Analysis of Existing Virtual Laboratories

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Abstract. This article describes the concept of a virtual laboratory and provides examples of their use in the field of computer science. E-learning implemented by educational institutions should include not only educational methodical complexes on disciplines (modules), but also software aimed at the development of professional competencies. The best way to build competences is a virtual laboratory, simulated in an e-learning environment onto real world objects. Creating a virtual laboratory allows, on the one hand, to experiment with the equipment and materials that correspond to the real lab, on the other, to get acquainted with the computer model for the development of practical skills in professional activities. Note that not every educational institution can afford to purchase expensive equipment, which is costly in maintenance, purchase supplies, and most importantly, the replacement at its improvement. The versatility of virtual laboratories compensates these shortcomings. Virtual Lab provides students with the complex problems of various domains, virtual instruments to formalize the process conditions, the means to solve the problem; teachers are able to monitor, diagnose the process of mastering the material. Thus, students can independently form practical skills in the time convenient for them, not limiting themselves to the times and the territorial remoteness of the educational organization.

Keywords: virtual laboratory, educational resource object modeling, interactive method, innovative technologies, virtual educational environment, experiment, software, distance learning.

INTRODUCTION. Interactive computing educational resources are usually scattered across the network. Moreover, their creation requires special knowledge in the field of programming, which makes them complex and expensive. As a result, their scope and coverage are limited. Before development, it is necessary to study the features of existing virtual physical laboratories.

MAIN PART. The Virtulab service is a set of educational interactive works that allow students to conduct virtual experiments in physics, chemistry, biology, ecology and other subjects, both in three-dimensional space and in two-dimensional. Developers present their software as the effective use of interactive tests and lessons in the educational process not only improves the quality of school education, but also saves financial resources, creates a safe, environmentally friendly environment [1].

Virtual Lab is an interactive environment-based software for experiment simulation. The laboratory mainly focuses on experiments to demonstrate theoretical concepts. A simulation environment is designed to convey a sense of immersion, as if students were doing an experiment in the real world. The experiment can be implemented on the basis of an autonomous access application or on the basis of a web server and a web browser.

The main goal of developing the concept of a virtual laboratory is to complement a real physical laboratory in training. The main tasks of virtual laboratories are [8]:

- reduce maintenance costs.
- remote access to various virtual laboratories.
- motivate students to conduct experiments in their own interests.

The main goal of the virtual laboratory is that the user can easily increase his knowledge and improve the application of fundamental concepts to practical work.

In addition to remote access, virtual laboratories can also be remotely configured, which allows each individual student to provide the necessary tasks and virtual models, with their settings as needed for specific practical exercises. A virtual laboratory can be designed in various ways depending on the program course for which it is intended. According to the study [2], in the case of skillful design, the laboratory should have such characteristics as reconfigurability, scalability, cost-effectiveness, reliability, maintainability, and realism.

The laboratory must be very flexible and re-configurable. Different topics and tasks require different models. It is necessary to develop and add new ones.

The laboratory must be scalable and must be able to support many students. Student groups should not be large due to lack of resources.

The cost of installing and maintaining the laboratory should be much less than what is being modeled in the laboratory. For example, physical processes that require a large amount of equipment.

The laboratory should be able to withstand and handle unintentional student errors in actions during improper laboratory work.

The laboratory should be easy to maintain. Common tasks, such as backing up and applying updates, should be easy to do and automated to the extent possible.

The laboratory should be of practical value and based on laws from the subject area.

According to methodological studies, a virtual laboratory should include:

- a module for simulating a laboratory experiment;
- control module;
- telecommunications module;
- identification module;
- training module;
- testing module;
- transaction accounting module;
- visualization module;
- module for maintaining electronic educational resources;
- monitoring module.

In turn, founded by Nobel Prize winner Karl Wyman, the PhET Interactive Modeling Project at the University of Colorado creates free interactive mathematical and scientific models. PhET models are based on extensive research in the field of education and attract students through an intuitive, playful environment where students learn through research and discovery. PhET provides interesting, free, interactive, research-based scientific and mathematical modeling. Each model is rigorously tested and evaluated to ensure training effectiveness. These tests include interviews with students and monitoring the use of models in the classroom. The simulation is written in Java [8], Flash, or HTML5, and can be run online or downloaded to a computer. All open source simulations. Several sponsors support the PhET project, allowing these resources to be free for all students and teachers [7].

