Virtual Laboratory Work of Physics

Shuichi KAWABATA, Yachiyo YAMADA and Masaomi SANEKATA
Physics Laboratory, Faculty of Eng., Tokyo Polytechnic University
1583 Iiyama, Atsugi Kanagawa, 243-0297 Japan

Abstract-Laboratory work is the principal subject in physics. The laboratory work in physics education is important not only for the acquisition of the fundamentals of the experiment but also to cultivate the students' interest in physics. Students will understand the laws of physics empirically and intuitionally through their laboratory work. The empirical knowledge through the laboratory work would be more impressive for the students than the passive one obtained from the textbook. But the traditional approach to laboratory work is too professional and advanced for our students. The multimedia approach based on the Internet was developed to help the student's laboratory work.

I. INTRODUCTION

In our university, most first year students of the faculty of engineering are doing laboratory work of physics however nearly 20% of the students have not learned physics in high school,. Basic physics is essential background of our curriculum. This is due to the diversity of the entrance examination system of university in Japan. The number of the first year students who did not take physics in high school is gradually increased [1].

They are unfamiliar with physics and complain about the conventional methods which employ many mathematical formulas. The fundamental knowledge relevant to the experiment is indispensable to the comprehension of the essence of the physical phenomenon under study.

The students are obliged to prepare for their laboratory work. But, we have found the pre-study which involves reading conventional directions was not satisfactory for the preparation of the laboratory work, especially for the students who had not learned physics in high school.

Recent students in Japan seem to find it difficult to grasp the whole image of laboratory work without visual aids [2, 3]. We are planning to develop a new approach to laboratory work of physics that is more lucid and intuitional, than the conventional one by means of the multimedia and Information Technology.

II. SYSTEM

The new laboratory work directions are written in HTML (Hyper Text Markup Language) and can be seen through the Internet independent of the platform. The video clips are also seen using common media players such as Real Player and Quick Time on the Internet. Students can study the virtual laboratory work at any time when they want. Students can also repeat the study until they get a sound understanding before and/or after the laboratory work. The contents of the new laboratory work can be randomly accessed for frequent study. The new laboratory work directions will help the student to prepare his laboratory work with ease and is expected to promote their interest in the laboratory work. We call the new approach "*virtual laboratory work directions*".

Another merit of the virtual laboratory work directions is that a frequent revision is readily accomplished by editing the contents on the computer.

We have accomplished the virtual laboratory work directions for the subjects "Polarized Light" and "Reflection and Refraction of Light". They contain a text with illustrations and photos, computer simulations and demonstration video clips. The virtual laboratory work directions of those experimental subjects are put to trial in the class.

III. MULTIMEDIA APPROACH

The virtual laboratory directions are composed of text, illustrations, photos and video clips. The text concisely describes the basic knowledge including the theory and the procedures of the laboratory work.

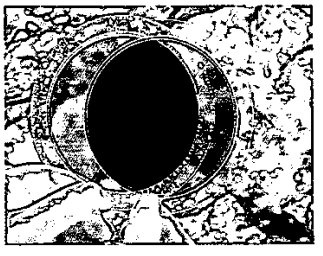

Fig. 1 Top page of the "Polarized light " in the virtual laboratory work directions

In the text, mathematical formulas that represent the physical phenomena are limited and the derivation of the equations is closely followed. Theories and basic concepts of the experimental subject are also shown by means of illustrations and photos as far as possible.

0-7803-8596-9/04/$20.00 ©2004 IEEE

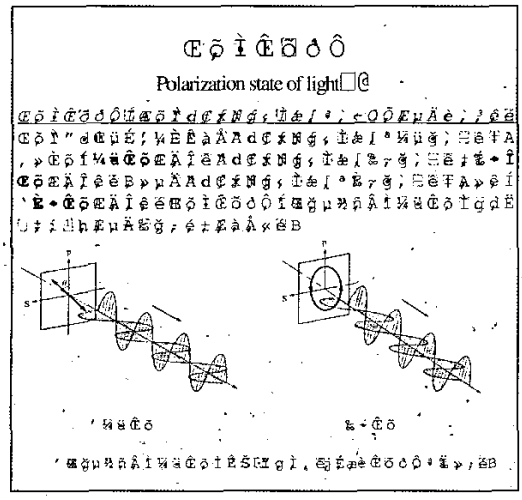

Fig. 2 The basic concept of the polarization of light
The nature of the polarized light is explained schematically.

