Research on Collaborative Reform of Computer Experimental Teaching and Laboratory Construction in Universities

Jia Huang*
Department School of Information Engineering, Tianjin University of Commerce, Tianjin, China
**Corresponding Author*

Abstract: To effectively cultivate high-quality computer science professionals, institutions must coordinate both computer-based experimental instruction and laboratory infrastructure development. Traditional computer experimental teaching features relatively isolated content and employs rather limited methods for student assessment. Laboratory management also faces challenges such as insufficient levels of automation and low operational efficiency. These issues all pose significant obstacles in the process of universities cultivating high-caliber talent. Building upon the undergraduate teaching reform initiative at Tianjin University of Commerce, this paper establishes a collaborative model for teaching and laboratory development that integrates experimental instruction content, combines laboratory hardware and software resources, and employs multidimensional, detailed student evaluation systems. This model enables modularization of experimental teaching content, intelligent laboratory management, and multi-dimensional assessment of student competencies. It provides practical references for the collaborative and efficient development of computer experimental teaching and laboratories in local universities.

Keywords: Computer Experimental Teaching; Laboratory Construction; Collaborative Reform; Data-Driven Evaluation

1. Introduction

Society has raised higher expectations for universities in fostering students' practical and innovative capabilities, with the rapid advancement of artificial intelligence technology being the primary driver behind this trend. Computer disciplines are placing increasing emphasis on personal competencies in talent development. As a vital component of university education, the computer laboratory serves not only as a practical platform for fundamental theoretical instruction but also as a key environment for developing students' individual competencies. Therefore, in university computer education, computer laboratories not only facilitate the integration of theory and practice but also foster students' innovative and practical skills [1].

Driven by the rapid advancement of educational digitalization and universities' initiatives in developing new engineering disciplines, traditional computer experimental teaching methods and management models can no longer meet the demands of talent cultivation in higher education institutions. The requirements of traditional experimental teaching are entirely aligned with theoretical courses, resulting in a lack of systematic in experimental teaching resources and severely hindering the development of systematic engineering capabilities [2]. The effectiveness of student performance in experimental teaching relies entirely on experimental outcomes, with evaluation criteria being overly simplistic and unable to provide an objective assessment of students' capabilities. Furthermore, laboratory management faces challenges such as difficulties in equipment maintenance, low operational efficiency, and insufficient competence among management personnel [3].

Building upon a university-level educational reform initiative and integrating insights from higher education laboratory management practices with existing research findings, this paper endeavors to explore an innovative approach for enhancing experimental teaching efficiency and advancing scientific laboratory development. Universities need to establish a socially relevant computer-based experimental teaching system. By refining the corresponding teaching models, we can cultivate more computer science professionals who are suited to industry needs and possess strong comprehensive competencies.

2. Current Situation and Problem Analysis

2.1 Problems in Experimental Teaching

Colleges bind experiment tasks closely with theory lessons, all experiment arrangements have to match the progress of textbook courses, teachers cannot rely on these fixed experiments to train students' operational skills and creative thinking [4]. Real competition tasks and enterprise practical cases are rarely added into learning resources, colleges are unable to train students with solid practical ability and creative minds.

Teachers only let students finish all experiment operations inside offline lab rooms, there is no usable online learning system for experimental courses, different theory courses are separated from each other without inner connections, this separation becomes more obvious when looking at different course experiments, students cannot build complete logical thinking for engineering work [5].

Teachers use too simple and fixed standards to judge students' experiment results, teachers mainly grade students by the written experiment reports they hand in. There is a lack of evaluation for students' process performance, teamwork skills, innovative abilities, and problem-solving capabilities [6].

2.2 Challenges in Laboratory Construction and Management

The current laboratory management systems are inadequately enforced, rendering them merely formalistic in nature. The management system lacks regular updates, and its provisions are not adequately aligned with actual circumstances. No effective supervision mechanism has been established. There exists a phenomenon of self-supervision, where the supervisory function is merely nominal [7]. The overlapping responsibilities in laboratory management have disrupted the previously well-defined division of duties, resulting in chaotic management and low efficiency.

The maintenance of experimental equipment is quite challenging, and its utilization rate requires further improvement. The laboratory's construction lacked a long-term, scientifically grounded planning approach and procurement strategy, resulting in a mix of outdated and new equipment. The specialized courses offered in laboratory services impose varying requirements on operating systems and demand a wide range of software solutions; sometimes even different versions of the same software are required, making software maintenance extremely complex [8].

3. Objectives of Collaborative Reform

3.1 From Independent Courses to Deep Collaboration between Teaching and Laboratories

The teaching content and experimental projects for computer theory courses in universities are typically designed independently by the instructors. The laboratory is responsible for maintaining various experimental equipment and setting up the necessary software and hardware environments for course requirements. In previous practices, communication channels between instructors and laboratories were inadequate [9]. To address this issue, this paper introduces an online information management platform. Teachers can proactively submit requirements for experimental conduct on the online platform, while laboratory staff can utilize it to adjust experimental environments and match corresponding software versions. The platform offers additional practical features: it automatically collects experimental codes submitted by students and comprehensively records teachers' evaluation results.

3.2 From Manual Management to Intelligent and Information-Based Management

Lab teacher handle most lab daily work by hand in the old management mode, such working modes waste lots of lab resources and bring many careless mistakes, colleges can combine digital service platforms and lab physical devices together with a new smart control system after finishing management adjustments, this combined system can watch all lab machines around the clock, it will send out warning messages to lab teachers once hardware faults or software breakdowns appear. The system also lets users reinstall software or reset device systems from far away with simple operations.

