Construction and Practical Exploration of an Open Management Model for Higher Education Liberal Arts Laboratories

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Abstract: Under the dual background of digital transformation and the New Liberal Arts concept, university liberal arts laboratories face challenges such as insufficient systematization and low resource utilization in daily management. This study employs foreign language laboratories as a case example. By analyzing existing issues in current open management models of liberal arts laboratories, we propose a continuous improvement mechanism based on the Plan-Do-Check-Act (PDCA) cycle theory. Through the construction of a hierarchical responsibility system, Standard Operating Procedures, multi-module open-access projects, information-based reservation and approval processes, and multi-dimensional evaluation mechanisms, a closed-loop management model for laboratory operation is established. Empirical results demonstrate that this model effectively enhances laboratory accessibility and resource utilization efficiency, providing theoretical support and practical pathways for the sustainable development of liberal arts laboratories.

Keywords: Liberal Arts Laboratories; Open Management Model; PDCA Cycle; Information-based Management; Evaluation Mechanisms; Resource Utilization

1. Introduction

In the higher education system, university laboratories, as a core component, play a vital role on the road of digital transformation. As an important facility for key activities such as ideological education and language education in colleges and universities, the liberal arts laboratory bears the important task of cultivating students ' practical and innovative ability. In the context of the new era, traditional liberal arts education urgently needs reform and innovation. The new liberal arts concept emphasizes interdisciplinary integration, practice orientation and humanistic care, aiming to cultivate talents with global vision and new era literacy [1]. The proposal of the new liberal arts concept puts forward more diversified requirements for the cultivation of higher education talents. How to effectively transform theoretical knowledge into practical skills and further cultivate innovative thinking has become the key direction and goal of the cultivation of new liberal arts talents. This goal is consistent with the goal of opening university laboratories to promote the cultivation of academic practice and innovation ability. Therefore, the scientific opening of laboratories helps to promote the implementation of the new liberal arts concept.

2 Research on the Current Situation of Open Management Mode of Foreign Language Laboratories in Universities

With the transformation of the laboratory from a single teaching platform to a multi-functional platform for talent training, cooperative innovation and scientific research, the open management mode of the laboratory has also undergone changes from the traditional teaching mode to the information means and digital concept. This study reveals some problems existing in the open management mode of liberal arts laboratories in colleges and universities by visiting and investigating the laboratories of some local undergraduate colleges and universities and sorting out the literature [2-5].

(1) Open management research is relatively scarce. In the field of laboratory management in colleges and universities, although there have been a lot of discussions on the open management of laboratories, these studies mostly focus on the open management of engineering laboratories and large-scale instruments and equipment, while the research on the open management of liberal arts laboratories is relatively rare, especially the research on the open management of laboratories combined with foreign language talent training and professional characteristics.

(2) There is no systematic and continuous reform.

There is a lack of systematic continuous improvement in terms of open demand, responsibility system, management system, training and evaluation. Isolated reform measures cannot fully address the challenges faced by the open management of laboratories. For example, in the case of unclear opening needs, the established open projects are difficult to meet the actual needs of researchers, thus affecting the effectiveness of laboratory management. There are defects in the construction of the responsibility system, which leads to the blurring of the responsibility boundary and increases the difficulty of management. The non-standardization of the system process also makes it difficult to effectively implement the laboratory opening.

(3) The lack of laboratory openness in a single form. In addition to the opening of laboratory places and equipment, it should also include the opening and sharing of laboratory digital resources, such as scientific research data, scientific research publications, research tools and other scientific research infrastructure. In terms of the opening process and audit system, there are problems such as cumbersome audits, slow appointments, non-compliance, and lack of institutional constraints. These problems reduce the efficiency of laboratory opening and limit the degree of openness.

(4) Insufficient combination of laboratory projects and enterprises. At present, most of the laboratory open projects have not realized the integration of production and education, and the degree of integration with enterprises is low. The experimental content is rarely or not updated with industrial development, which leads to the disconnection between laboratory research results and practical applications, and it is difficult to effectively promote the development of science and technology and the progress of social economy.

