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Development of computer courses in practical physics under the conditions of distance learning by means of Java technology

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In the teaching of natural-science disciplines the laboratory works are one of the basic methods of learning the physical concepts. Under the conditions of distance learning of physics the trainees do not have of the possibility to use the laboratory. The use of compute-based laboratory' practice is the most natural solution of this problem. The development of computer laboratory practice includes methodical and technical aspects, which -will be examined in this paper.

Introduction

In teaching of natural-science disciplines laboratory works are one of the basic methods of studying the phenomena. Under the conditions of distance learning, in the course of physics, the trainees are deprived of the access to the laboratory of educational institution. This raises the question what can be adequate replacement for laboratory work. Physical science in its essence is experimental. It is traditional setting experiment, in the education, it pursues the purposes: the formation of the skills to observe and to explain physical phenomena, to use physical instruments, to treat the results of measurements and to draw conclusions on the basis of experimental data. The use of a computer laboratory practical course is the most natural output from this situation. The efficiency of distance learning in many instances depends on the organization of training material. During the development of this material it is necessary to consider the edifying principles of training courses creation. Furthermore, it is necessary to maximally use the possibilities given by computer tele-communications and modern information technology. Thus, the development of computer laboratory practical course includes *learning method and technical aspects.* Learning methodical aspect is caused by the need for the selection of the maintenance of the course of physics, selection computer models of the studied phenomena, selection of the most *productive model of education.* Technical aspect is caused by the need of developing the

computer laboratory practical courses with the help of computer technology of those considering the specific character of Internet environment and special feature of interaction of the distributed groups. Among the variety of means of development of computer laboratory practical courses *Java technology* appears to be most promising one.

Learning methodical aspects

The organization of laboratory practical course in physics under the conditions of distance learning is caused by the following factors:
   (a) the content of physics course;
   (b) the phenomena and laws, which require greatest attention are, i.e. by the appearing to be fairly .complicated for understanding;
   (c) the phenomena and laws, for which it is possible to create methodically substantiated computer model;
   (d) the selection of educationally model.
   The content of the first and second items is determined by curriculum of distance learning centres. The greatest difficulty causes the third factor, since computer model is the formal description of studied phenomena. Traditionally laboratory practical course is the means of experimental checking. Under conditions of distance learning this is impossible. Consequently, it is necessary to station the means of trainees' knowledge formation. I.e. computer model will make it possible to form the precise representation of formal model, which imitates the physical phenomena in question. However, the successful use of a computer laboratory practical course of distance learning depends on the selection of education model (Tarassov & Johansson 2002). All modem methods of education are based on the principle of constructivism, which assumes the active operation of our own knowledge trained on formation. Students work with the data given by teacher, by scientific information, literature and the like. They participate in the debate groups. Computer laboratory practical course can be considered as one of the *active learning* model elements. Among the variety of similar models of education it is possible isolate two, a *discovery learning* and *case-based learning.* They are most organically combined with the computer laboratory practical course. The crucial method of active learning (for distance leaning in practical physics), from my point of view, is discovery learning and it will be examined first.

Discovery learning

In discovery learning students are encouraged to discover principles by themselves (Slavin 2002). This is the most natural method for physics, since it provides carrying out of experiment. It includes five states: problem, experiment, analysis, principles, and solution. Figure 1 depicts the transition diagram of discovery learning. In the Problem state students are given a problem that they have to solve. They have experiences and conduct experiments to consider matters from different points in the Experiment state. After conducting experiments the students obtain a plenty of experiment data that are to be processed and analyzed in the Analysis state.
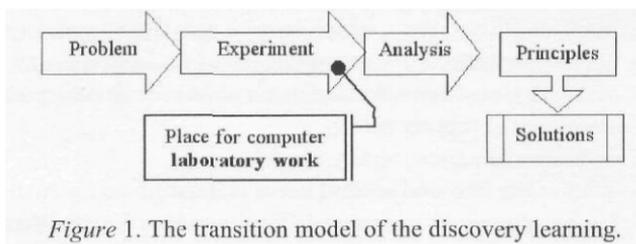

*Figure* 1. The transition model of the discovery learning.

