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Civil Engineering Laboratory Safety Management in Select Public Universities

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Abstract: This study takes civil engineering laboratories of public universities in Jiangxi Province as the research object to analyze the current state of safety management in laboratories. This will provide a reliable management system reference for laboratory safety in public universities in Jiangxi Province from a new perspective. This study employed the qualitative method which involves emerging questions and procedures, and the data collected in the participant's setting. The following conclusions were obtained: the problems of safety management in civil engineering laboratories, the causes of the problems and their solutions.

Keywords: Laboratory Safety; Qualitative Analysis.

1. Introduction

Campus safety has always been the focus of public safety management in China, and laboratory safety, as an important component of campus safety, has gradually become a hot topic of social security. University laboratories are important places for universities to carry out experimental teaching, vocational skill training and appraisal, vocational skill competitions, professional research projects, productive activities, and the integration of industry and education. They are also important locations for deepening industry education integration, school-enterprise cooperation, and achieving the development of university education [1]. With China's priority development of education and support for technological innovation, the number of university laboratories is increasing year by year. The scope of professional disciplines covered by university laboratories is wide, with a large number of teachers and students participating in experiments, practical training, scientific research, and productive activities. There is a large turnover of experimental personnel, a large number of experimental and practical teaching tasks, a sharp increase in experimental and practical training duration, and a variety of instruments, equipment, and materials in the laboratory. Potential safety hazards and risks are complex. The laboratory serves as a place for the concentration of human and financial resources in universities, as well as a "powder keg" for various hazardous chemicals and safety hazards. In the past decade, laboratory safety accidents have been frequent.

Instruments and equipment may also generate light, electricity, heat, radiation, and other hazards during operation [2]. The issue of laboratory safety management is very serious, and the frequent occurrence of accidents has seriously constrained the healthy development of universities. Therefore, how to prevent and control the occurrence of laboratory safety accidents is one of the key issues that universities must pay attention to solve. This study focuses on safety management in civil engineering laboratories.

Civil Engineering is a highly practical major, and the theoretical knowledge has to be combined with the practical in order to produce excellent graduates. Therefore, students have to carry out experiments, practical training and scientific research in laboratories. There are many types of civil engineering laboratories, including engineering measurement laboratory, civil engineering mechanics laboratory, civil engineering materials laboratory, building engineering structure laboratory, engineering mechanics laboratory, civil engineering testing laboratory, civil engineering modeling laboratory, civil engineering simulation laboratory and so on. There are the following common instruments in civil engineering laboratories: fast freeze-thaw testing machine for concrete, universal material testing machine, self-balancing structural vertical loading reaction force system, steel truss static loading system structural loading test system, for on-site structural static and dynamic testing of the rebar locator, digital rebound meter, drilling and core taking machine, laser sweeping instrument, engineering simulation software, intelligent building materials, such as radioactivity detector, etc. To summarize, there are many instruments in civil engineering laboratories, it will involve plumbing safety, mechanical and electrical safety, chemical safety, and fire safety, which require the strengthen of the safety management [3].

2. Statement of the Problem

This study aims to improve safety management in civil engineering laboratories in public universities. Specifically, it examines these issues.

(1) Problems of safety management in civil engineering laboratories in public universities.

(2) Causes of safety management problems in civil engineering laboratories in public universities.

(3) Methods of solving safety management problems in civil engineering laboratories in public universities.

3. Data Gathering Procedure

In this study, a total of 30 informants from 3 public universities in Jiangxi Province, China. 10 teachers were selected from each university to participate.

The researcher set for an appointment to have a separate initial meeting with the informants to target the following tasks: establishing rapport, explaining the purpose of the study and signing of the informed consent. The informed consent form consists of the following parts: brief introduction to the study, explanation of the significance of

the study, potential contribution of the informants, an assurance that anonymity and confidentiality would be maintained, and that the r informants' participation in the study is voluntary hence they could withdraw from the study any time without penalty or loss of benefits. The primary goals of any informed consent document according to Eyler and Jeste [4] is to ensure and preserve the autonomy of research informants through the full provision of information regarding the research process, the voluntary nature of the consent, and the assurance that the informants has the ability to make the decision. The interviews were conducted in Jiangxi Province, China. Each teacher was interviewed for about half an hour.