(5) The degree of laboratory opening informatization is insufficient. In the context of the digital era, the rapid development of information technology has brought new opportunities and challenges to laboratory management. However, many laboratories still rely on traditional management methods and lack the full use of information technology, which limits the improvement of laboratory management efficiency and innovation ability.

(6) Lack of effective evaluation system support. The lack of an effective evaluation system makes it difficult to obtain accurate evaluation and feedback for the open management of laboratories, which brings difficulties to the management and operation of laboratories. Without a clear evaluation system, it is difficult for managers to comprehensively evaluate the effect of experimental opening and the work of teaching and research personnel, and to accurately judge everyone's ability and potential. As a result, laboratory resources may not be optimally utilized, and teamwork and coordination may also be affected. Therefore, it is very important to establish an evaluation system with clear standards and processes to support the development of laboratory open management, improve laboratory utilization and output of teaching and research results.

3. Thinking of Laboratory Open Mode

The opening of the laboratory includes three levels of opening, the opening of time, and the choice of experimental time by teachers and students ; open content, teachers and students choose teaching, scientific research projects, competitions and other experimental content; the opening of the object, for different professions, different schools for academic cooperation and exchange. According to the above three levels of openness, the establishment of management measures are as follows : taking the system as the guarantee (introducing PDCA thought to establish a continuous improvement management mode), multi-level open projects as the basic elements, information-based appointment audit process as the implementation means, effective evaluation system as an important measure, open laboratory teaching and laboratory integrated management system as the basic platform, to build a complete laboratory operation and management mode, as shown in Figure 1.

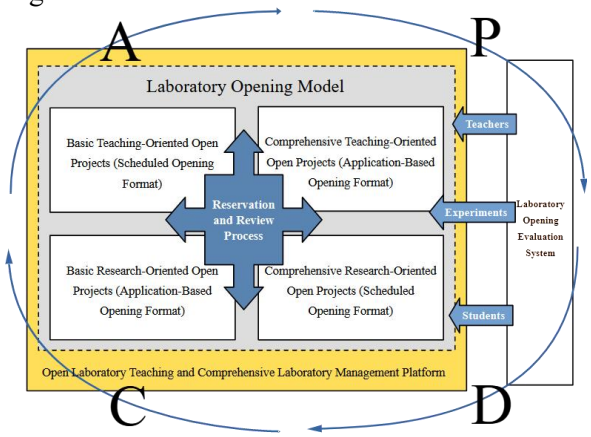

Figure 1. Overall Scheme of Laboratory Operation and Management Mode Reform

4. Establish a Continuous

Improvement-oriented Laboratory Open Management Model

By constructing a full participation mechanism, implementing the whole process quality monitoring and implementing continuous improvement strategies, Total Quality Management (TQM) achieves the dual goals of maximizing value and sustainable development of the organization. As the core implementation framework of TQM, PDCA cycle (Plan-Do-Check-Improve) constitutes the basic methodology of quality management: establishing standardized quality objectives in the plan stage; implement the specific implementation plan through the implementation link; using the inspection mechanism to evaluate the process deviation; finally, the management closed-loop optimization is realized in the improvement stage. In this paper, the PDCA management mode is introduced, and the process of open operation of the laboratory, the participants and the multi-dimensional responsibility system are connected in series to the process of PDCA management, forming a sustainable development laboratory PDCA cycle closed-loop management operation mechanism, as shown in Figure 2.