The demonstrations of the physical phenomena are prepared in the directions as the video clips. Computer simulations are also employed to analyze the phenomenon. The demonstration video clips and computer simulations make it easy for the student to understand the physical phenomena. The graphics and video clips of the demonstration experiment as the contents will let students easily comprehend the virtual directions.

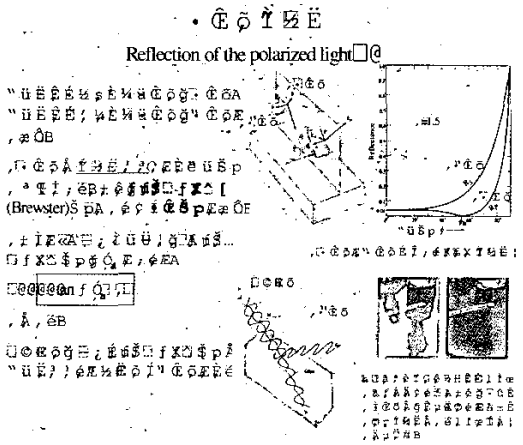

Fig. 3 Theories in the reflection of polarized light
The nature of polarized light in reflection is summarized. The phenomenon at the Brewster angle incidence is explained visually.

The procedures of the laboratory work are also explained by using video clips that simulate the experiments.

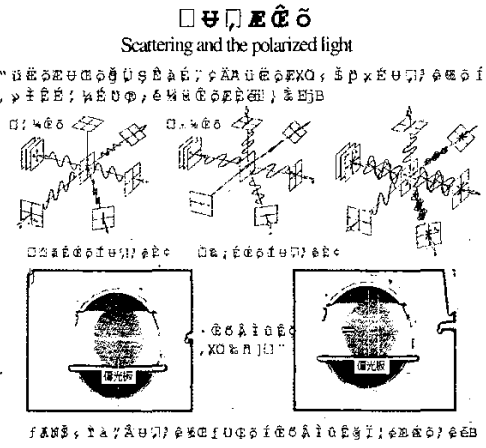

Fig. 4 Demonstration video clip of the experiment.
The phenomenon in scattering of the polarized light is demonstrated with a video clip.

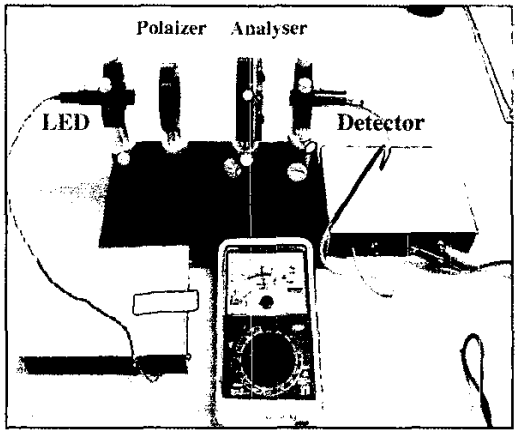

Fig. 5 Experimental setup and Video clip of the experimental procedure
The procedures of the experiment of the Malus' law are explained with a video clip. Clicking of the picture starts the video clip in the virtual laboratory directions.

Students can understand the manipulation procedures of the experimental apparatus visually as well as its detailed figure by viewing the video clips. Video clips show the experimental procedures and their consequences much more realistically than the conventional approach described by using text and graphics only. Students can experience the laboratory work virtually by clicking the button of the video clip in the directions.

IV. DISCUSSIONS

We have made a multimedia text of physics written in HTML to be seen on the Internet [4-6]. It contains not only video clips of the demonstrations of the experiments but also the java simulation programs of physics phenomenon. Students can execute the simulations of the physical phenomenon by clicking the button in the text. The multimedia text is now used in the introductory physics class and has a good reputation among the students. But the study in the classroom has some limitations motivating the student's interest in physics compared with the laboratory work. The lecture in the classroom is truly virtual compared with the laboratory work.

