**New Multimedia Teaching Tool Using Remote Physics Experiments**

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**Abstract** The contribution demonstrates practical application of the remote and virtual experiments within e-laboratory for the *World in Motion* physics unit performed via the strategy of Integrated e-Learning (INTe-L) with the focus on the exploratory function of physics. The paper introduces the possibilities of utilizing the e-experiments in the secondary physics educational process. The way how *World in Motion* as a new teaching tool, was designed and is outlined as well. It is based on three basic components of INTe-L: real remote experiments, virtual experiments and e-study materials. Complementary materials comprise tests and games for the student’s background knowledge.

**Keywords** Integrated e-Learning; multimedia teaching tool; motion; Physics; remote experiment; virtual experiment

I. **INTRODUCTION**

The teaching strategy of university Physics based on the classical stereotype accumulating basic models and laws undergoes a crisis [1]. The same concerns the subject of Physics (and natural sciences in general) in primary and secondary schools. Generally, we can say that today’s students are not interested in natural science; they neither like Physics nor understand it. There are many reasons for this:

- application of teacher-centred approaches;
- too much theory presented and too little practical experience;
- importance of understanding Mathematics as an unpopular subject;
- outdated educational methods, forms, tools and teaching materials used in educational process.

Substantial changes were introduced by the new School Law that came into force in Slovakia on 1 September 2008. It concerns the changes in the field of curricula, the number of teaching hours for individual subjects and the requirements regarding the teachers and students. The change in the number of teaching hours is naturally connected with the reduction of the basic topics to be taught. In Physics, teachers have to omit many topics that have always been considered to be a part of general education and understanding of the real world phenomena. Students have chance to learn about them only in the case they choose Physics as the subject of their further study. The question is whether the students want or master the study of Physics after the secondary school physics course reduced in such way.

What can the physics teachers do about this? The solution seems to be in the way and methods of reviving the students’ interest in Physics, and intensifying their motivation for natural science. We therefore recommend the new strategy of education as an integrated e-Learning (INTe-L) proposed by Schauer et al. [2] accompanied by the modern teaching tools. INTe-L strategy is different from the traditional model of education where the focus is on the knowledge of formulas, definitions, facts and equations, with the teacher leading the process. The new approach, instead, prefers the student-centred education based on the methods of scientific work, such as active observation of natural phenomena, experimental data collection, their evaluation and interpretation. Various researches have confirmed much higher effectiveness of such type of knowledge acquisition [1].

This paper presents *World in Motion* as the new multimedia teaching tool based on physics e-experiments and INTe-L strategy.

II. **INTEGRATED E-LEARNING**

The INTe-L strategy is based on utilization of experiments and on the methods of scientific work. These were declared by Carl Wieman, a laureate of Nobel Prize in Physics [1]. The main feature of these methods comprise observation, search for proper information, data processing and storing, work organization and planning, data and results presentation, etc.

INTe-L can be defined as *the interactive strategy of teaching and learning based on the observation of the real world phenomena by the real e-experiment, e-simulations based on the principal features of the physic laws and e-teaching tools such as interactive e-textbooks, manuals and instructions providing information and theoretical background for the understanding and quantification of observed phenomena* [2, 3].

Generally, INTe-L is a higher generation of classical e-learning enhanced by the experiment as an integral part of the education of natural sciences. It is based on three components that will be discussed in detail below.
A. Real Remote Experiments

Remote experiment is a real experiment with real laboratory instruments and equipment that can be controlled by a user from his/her computer through the Internet. The experiment can be conducted from any place all around the world, the values of adjustable quantities can be modified, and, after the measurement, the experimental data can be imported into user's computer. Some of the real e-laboratories i

\[ \text{www.ises.info, kf.truni.sk/remotelab in the Czech and Slovak Republics or rcl.physik.uni-kl.de/} \] in Germany i are accessible 24/7 by all the users via the Internet.

B. Virtual Experiments

The second component of INTe-L is a virtual experiment. It simulates different phenomena of the real world. It runs within an html page opened by a user, e.g. http://www.walter-fendt.de.

Perhaps one of the most popular pages with these simulations is the page of the Colorado University at Boulder on http://phet.colorado.edu. The presence of virtual experiments in the educational process enables the teacher to demonstrate many real phenomena that otherwise could not be presented in classes (e.g. a free fall on Mars etc.). Virtual experiments enable attracting the students\' attention and enhancing their understanding of the observed phenomena. They simulate the idealized reality while neglecting the noise and impact of real experiments. It is therefore appropriate to combine the utilisation of real and virtual experiments in educational process. Students thus get a chance to compare reality and ideal condition.