The informed consent was discussed by the researcher and signed by the informants a day before the interview. During the interview, the researcher asked the permission from the participants for the use of audio tape recorder to properly document all the information shared by them.

4. Data Analysis

In formulating and producing the results, thematic analysis was used. Braun and Clarke defined thematic analysis as a method for identifying, analysing and reporting patterns within data. It minimally organizes and describes detailed data. This research study undertook the following procedures:

(1) Familiarizing with the data

The interview proceedings were transcribed in verbatim by the researcher focusing on writing the descriptions and merely translating the thoughts of the informants. The researcher became familiar and understood the respective responses of the informants through multiple readings.

(2) Generating Initial Codes

The researcher opted to do manual coding and analyzed, identified and coded the statements from the transcripts and all approved significant statements were considered to be the unit of analysis.

(3) Searching for themes

In identifying the initial themes, the researcher categorized and grouped the codes using a matrix to identify the common themes which will form the essential structure and framework of the entire data for the statement of the problems.

(4) Reviewing themes

After carefully examining the common themes, the researcher started to improve them into more significant themes and ensured that the identified themes are related to the entire data.

(5) Defining and naming themes

The emerging themes were given descriptions and the researcher identified relevant quotes related to the emerging themes.

5. Results

5.1. Problems of safety management in civil engineering laboratories in public universities.

5.1.1. Electrical Hazards

Based on the results, it can be gleaned from the significant statements of the informants that electrical hazards are one of the major concerns in laboratories. With the exposure to electrical energy, it may lead to various hazards like burn, electrocution or electric fires.

Table 1. Respondents' Descriptions About Electrical Hazards

Respondent No.	Respondents' descriptions
2	The biggest safety hazards are electrical safety, such as leaky outlets, electrocution from instruments, drying ovens, and so on.
3	Electrical safety, fire, and lab equipment risks. Broken glassware also injures people, and some laboratory instruments such as bamboo and wood are easily combustible.
4	Electricity safety, rotating equipment such as mixers may hurt people.
15	Electricity safety, forgetting to turn off the electricity when leaving may cause a fire.
19	Electrical wiring in laboratories poses safety hazards such as electrocution, short circuits, electrical fires, etc. Electrical accidents are more likely to occur, especially in humid.
29	Leaking of electricity in the server room, high-power electrical equipment is prone to fire, and fires can occur due to poor contact with switches.

This particular result is consistent with the study of Olewski [5] where it was revealed that risks in academic research labs are often underestimated due to lower hazardous material inventories and fewer reported accidents globally. The distinction between hazard (potential harm) and risk (likelihood and severity of harm) is crucial for effective risk management. Applying process safety management principles to university labs is essential due to significant risks associated with experiments and a persistent misperception of labs being 'low risk'.

5.1.2. Mechanical Hazards

Moreover, some informants mentioned that specific risks may also include injuries from mechanical hazards that are associated with rotating machinery and high-power equipment, lifting and plumbing issues.

Table 2. Respondents' Descriptions About Mechanical Hazards

Respondent No.	Respondents' descriptions
6	Mechanical injuries (e.g., mixers, presses, etc.), lacking of safety education, and unfamiliar with laboratory procedures.
11	Mixers and presses can cause mechanical injuries to students.
12	Mechanical injuries, plumbing safety, and lab supplies can also lead to safety issues.
22	Mechanics experiments utilize large-scale equipment operation in the safety risk is relatively large.
24	Civil engineering laboratories perform pressure tests on construction materials and use large instruments. This can lead to problems such as mechanical injuries and electrocution.