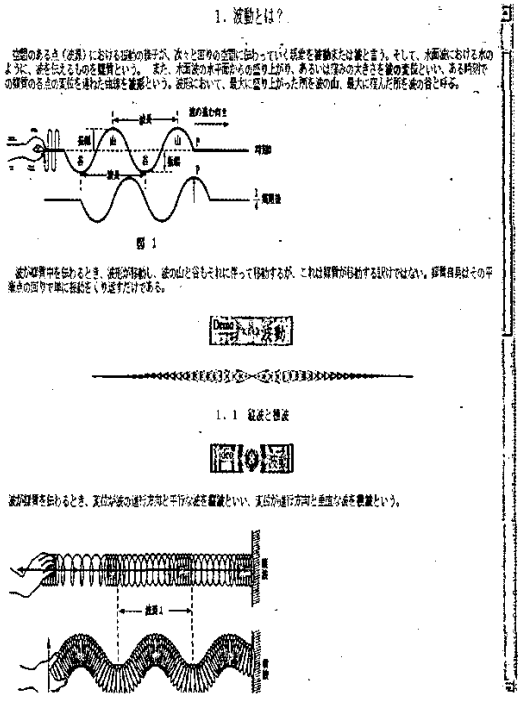

Fig. 6 Sample page of the multimedia text
The text describes about the wave motion and the important sentences are stressed in red, which shows the students what they must remember. Two buttons in the text "Demo" and "Video" are the start buttons of the simulation and the video clip, respectively. (After Ref. 4)

The laboratory work has many important functions in physics education. But the following three functions of the laboratory work are the most basic.

(1) Students will acquire the fundamental skills of carrying out experiments through the laboratory work.
(2) Students can learn the applications of the laws of physics to the measurements.
(3) Direct observations of the physical phenomenon will give the student the best understanding of the natural laws and possibly cultivate their interest in physics.

The last function seems to be the most important in the introductory physics. The surprise the students receive during the observation of the physical phenomenon through the laboratory work will become the motivational force for the study of physics.

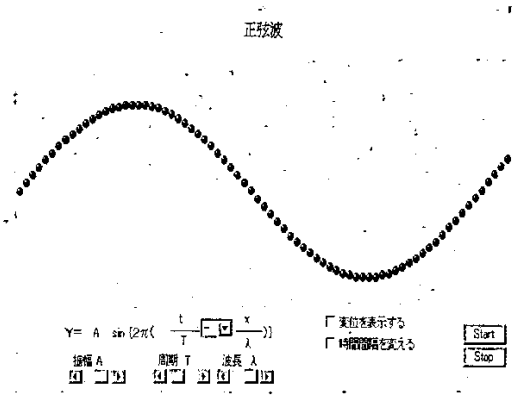

Fig. 7 The java simulation of the "Sinusoidal wave"
An amplitude A, a period T and a wavelength λ of the sinusoidal wave can be changed with the slide bars in the display. And as the change of the sign in the wave formula the direction of the traveling wave is opposed. Student will understand the correspondence between the wave parameters and the graphical sinusoidal wave and the change of the propagation. (After Ref. 6)

In laboratory work it is preferable for the student to have a full understanding of the subject before the experiment. But usually students see the experimental setup for the first time and then learn to manipulate the experimental apparatus at the same time. That is, most of students begin their laboratory work without any background of the experiment. Most of the student remarks that "we understand what we should do in the laboratory work when we are writing the report of the experiments." That is to say that it is at the end of the laboratory work that the students grasp the concept and purpose of the experiment. Of cause students are unable to start the experiment over again. The virtual laboratory work directions will prevent this situation. Students will get the whole concept of the laboratory work through the directions before the class. This will make the laboratory work more fruitful. Students also refer to the virtual laboratory directions when they prepare the report of the laboratory work.

V. CONCLUDING REMARKS

The virtual laboratory work directions are very different from the traditional approach in that the concept is oriented to beginners in physics study. Most of the traditional directions are oriented to the senior class and therefore they are high level. Next, the virtual laboratory directions employ many visual aids to help the student's comprehension. The descriptions in the text are intended to be concise to give a broad but a complete image of the laboratory work. Mathematical formulas that seem to confuse the student are avoided as much as possible. Students can refer to the virtual laboratory directions through the Internet. This will help the self learning of the student. The promotion of students' motivation for the laboratory work is the one of our educational goals for the students.

REFERENCES

[1] http://www.dnc.ac.jp/old_data/suii3.htm (2004) National Center for University Entrance Examinations (Japan)

[2] Proceedings of PC Conference 2000, Hokkaido Univ. 2000

[3] Proceedings of PC Conference 2002, Kagoshima Univ. 2003

[4] S. Kawabata; "Hyper Text of Physics for Freshmen – Wave Motion –", Proceedings of the 2nd Japan-China Symposium on Physics Experimental Education in Universities, The Physics Education Society of Japan, 87-90 (2000), ISSN 0385-6992

[5] S. Kawabata; "Making of the Hyper Text of Physics by means of Html and Java", The academic reports of the Fac. of Eng., Tokyo Institute of Polytechnics, 23, 19-25 (2000)

[6] S. Kawabata and H. Kowa; "CAI System and Authoring of Problems for Exercise", 2nd International Conference on Information Technology Based Higher Education and Training, 2001, ISBN4-87755-109-3