C. E-textbooks

The third component is an e-textbook. Besides the theory, these materials comprise animations that make the work with the book more effective and attractive for students. Testing programs generating the series of questions and enabling the students to verify their knowledge are a common component.

The implementation of INTe-L strategy i.e. e-learning with the massive support of experiments i is supported by the following findings:

- Physics belong to unpopular subjects and one of the reasons is the lack of experiments [1].
- The presence of the experiments in the Physics classes influences the students' positive attitude to the subject [4].
- Education supported by interesting electronic means leads to the reduction of negative attitudes to Physics [5].

Other reasons for the implementation of the remote and virtual experiments (e-experiments) in education are the following benefits:

- saving time, space and money; enabling flexible time management;
- motivating students to play with or operate the apparatus via the Internet;
- providing distance education, an option also for physically-challenged students [6];
- demonstrating the experiments that could not be conducted in a school laboratory (e.g. proving that the acceleration due to gravity is not constant on the Earth).

It is very important to start with this new way of the knowledge presentation and acquisition from the very start of the Physics studies. We therefore start with the topic of \(f\)Motion within the \(f\)Mechanics\ unit, since the experiments there are essential, yet remote experiments are generally missing [7]. The main difficulties are:

- to construct PC controlled actuators able to pick up the motion lasting only a couple of seconds or even fractions of a second;
- to construct the experimental equipment enabling to move the apparatus to its starting position remotely.

Recently, we have designed and devised two remote experiments within the \(f\)Mechanics\ unit: \(f\)simple pendulum\ and \(f\)Free fall in a glass tube\ [8]. Two experiments are a part of e-laboratory that was built in the Department of Physics, University of Trnava in Trnava. At present, e-laboratory offers ten remote experiments and provides remote open access via www page on http://kf.truni.sk/remotelab.

III. \(f\)WORLD IN MOTION\(f\)TEACHING TOOL

Implementation of INTe-L strategy in the educational process means that the teacher starts the lessons with a real life phenomenon while choosing suitable experiments, either real (hands-on) or remote real, then continuing with virtual experiment and e-textbook with corresponding study materials, and finally combining them in an appropriate way, thus forming a compact and attractive teaching unit.

Our aim is to help teachers prepare such type of lessons by reducing laboriousness of their input, and increasing the students' involvement. We developed a multimedia teaching tool by the title \(f\)World in Motion\ that covers selected topics within the \(f\)Motion\ unit on the level of the secondary school Physics.

A. Software used

The teaching tool was developed by using Macromedia Flash 8 software (Fig. 1) enabling to create extremely small and fully dynamic interactive applications running under the common web browsers and operational systems [9]. Flash contains an object-oriented language called ActionScript. Besides creating the overall design of the multimedia teaching tool, we used it also to program the tests and games. Though our Flash library contains more than 450 items, the final product is relatively small: the application size is 14.5 MB, so that it can be comfortably sent by e-mail. Another advantage is that the final file can be used in the form of either a web page or exe flash file etc. so that the user does not need a special program to run this application. Besides, the author does not need extra experience in programming in order to develop a simple product in Macromedia Flash.
Figure 1. Teaching tool in Macromedia Flash; 1 - stage, 2 - timeline

B. Content of the "World in Motion"

Our multimedia teaching tool (Fig. 2) contains complete teaching materials concerning the following topics:

- One-dimensional uniform motion and uniformly accelerated motion;
- Free fall;
- Motion in homogeneous gravitational field (motion of projectiles);
- Uniform circular motion;
- Oscillating motion.

During the preparation of the teaching tool, we took into consideration the way of presentation and acquisition of the knowledge preferred within INTe-L strategy, i.e. from active observation and experimentation to acquisition of new information [3]. The result is the tool contains 24 various experiments.

We tried to design the content in an attractive way, since our aim was to motivate students also by visually attractive material. The presented teaching tool allows: a) a teacher to facilitate the implementation of the INTe-L strategy in direct education process; b) a student to study with the support of the latest ICT in a highly interactive way.

"World in Motion" consists of eight components (see Fig. 3: from top to down left: In the Playground, Lab World, A Little Bit of Theory, Glossary; right: Games, Let's Count, Do We Already Know It?, Links). We introduced a few unconventional features that are not a typical part of the Physics lessons, e.g. remote experiment or didactic games.

