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Virtual Laboratory for Physics Teaching

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Abstract. This paper presents the outcome of over 10 years of work of the team of specialists on creating a virtual laboratory for physics training for general secondary schools in Mongolia. The laboratory can serve as an experimental base for studying physical phenomena in teaching and learning Physics. In construction of models for physical processes and laws, programming tools such as object oriented Delphi, C++, Java, C# and OpenGL graphics library are used.
Conducting laboratory "investigations", students become able to perform numerical measurements and get computer estimations of physical quantities. By means of intensive and active discussions and debates around the facts and data, the students should interpret and deduce formulation of physical laws and regularities. This leads to "discovering" the fundamental laws of physics by students themselves.

Keywords: Modelling in Physics, Numerical Experiment, Virtual Laboratory, Student-Centred Training, Simulation and Interpreting Physics Processes

1. Introduction

Revolutionary progress in information and communication technology [1] revealed wonderful opportunities for improving the quality of schooling. We have been witnessing how new methodological principles based on contemporary scientific paradigm shift and related reforms of education systems are carried out on the foremost achievements in ICT. The education system of many countries faces new challenges to ensure equal access to information for their citizens and provide active, participatory and experiential learning in their training.

With regards to the new demands of the times, modern education needs to meet these requirements and keep a pace with quickly growing need for information. There is no doubt that today everyone intuitively believes that multi-media technology can be fruitfully used to ease the process of acquiring new experiences and skills and at the same time opens up numerous opportuntities to experiment with new knowledge. These requirements are also set as an urgent need in Mongolian education as well [2].

2. The Virtual Laboratory

2.1. Need in Virtual Laboratory

For a long time, Physics training in our country was conducted mostly without or with a very poor experimental base. It means that Physics instruction almost entirely was and still in many places today is carried out by lecturing and writing "frozen" formulas on the board. As a consequence of the unsatisfactory quality of instruction, i.e explanatory and display teaching, now we see why many students in Mongolia show very little desire and motivation in learning Physics[3].

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It is hoped that introducing and using a virtual laboratory in teaching and learning undoubtly will bring in new possibilities to motivate and empower students by providing opportunities for independent and experiential learning for them. Our experience with modeling shows that computer simulation of physical phenomena through trying out related numerical experiments will promote students' thinking, enabling them to solve problems not only in the field but also in wider perspectives (social problems as well).

The students, based on their results of numerical experiments, are very much encouraged to formulate the essential laws in Physics by themselves. Generally speaking, there are two types of activities that help learners to develop their thinking skills:

- By conducting laboratory "investigations", students become able to perform numerical measurements and related computer estimations of physical quantities
- Then, by intensive and active discussions and debates, the students interpret new facts and data to make them meaningful for themselves. This leads to "discovery" of the fundamental laws or physical regularities.

As a whole, the set of activities of the lab helps students to become real investigators and explorers of the physical and natural phenomena.

The laboratory has been tested out several times during physics classes. The special group of experts has been appointed to conduct a parallel testing of the lab. Recently on conclusions and recommendations the Virtual Laboratory (CD) has been officially approved by the order of the Minister and it was recommended to use it in physics classes in secondary schools.

2.2. Main Principles

The Virtual laboratory serves as a computer based numerical laboratory for teaching Physics. It consists of logically interconnected learning[4],[5] activities to help learners:

- become able to take numerical measurements and evaluations of the processes being explored
- process and interpret the data (information/facts) to make them meaningful for themselves through intensive discussions
- students become able to write out formulas and formulate fundamental laws of physics themselves.

The Virtual laboratory will contribute into teaching and learning processes in the following ways:

- Gives opportunities for students to learn by doing
- Offers interesting, motivating activities to discover
- Ensure a lively classroom interaction through discussions and debates
- Develops thinking skills and problem solving skills of students
- Opens a wide variety of possibilities to use these kind of resources for independent or self-study in both formal and non-formal education. It can be effectively used in distance learning especially for our conditions when the population is scattered over vast territory.

2.3. How to use VL in classroom

Taking into account the experience of other countries we recommend to use VL in the following ways:

- At the beginners' level the animated objects of virtual laboratory could be used as ideal demonstration tool to present physical processes. For better results it should be combined with simple hands-on tests and experiments.
- At the higher grades when students have gained the basic knowledge and experience in Mathematics they are asked to carry out testing and estimations. These are followed by intensive discussions on the results of the measurements and related estimations to formulate own physical conclusions.