This is reiterated in the study of Wahab et al [6] where it is stated that the importance of effectively managing risks to ensure the well-being of individuals working in academic laboratories. Mechanical hazards are a significant concern in laboratory safety management. These hazards can arise from equipment malfunctions, improper use of machinery, or inadequate maintenance. Proper training, regular equipment inspections, and implementing safety protocols are essential to mitigate mechanical hazards in laboratory settings.

Likewise, chemical and fire hazards are also mentioned.

5.1.3. Inadequate Safety Training

This includes insufficient training on proper procedures and emergency response. It can be reflected from the testimonies of the informants that lack of safety education training, unfamiliarity with the equipment and problems with procedural operations are significant concerns.

Table 3. Respondents' Descriptions About Inadequate Safety Training

Respondent No.	Respondents' descriptions
7	Some laboratory members may be less aware of safety issues and neglect safety regulations and operating procedures, which may easily lead to safety accidents.
8	In addition, many teachers and students lack safety awareness and perform experiments without following the procedures.
9	Teachers and students lack safety training, do not understand the safety operation procedures, and are prone to operational errors.
16	Safety accidents can be triggered by such things as operator misconduct, carelessness, and lack of safety awareness.
22	Improper handling of equipment can lead to safety incidents.
25	Large instrument and equipment operation rooms where operators may have accidents if they do not have adequate safety training.

This finding is affirmed by the result of the study of Drysdale [7] wherein he gave emphasis on the importance of understanding fire dynamics for the development of effective fire prevention and suppression strategies. His study highlighted the need for comprehensive fire safety measures, including regular fire drills, proper storage of flammable materials, and the use of appropriate fire suppression systems to mitigate fire hazards in various settings.

5.1.4. Improper Operation and Equipment Care

Table 4. Respondents' Descriptions About Improper Operation and Equipment Care

Respondent No.	Respondents' descriptions
7	Maintenance of laboratory equipment may not be timely enough, resulting in unstable operation or safety hazards.
10	Improper operation may lead to equipment failure and accidental injuries.
15	Injuries caused by irregular operation in the experiment.
21	Tools and equipment in the laboratory require regular maintenance, and poor maintenance may lead to equipment failure and unstable operation.
22	Improper handling of equipment can lead to safety incidents.
27	Untimely maintenance of experimental instruments, such as the loss of a screw on the instrument can cause damage to the instrument, which in turn can lead to safety accidents.

Based on the responses of the informants it was revealed that improper operation and inadequate maintenance of laboratory equipment poses significant safety risks. Without recognizing its importance this can lead to equipment failure, safety hazards, and decreased operational efficiency. Delays in maintenance and improper handling of equipment are common issues.

This result is similar to the findings of Burke et al [8] who stressed that improper operation and poor maintenance practices are major contributors to workplace accidents and injuries. Likewise, it was also highlighted in his study the necessity of effective training programs that educate workers on proper equipment use and maintenance procedures. By ensuring that employees are well-trained and understand the importance of regular equipment maintenance, organizations can prevent accidents, improve operational efficiency, and maintain a safer work environment.

5.2. Causes of safety management problems in civil engineering laboratories in public universities.

5.2.1. Low Level of Safety Awareness

Looking further on the results, a theme emerged which is the low level of safety awareness among students and faculty. This is often due to inadequate training and a lack of understanding on safety protocols.

Table 5. Respondents' Descriptions About Low Level of Safety Awareness

Respondent No.	Respondents' descriptions
4	Doing experiments is inherently somewhat dangerous, but there is a lack of safety awareness among students and faculty.
6	Faculty and students have a low level of safety awareness and rely on experience to operate instruments rather than based on proper procedures.
9	Sometimes students' lack of safety awareness can lead to safety accidents. Teachers do not transmit safety awareness to students.
14	Carelessness of operators, faulty electrical wiring, inadequate maintenance of equipment, improper storage of chemicals, and other conditions may lead to fire risks. Aging laboratory equipment and lack of safety awareness.”
24	Experimenters do not follow the procedure and do not make adequate preparation for the experiment. Aging circuits and other causes can cause fires.
26	Operators are not safety conscious and have inadequate knowledge of chemical hazards
30	Experiment teachers do not have safety awareness.

