Research on the Construction of Safety Management System for Laboratories and Training Rooms in Higher Vocational Colleges - A Case Study of Zhejiang Dongfang Polytechnic

Kaixuan Zhu
Zhejiang Dongfang Polytechnic, Wenzhou, Zhejiang, China

Abstract: Taking Zhejiang Dongfang Polytechnic as an example, this study focuses on optimizing the safety management system for laboratories and training rooms in higher vocational colleges. As a 5A-level Safe Campus in Zhejiang Province, the college has established a three-level management system and a regular inspection mechanism, but still faces challenges such as insufficient informatization and lack of a unified platform for process supervision. To address these issues, this paper constructs a comprehensive system of "grid-based responsibility, scenario-based training, intelligent supervision, and collaborative governance" from four dimensions: deepening responsibility, innovating education, empowering technology, and promoting collaborative governance. By implementing grid performance management, expanding VR/AR immersive training, building an intelligent management platform, and improving the school-enterprise co-governance mechanism, the study promotes the transformation of safety management from a "human-oriented prevention" model to an integrated model of "human, technical, and intelligent prevention", aiming to provide practical reference for similar institutions.

Keywords: Higher Vocational Colleges; Laboratory and Training Room Safety; Grid-Based Responsibility; Intelligent Supervision; School-Enterprise Collaboration

1. Introduction

Laboratories and training rooms are core venues for higher vocational colleges to carry out practical teaching, skill training, and technological research and development. Their safety management level is directly related to the personal safety of teachers and students, the stability of teaching order, and the quality of talent training. As a "Double High Plan" construction college and a 5A-level Safe Campus in Zhejiang Province, Zhejiang Dongfang Polytechnic has always placed campus safety in an important position. It has established a three-level safety management system covering the college, schools/departments, and laboratories. With strong leadership attention, the college organizes more than 20 various safety inspections every year and has achieved full coverage of safety access education for new students. In particular, the "First Lesson of the Semester in the Laboratory" has been implemented to strengthen the safety education responsibility of practical training instructors. However, with the upgrading of industrial technology and the deepening of vocational education reform, training equipment has shown a trend of intelligence and complexity, with increasing usage intensity, and the demand for open sharing and productive training is constantly expanding. The traditional management method relying on manual work and experience is facing new challenges [1]. At present, the college mainly relies on general office software (such as DingTalk) for safety inspection and rectification tracking in the safety management of experimental and training rooms. Information collection, collation, and filing are highly dependent on manual work, lacking a unified digital monitoring platform and dynamic risk early warning capability, resulting in management efficiency and refinement level being difficult to meet the requirements of the new development stage [2]. Therefore, how to further construct a systematic, complete, intelligent, and efficient experimental and training room safety management system that fully reflects the characteristics of higher vocational education on the existing good foundation has become an important issue with both theoretical value and practical urgency.

This study aims to put forward an operable system optimization path by systematically analyzing the current situation of the college and combining modern safety management concepts and information technology, in order to provide reference for the college and even similar higher vocational colleges to improve the safety governance capacity of experimental and training rooms.

2. Analysis of the Current Situation of Safety Management for Laboratories and Training Rooms

2.1 Existing Foundations and Distinctive Advantages

After years of construction, the school has formed a certain institutional foundation and practical accumulation in the safety management of experimental and training rooms, which constitutes the realistic starting point for system optimization.

A preliminary institutional framework has been formed, and inspection and supervision have been normalized. Zhejiang Dongfang Polytechnic has established a three-level safety management organizational structure covering the school, college, and laboratory levels, and formulated a series of rules and regulations including the "Measures for the Safety Management of Laboratories", "Detailed Rules for the Management of Hazardous Chemicals", and "Safety Operating Procedures for Special Equipment". The school's safety work leading group coordinates and coordinates, each secondary college implements the main responsibility, and laboratory managers are responsible for on-site execution, with a relatively clear hierarchy. the college has formed a relatively strict safety inspection and supervision mechanism. Led by school leaders, it organizes more than 20 regular and irregular safety inspections covering all experimental and training venues every year. This high-frequency inspection has effectively promoted the transmission of safety awareness and the investigation of on-site hidden dangers, creating a management atmosphere that attaches importance to safety [3].