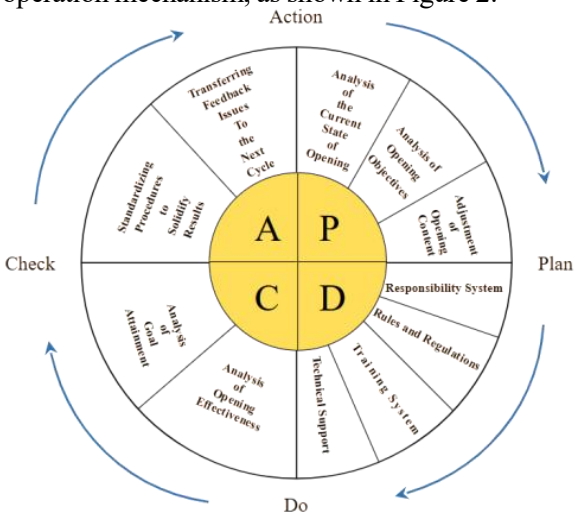

Figure 2. Total Quality Control PCDA Diagram

4.1 Establish Hierarchical Responsibility System

Build a ' 4 + X ' hierarchical management system [6], of which level 4 is the laboratory center, teaching and research section, laboratory management personnel, practical guidance teachers, X represents the dynamic practice group, forming a management structure of upper and lower linkage, see figure 3. The foreign language teaching experiment center coordinates the overall situation, divides the regional laboratories according to the professional attributes and functional requirements, each teaching and research section is responsible for the open management of the corresponding area, and the director of the experiment center coordinates the cross-regional cooperation. Each laboratory formulates differentiated management rules according to professional characteristics, implements the principle of ' use-management-responsibility ' integration, and is jointly responsible for daily operation and maintenance by full-time administrators and professional teachers. The large-scale instruments and equipment are implemented by the centralized management of the college, and the practice group, as the basic unit, is supervised by the instructor throughout the whole process, forming a two-way closed-loop mechanism of college deployment-regional implementation-problem feedback.

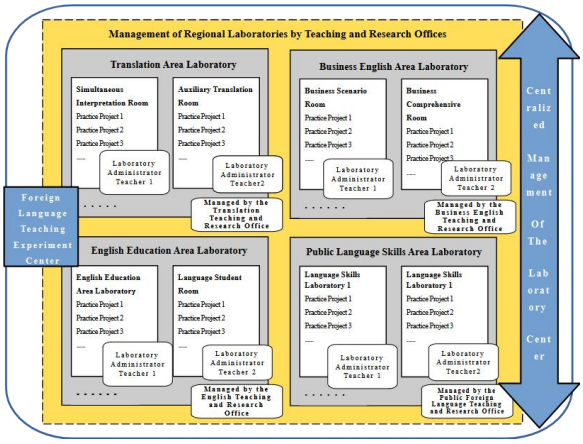

Figure 3. 4 + X Responsibility System

Through the central hub role of the laboratory, the system transmits the policy to the teaching and research section, management personnel and practice group step by step, and collects problems to form an improvement plan. The combination of top-down responsibility implementation and bottom-up response feedback promotes the continuous optimization of laboratory hardware facilities and management efficiency, and builds a sustainable management system of planning-implementation-feedback-improment.

4.2 Establish Process Rules and Regulations

The laboratory established a multi-level safety management system covering the whole hospital. First, the user's code of conduct, clear laboratory access authority and operational authority; second, the equipment operation process, clear equipment operation standard steps; third, laboratory equipment safety, storage management and leasing. Through process standardization, unified operation

benchmarks can be achieved, security risks can be reduced, and resource allocation can be optimized to improve the efficiency of interdisciplinary laboratories.

4.3 Establishment of Training System

The training service system of the laboratory is constructed. The college-level training focuses on basic safety and common norms, covering all personnel ; laboratory training to strengthen equipment operation and emergency plan, for professional regional users ; project training focuses on equipment service academic research and data analysis. The training content presents a gradient feature, as shown in Figure 4. The outer layer training ensures that the basic ability is up to standard, and the inner layer training implements customized teaching according to the laboratory characteristics, project requirements, and personnel level, forming a dual guarantee system of full compliance and precise improvement.

