CONSTRUCTING A COMPUTER SIMULATED EXPERIMENT TESTING SYSTEM

Ben Yang, Shardrom Johnson* and Daniel Hsu

School of Computer Engineering and Science, Shanghai University, Shanghai 200072, P. R. China

**Information Centre of Shanghai Municipal Education Commission, Shanghai 200433, P. R. China*

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Abstract: This paper describes applications of Computer-Assisted theory to testing; reviews related research on Computer-Assisted Testing, Computer-Assisted Instruction and Computer-Based Education; and introduces the analysis, design, and development of the Computer-Simulated Experiment Testing System (CSET). The simulation of electrochemistry experiment is being described with the CSET theory. With the intelligent processing mechanism and web-based multimedia platform, the CSET theory can be the important part of Computer-Based Education.

1 INTRODUCTION

With the further development of instructional content and course system, the Computer-Based Education (CBE) has become the principal direction and important method (Xia, 2000). Intelligent CBE system based on multi-media and hyper-media comes into existence as the situation requires. Meanwhile, the Computer Assisted System subdivides to Computer Assisted Instruction and Computer Management Instruction in the process of instruction activities. We can see a good application in U.S. patent. The invention assesses the students' progress, and selects appropriate lessons for the student at the time (Seifert, 1999).

Based on the specific content, there are two major phases in the process of instructional activity. One is implementation of instruction, namely how to help educates to learn. Another is assessment of instruction, namely how to evaluate knowledge mastery. This is usually called the process of experiment testing (Xia et al., 2003).

Assessment is an essential aspect of all instruction and Interest in Computer Assisted Assessment is growing rapidly. It is increasingly accepted that assessment is the engine that drives a great deal of students' learning. With the wave to widen participation in higher and further education, combined with reductions in the actual amount of resource per student, it is impossible to extend traditional assessment processes, practices and instruments to meet demand (Brown et al., 1999).

What and how well students have learned and so do students themselves. Assessments can take the form of a quiz or examination to test students' learning achievements or a questionnaire to investigate students' attitudes and reactions to new instructional courseware (Chou, 2000).

A key subject of experimental testing is to make full use of the simulation function and management function, which is highly valued by education with electrical audiovisual aids and experiment instructor.

2 COMPUTER SIMULATED EXPERIMENT TESTING

2.1 Development of CSET System

The experiment testing as the important parts of instructional activity emphasizes examining the manipulation of equipments and operating specifications. On the basic requirements, the purpose of developing CSET system is listed below.

2.1.1 Maintain Impartiality and Objectivity of Scoring

Because of strict environment of experiment testing, it is difficult to give the accurate scoring. There are two kinds of factors. One is human factor. Usually

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several examinees are invigilated by one instructor through their whole process of experiment. Only those errors being observed are effective and can be scored. So the experiment testing varies different evaluation standard from different instructor and different time. Another is non-human factor. It mainly reflects the mismatch between equipments and examinees. There are two generalized solutions, to supply the randomness of testing, to maintain the consistency of testing, in which examinees are divided into groups.

Considering the above factors, examinee can be put on the same platform and at the same starting point by using networking computer to assist experiment testing. All those make sure the impartiality and objectivity of testing.

2.1.2 Extend Choosing Range and Reduce Equipment Cost

Considering the limited environment, there're few experiments can be chosen because of slow reaction process and complicated manipulation. Moreover, the cost also affects on the range that the experiment to be chosen. The equipments are used frequently and repeatedly in a short time so that it not becomes less accurate and shorter operational life span, but leads to environmental problems. Therefore it is safer, more efficient and less-wasted to interact with examinees by using real-time simulation to score and have error-analysis process (Xia et al., 2003).

2.2 Rationale of CSET Theory

Computer Simulated Experiment Testing is a new kind of computer-based education theory (Xia, 2000). It's on the basis of specific experiment testing process (as Figure 1 shows) to raise the pattern of computer-involved testing. The details can be read for reference (Xia et al., 2002).