VL will be suitable for students' self-study of physical processes through tests, calculations and discovering their laws and regularities. Such application of virtual laboratory undoubtly will promote developing research interests and skills of students and improve their scientific thinking.

2.4. Challenges

There are several issues that could be raised while teaching Physics using the VL. They are closely related with e-readiness of teachers and schools.

The first issue is related with experiences and skills of teaching staff. It requires special training (in-service) for physics teachers to become able to manage e- learning process of students as well as guide and monitor a knowledge construction process of their learners. The second issue is related to the provision of additional resources and support. The VL is designed to replace all learning and teaching aid materials. For better results and success of learners it should be noted that the students' numerical experiments of physics phenomena should be supplemented with or reinforced by elementary experiments based on the availability of facilities. Such simple experiments will be essentially important to understand physical phenomena [6].

The third issue is related to a hardware provision. To implement VL school computers must be equipped with Intel Pentium-IV and above. Programming tools/languages such as Delphi, C, C++, Java, C# are to be installed on the computers along with the OpenGL graphics library. Last but not least important issue can be raised about school management and administration. It is crucial both for teachers and learners that school principals and training managers must be really interested in understanding and implementing ICT based technology in the training processes.

2.5. Virtual Laboratory Examples

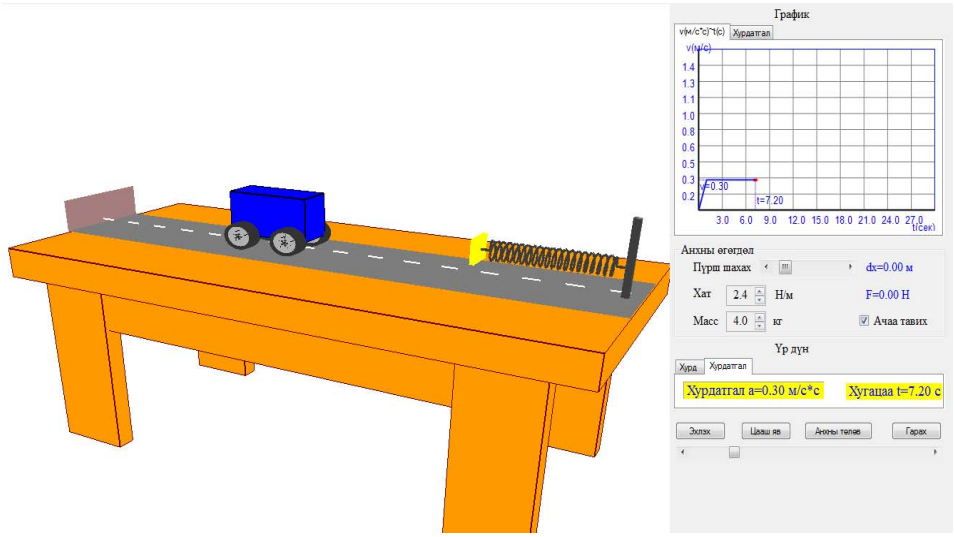

Fig. 1: VL desk for studying Newton's law

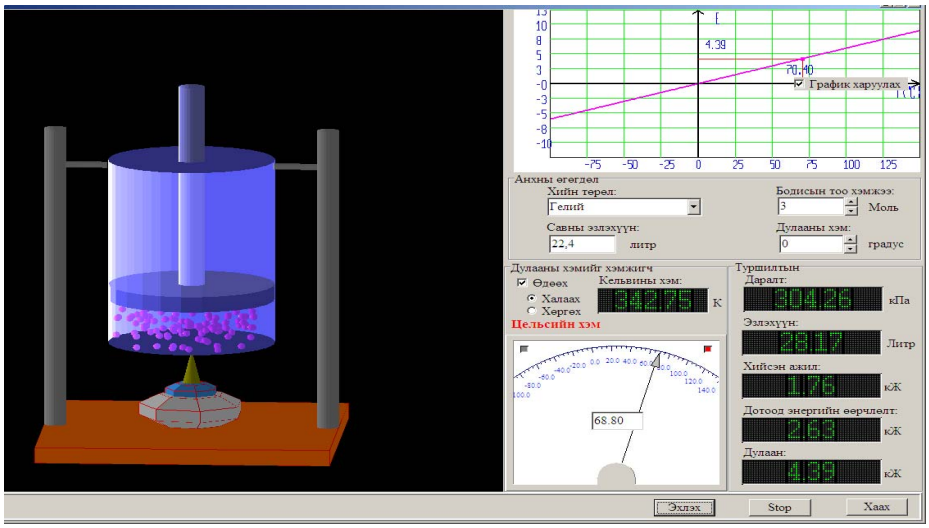

Fig. 2: VL for first law of termodynamics

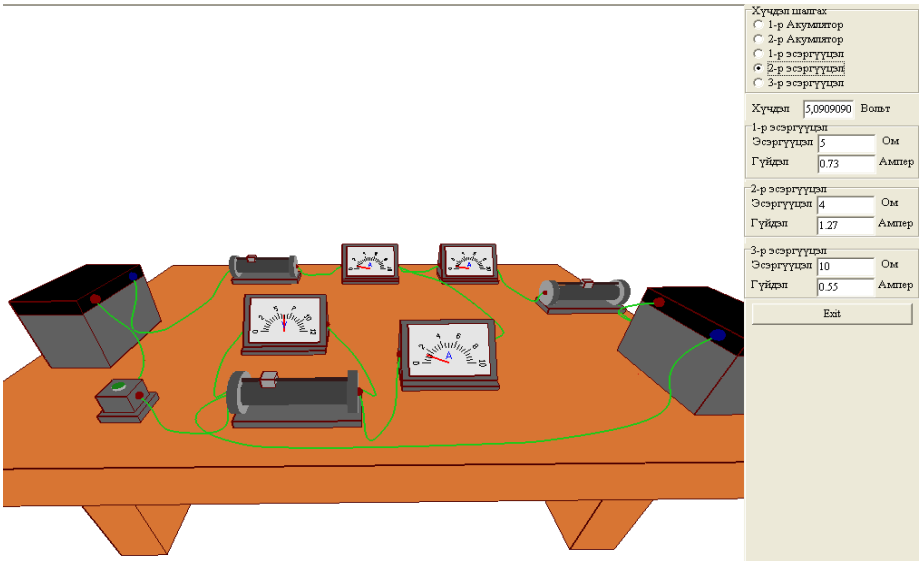

Fig. 3: VL desk for studying Kirchhoff's Voltage Law

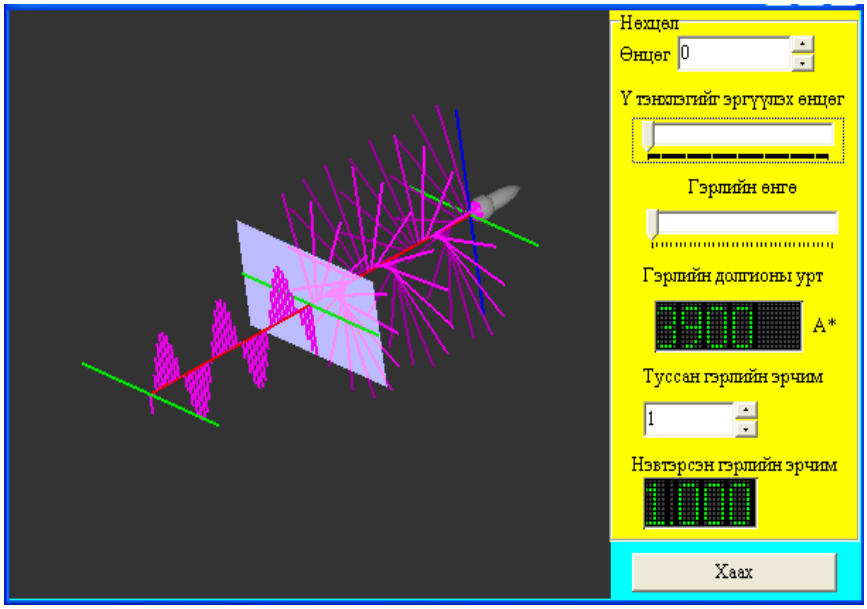

Fig. 4: VL experiment for Malus's law of light polarization[7].

3. Acknowledgements

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