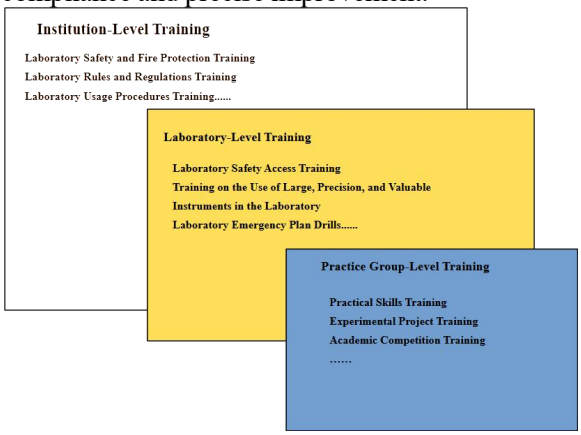

Figure 4. Training System Hierarchy Diagram

5. Establish Multi-module, Multi-level, Multi-channel Open Projects

In order to meet the needs of differentiated development of disciplines, through modular design, an open project set with professional characteristics and commonness training is formed. Taking language practice as an example, the oral English module emphasizes the cultivation of academic communication ability in the professional English direction, and focuses on daily communication ability training in the public English direction, so as to realize the multi-level goal setting of the same module. Based on the three-stage development law of "foundation of basic ability-improvement of comprehensive quality-breakthrough of innovation ability," the open laboratory project is systematically planned into four major practical types [7-9], and a complete ability chain from operation standard training to scientific research is constructed. Each type of project implements a gradient access mechanism, and students can independently choose the adaptive development path according to their academic progress and ability level. The open type is shown in Figure 5.

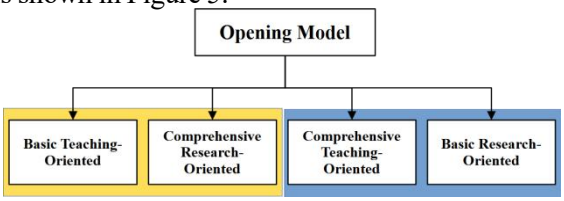

Figure 5. Open Project Category Diagram

Basic teaching oriented: docking talent training program, focusing on the implementation of the basic links of experimental teaching, focusing on experimental teaching tasks, facing all students.

Comprehensive research oriented: for the cultivation of top-notch talents, establish a research-competition-production collaborative mechanism, the main projects are subject competitions, scientific research topics, etc.

Comprehensive teaching oriented: professional ability improvement, mainly professional compulsory experimental courses, curriculum release comprehensive, design self-selected experimental projects for students to choose.

Basic research oriented: to build a bridge from course experiment to scientific research training, covering college students ' innovation and entrepreneurship training plan, course extension project, graduation design pre-research and other types.

6. Establish an Information-based Appointment Review Process

The full opening of the laboratory needs to rely on the information management platform to achieve efficient operation. Through the integration of more than 10 functional modules such as experimental teaching, equipment management, and open reservation, the laboratory open information, equipment resources, and curriculum arrangements are published on the platform. Teachers and students can complete the safety access assessment, appointment application and access control authorization online, and the platform can display the equipment status, appointment time and technical personnel information of each laboratory in real time, so as to realize the whole process digital management of " one network office " [10-11]. The appointment process is shown in Figure 6.

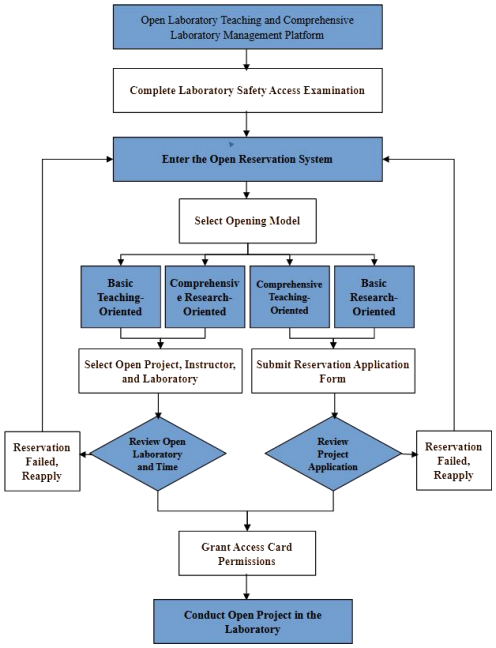

Figure 6. Reservation Process

The platform establishes a traceability mechanism for experimental behavior, and hierarchically freezes permissions for phenomena such as breaking contracts and violating laboratory regulations. Students need to complete laboratory behavior norms, safety knowledge, and resume appointment qualifications after practical retraining. The mechanism realizes the discipline constraint of the laboratory through the data-driven behavior management mode, and plays an educational role in cultivating students sense of responsibility and scientific literacy [12].