3.3 From Experience-Based Evaluation to Data-Driven and Multi-Dimensional Comprehensive Evaluation

Traditional evaluation of student experiments relies on teachers' subjective assessments based on experimental reports and results [10]. The supporting information for evaluation relies solely on experimental reports, lacks comprehensive and objective data support, and is highly subjective, making it difficult to accurately reflect students' true proficiency levels. Therefore, following the reform, an intelligent information platform will be utilized to collect various data from students' laboratory courses, including experiment duration, code accuracy, and operational proficiency. By leveraging these data, we can develop targeted assessments of students 'academic performance, integrating teachers' subjective evaluations with various metrics to provide a comprehensive and objective evaluation across multiple dimensions. Students can also engage in targeted training based on their assessment results to address their weaknesses.

4. Implementation Methods of Collaborative Reform

The ultimate goal of the coordinated reform in computer experimental teaching and laboratory development is to foster students' practical skills and innovative capabilities throughout the talent cultivation process. This study establishes a framework that starts from teaching content, leverages laboratory hardware and software resources along with an intelligent information platform, employs a diversified evaluation system, refines student competency assessment, modularizes experimental learning components, and thereby fosters practical and innovative capabilities. Ultimately, this ensures that students' competencies better align with societal needs.

4.1 Modularization of Teaching Content

This paper utilizes courses such as Principles of Databases and Large Database Systems as foundational references to establish connections between different subjects and redesign the experimental content framework. Teachers set up separated experiment units to start from basic operational tasks, students can build simple program systems step by step within these units, and they will gradually master the basic hands-on abilities needed, teachers also take real competition tasks and actual work demands from enterprises as learning materials, these materials help students get better at coming up with new ideas during practice.

Teachers arrange basic training parts to help students learn how to operate software tools and grasp basic coding rules, students need to get used to coding tools and memorize standard code rules well, the system design unit lets students turn their design thoughts into usable software structures, then write codes and run tests to turn these structures into complete working programs, the creative practice unit uses real test tasks from companies, students can practice with these real industry material.

4.2 Intelligent Laboratory Equipment

Laboratory resources constitute the material foundation for experimental teaching. Most university computer laboratories currently face issues such as outdated equipment, fragmented management, and inefficient resource allocation, making it difficult to meet the demands of modular and open educational approaches. Establish a unified laboratory resource management platform.The platform records all laboratory data, providing robust data support for laboratory management.

Leveraging cloud desktop, IoT, and big data technologies, we have developed an integrated management platform with the following features:

Intelligent device management. Centralize management of all laboratory equipment, including computers, servers, and network devices. Additionally, it supports remote power-on/off operations, system restoration and data transfer from afar, as well as bulk software deployment.

Tracking and recording of the experimental process. Record student procedures, track experiment progress and market conditions, as well as fault occurrences.

Dynamic allocation of laboratory equipment. Intelligently allocate software and hardware resources based on the needs of teachers and students to improve utilization efficiency.

Data visualization analysis. Collect various data during equipment operation and refer to information such as student experiment completion rates to provide a basis for management optimization.

Centralized control of terminals. Utilize cloud desktop technology to achieve centralized management of endpoints, unified system updates, and centralized virus protection, thereby reducing maintenance costs and workload.

4.3 Multi-Dimensional and Refined

Evaluation System

The evaluation of students' experimental performance has been transformed from a single criterion based solely on lab reports to a multidimensional approach that incorporates reference to the experimental procedure, assessment of experimental outcomes, and comprehensive competency evaluation. The experimental procedure primarily evaluates aspects such as preparation status, operation duration, and operational proficiency. The evaluation of experimental results primarily considers code correctness, experimental outcomes, and the defense performance. The comprehensive competency assessment encompasses programming skills, code testing capabilities, system design abilities, teamwork skills, and innovative thinking. Based on the assessment priorities, teachers establish quantitative quality benchmarks and weights for each dimension, then conduct comprehensive evaluations of each student using actual data, thereby shifting from a single-standard evaluation to a data-driven, multidimensional approach.

Furthermore, during the actual evaluation process, the assessment criteria for each dimension should be refined in detail. First, the evaluation of experimental procedures should consider students' classroom performance, adherence to operational standards, and progress in task completion. Secondly, when evaluating experimental outcomes, particular emphasis should be placed on the accuracy of results and the completeness of project reports. Finally, in the comprehensive ability assessment, depending on the specific focus of the experimental content, evaluations may incorporate aspects such as students' problem-solving skills, teamwork abilities, or presentation and defense capabilities. By conducting multi-dimensional evaluations of operational processes, experimental outcomes, and comprehensive abilities—supplemented by detailed assessment criteria for each dimension—the evaluation system transforms a previously simplistic and subjective approach into an objective reflection of students' overall capabilities based on measurable data.

5. Conclusion

Given the rapid advancement of digital and intelligent technologies, experimental teaching and laboratory infrastructure development in university computer science programs require accelerated reform and modernization. Colleges should progressively implement modularized approaches to experimental curriculum design, enhance the intelligence level of experimental equipment, and refine teaching evaluation methods to ensure greater comprehensiveness and precision. In subsequent work, the colleges should continuously refine the reform plan and provide sustained, effective support for the development of computer-based experimental teaching and laboratory infrastructure in higher education colleges.

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