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A Web-based Teaching Case in Basic Mechanical Experiments: Design, Application and Evaluation

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Abstract—The traditional on-site laboratory is now facing a challenge such as cost, space or time. As a complement, a web-based teaching platform has been established for basic mechanical experiments at South China University of Technology. All processes of an experimentation including preparation, execution, help, report and evaluation are implemented in the platform. Eleven projects of remote experimentation have been developed and some of them have been applied for undergraduate students in mechanical basic courses teaching. By questionnaires from students, most of the participants identify the flexibility in time and space, and the effectiveness of remote experimentation. Finally, discussion on benefits and limits of remote versus traditional experimentation are analyzed and further improvements are suggested.

Keywords—basic mechanical experiment, remote experimental mode, web-based teaching platform, teaching case, application and evaluation

I. INTRODUCTION

Basic Mechanical Experiment Center of South China University of Technology was founded in March 2005 and named as National Experimental Teaching Demonstration Center by Ministry of Education of China in 2006. Basic mechanical experiment laboratory (BMEL) accordingly came into being as the basic but important part of the center for students to obtain mechanical experimental knowledge, operational skills and innovative abilities. The BMEL provides 24 basic mechanical experiments for courses taught per year for over 2,000 undergraduate students among about 20 majors.

In recent ten years, the number of undergraduates significantly increases accompanying experiment course requires large amounts of experimental resources and manpower [1]. Unfortunately, the center is not affordable to provide enough laboratory capacity. The current solution is the fact that some comprehensive training has to be cut down under holding necessary basic experiments for the numerous students.

Advancements in telecommunication technologies based on multimedia and internet opened up a new mode for experimental teaching, i.e. remote experimentation [2]. Esche listed 14 benefits of remote experimentation [3]. These advantages over traditional method can relieve the current pressure in scheduling, equipment, space, time and teaching staff.

Experiments in BMEL can be categorized by basic experiments, skill enhance experiments and research and innovative experiments [4]. Basic experiments are usually used for concept explanation, understanding an essential part of the scientific methodology within mechanical basis that were studied in the course. These basic experiments can also be conducted remotely. As a result, series of virtual or simulated experiments and remote control type experiments have been developed to replace conventional methods. In addition, a remote teaching platform for basic mechanical experiments (RTPBME) has been established. Students can conduct experiments partially, even extensively in RTPBME by a web-based access. Thus, laboratory resources can be used for more experimental projects of hands-on training and creative training if some experiments for basic concepts or theory understanding are run in RTPBME [5].

II. AN OVERVIEW OF RTPBME

Students can use their web browser to perform remote experiments through the web page of RTPBME. RTPBME provide flexible environment that offer much more interactivity than traditional static content. Fig. 1 shows the homepage of RTPBME, Table I lists eight functional modules.

Naturally separating teachers and students in time and space, RTPBME, serving as a substitution of teachers, provides more resources (such as learning materials in texts, pictures or videos, and operation guidelines, and etc) and help ways for students to facilitate the execution of the remote experiments [6].

Besides FAQ and discussion group, there are three other help ways. By related links, students can obtain general or extensive knowledge about experiment. Forum is also a way for students to acquire the information they want about the experiments from the collections of the forum to solve problems. Moreover, a help online can be used in the process of experimental operation by means of text, pictures, sound or 3D animation.

Fig. 1. Homepage of RTPBME

TABLE I. EIGHT FUCTIONAL MODULES

	Function	Description
1	Scripts	Provide necessary materials such as experiment tasks, theoretical background, guideline to conduct, data analysis, and et al.
2	Reservation	Reserve the equipment and time for remote control type experiments
3	Experiments	Run simulated software or real physical experiments remotely
4	Report	Write and submit report for students, grade and evaluate report for teachers
5	Software download	Provide plug-in in running experiments
6	Questionnaire	A platform for students to evaluate experimental teaching and give suggestions
7	Forum	A communication platform among teachers and students, where participants discuss experiments, issues questions and comments.
8	Help	FAQ: a frequently asked questions database for inquiry Discussion group: students can create and edit the contents and exchange their gained know-how related to experiments among each other and with teachers.

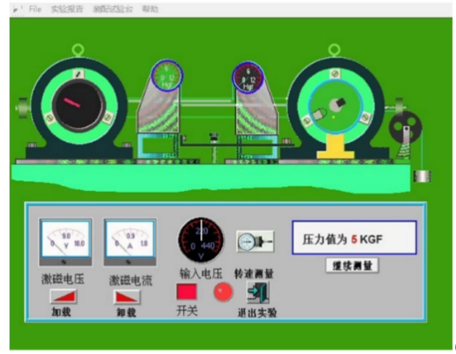
III. DESIGN OF REMOTE EXPERIMENTS

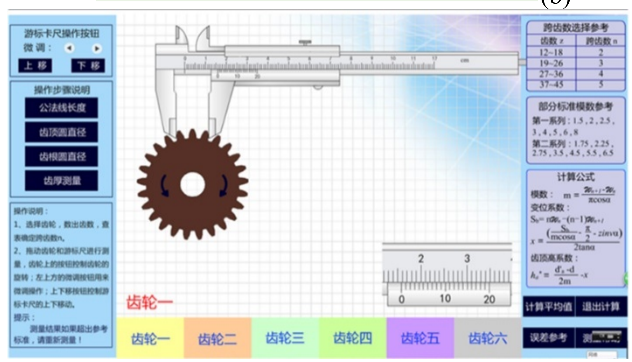
11 projects of experimentation can be applied for undergraduate students in RTPBME, which are divided into three types as follows.