7. Establish an Effective Laboratory Open Evaluation Mechanism

The establishment of an open laboratory evaluation mechanism is conducive to reforming the methods of experimental teaching, cultivating students ' independent learning ability and innovation ability, and making full use of laboratory equipment. To use laboratory opening more effectively, it is an important measure to establish a reasonable and effective evaluation mechanism.

7.1 Evaluation of Experimental Instructors

The construction of the experimental open evaluation mechanism requires the implementation of teacher incentive strategies, combining the teacher's personal goals with the laboratory's open goals. Through the combination of quantitative assessment (project level, opening time) and dual-track incentives (floating class fees, professional title evaluation, etc.), teachers are actively encouraged to transform scientific research topics into teaching projects, so that students can get subject competitions and scientific research training in open experiments, and form a mutual feeding ecology of teaching and scientific research. The teacher evaluation formula is obtained: teacher evaluation = class hour + teaching assessment + excellent performance award + title bonus. The Office of Academic Affairs, the Office of Scientific Research, the Office of Quality Control and the Office of Personnel added the index assessment of open projects in the evaluation of teachers.

7.2 Evaluation of Experimental Technicians

To construct the incentive mechanism of the experimental technical team, one is to consider the teaching support dimension (the intact rate of experimental equipment,etc.),the service dimension (competition awards, scientific research projects, etc.), and the open management dimension (appointment response time). The second is to implement a quantitative assessment index system, including equipment maintenance work order quantity, safety accident rate, teaching and research praise rate included in the performance allocation algorithm. For the management of excellent laboratory management personnel title evaluation tilt special allowance floating mechanism. From the multi-dimensional accounting workload, G = G1 + G2 + G3 + G4 + G5, where G is the annual workload ;G1 is the daily management and maintenance workload of the laboratory, which is mainly calculated from the number of laboratories managed, the number of equipment sets, and the total amount of equipment assets. G2 is the workload of experimental teaching, calculating the number of laboratory opening hours (number of students × opening hours) ; G3 is the laboratory construction workload, presided over and participated in the laboratory construction ; G4 is the workload of technology and research services ; g5 is the workload of open experiments, including the workload of guiding students to open experiments, the workload of developing open experimental projects, the workload of opening hours of managed laboratories, the workload of open laboratory management and maintenance, etc [13]. The third is to correctly evaluate the positions of experimental technicians and improve the recruitment mechanism. In order to fundamentally stabilize the experimental team and develop healthily, it is necessary to formulate a suitable professional title evaluation mechanism, smooth development channels, and eliminate personal development obstacles. The evaluation subjects of

experimental technicians are mainly the academic affairs office and the experimental center of the college.

7.3 Evaluation of Students

The laboratory opening mechanism constructs a multi-dimensional autonomous learning space, breaks through the one-way transmission mode of " teacher demonstration-student imitation " in traditional experimental teaching, and forms a personalized training scheme of flexible time management and modular project selection, so that students can truly become the main body of learning. Based on this understanding, the open evaluation of the laboratory is based on the combination of students ' self-evaluation and external evaluation. Self-evaluation needs to guide teachers to guide students to correctly evaluate the open process of the experiment, find out the advantages, disadvantages and areas to be improved, carry out ' meaningful learning ', ' free learning ', and stimulate learning potential. External evaluation includes the instructor 's comprehensive assessment results of the experimental process and experimental results. Self-evaluation and external evaluation, the implementation of the experimental open credit system, the laboratory integrated management platform for students entering the laboratory to complete the open project accumulated points, encourage students to participate in the laboratory open activities, cultivate students ' practical and innovative ability. For students who accumulate more points, the comprehensive evaluation is added. Give preference in participating in subject competitions, evaluating first and recommending enterprises first when graduating. The student evaluation formula is obtained: student evaluation = self-evaluation + external evaluation + integral accumulation. The evaluation subjects are open project instructors, open laboratory teaching and laboratory integrated management platform cumulative points.