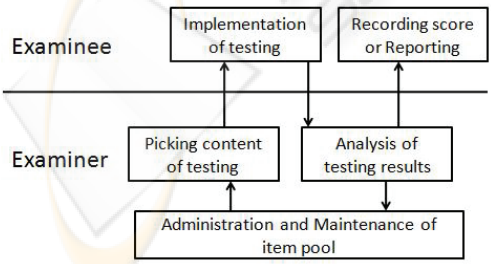

Figure 1: Basic Flow of Experiment Testing.

A good test will not only help the instructor to evaluate students' learning status, but also facilitate the diagnosis of the problems embedded in the students' learning process (Hwang et al., 2005).

2.2.1 Preparation and Generating of Testing

This phase mainly uses existing management pattern of item pool for reference, which is divided into three parts (as Figure 2 shows). First, build the model of experiment testing. Second, keep the maintenance of item pool. Third, generate the contents.

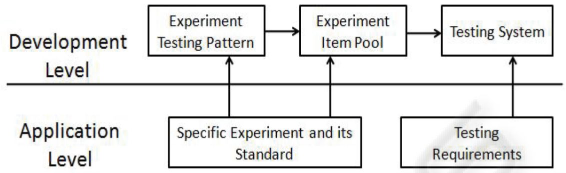

Figure 2: Preparation and Generating of Testing Content.

2.2.2 Implementation of Experiment Testing

This is the phase with which the users directly interact to the system. It mainly includes process-simulated management and real-time monitoring management (as Figure 3 shows). The process-simulated management reflects all segments and running status of testing to simulate the whole process. The real-time monitoring management is mainly to record the data path of programs and to record the contents of assisted-services.

Reference (Shavelson, 1992) further suggests using computer simulations for hands-on performance assessment. In their project "Electric Mysteries," students were required to replicate electric circuits by manipulating icons of batteries, bulbs, and wires.

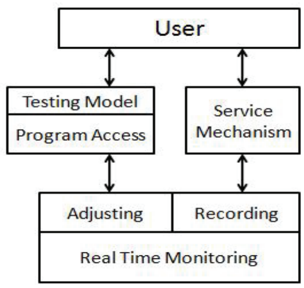

Figure 3: Implementation of Experiment Testing.

2.2.3 Analysis of Testing Results

After testing, the management reflects two aspects. One is to be judged by comparing with the standard library. Another is to get information and conclude the records to maintain and modify the testing model. This method can reduce the error rate and improve the reliability.

Over the past several decades, a wider range of assessment strategies has gained prominence in classrooms, including complex assessment items such as individual or group projects, student journals and other creative writing tasks, graphic/artistic representations of knowledge, clinical interviews, student presentations and performances, and so on (Ramakishnan and Ramadoss, 2009).

Based on above discussion, the CSET theory shows the special advantage of computer-assisted system by compromising the merits of simulation and dynamic strategy control.

2.3 CAI, CAT and CSET

All kinds of courses can be provided by the CAI system, which is based on knowledge-imparting. Comparatively speaking, the CSET system is limited in some specific field. But it still need resources and material to computerize those experimental testing.

In the field of CAI, the computer-assisted testing theory is the first one to be introduced into educational testing. The CAT theory has a complete set of summary on guiding testing process, and it has been proved to have powerful testing functions. But it is limited to objectivity testing. The questionnaire is usually composed of choice question, true-false question and matching question, which makes it ineffective and inefficient to test manipulation and experiment. And, the experiment testing requires not only omnibearing environment and process simulated functions but also the functions of collecting effective data and manipulations. We can't get all of these from the CAT system.

The CSET system uses three kinds of instructional pattern: one is the manipulation and exercise; the other is the tutorial instruction; another is the simulation.

According to the process of manipulation and exercise pattern, users get real-time results of the adaptive questions by using networking computers. This pattern is not just for imparting knowledge, but for strengthening the learnt knowledge by the large amounts of questions or exercises.

The CGI programming will be used to control presentation by the adaptive questionnaires. The adaptive questioning uses the answers to some certain questions to determine the next series of questions and skip unrelated questions (Chou, 2000).

