A study of the process-based evaluation approach for college experimental courses

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ABSTRACT: In this article, fairness, interaction and timeliness issues with the current university experimental course evaluation system are analysed. The article presents an evaluation approach based on the processes behind experiment-related courses. The model emphasises the evaluation of the whole experimental process, embodies the characteristics of computer-aided experiments and student-oriented philosophy. This article also introduces the practice and results of the model based on a trial with third year student majors in telecommunication and communication engineering with an experiment-related course on communication principles.

ANALYSIS OF PROBLEMS IN THE CURRENT EXPERIMENT EVALUATION SYSTEM

Cultivating students' abilities in practice and innovation will be a major component of university laboratory construction in the future, especially for students taking an engineering major [1]. Currently, there are many issues associated with student experiments and many new ideas about experimental reform may face specific problems when they are actually implemented [2]. In this case, the reform of experimental evaluation serves as a good entry point. The evaluation processes of experiments may occupy relatively little time, yet it plays an important role in terms of experiment preparation, operation and control [3].

From the perspective of experimental evaluation, current problems in college engineering experiments mainly exist in fairness, interaction and timeliness issues of the evaluation process.

FAIRNESS ISSUES OF THE EVALUATION PROCESS

Current evaluation is primarily based on whether students have done the experiment or written up the experiment report or teachers' other subjective impressions. Inadequate evaluation results in a lack of fairness. For example, experimental evaluation based on experiment reports or based on experimental groups often causes uncertainties in students' individual assessments.

In addition, some evaluations are based on whether experimental results are in line with expectations, thus, experimental instrument problems could be the cause of accidental factors which contribute to a lack of objectivity. Such evaluation methods have a negative influence on rating students' performance, more importantly, it hurts the enthusiasm of the students to complete the experiment.

THE ONE-SIDEDNESS PROBLEM OF EVALUATION

The current experimental evaluation approach is largely focused on the outcome and such an evaluation model over-emphasises results while the process of the experiment is ignored. It makes indicators too fuzzy and operations too subjective. However, experimental education actually has a high requirement for operational details, such as experimental purposes, principles of experiments, experimental procedures and experimental apparatus. It requires students to find existing problems and solution methods in the experiment, and students should be able to perform experimental results analysis.

All these elements have their own requirements and characteristics. There are several critical control points through the experiment process. A good evaluation system should be able to reflect students' assessment in these critical control

points more fully. In other words, the critical control points should be able to cover the entire experiment process. However, the current mainstream evaluation approach is often one-sided for each of the key points.

LACK OF INTERACTION DURING THE PROCESS OF EVALUATION

Currently, the main purpose of students' evaluation is to serve as part of the overall course assessment. However, problems that have appeared in the course of the experiment in the laboratory are rarely discussed. A score reflected in the test report has a limited capacity to contribute to improving students' experimental skills. If feedback is mainly reflected in the test report, and cribbing is a common phenomenon in test reports, teachers receive little real feedback from the students. It is, therefore, difficult to improve experiment-related education. In the absence of standardised design, teachers' qualitative analysis tends to be susceptible to limitations and is simplistic. Teachers often blame students' unsatisfactory experimental operation on their low level of skills or lack of effort.

The fact is that an experimental test often means the end of teaching activities and it magnifies the emphasis on examination results; it depreciates the effect of diagnosis, feedback and interaction. The end of examination and the end of experimental education are synchronised, so teachers are less motivated to analyse the examination results, since the analysis of experiments and current teaching periods are separated [4].

THE EFFICIENCY AND TIMELINESS ISSUES OF EVALUATION

Experimental evaluation needs a large number of questions to be asked, thus, it cannot be completed in a short period of time. Even if teachers complete the marking of experiment reports, it often takes a relatively long time and cannot make a deep impression on students. For teachers, even the simplest statistics, such as *average points*, *rate of excellence* and *fail rate* are difficult to calculate. To calculate these indicators, teachers must first input the results and, then, perform statistical calculations. Therefore, teachers rarely consider experiment results in terms of them being *partial degrees*, *standard poor* or *distinction degrees*. [5]

THE SCIENTIFIC ANALYSIS OF EVALUATION

Teachers can often obtain a subjective impression of students' experiments during guidance sessions and by reading experimental reports. However, the subjective impression is often integrated and fuzzy, as these impressions are often received in the course of the experiment or report marking. Without quantitative analysis and assessment, teachers lose the opportunity to process the experimental data further. The archived results of the evaluation system of experimental education are often put away, and the issues raised during experiments are, therefore, not summarised, analysed and there is no feedback to students. This means that a lot of valuable information is not fully used, and effective experimental quality control is difficult to achieve.