Safety education has been continuously carried out, and the form of exploration has characteristics. The college has achieved full coverage of laboratory safety access education for all new students, ensuring that students "receive training before entering". Among them, the "First Lesson of the Semester in the Laboratory" has become a characteristic link, requiring practical training instructors to conduct targeted on-site safety explanations combined with the professional characteristics and potential risks of the courses they teach, initially integrating safety education with professional teaching. In addition, relying on the construction foundation of "5A-level Safe Campus", Zhejiang Dongfang Polytechnic has made innovative explorations in the form of safety education and training. For example, its fire control room has independently developed a fire safety experience course based on virtual reality (VR) technology, allowing students to learn fire escape and fire extinguisher use skills in an immersive environment, providing valuable experience for innovating the traditional safety education model [4].

It has a profound foundation in overall security, and governance experience can be transferred. As one of the first batch of "5A-level Safe Campuses" in Zhejiang Province, the college has accumulated systematic management experience in overall campus safety governance, including public security prevention and control, fire safety, traffic safety, food safety, etc., forming a governance pattern of multi-departmental linkage and combination of people-oriented prevention, physical prevention, and technical prevention. This overall safety culture and management foundation provide a good organizational guarantee and environmental support for making breakthroughs in the safety management of experimental and training rooms. Some mature governance concepts and collaboration mechanisms have the potential to be transferred and adapted to the field of training room safety management.

2.2 Main Problems and Challenges

Despite the above advantages, focusing on the special scenario of experimental and training rooms with strong professionalism, concentrated risks, and dynamic changes, the current management system still exposes several deep-seated problems that need to be solved urgently.

The responsibility system needs to be deepened, and the collaborative efficiency is insufficient. In the operation of the existing three-level management system, there are problems of "attenuation of vertical transmission and gaps in horizontal connection". The school-level focuses on macro policies and supervision. The safety management responsibilities of secondary colleges are often intertwined with heavy teaching and scientific research tasks, and sufficient full-time safety management personnel are not allocated, resulting in scattered management energy. Safety officers at the laboratory level are mostly part-time professional teachers, and there is no effective incentive and restraint mechanism for the performance of their duties. Especially in the training rooms co-constructed by schools and enterprises and used across disciplines, the boundaries of safety management responsibilities among schools, enterprises, and different colleges are blurred, and the collaborative management process is not smooth, which is prone to "multiple management" or "management vacuum" areas [5]. Safety performance has not been deeply and rigidly linked to the annual assessment, evaluation of excellence, and resource allocation of departments and individuals, leading to weak sense of main responsibility among some subjects and insufficient endogenous motivation for management.

The effectiveness of education needs to be improved, and the scenario fit is not tight. Although safety education has achieved "full coverage", its effectiveness needs to be deepened. The current educational forms are still dominated by traditional models such as classroom lectures, video watching, and online answering. The content focuses on general safety knowledge, and is not closely combined with the specific operation scenarios and risk types of different majors, different types of work, and different equipment, leading to students feeling that "learning is disconnected from application". Although there is a preliminary attempt at VR safety experience, the covered scenarios (mainly fire protection at present) and the scope of benefited students (only piloted in some majors) are very limited, and it has not formed a large-scale and systematic immersive training capability. Some students have passed the access exam, but there are still fluke psychology and illegal operations in real training, and safety knowledge has not been effectively transformed into a solid sense of safety and conscious safe behavior habits [6]. The guiding role of teachers needs to be further played, and there is a lack of systematic teaching design support for how to seamlessly integrate safety education into every practical teaching link.