Let us describe the individual parts of the content with short comments.

- Motivational part "In the Playground" contains five videos showing different types of motion performed by a little girl in the playground. Our aim was to show mainly the motion all around us, not only in the Physics textbooks. The videos are without titles or explanations. At the beginning their role is to motivate students. Later, in the testing part, students have to answer the questions about the playground activities from the physical point of view.

- Working part "Lab World" is the main part of the tool, inspired by the fundamental idea of INTe-L strategy i.e. to activate students and to show them how to explore the real world phenomena. It contains experiments (direct URLs to work out or videos to watch), assignments and photo galleries of the experiments. This part is dependent on the Internet connection, as the majority of the experiments are remote or virtual. Even the real experiments, where user can see off-line videos, need the Internet to download the experimental data. Via this teaching tool, we introduced four ways of experimentation into the Physics education: real PC assisted experiment, real remote experiment (Fig. 4), real experimental video with analysis via software Tracker, and simulation as virtual experiment. The assignments contain 117 items aimed at the analysis of the experiments, solving the problems or working with graphs.

- Theoretical part "A Little Bit of Theory" contains basic theory regarding the five abovementioned topics
Figure 4. Remote experiment page: “Free fall” with many pictures illustrating the real world situations. Our aim was to develop e-material meeting the basic requirements of an e-learning course:

- goals need to be set up clearly;
- contents need to be divided into closed chapters or learning units [10];
- keywords need to be written in the beginning of the chapter;
- requirements need to be specified;
- different fonts and colours should be used;
- many examples, applications, solved problems should illustrate the phenomenon studied [11].

- “Glossary” for quick orientation in the theory covered. It includes an alphabetically ordered glossary of all the important terms and quantities used in the theoretical part.

- “Games” to work with science knowledge in an informal way. It contains four games: two kinds of the Pairs game (one with physical quantities and units, another with famous physicists), Who wants to be a millionaire?, and Hangman (Fig. 5).

- “Let’s Count!” to solve physical problems contains a set of 30 completely solved problems with a short explanation and analysis. All the problems are connected with the real world in order to demonstrate that Physics is not only about the abstract terms without meaning.

- Testing part “Do we already know it?” consists of five multiple-choice tests with final evaluation covering all the topics in the tool. Student can choose one of four options by clicking the right answer. This part also contains the final test (without correct answers) “Physic in the playground” (Fig. 6) where students have to judge the playground activities from the physical point of view. The testing part is important for self-study where the students need a kind of feedback.

- “Links” contain a list of the literature used in the tool, links to set of real remote and virtual e-laboratories and a few interesting pages with physical content.

IV. CONCLUSION

In the presented paper, we introduced a progressive strategy of education “Integrated e-Learning via multimedia teaching tool “World in Motion”. The fundamental part of it is an experiment as a device to motivate and activate students. In the tool, for the first time, combined are four various types of experiments: real (PC assisted and remote), video analysis, and virtual experiments. This variability enables students as well as teachers to work with various ICT technologies and to develop not only science thinking but also their computer competences.

The teaching tool designed in software Macromedia Flash 8 combines the basic components of INTe-L with additional materials useful in educational process. The questions and tasks in the tool should challenge the students’ critical thinking, creative approach to the problems and, as a result, deeper comprehension.

The tool is a complex product designed for the secondary schools students and teachers. In eight units, it contains 24 experiments, 117 assignment items, 30 solved problems.
5 didactic tests with answers, one didactic test without answers, 66 terms in glossary, 9 videos, and 487 library items. It enables teachers to implement INTe-L into direct education process. We hope that:

- it is a good example of inquiry constructivist teaching and learning for prospective and also in-service teachers.
- it involves learners in the construction of knowledge;
- it demonstrates the utilization of the latest ICT in the teaching and learning process with better visualization, experimentation via the Internet and in-depth understanding of content, while developing the abilities and skills necessary to create conceptual links across the subject area via different planning of learning activities.

Although the tool has not been implemented in the education yet, our experience with e-experiments in education proves that:

- the students like to play with simulations;
- their ability to solve the problems by using e-experiments is much better than without them;
- project-based learning with the support of remote experiments increased the students’ motivation and deepened their knowledge.

The outcome of the research into teaching/learning Physics via the presented teaching tool is currently being analysed and will be soon disseminated (school year 2011/2012).

The multimedia teaching tool will be distributed via CD and soon will be available on the Internet.

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