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Game-Based Interface for Virtual Interactive Laboratory of Mechanics

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Abstract

In the field of mechanics carrying out of experiments plays a key role in the learning process. However necessary laboratory equipment is not always available. To this end, a plenty of educational institutes over the world has recently started to develop interactive systems that facilitate the process of preparation for real experiments or replace them. In this regard a question arises about the interface and operation style of such educational software.

We have chosen so called interactive "serious game" as a style of our software functioning. As an educational tool serious games have been applied not long ago, but intensely – they are already integrated into teaching process in a number of schools, colleges, universities and even research institutes. Gaming component in such educational processes has allowed enhancing and supporting learning, making the process of study fascinating.

The aim of present report is to describe the process of the development of the interactive educational complex "InMechLab" – the interactive game-based mechanical laboratory for students specialized in Mechanics. Students start to communicate with this virtual model of laboratory before carrying out real experiments to enhance the quality of preparation to them. A user can feel him immersed in a real lab with available information on the main theoretical concepts and experimental methods. This software is designed to help students and lecturers, as it includes not only detailed theoretical statements on the subject of experiment, but also tests and visual experiments, in which users can check their knowledge before conducting the actual experiment.

1. Introduction

One of the distinguishing elements of engineering education is the laboratory requirement [1]. However necessary laboratory equipment is not always available and students do not have free access to it since numerous experiments are too expensive. This is why virtual laboratories, simulation environment laboratories and remote laboratories via the Internet started to develop and to use in educational process [2]. The advances in web technologies, in conjunction with the improved connectivity of test and measurement devices make it possible to implement e-learning applications that encompass the whole learning process. There are many examples of such implementation in the area of physics [3], electronics [4] and engineering [5, 6].

The present paper is concerned with the employment of computer facilities in the study of some aspects of such fundamental science as mechanics. The course of studies on mechanics in the Institute of Mathematics, Mechanics & Computer science of Southern Federal University includes theoretical mechanics, engineering mechanics, continuum mechanics, elasticity and plasticity theory, hydromechanics, fracture mechanics and so on. According to the established practice students are divided into groups of 3–5 persons to take part in laboratory researches. The students of every group learn jointly theoretical background, experimental methods and order of operations and then carry out an experiment.

The aim of the system of a computer support of an educational experiment *InMechLab* is giving a help to the students during their independent work, emphasizing and focusing their attention on the main theoretical concepts and experimental methods. Our experience tells that a participation in the real experiment and even successful completion of it does not mean successful acquirement of a knowledge minimum which is assumed to be obligatory. So, another goal of the system is to induce the students to apply all required knowledge and, in that way, to ensure their acquirement.

From the formal point of view *InMechLab* is a software which examines students' grounding and admits (or nor admits) the group to laboratory researches. The *InMechLab* system was developed initially as a knowledge control tool only [7]. However, it turned out, that it can be used as an effective educational tool too.

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2. Why the game?

The intercourse of the students with the system is realized in the form of a computer game. It was not a simple decision but there exist a number of reasons which justify this choice.

In recent years, there has been a growing interest at universities and research institutes in the development and application of the innovative teaching techniques. One of the most surprising successes in this field was connected with interactive “serious games” – the accepted term for games with an educational intent [8]. They need to be engaging, although not necessarily fun, while the learning can be implicit or explicit. These games have proved their efficiency since they were successfully used in military train operations [9], in health sector as strategy for medical practitioner preparation [10], in business [11], commerce and other spheres, where it is possible to simulate different realistic situations for upgrading professional skills. Detailed analysis on a sample of 139 articles devoted to the usage of gamification in education and published in top journals over the last 5 years (2010–2014) is presented in [12]. As to the games as a teaching tools for engineering students the review [13] demonstrated that the implementation of games in undergraduate engineering classrooms has shown the improvement of student learning as well as attitudes.

We think that both at teaching and at the knowledge control a student must feel himself free and liberated as much as possible. And the game, undoubtedly, gives an opportunity to eliminate superfluous tension and nervousness.

The game-like form of the system leads to a stimulation of an interest and to substantial increase of motivation. An aspiration "to win" makes even repeated solving of standard educational problems and exercises less tiresome. The students feel an interest to work with the program by their own after classes.

The teacher-student intercourse always has some non-formal, non-official traits. The teacher can joke (even at exams), the student can reply to his joke. So, a computer must have some abilities to "joke" and allow to "play jokes" with it. The game-like form seems to be most appropriate for using such non-formal elements.

From various types of existing computer games we have chosen so called adventure games. They have been already used in teaching for a long time. As an example, a special issue of "Simulation & Gaming" journal (Issue 4, 1990) could be mentioned here, that was devoted to an application of such games to language learning. The characteristic feature of these games is almost full freedom of game's hero to choose his actions. He can open and close doors, drawers and closets, read notices and announcements, take and drop different items, stare at walls and do other necessary and unnecessary deeds. The hero is more or less free to choose a ways to his targets. Some of these ways are correct, others – misleading, but having gone through them hero eventually finds solution and achieves his goal. This special feature is very attractive for the creation of educational "word" someway adequate to real (Fig.1).

