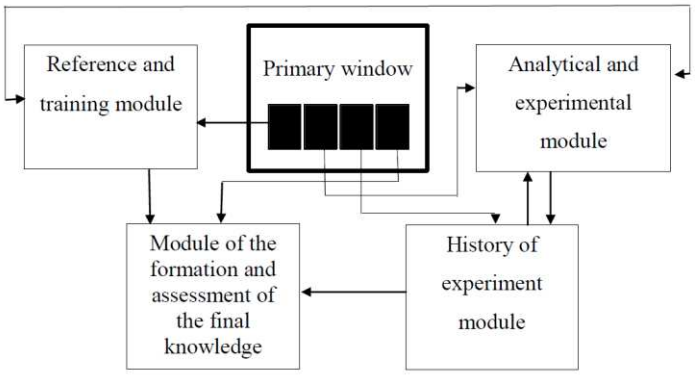

Fig. 1. Diagram of the navigation between the interfaces of the modules of the simulator.

The reference and training module contains teaching and learning materials (formulation of problems, the key theoretical information on the methods of solving, class assignments, scenarios how to carry out experiments using the simulator), as well as detailed instructions how to manipulate the simulator, and so on.

The analytical and experimental module of the simulator allows students to carry out the following procedures, depending on the sphere of application:

- to solve problems using different modes (demo mode, training mode, control and evaluation mode) with the aim to study methods of solving problems and to acquire practical skills;
- to carry out different experiments aimed to evaluate the effectiveness of the application of the method for solving problems depending on the initial conditions set and parameters of the method;
- to carry out experiments with the simulation model of the system in order to study the effect of the input variables and parameters upon the performance effectiveness of the system, with the further optimization of the system functioning process;
- to save results and to give access to all the results of the experiments carried out previously, which were saved in the local and cloud storages.

The module "History of experiment" makes it possible to look through the information on all the experiments performed. Any experiment can be opened again in the analytical and experimental module in order to continue the study.

The module of the formation and assessment of the final knowledge contains a set of tests, questions referring to the results of the experimental studies carried out, which lead the student to the formulation of conclusions and to the generation of new knowledge on the basis of the experimental data obtained. A textual description containing the main conclusions, generalizations, recommendations, etc. based on the answers to the proposed questions is compiled on completion of the testing.

So, the simulator supports all the stages of the process of inductive teaching from the problem formulation, by carrying out a series of experimental studies till the formulation of generalized conclusions, and implements the logic in the presentation of teaching materials from particulars to generals.

Now we describe some examples of the training simulators elaborated in the framework of the concept of inductive teaching to be used in teaching applied mathematical disciplines.

IV. TRAINING SIMULATOR AIMED TO PRACTICE GENETIC ALGORITHMS FOR OPTIMIZATION

The teaching process is built on the basis of solving the travelling-salesman problem [3]. The simulator makes it possible to obtain theoretical information on genetic algorithms for optimization, to acquire skills how to use them for solving optimization problems by the example of the travelling-salesman problem, as well as to carry out experimental studies on the effectiveness of using genetic algorithms for solving this problem depending on the initial conditions set and operating parameters of the algorithm [4]. The simulator implements different scenarios of experiment procedures. For example, there are foreseen possibilities to carry out experiments aimed at studying the effectiveness of the algorithm depending on the type and parameters of the genetic operators of crossover, selection and mutation, to study of the velocity and convergence region of the algorithm depending on the size of the initial population or the probability of the using of mutation operators, and others (Fig. 2).

Several users can use this simulator to carry out joint studies and to exchange the experimental results using the cloud storage. The mechanism of interaction between the users is implemented on the basis of the client-server model.