From the perspective of education, different measurements describe different objectives and comprehensive analysis of various measurements could reveal the inherent qualities of education. However, the measurement system consists only of the average and the failure rate; the *excellent* rate is not complete. The key to building a complete measurement system is the standard and automatic analysis platform of quantitative analysis. It should be able to provide statistical analysis support to teachers, since not all teachers have the knowledge and skills for producing educational statistics [4].

THE FEATURES OF PROCESS-BASED EVALUATION MODE

The current trend of reform in experiment evaluation is to introduce new experimental modes to encourage a move away from uniformity to diversity in evaluation. Improvement of the experimental evaluation system is one of the innovations in this context. The innovative ideas are mainly reflected in:

Process-oriented Characteristics in an Evaluation System

Experimental problems seem like operational problems, yet they are actually mental problems or a more advanced type of mental problem. The main difference between conducting experiments and classroom teaching is that classroom teaching is aimed at students obtaining knowledge, while conducting experiments is problem-oriented. It requires students to use knowledge to solve real-world problems, which is a more advanced requirement.

Conducting experiments is a complex process that includes understanding experimental purposes, mastering experimental principles and resolving laboratory procedures. It also requires students to find experimental solutions and to analyse experimental results.

A rational evaluation system should combine both formative and summative evaluations. Formative evaluation should be performed several times during the process of learning. Summative evaluation is a one-time assessment by the end of the experiment [6]. Process-based experimental evaluation system includes the purpose, principles, steps and result in order to perform a full range of inspections and evaluation, particularly with regard to operational evaluation. This places a high demand on teachers to consider each element to fully reflect the experimental procedure.

The form of test in process-based evaluation is still a paper test or examination, but the emphasis of the test is on students' comprehensive experimental quality and ability [7].

Computer-Assisted Features of an Evaluation System

To address the timeliness interactive problems of the evaluation system, appropriate technical tools must be introduced. Apart from reforms of experimental test questions, the use of computer information systems and computer networks are also an important aspect.

A computer-assisted testing system is the physical carrier of the test questions and test channel. In the meantime, a computer information system provides timely feedback of evaluation results, and it makes analysis and refinement for further studies feasible.

With the introduction of a computer-assisted system, experiment teachers are able to examine the effectiveness of their own experimental designs. The teachers are, therefore, able to review and improve their experimental procedures, and they can also gradually expand the test database;

A typical computer-assisted process-based evaluation includes the following steps. First, students take the test. Second, the system automatically generates quantitative analysis of achievements distribution. Third, the teachers undertake qualitative analysis based on the quantitative analysis. The system also enables students to be categorised in accordance with classes or instructors, so that the school can evaluate experiment teaching quality and impact. Test results can also be classified according to grades, so that it provides reference for follow-up courses design.

Reflect the Student-oriented Philosophy and Focus on Practical Results

A well-designed evaluation system pays attention not only to students' experiment results, but also to teachers' teaching effectiveness. Most importantly, it reflects the *student-oriented* logic. By identifying deficiencies in education, it helps to improve test processes and serves an evaluation guide function. The participants are not only the teachers, but also instructors and designers of syllabus and teaching plan.

REALISATION OF A NEW EVALUATION MODEL

The new evaluation model was brought into practice in the Communication Theory course taught by the Telecommunications Department of the University of Ningbo.

SYSTEM IMPLEMENTATION

The new evaluation mode is based on the existing experimental approach, using computer-aided systems. The system is implemented by senior teachers and instructors who have worked together for many years in experiments with communication principles. The test question database is different from the theory test questions, because it covers details in each step of the experiment and fully reflects the *operationally-oriented* idea. For example, the test questions include an operator panel with a large number of pictures, waveform images and wiring diagrams.