Information support is obviously lagging behind, and intelligent control is lacking. This is the most prominent shortcoming in the current management system. The safety management process is highly dependent on general office software such as DingTalk for approval and circulation, which has problems such as inconsistent information formats, scattered records, difficult retrieval, and cumbersome process traceability. The closed-loop management of hidden danger investigation, rectification, and acceptance mainly relies on manual summary, which is inefficient and prone to omissions. Most importantly, there is a lack of a unified safety information management platform for experimental and training rooms, which cannot accurately track and conduct inventory early warning for the whole life cycle (procurement, storage, collection, and disposal) of hazardous chemicals; it cannot conduct real-time online monitoring and fault diagnosis of the operating status of large-scale instruments and equipment, high-temperature and high-pressure devices, and ventilation systems; it cannot continuously collect and alarm for excessive risk parameters such as toxic and harmful gas concentrations, temperature, and humidity in the environment. The entire management process is in a state of "data silos", unable to achieve dynamic risk perception, intelligent early warning, and data-based precise decision-making, and there is still a large gap from the goal of "smart security" [7].

3. Optimization Paths for the Safety Management System of Laboratories and Training Rooms

Based on the above analysis of the current situation, following the principles of "problem-oriented, school-based, systematic reconstruction, and phased implementation", this study proposes to carry out collaborative optimization from four dimensions: responsibility mechanism, education and training, supervision mode, and governance structure, and construct a three-dimensional and closed-loop new safety management system for experimental and training rooms.

3.1 Grid-Based Responsibility System: From

"Three-level Structure" to "Precise Post Assignment"

The key to solving the problem of responsibility emptiness lies in refining management units, specifying responsibility subjects, and quantifying evaluation. It is recommended to fully implement a "grid-based" refined safety management model on the basis of the existing three-level structure.

Firstly, scientifically divide grids. Take a single experimental and training room with relatively independent physical space and unified risk types, or a specific functional area in a large training room (such as a temporary storage area for hazardous chemicals, a high-temperature processing area) as the basic management grid. Each grid has a unique "grid safety supervisor", preferably a backbone teacher or full-time experimenter who undertakes the main teaching tasks of the laboratory, and is entrusted with clear daily safety management powers and responsibilities.

Secondly, construct a five-level responsibility list. Form a clear responsibility chain of "school safety work leading group (overall decision-making and supervision assessment) - relevant functional departments such as the Security Department, Academic Affairs Office, and Logistics Department (standard formulation and professional support) - secondary colleges (implementation of main responsibilities and resource guarantee) - grid units (daily management and on-site control) - post personnel including teachers, students, and visitors (direct execution and self-management)" [8]. By signing differentiated "Work Safety Responsibility Certificates" or "Safety Commitment Letters" level by level, the pressure is transmitted to the terminal.

Thirdly, strengthen the management of collaborative boundaries. For laboratories co-constructed by schools and enterprises and used by multiple colleges, the leading department must organize relevant parties to jointly sign a "Joint Safety Management Agreement", which formally clarifies the specific responsibilities, interface relationships, and collaboration procedures of all parties in equipment maintenance, consumable supply, personnel training, daily inspections, emergency response, etc., in the form of a written document to avoid shirking responsibilities.

Finally, implement quantitative performance assessment and incentives. Drawing on the idea of "points-based" management [9], establish a quantifiable "safety performance points" system. For each grid, set key performance indicators (KPIs) including "hidden danger self-inspection rate, timely rectification rate, violation occurrence rate, participation and passing rate of safety education, number of adopted safety improvement suggestions", etc. The points results are publicly announced every month, and strictly linked to the annual assessment and funding allocation of secondary colleges, and associated with the performance salary, professional title evaluation, and evaluation of excellence of grid supervisors. Special safety construction fund rewards will be given to grids that maintain high points (green card) for a long time; grids that fail to meet the points (yellow card, red card) will be warned, interviewed, or even suspended from operation, effectively changing from "passive response to inspections" to "active pursuit of safety".

3.2 Scenario-Based Education and Training: From "Universal Publicity and Education" to "Immersive Experience"

To improve the effectiveness of safety education, it is necessary to promote its transformation from knowledge inculcation to ability training, and from centralized publicity to whole-process infiltration.