Wolfram demonstrations is a project designed by Mathematica creator and scientist Stephen Wolfram as a way to bring computational research to the widest possible audience. Wolfram demonstrations is an open source project that uses dynamic computing to cover concepts in science, technology, mathematics, art, finance and other fields. [9]. Mathematica users from all over the world who are involved in promoting innovative demonstrations.

From primary education to advanced research, topics span an ever-growing array of categories. Some demonstrations can be used to revitalize the classroom or visualize complex concepts, while others shed new light on cutting-edge ideas from academic and industrial working groups. Each of them is checked and edited by experts to obtain clarity, visibility, quality and reliability.

All demos are freely distributed on any standard computer with Windows, Mac or Linux operating systems. In fact, you don't even need a Mathematica project. You can interact with any demo using the free Wolfram CDF Player. If Mathematica is installed, you can experiment and modify the code yourself.

Demos can be created with a few short lines of code. This opens the door for researchers, teachers, students and professionals of any level to create their own complex mini-applications, and then publishes them and shares them using Wolfram's calculated document format (CDF) [4]. The Wolfram demonstrations project is part of the Wolfram Research family of free online services — Wolfram Alpha, the world's first computing engine; MathWorld, a math site, as well as Wolfram, WolframTones, and others [5].

An important unique feature of another Molecular Workbench virtual lab is that it reproduces simulations in a learning context. It supports the rendering and development of learning activities, which are usually sequences of learning steps that use mathematical models for learning. Learning activities can be as simple as a demonstration that shows a single concept, or as complete as a digital textbook that provides all the educational material for a topic or something in between [3]. The Molecular Workbench authoring system can be used to create all these different levels of learning activity prepared in the classroom, with customizable user interfaces for different students. This authoring system was used to produce many of the existing activities available through a browser-like MVT delivery system. Molecular Workbench has more features designed to support learning. This allows teachers to create new activities or modify existing ones. All these functionalities, as well as modeling and creation capabilities, are easily integrated into a single system with simple, intuitive graphical user interfaces. All these things are put together, the size of the downloaded software is only 1.6 MB [10].

The virtual physics lab can be used in a variety of ways to revitalize the teaching of physics:

- as an animated board;
- as a virtual experiment to obtain typical data measurements;
- as an auxiliary curriculum;
- as a tool for qualitative research;

- as a demonstration of how to conduct an experiment to allow students to control real physical equipment in a laboratory;
- as a tool to expand knowledge about subjects and deepen understanding of students as well as teachers.
- as a reference encyclopedia of interactive experiments;
- as an inexpensive data recording package (using the microphone input of a sound card or mouse as an angle position sensor).

The resource is intuitive in its work, and each simulation includes instructions, as well as a brief description of the physical theory. After installation on a school server, a class of students in a computer class can work simultaneously on any number of virtual models. Some of the animations and virtual experiments go beyond what is required at school, but are included to empower students. Virtual physical laboratory is successfully used in a wide range of training programs in different countries [3].

Among the available laboratories, we highlight the qualities that determine the convenience and functionality of a software product.

Currently, a feature of the implementation and use of virtual laboratories is that if free systems allow you to collect your own experiments, either they are divided into separate unrelated modules, or models cannot be edited by the user of the service, or statistics about the laboratory work done in the laboratory system cannot be obtained, for example Virtulab, Wolfram.

It is noticeable that the infrastructure of virtual laboratories is rarely covered in publications, and basically the market for software solutions is monolithic systems, with built-in virtual models that cannot be edited and expanded, as is the case with Virtulab, VPLab, Molecular Workbench.

Business solution VPLab [6], which provides a full package of training and control based on a virtual laboratory, paid and English.

The Molecular Workbench created virtual physical models based on the Java platform, in particular, Java applet technology was used [3]. It allowed using the same language both for writing a web service and for virtual models. Applets contain a large selection of visualization tools, create screen forms, and support user interaction. Nevertheless, the use of Java applets has its drawbacks which complicate the use of virtual models:

- Requires the installation of a Java plug-in for the browser;
- the applet cannot be used until the virtual Java machine starts, the launch of which takes time;
- due to the insecurity of applets, users by default will not be able to launch them;
- Often requires the use of a specific Java runtime.

Therefore, you should focus on creating models using Java Script, since this implementation language does not require additional actions, except using a modern browser.

CONCLUSION. This situation makes the question of developing an information infrastructure that allows to load virtual models in a generalized form with the expectation of editing them and the ability to expand the services of a virtual laboratory relevant.

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