On the basis of the experiments and data analysis the students discover the underlying principles and concepts in the Principles state. Finally, in the Solution state, they produce a solution using the discovered principles (Tarassov & Johansson 2002).

Physical world has been getting important as an educational tool to support learning by doing. It provides computer simulation of restricted environment, in which a learner can manipulate the existing objects directly and see the result of her/his action intuitively. A learner explores the world and tries to discover the knowledge and laws in the learning domain. Such a situation is educationally quite good because it promotes a learner's initiative, motivation and interest. Here, discovery learning becomes a central issue.

Case-based learning

The method of case-based learning is a learner-centered approach, which includes students' research and interactions with each other while studying an object or problem of special importance (Enkenberg 2001, Herreid 1994). Figure 2 depicts model of case-based learning in the form of a transition (or state) diagram. Let us describe each state in details.

Figure 2. The transition model of the case-based learning.
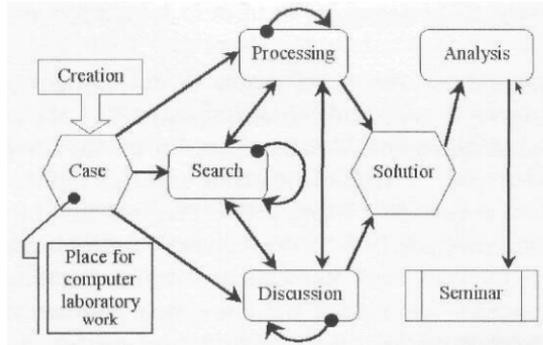
The Creation state includes creation of a case or a series of cases. Cases are usually developed by a teacher, but students may also be involved in this. A case consists of different kinds of material: texts, images, animations, audio, video and computer laboratory work. After that, the case is presented to students. It is denoted by the Case state. The students thoroughly examine the case and all information pertaining to it. Then transition is possible into the Processing, Search or Discussion states.

In the Processing state, the students analyze the case and process information, either included in the case or found elsewhere, to look at it from different points of view. After this, the students may go into the Discussion, Search, or Solution states, or make another iteration of Processing. When the students feel they do not have enough information they can search for it. This is called the Search state. A source of information may be a digital library, web page, collection of papers, or set of structured concepts of the problem domain. Having searched, the students may proceed to the Processing or Discussion states, or return to Searching. The Discussion state includes work in small or larger groups. Here the students discuss the case, the information, and results of the processing state. They can also discuss partial solutions to the case made by any student. After discussion, they may go into the Processing, Search, or Solution states, or repeat the Discussion state.

The students create and present their solutions in the form of a document or report in the Solution state. The Analysis state comes next. In it, the teacher analyses the students' solutions and prepares a final seminar, which follows as the Seminar state. The final seminar is conducted by the teacher and involves consideration of different solutions and discussion of the case. The seminar may stimulate creating new cases. The teacher can take part in the process on any stage, not just the final seminar. Computer laboratory practical course may be used in this model of education as component of case and checking means of the intermediate solutions.

Technical aspects

Among the variety of means to develop computer laboratory practical courses it is possible to distinguish Java - technology. Its platform independence and network directionality are the advantages of this technology. That makes it possible to create applets - application built-in in Web documents. Java API (Application Program Interface) gives the programmer independence from the operational environment access to creation of the complex Internet applications - by such means, as network "sockets", "streams" and graphic window system. Furthermore, Java makes it possible to create client - server applications, realizes connection with the network data bases with the help of interface JDBC (Java Data Base Connectivity).

Structured elements of computer laboratory practical course

Computer laboratory practical course is constructed according to the same diagram, as full-scale.

(i)   Setting theme and purpose of the work.
(ii)   Basic theoretical information.
(iii)   Description of plant.
(iv)   Description of operation.
(v)   Allowance to the work.
(vi)   Execution of laboratory work.
(vii)   Analysis of the obtained results.
(viii)   Checking.