Although the experiment testing belongs to the field of instructional assessment, there are lots of commons in the references of those CAI patterns, such as the command of experiment by the pattern of manipulation and exercise, the hands-on ability by the pattern of simulation. So the three instructional patterns of the CAI theory have definite referential effect on experiment testing.

3 THE CSET CASE

The CSET system is being designed to test students' learning achievements and evaluate course under the networking learning environment. Both in concept and construction, the CSET project is intended to integrate three major components: system, evaluation, and interface in its analysis, design, and development phases.

3.1 Analysis Phase

To show the advantage of CSET theory, we use the software engineering to develop the specific CSET system which is based on electrochemistry experiment "Measurement of Electrode Potential". This experiment is mainly used to measure an unknown side of electrode. The basic steps are listed below. First, use saturated KQ solution as electrolytic bridge to make the battery under test. Second, connect test circuit according to compensation method. Finally, adjust the potentiometer to read scale and we get the electromotive force of battery under test.

This experiment requires examinees to prepare in three phases.

1. The phase of preparation. It emphasizes the usage and principle of compensation method. The examinees are required to be capable of adjusting electromotive force by using potentiometer and formula. (t as ℃)

2. The phase of manipulation. It emphasizes operating-specifications, note-taking of experimental data and the capability of using galvanometer.

3. The phase of follow-up. It emphasizes on using the function to calculate the standard electromotive force and find the difference with referential data.

According to the basic steps, we have requirement of practical experiment testing. First, understand the conventional manipulation well and check the equipments before experiment. Second, be familiar with the specific steps and all the equipments listed. Third, be familiar with the method of data process and evaluate based on experiment value and provided value.

To resolve the problem of flexibility between structural programming and system flow, the scheme which sets down the sequence of range and ignores the flow sequence in the range has been proposed.

1. The fundamental analysis. Based on the requirement of different knowledge, the system is divided into four levels (as Figure 4 shows).

2. The assignment analysis. Based on the different content in the assignment, the system is

divided into the design of flow, the simulation of manipulation, data process, score process etc (as Figure 5 shows).

3. The flow analysis. The fundamental range sequence is determined by the basic flow of system. But the specific manipulation flow inside the range is concealed. The Figure 6 shows the basic flow.

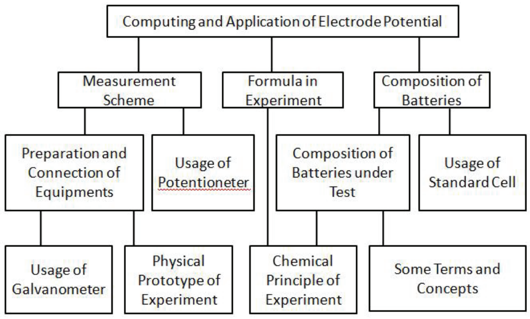

Figure 4: Fundamental Analysis of CSET System.

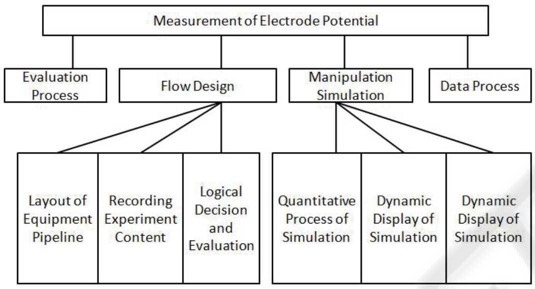

Figure 5: Assignment Analysis of CSET System.

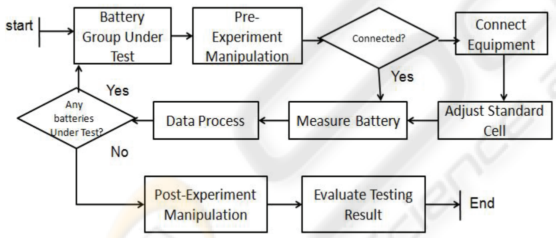

Figure 6: Flow Analysis of CSET System.