7.4 Evaluation of Laboratory Utilization

The effective way to evaluate the effect of laboratory open management mode is to evaluate the utilization rate of laboratory. The evaluation method of laboratory utilization rate is mainly based on the number of hours and open projects in each semester. The number of hours is the number of students in this laboratory in each semester multiplied by the number of hours in the class, and the number of open projects is the laboratory course. The number of projects emphasizes the category and quantity of open projects. These two statistical methods have certain evaluation effects in basic teaching laboratories, but have certain limitations for professional laboratories and large equipment laboratories [14-16]. This topic comprehensively considers the various factors of the laboratory, and incorporates the laboratory's resource input, different equipment quota machine hours, and the value of teaching and scientific research instruments and equipment per student in different majors into the calculation range, and proposes an evaluation system with laboratory opening rate, equipment utilization rate, and resource utilization rate as the main evaluation indicators.

The opening rate of the laboratory is calculated by dividing the annual actual class hour K by the full class hour M. The annual actual class hour is the teaching plan to arrange the class hour K1, the professional talent training program experimental project class hour K2, and the subject competition K3, scientific research K4 and other non-teaching arrangements open class hours. The full class hour N is formulated according to the actual situation of the teaching experiment curriculum arrangement in colleges and universities, experimental differences, curriculum differences and other factors.The calculation formula of laboratory opening rate is obtained:

$$\text{Laboratory opening rate} = \frac{\sum_{i}^{n} K_i}{M} \quad (1)$$

Among them, Ki is the actual course and project class hour, and M is the full class hour of laboratory equipment.

The equipment utilization rate refers to the actual number of person hours divided by the number of person hours of the equipment. The actual number of person hours is the number of students in the laboratory S multiplied by the class hour K of the class. The number of person hours of the equipment is the number of experimental instruments and equipment (set / group) × the number of people in each set (set / group) × the available experimental hours of the equipment, in which the available experimental hours of the equipment are reduced year by year according to the depreciation of the equipment. The calculation formula of equipment utilization is obtained:

$$\text{Equipment utilization} = \frac{\sum_{i}^{n} K_i \times S_i}{T1 \times T2 \times T3} \quad (2)$$

Among them, Ki is the actual course and project class hour, Si is the number of experimental courses and projects,T1 is the number of

experimental instruments and equipment (set / group),T2 is he number of people in each set (set / group),T3 is the available experimental hours of the equipment.

The utilization rate of resource source is divided by the value output value of the laboratory and the resource input of the laboratory. The value output V of the laboratory contains three items, one is the number of students in the laboratory multiplied by the value of teaching and research equipment per student V1, and the second is the credit value of the laboratory open project V2. The credit value can be calculated by the total professional credits and tuition fees. The third is the service value V3 of the teaching and research project, including the service cost of the laboratory and the value of the project research score. The value of the laboratory output V=V1+V2+V3.

The resource investment of the laboratory mainly includes the investment of basic construction, which is mainly the housing area R1, the equipment investment R2, the manpower and material resources investment R3 and other resources investment R4. Among them, the investment in infrastructure decreases with the increase of the service life of the house, and the investment in equipment decreases every year according to the depreciation rate of the equipment. Laboratory resource input R=R1+R2+R3 +R4.Get the resource utilization calculation formula:

$$\text{Resource utilization}=\frac{\sum_{i}^{n} V_i}{\sum_{i}^{m} R_i} \quad (3)$$

Vi is the value output value, and Ri is the resource input value.

Through the evaluation of the utilization rate of teachers, experimental technicians, students and laboratories, an effective evaluation system for the open management mode of laboratories is established, and a closed-loop process of ' feedback-evaluation-improvement ' is formed. While improving the opening rate and quality of the laboratory, more students and teachers are encouraged to participate in the opening of the laboratory.

8. Conclusion

The construction of a sustainable laboratory open management model is mainly to cultivate innovative talents, transform theoretical knowledge into practical ability, and change the traditional practice of professional teaching depending on theoretical teaching. At the same time, through opening up, promote academic exchanges, improve the quality of personnel training, create excellent research platforms, expand research fields, and promote the improvement of the academic level of the laboratory. As a systematic project, laboratory opening requires the collaborative participation of multiple departments, the deep cooperation of faculty and staff, and the support of resource integration. The standardized operation of scientific research laboratories not only supports the efficient implementation of personnel training, discipline construction, scientific research and social service functions, but also serves the major strategic layout of the country and the needs of regional economic and social development, and provides strategic support for enhancing the core competitiveness of the school.

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