Some elements of network computer laboratory practical course may be absent, depending of the form of education. On the basis of practical course directionality to Internet DHTML (Dynamic Hyper Text Markup Language) is the most effective for the realization of items 1 - 4. Furthermore, for increase functionality and possibilities of interaction with the user it is possible to use JavaScript language (in the composition of DHTML pages). It is possible to realize in Web- documents (for the computer laboratory practical course) the assignment test which makes it possible execute item 5, by using this language. The selection of DHTML is not random, since the majority of modern network textbooks are created with its help. Laboratory practical course, that is carried out in the form of Web - document, is easy to integrate into the existing systems of the network support of face to face and distance learning. The execution of laboratory work (item 6) provides students work with computer model. That can be easy realized by Java applets. Furthermore, this approach does not require use of supplemental programs by users, since applets are executed in the JVM (Java

Virtual Machine), which is component element of modem Web browsers majority. At the end of students work, they must draw work conclusions, after answering to test assignment (items 7, 8). Solving the items it is possible to use different approaches; however, 1 see the following version. Since the result of students' analysis from the accomplished work must be fixed on the network education server, it is expedient to use servlets or JSP- pages for using a connection to the data base. Furthermore, with their help it is possible to realize the test assignment, processed from the side of server, but not from the side of user to avoid falsification. The results of testing can be carried into the database.

Interaction of the components of the practical course

The diagram of components interaction for network laboratory practical course with the use of computer models may appear as follows (Figure 3).
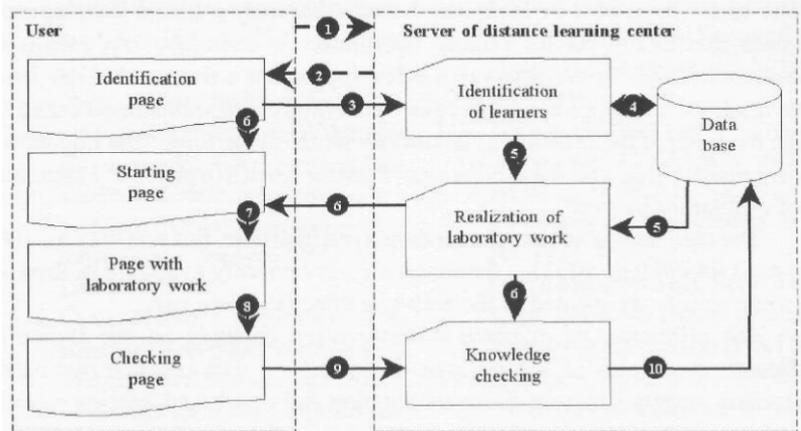

Figure 3. The diagram of components interaction

Trainee is connected to the separated server of education (1) and goes to the identification page (2), where he/she fill form (name and password inputting). The obtained information (3) is treated by servlets (by JSP), retrieval of training activity information of trainee is achieved from the data base (4). On the basis of obtained data Web- document of the planned (in accordance with the training process) laboratory work is transmitted to trainee (5,6). The work of student begins from the initial page, where he/she becomes acquainted with the purpose of research. There obtain references to the supplemental information and he/she studies the course of research work.

After preparation for the work the trainee passes the test, carried out with the help of language JavaScript, with the help of which degree of readiness for the execution of work is revealed the. In case of successful passage of the test, the student goes to the page of laboratory work execution (7), where he/she takes up work with the active computer model. The exam of laboratory work provides analysis of the obtained result (output written by student), and the passage of the controlling test (8). The test assignments are extracted from the data base server of education and are sent to trainee (5, 6). At the end of testing the versions of answers and output are sent to the server of education (9) and are treated by appropriate servlets (by JSP), result will be brought in into the data base (10).

Concluding remarks

The technical aspect of computer-based laboratory practice development under the conditions for remote instruction is examined. As means of computer-based laboratory practice development it is proposed to use Java-technology. The application of Java- technology is demonstrated based on the example of the creation of laboratory work on the topic "the imposition of mutually perpendicular oscillations" from the branch of physics "kinematics of oscillatory motion".

   The realizations of that are not displayed in article, but you may get it by e-mail (aks@dem.ru). This demonstration is currently available in Russian (some results are located in the web-site http://aks.dem.ru)

   The efficiency of distance learning often depends on the choice of didactic principles of the courses. In future, we will examine two active learning models. They are discovery learning and case-based learning models.

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