A. Simulated Experiments

Fig. 2 shows four simulated experiments that imitate real experiments by software as if they happen on real infrastructure [7]. Fig. 2(a) and (b) demonstrate the control-panels of sliding bearing experiment and belt transmission experiment separately, which are the same as real instruments. These experiments need to set up extract mathematical models to produce the same physical quantities for measurements to demonstrate real performances of experimental infrastructure. Students analyze the results in different parameters or variables by the theory studied in the course. These experimental softwares are developed by VB language. The experimental instruments and operations of gear measurement experiment and envelope cutting gear experiment are imitated by FLASH program. In the simulated programs as shown in Fig. 2(c) and (d), a complete process can be executed for measuring gear's parameters and observing the envelope cutting behavior of gears with different gear variables.


(a)


(b)


(c)

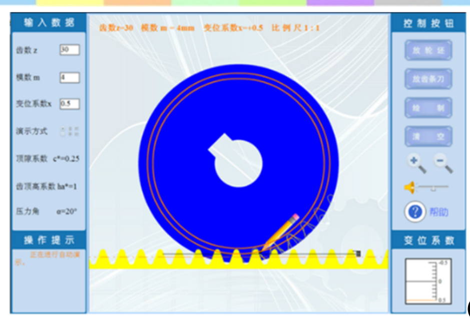
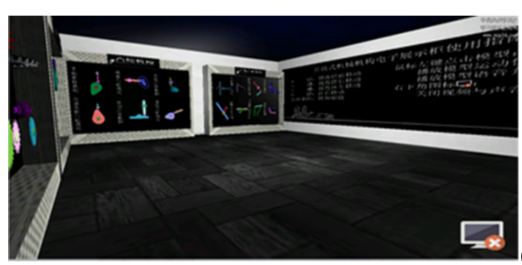

(d)

Fig. 2. Simulated experiments

B. Virtual Reality Experiments

Fig. 3 shows four virtual reality experiments that construct virtual laboratories to emulate hands-on experience in a virtual space by 3D modeling and Virtual Reality Modeling Language.

Fig. 3(a) and (b) are separately and virtual display cabinets of mechanical mechanism [8] and elements [9]. Fig. 3(c) shows one of virtual laboratory scenes in diesel engine assembly and disassembly [10] and (d) is an interactively assemble and disassemble environment in gear reducer.


(a)

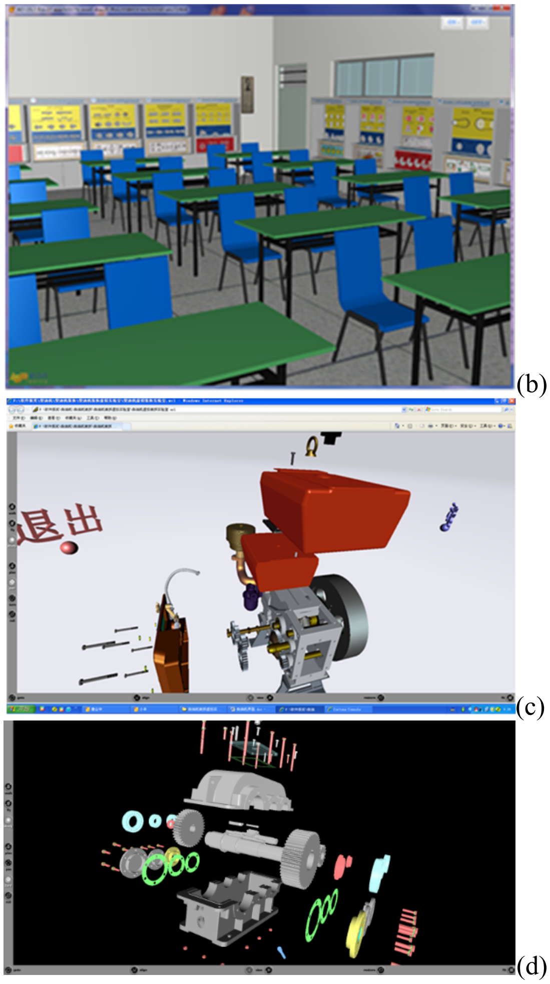


Fig. 3. Virtual reality experiments

C. Remote-control Experiments

The remote control type experiments can run experiments by interacting with real devices from outside the laboratory [11]. Three experiments of hydrodynamic sliding bearing, mechanism motion analysis and multi-belt transmission test in laboratory are based on computer-controlled experimental devices, so these experiments present are further developed a program to allow control over experiment via the internet.