Firstly, systematically develop and expand VR/AR immersive training courses. Integrate internal and external resources, set up a special team, and systematically plan the VR/AR safety training course system. In terms of content, quickly expand from the existing fire safety to core scenarios that are most common and dangerous in higher vocational training, such as mechanical injury prevention (such as CNC machine tool operation, testing equipment safety), electrical safety (such as electric shock prevention, circuit maintenance), and special equipment safety (such as hoisting machinery, pressure vessels) [4]. In terms of management, formulate a clear construction roadmap, strive to build a virtual simulation training module library covering high-risk training projects of all key engineering majors, and incorporate it into the talent training programs of relevant majors.

Secondly, deepen the integration of "curriculum ideology and politics" and safety education. Vigorously promote and optimize the "First Lesson of the Semester in the Laboratory", upgrading it to a standardized and normalized teaching link. More importantly, promote safety education to "enter the syllabus, enter the lesson plan, and enter the classroom". Organize teaching teams of each major to develop a "Guideline for the Integration of Safety in Practical Training Teaching" for the major, guiding teachers on how to simultaneously analyze the safety risk points, key operation specifications, and emergency handling procedures when teaching each practical skill point, realizing the "seamless" and "whole-process" safety education [10].

Thirdly, establish and strictly implement a "trinity" safety access and competency certification system. Design a progressive access process of "online general safety knowledge assessment + special VR risk simulation disposal assessment + offline actual equipment safety operation certification". Students must pass the previous link in order to enter the next link. In particular, the actual operation certification requires completing the whole process including pre-startup inspection, standardized operation, fault identification, emergency shutdown, and post-event finishing on real equipment under the supervision of teachers. After passing the assessment, an electronic "safety operation license" will be issued, which will be linked with the access control system to realize "certified post and person-certificate integration". At the same time, establish a regular review mechanism for safety qualifications to ensure the continuous effectiveness of capabilities.

3.3 Intelligent Supervision Means: From "Manual Circulation" to "Data-Driven"

To address the shortage of informatization, the core measure is to plan and build an intensive and intelligent "comprehensive safety management platform for experimental and training rooms" as the "digital hub" for the efficient operation of the system [11].

The platform should integrate technologies such as the Internet of Things, big data, and artificial intelligence, and have the following core functional modules:

Full-process closed-loop management module: Realize the onlineization of safety inspection standards, mobile phone-based reporting of hidden danger investigation by taking photos, automatic assignment and tracking of rectification tasks, online completion of review and acceptance, and automatic data filing and analysis. Completely replace scattered paper records and social software circulation, and realize the onlineization, standardization, and visual closed-loop of all business processes.

IoT perception and visual monitoring module: Through the deployment of an intelligent sensor network, real-time collect key data: at the equipment level, monitor the operating current, vibration, and temperature of large-scale equipment; at the environmental level, monitor the temperature, humidity, VOC concentration, flame, and smoke in hazardous chemical warehouses and use areas; at the facility level, monitor the face wind speed of fume hoods, fire pipeline water pressure, and emergency lighting status. All data are aggregated to the platform and displayed in a centralized, dynamic, and visual manner through the "one map of campus training safety", realizing real-time perception and "unified view on one screen" of the overall safety situation [7].

Intelligent early warning and risk assessment module: Based on preset rules and machine learning models, the platform can automatically identify abnormal states, classify them (such as general early warning, important alarm, emergency alarm), and push them to relevant grid supervisors, safety managers, and department leaders in a targeted and timely manner through various methods such as platform messages, short messages, and APP notifications, realizing the transformation from "post-event disposal" to "pre-event early warning and in-event intervention".

Data analysis and decision support module: The platform automatically aggregates all safety-related data, and uses big data analysis technology to regularly generate multi-dimensional analysis reports, such as the distribution of hidden danger types, high-frequency violations, equipment failure trends, and evaluation of education and training effects. These data insights can provide scientific decision-making basis for management, which can be used to optimize the direction of safety investment, adjust inspection priorities, and improve training content.