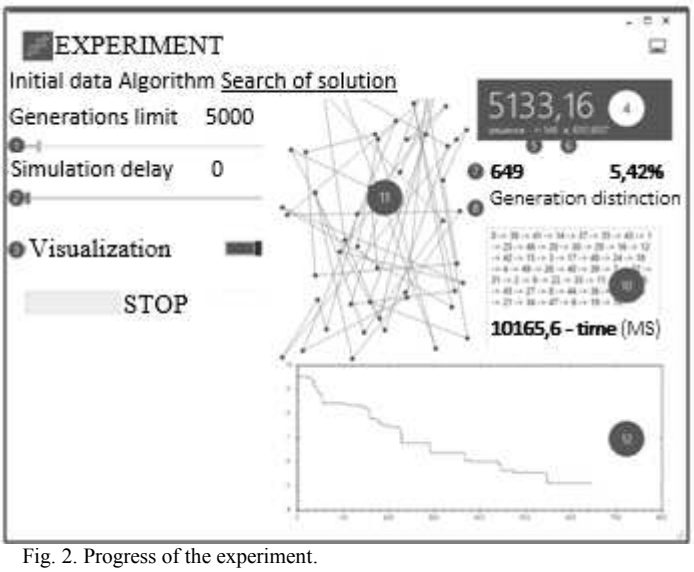

Fig. 2. Progress of the experiment.

The modules of the simulator function as clients, and the cloud storage functions as a server. So, several users can carry out simultaneously the same experiment, whose results are saved in the cloud storage (Fig. 3).

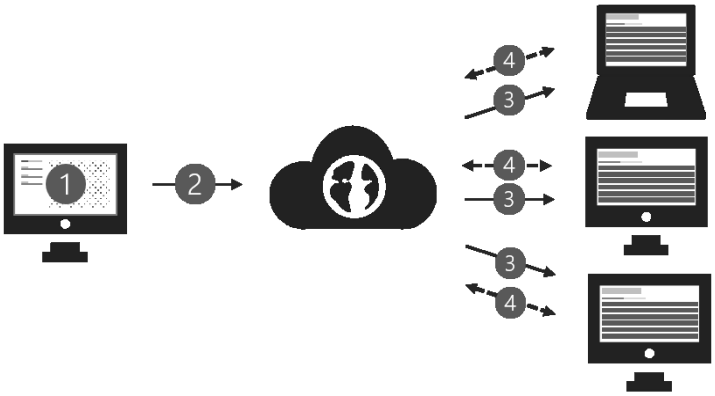

Fig. 3. Exchanging scheme by the initial data and the experimental results by means of cloud storage.

The simulator can be also used in the autonomous mode in case of the lack of the relevant technical facilities, or in case of necessity to connect it to an external storage.

The possibility of the simultaneous work of several users carrying out the same experiment makes it possible to collect much more information for a shorter period of time, thus improving the quality of the conclusions based on the experimental results.

V. TRAINING SIMULATOR TO PRACTICE SIMULATION MODELING OF THE COMPUTING CLUSTER OPERATION

The simulator is designed to teach for evaluating the effectiveness of the system functioning and its optimization on the basis of the simulated model by the example of the computing cluster [5]. The simulator implements the following functionalities:

– to carry out simulation experiments using the computing cluster model, built according the star topology, with a graphical display of the cluster structure and visualization of the modeling process;

– to study the effectiveness of the computing cluster operation depending on the initial conditions and parameters of the model (number of problems to be processed, minimum time for processing of one Megabyte of information, number of processing computers, type of service discipline, service time distribution);

– to calculate key features of the effectiveness of the computing cluster operation on the basis of the simulation and analytical methods, while the results are presented textually and graphically.

The researcher is to select the optimal parameters of the computing cluster operation basing on the results of the experiments performed.

VI. CONCLUTION

The elaborated programs/simulators are successfully tested and used for teaching the relevant course units of the following disciplines: “Optimization Methods” and “Simulation Modeling”, which are incorporated in the following Bachelor’s Degree programs: 09.03.01 “Informatics and Computer Engineering”, and 09.04.01 “Software Engineering”.

Using the simulators supporting inductive teaching methods in the academic activity, students can acquire skills of generating new knowledge, knowledge management, planning and carrying out research activities.

The Chair of Computer Engineering of the Novosibirsk State Technical University continues to develop this complex of training simulators to be used in studying applied mathematical disciplines applying soft algorithms.

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