Only the students that complete the experimental operation studiously are able to answer these questions well. The *waveform images* in the questions are not only taken from the final results of experimental process, but are also taken from experimental waves in the middle of debugging. Sometimes, it can even include an erroneous waveform arising from a connection error. Only students who had done debugging down-to-earth can answer these questions correctly.

In addition, every student should complete a test of the contents of an experiment in the experiment field. Each student is given limited time, and once the test is complete, timely test feedback is given to students. The test results are stored in a database on the network.

Field testing is carried out under the supervision of the teacher, eliminating any imposters that might exist in general on-line examinations. Questions are drawn randomly from a question database, avoiding the problem of students guessing questions and asking about the answers to test questions. All these elements encourage students to spend time mastering the entire experimental process to each critical point.

COMPUTER-AIDED SYSTEM

The computer-aided evaluation system adopts a B/S multi-tier architecture, and uses TCP/IP as its underlying protocol. It enables the system to be implanted easily into remote experiment platforms. For database access, application logic implementation is completed on the server side. In this way, the client tier, data tier and application services tier are strictly separated. It improves the efficiency and stability of the application. From the perspective of maintenance and management, B/S also has significant advantages.

The development platform of the module uses ASP and ASP.NET platform from Microsoft. The backstage uses ACCESS and SQL server database platforms, and generates the database of questions, user libraries and test results for process-based assessment. The assessment question database applies different functions for different levels of administrative permissions.

The output of the experimental evaluation platform uses a standard format for a comprehensive analysis, and it provides instant feedback with evaluation indicators and graphics. The output data can be archived in XML format, thus, the system has the characteristics of information integration and cross-platform features. Moreover, the system has an open data interface and multiple format data can be output and conversed through XSL specification of W3C [8].

PRACTICAL EFFECTS

After the introduction of new experimental models, experiment evaluation and experiment operation are synchronised, and the effects were as follows:

- Students were able to retain their own comprehension and evaluation of results from the previous experiment through the testing platform. Students can, therefore, immediately discuss any relevant issues with teachers, and they can improve existing problems and deficiencies in subsequent experiments in a timely manner;
- Students' attitude in preparing experiments becomes more serious. The quality of questions students raised is higher and laboratory disciplines also achieve a noticeable improvement. Moreover, there is a remarkable increase in students' reading in experimental guide books;
- Students' interest in conducting experiments was increased, and some teachers received many comments and suggestions from students. Many students changed from *others wanted me to do experiments* to *I want to do experiments*;
- Recognition of fairness in experiment scores among students rises.

With access to feedback in a timely manner, teachers are able to target the commonly faced problems in the lectures.

FURTHER IMPROVEMENT NEEDED

Although the new evaluation approach has made some improvements to the current system, there are still some important issues to be considered.

Experimental Design

The evaluation system is based on existing test steps and accomplished by building the appropriate test. However, the evaluation does not cover elements outside the current model, such as experimental connection schematic diagrams. In other words, students' design ability is not taken into account.

Test Database and Scientific Analysis of Results Needs to be Strengthened

The effectiveness of test questions needs to be revised, such as whether the form and content of the questions are consistent with experimental objective and programme. Also, the layout of testing key points and distribution of testing difficulty needs to be reasonable. Moreover, scientific analysis of the results still needs to be strengthened.

In response to the problems above, a more comprehensive support platform combined with general computer simulation software and hardware is needed.

CONCLUSIONS

This article’s focus was problems in the current college students' experiment evaluation system. It recommended using a computer-aided system to realise a process-based experimental evaluation system. By adopting the new system, it sought to solve issues that exist in the current evaluation system, such as incomprehensive evaluation, lack of interaction and timeliness problem.

Some good results have been achieved through the actual operation of the new system. This article proposed a new process-based experiment evaluation mechanism for college engineering students. The improvement of experimental design and operation under the new system could be based on a more comprehensive experimental platform.

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