The platform construction should adopt the strategy of "overall planning, phased implementation, and priority to urgent needs". In the first phase, closed-loop management of hidden dangers and IoT monitoring of key areas can be realized first; in the second phase, gradually expand the monitoring coverage and develop intelligent early warning models; in the third phase, improve data analysis functions and explore data docking with other smart campus systems of the school.

3.4 Collaborative Governance Mechanism: From "Internal School Management" to "School-Enterprise Joint Prevention"

Higher vocational education has distinct characteristics of integration of production and education. The safety management of experimental and training rooms must break out of the campus walls and build an open and collaborative governance ecology.

The primary task is to deeply embed safety clauses into school-enterprise cooperation contracts. When signing or renewing school-enterprise cooperation agreements, an independent "safety management appendix" or a special chapter must be set up to clearly stipulate the specific safety responsibilities of the cooperating parties (schools, enterprises, and sometimes students) in the co-construction of training bases or order-based training. The content should include: the proportion of investment in the construction and maintenance of safety facilities, the safety standards and annual inspection responsibilities of equipment donated or provided by enterprises, the safety guidance responsibilities of part-time enterprise teachers or technical instructors, the dual safety management interface for students during internships in enterprises, and the emergency linkage mechanism and responsibility division principles in the event of safety accidents (incidents). Through contractual means, clarify the powers and responsibilities from the source and lay the foundation for joint management [5].

Secondly, establish a normalized school-enterprise safety interaction mechanism. Regularly invite safety directors, engineers, or senior technicians from cooperative enterprises to enter the campus to participate in risk assessment, safety audits, and joint inspection activities of training rooms, and discover potential risk points in campus management that are easily overlooked from the perspective of industrial frontlines. Actively introduce and localize the application of mature and efficient safety management tools and methods from cooperative enterprises, such as "6S" (sorting, straightening, sweeping, cleaning, standardizing, safety) on-site management, Job Safety Analysis (JSA), Behavior-Based Safety (BBS), etc., to improve the professionalism and standardization of school safety management.

Finally, explore the construction of a co-constructed and shared "safety training and education base". Cooperate with leading enterprises, industry associations, or emergency management departments in the region to jointly invest in the construction of a high-standard "real-scene safety production training center". The center not only serves the practical assessment of various safety skills and special operation training and certification for on-campus students, but also carries out safety re-training and skill improvement for employees of cooperative enterprises, and can provide safety production training services for small and medium-sized enterprises in the region. Through this "co-construction, sharing, and win-win" model, the school can introduce the most cutting-edge industrial safety standards and real practical cases, enterprises can obtain convenient and efficient employee training channels, and the government can improve the regional safety production training capacity. Finally, a sound governance pattern of multi-party collaboration, resource complementarity, and joint risk prevention among government, schools, industries, and enterprises will be formed.

4. Expected Effects and Implementation Prospects

The implementation of the above "four-dimensional linkage" optimization path is expected to systematically improve the safety governance level of the experimental and training rooms of Zhejiang Dongfang Polytechnic, which is specifically reflected in the following aspects:

Significant improvement in management efficiency. The completion of the intelligent management platform will bring a qualitative change in the efficiency of safety information processing. It is expected that the average cycle of safety hazards from discovery to closed-loop rectification can be shortened by more than 50%, and the time that managers spend on data collation and report preparation can be reduced by 70%. The full onlineization and transparency of processes will greatly improve the efficiency of cross-departmental collaboration, making the operation of the safety management system more smooth, accurate, and traceable.

Qualitative enhancement of risk prevention and control capabilities. The deployment of the IoT perception network and intelligent early warning system will realize the leap from "people-oriented prevention" to "technical prevention + intelligent prevention". Through 24/7 uninterrupted monitoring and intelligent analysis of equipment status and environmental parameters, most potential physical and chemical risks can be detected in advance. It is expected that more than 80% of safety accidents caused by equipment failures or environmental abnormalities can be prevented. The dynamic risk assessment mechanism makes the allocation of safety resources more scientific, which can focus on the real high-risk links and achieve precise prevention and control.