Fig. 4 shows a web interface of access to experiment setup.

Fig. 4. Remote-control experiments

IV. Application and Evaluation

A. Application

The robot virtual simulation platform can be found by login to mechanical basic experimental teaching website (http://222.16.42.167/jixie/index.aspx). The experimental platform is open to all students, students can log in to the website anytime and anywhere.

In fact, the experimental projects in the traditional on-site laboratory are relatively inadequate for course lecture because of lab resources. Currently, a hybrid on-site/remote approach was applied for most major students. The simulation or virtual experiments can replace some basic verification type experiments or demonstration experiments. The more resources in the lab are for design type, integrated type and innovation experiments.

For a few of major students such as industry design and bioengineering, there is no any experiment to be arranged in the course teaching before because they are in another campus far from the laboratory in the main campus. Now remote experiments can provide necessary experimental projects for them.

B. Evaluations

Questionnaires on the impact of new experimental mode are focused on efficiency of the RTPBME and effectiveness of the remote experiments. The students were asked to rate five scales from 1 (lowest) to 5 (highest). Fig. 5 to Fig. 7 explain the outcomes of questions from students.

The evaluation that remote experimental mode is flexible or convenient for their schedules and access is shown in Fig. 5. Nearly 50% students gave the highest score, 82% of the students gave above 4.0 evaluation.

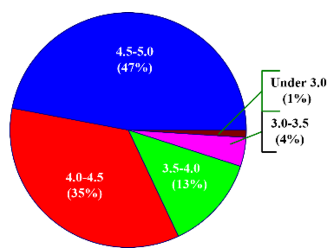


Fig. 5. Convenience of experiments

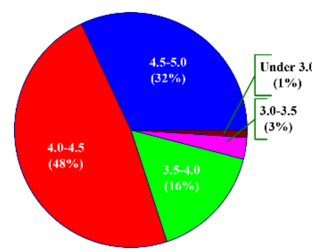
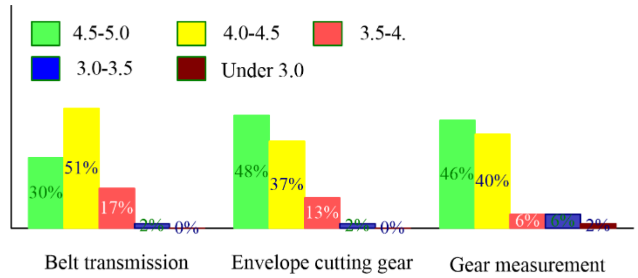


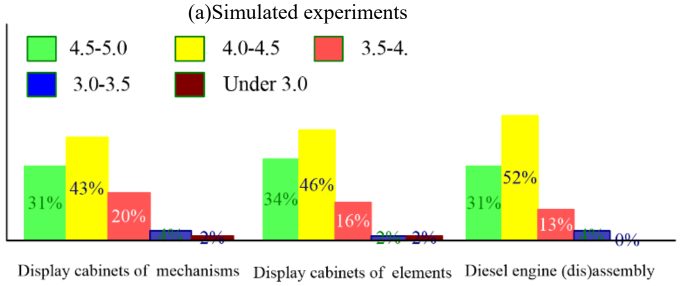
Fig. 6 Learning materials and helps

As shown in Fig. 6, 80% of the students gave more than 4.0 evaluation for supporting materials and helps of experiments in RTPBME. Other results show that the RTBME should further be improved to provide better learning conditions for students.

we get responses on effectiveness of remote experiments from participants. As shown in Fig. 7, of the students responding to the remote experiments, both of envelope cutting gear experiment and gear measurement experiment got the top (48% and 46% respectively) in the best effective scales (4.5-5.0), others had the highest percents in the range from 4.0 and 4.5.



(a)Simulated experiments



(b)Virtual reality experiments

Fig. 7. Effectiveness of remote experiments

Besides the above questions, students' comments and suggestions are gathered in order to further develop the RTBME. By analysis of the results, it is obvious that the evaluation vary with students' differences in cognitive style and/or students' ability. So individualized service should be improved for the RTBME. A rather challenging problem is the perceived difficulties in enforcing the independence of student work when performed remotely, thus a few students do not adapt to or accept this mode from the start. A big discussion is related to the effectiveness of remote versus hands-on, some students initially conceived that the traditional method is of importance to experience real devices. Thus, they still want a direct hands-on interaction with the experimental equipment although the general goals of experiments are achieved.

V. Conclusions

Remote experimentation is a new teaching mode for most students. We run the remote experimental projects through RTBME for basic mechanical experiments. The convenience, flexibility and effectiveness of remote experimentation are identified by most of participants. Through positivistic analysis of the information from students' perceptions and suggestions, further improvements were focused on providing a better personalized learning environment and enhancing experimental models of reality to largely match actual reality.

Although numerous advantages of remote experimental mode exist, some experiments are limited by remote implementation. As a result, the hybrid on-site/remote approach is suggested, which will contribute to the enhancement of experimental contents and further enable students to be exposed to a more comprehensive experimental experience.

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