3.2 Design Phase

The system contains two parts, one is the administration module and the other is the simulation module. In the design of administration, the flow is divided into five steps, namely the preparation of experiment, the connection of equipment, the manipulation, the data process and the finishing off. So it's easy to be monitored in sections during the runtime. In the design of simulation, these specific equipments used in the experiment are displayed in the same interface (we call the virtual equipment), such as potentiometer, galvanometer, battery under test, working power supply, standard cell etc. Those virtual equipments can describe the dynamic variation.

Because of the fixed range sequence and ignored inner-range flow, the evaluation adopts the method of setting flags indirectly, recording when meeting flags and scoring after experiment. Fixed range sequence means that the CSET system will check precondition to move into next phase. For example, in the phase of preparation only if the examinee gets the positive and negative charges correct, then they can move to the phase of pre-check. Meanwhile, when they get all equipments checked, then the phase of preparation is finished. Otherwise, the system will deduct corresponding points. Ignored inner-range flow means that the manipulation is not restricted with the sequence (except the experiment requires). When the examinee finishes all the required manipulation, then he can move to next phase. Take the example mentioned above. As to variable resistance and switch, their checking manipulation would not affect other equipments. So we can ignore the specific sequence within the range and only pay attention to the complete of flags. In the phase of evaluation, we can get the score according to those required flags and backtrack the error easily.

The subject of test administration will discuss obtaining examinee responses scoring them, recording them for later use, reporting and interpreting the results and giving prescriptive advice (Bunderson et al., 1988).

3.3 Development Phase

The main frame is the specific platform for examinee to get testing. The development of CSET involved the specification which is to fulfil the production requirements identified in the analysis and design phase.

1. The design of menu and confirmation key. Adopt one-level menu and hotkey to realize the control of five phases. It helps examinee to know which phase they are. In that phase, we've set a Confirm flag. This flag is not only good for manipulation but also good for system control.

2. The design of standard cell, battery under test and external battery. In this experiment, these equipments are only referring to the process of connection and power-off.

3. The design of connection frame. We set a pop-up window to guide examinee to manipulate with the given information.

4. The design of galvanometer. We put three buttons on it. They are 'OFF', 'ON', and 'RESET'.

There is a visual window of this rectangle equipment as well, namely cursor observing window. The range and the way cursor moves is based on the runtime experimental data.

5. The design of potentiometer. In the practical experiment, the potentiometer includes many functions, such as the calibrating input of standard cell, the protection key of galvanometer, the adjusting of variable resistance, and the replacement of switches. According to the testing requirements, these functions must be kept in the environment of simulation.

a. The design of external terminal. On the side close to connecting device, the ports of the galvanometer, standard cell, battery under test and external battery are listed in proper order.

b. The design of knob of potentiometer. Because it's difficult to manipulate with knob in the simulation, we replace it with button '+' and '-'. Meanwhile, we can read the runtime value from the display.

c. The design of electromotive force of standard cell. Provide the box to input the temperature calibrating value and determine the value to the second decimal place.

d. The design of variable resistance. Put a 'RESET' button to have zero check and put 'coarse adjustment', 'fine adjustment', and 'trimming'. We can use direction key to switch the level and read the value from the display.

e. The design of switch. Based on the practical requirements, we put 'OFF', 'Standard' and 'Under test'.

f. The design of protection key of galvanometer. We put 'short circuit', 'small end', 'large end' and provide a time parameter to maintain galvanometer.

4 CONCLUSIONS

Computer-Based Education (CBE) has positive effects on students' attitude. Results indicate that computer-assisted and managed instruction and CBE used with disadvantaged students was generally effective (Bangert-Drowns et al., 1985). Also the application of CSET theory solves the common problem which other patterns are facing in the field of Computer-based education. The CSET system realizes the objective to test hands-on ability and simulate all kinds of practical experiments.

With the improvement of decision-supported system, expert system and knowledge base, the guiding of CSET theory will be strengthened, especially in the process of judging and evaluation. It will improve the stability and validity of the system when using the multi-database system. In the near future, as the network technique gets more applications, multimedia technique develops further, the web application of CBE will improve quickly. And we can see, the CSET system will be the important part of computer-based education with the intelligent processing mechanism and web-based multimedia platform.

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