Internalization of safety culture. Grid-based responsibility and performance points system stimulate the initiative of all staff to participate in safety management. Immersive, scenario-based, and full-cycle safety education makes safety knowledge no longer abstract rules, but "muscle memory" and conditioned reflex closely linked to their own professional skills. A campus safety culture of "everyone is a safety officer and every place is a safety post" will gradually form, and safety values will be deeply rooted in the hearts of the people and become the conscious code of conduct for teachers and students [6].

In the future, on the basis of platform construction, the school can further explore the application of big data analysis in risk prediction and management decision support, and promote the data interconnection between the platform and the campus smart security system and local emergency management departments, so as to build a higher-level smart safety ecology.

5. Conclusion

The safety management of experimental and training rooms is a fundamental and important work in the operation and governance of higher vocational colleges. Its complexity and professionalism require us to carry out top-level design with systematic thinking and promote reform with an innovative spirit. Zhejiang Dongfang Polytechnic has a profound foundation in overall campus safety, and has also made beneficial explorations and accumulated valuable experience in the safety management of experimental and training rooms. Facing the requirements of the new development stage, by focusing on four key dimensions: responsibility system, education and training, supervision means, and governance mechanism, and implementing the optimization path of grid-based, scenario-based, intelligent, and collaborative, it can not only effectively solve the current management difficulties, but also proactively construct a modern experimental and training room safety management system that conforms to the laws of higher vocational education, highlights the characteristics of integration of production and education, and adapts to the trend of technological development. The successful construction and practice of this system will provide a solid safety guarantee for the college to build a high-level vocational college and high-level professional groups. The "Dongfang Experience" formed through exploration is also expected to provide a set of referable, replicable, and promotable practical paradigms for similar higher vocational colleges across the country to improve the safety management level of training and achieve high-quality development.

Acknowledgments

This paper is supported by Teaching Reform Project of Zhejiang Dongfang Polytechnic (No. DF2024JGYB50).

References

[1] Chen Y, Yang T B. Countermeasures for the Safety Management of University Biological Laboratories Based on the Cultivation of Students' Safety Awareness. Journal of Jilin Medical University, 2021, 42(5):78-82.

[2] General Office of the Ministry of Education. Safety Specifications for Laboratories in Institutions of Higher Education. Beijing: Ministry of Education of the People's Republic of China, 2023.

[3] Li S M, Zhang J D. Thoughts on the Safety Information Management of University Laboratories. Experimental Technology and Management, 2022, 39(2):34-38.

[4] Qian Y. Discussion on the Safety Management of Experimental and Training Rooms in Higher Vocational Colleges. Management Observer, 2012(2):45-48.

[5] Wang Y. Safety Education and Management Strategies of University Laboratories under the Background of

"Three-All Education". Educational Theory and Practice, 2022, 42(16):56-60.
[6] Wei H, Lu L, Dai Y J. Main Problems and Countermeasures Faced by the Safety Management of University Biological Laboratories. Journal of Green Science and Technology, 2017(24):203-205.
[7] Yang M F. Research on the Construction of Laboratory Safety Management Standards. Quality Management, 2019(3):89-93.
[8] Zhou Y Y. Practical Paths of Intensive and Informatized Laboratory Management. Journal of Higher Education, 2024, 45(6):112-117.
[9] Zong H Q, Zhang Y L, Li H H, Zhang J, Chu M. Construction and Practice of Basic Safety Courses for University Laboratories. Research and Exploration in Laboratory, 2026, 45(1):264-268.
[10] Jing Y Y, Shu C B. Exploration of the College-level Laboratory Safety Management System Based on the Points System. Chemical Management, 2025(36):111-114.
[11] Wang Y Y, Li Y T, Zhong C T, Huang W B, Feng J Y. Strategies and Practice of Data-empowered Safety Management of University Laboratories. Research and Exploration in Laboratory, 2026, 45(1):246-251.