3. Gaming problems

The main problem which the player is solving permanently is the standard problem of adventure game. The hero has to execute the necessary action with the necessary object in the necessary place. It is these problems solving that forms an adventure plot of the game. However, in comparison with commercial adventure games, such problems are simplified as much as possible by means of special system of hints and advices.

When developing a game-like system it is not easy to resist the temptation to use some elements of traditional arcade games. However it is important not to turn these insertions to the end in itself. Elements of arcade games undoubtedly give rise to an interest and additional attention to the program. But, as mentioned in [14], the criteria for success or failure in the simulation must be determined not by good hand-eye coordination but by the learning objectives.

4. Educational problems

During the game a student has to solve educational problems of different types. Let's enumerate some of these types.

Fig.1. *InMechLab* screenshots: the game world.

1. "Construction of a sentence". The student makes up sentences, formulae or diagrams by means of a given set of words, mathematical expressions and picture elements.
2. "Calculation by formula". In some cases the student simply has to enter a number (theoretical value of critical load, length of plate and so on) which must be found beforehand by means of one of the main theoretical formulae. A response of the system on this number can be both immediate and postponed. Obtaining of initial data for the calculations is usually an additional problem, for example a problem of the following type 3.
3. "Measurements". Solving this type problem is connected with simulation of simple measuring equipment (ruler, Vernier caliper, micrometer etc.). The aim of the player is to superpose screen images of the object and measuring tool, make necessary adjusting and read and interpret the readings (Fig.2)

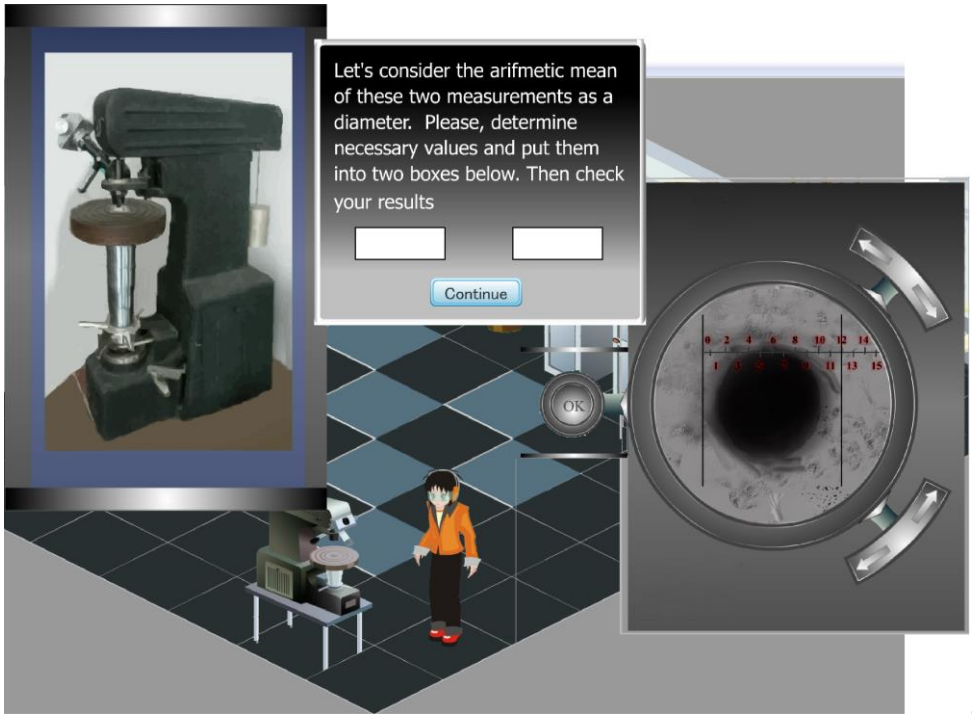

Fig.2. Modelling the measurements

It is clear that concrete realization and representation of each problem may significantly change from problem to problem even within the one type. One of the main system designing difficulties was a plot justification of educational problems involved. We have had to coordinate with the plot an origin of every problem and necessity of its solution for further advancement.
During the game the system constantly keeps a score. Such scoring allows a teacher to make prompt analysis of current situation, to determine the working stage at which students are situated. Moreover the increase of the score is an additional stimulus to the students.

5. Experiment modelling

The last part of every game is a simulation of a real physical experiment. The aim of this stage is to give to students some general ideas on the real course of laboratory researches, to acquaint with equipment working, to direct students' attention to problems which can arise during the experiment. Assembly of installation, measuring of specimen parameters and carrying out the experiment are simulated at this stage. The computer acts as a simulator and trainer allowing to develop or to consolidate some skills of experimental work.
Simulation of experiment consists of physical phenomenon simulation as well as modelling of measuring tools and equipment working. Phenomenon simulation is based on rather simple mathematical models. The main requirements to the representation of real experiment are closeness to naturally observed phenomena and clearness of demonstration. As to the working of measuring and other equipment the system includes some reactions on invalid actions of user more or less adequate to real and imitates the apparatus breakage and disrepair.

6. Conclusions

In the conclusion it’s worth to note that in the development of this interactive system not only lecturers but also students were involved. That leads to gradual enhancement and update of the software throughout the learning process. Close collaboration among members of this research team in technical and creative as well as pedagogical aspects makes the work on *InMechLab* exciting and entertaining.

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