In the study of Mullen [9], he examined factors influencing individual safety behavior at work, focusing on the impact of a low level of safety awareness. It suggests that enhancing safety awareness through effective communication and education is critical for promoting safe behaviors. The study highlights the need for organizations to foster a strong safety culture where safety awareness is prioritized and employees are encouraged to actively participate in safety initiatives.

5.2.2. Facilities and Systems Inadequacy

The informants noted that imperfect safety systems and insufficient safety facilities contribute to safety issues. This includes lack of basic facilities like ventilation, emergency showers, and proper storage. Some of them shared statements along this theme.

Similar to the answers of the informants, the study of Zwetsloot [10] highlighted the risks associated with inadequate systems and facilities. It argues that investing in robust health and safety management systems can lead to improved organizational performance and reduced accident rates. The study emphasizes the importance of adequate systems and facilities in maintaining a safe work environment and protecting employees' health and well-being.

Table 6. Respondents' Descriptions About Facilities and Systems inadequacy

Respondent No.	Respondents' descriptions
3	There is no specific laboratory operation procedure guidance.
7	The equipment cannot be maintained in a timely manner because of limited laboratory funds.
8	Inadequate laboratory safety facilities, such as emergency showers and ventilation equipment, which affect the ability to deal with emergencies.
12	With more and more equipment being purchased, the lab can't fit so much equipment.
15	Including irrational design of the test structure, irrational use of materials or poor quality of materials, operational errors in the test process and other factors.
16	Instruments are broken and not detected, and the management system is not perfect.
21	Lacking of funds to carry out equipment maintenance and insufficient attention to safety hazards. Laboratory management is not standardized, without a standard safety management system. The skills and safety awareness of the personnel are not in place.
25	Inadequate maintenance of electrical equipment, aging wiring, and irregular wiring may lead to safety hazards such as electrocution, short circuits, and fire.

5.3. Methods of solving safety management problems in civil engineering laboratories in public universities.

5.3.1. Financial and Technical Support

It can be noted from the findings that some of the informants mentioned that adequate funding to cover safety equipment, training, and maintenance is significant. Furthermore, technical support should also be given priority to ensure technical capabilities of the laboratory.

Table 7. Respondents' Descriptions About Financial and Technical Support

Respondent No.	Respondents' descriptions
1	The university has to give adequate funding to civil engineering laboratories to ensure safety management. It is also important to give some incentives to the teachers who write the laboratory safety manuals.
2	Invest more money to ensure laboratory safety.
14	Ensure funding and training for laboratory managers.
24	Universities should provide a variety of secure technical support
27	Maintenance and upkeep of equipment is to be funded by the University.

In laboratory safety management, economic and technical support are the basis for ensuring safety. Economic support ensures that laboratories are able to purchase and maintain the necessary safety equipment, conduct safety training, and prepare for emergencies, while technical support provides technical safeguards for the maintenance of equipment, the management of monitoring systems, and the prevention of accidents. Both are interdependent and mutually reinforcing, working together to improve laboratory safety, reduce accidents, and protect researchers and laboratory assets.

5.3.2. Training Programs for Laboratory Managers

Laboratories have hazardous materials and equipment. Training ensures that laboratory managers are knowledgeable in safety protocols.

Table 8. Respondents' Descriptions About Training Programs for Laboratory Managers

Respondent No.	Respondents' descriptions
8	Send more teachers out to learn advanced laboratory management experience.
11	The University should conduct regular fire training for students and faculty.
14	The University should conduct regular training for laboratory administrators, preferably at a specialized institution.
24	Increase training on laboratory safety.

Along the same vein, the study of Zhang [11] highlighted the increasing importance of laboratory safety due to the growing experimental tasks and personnel in university labs. It analyzes the current challenges in laboratory safety management in colleges and universities, such as inadequate layout and weak safety awareness, and proposes preventive measures to address these issues. It emphasizes the significance of safety awareness and education, which aligns with the need for comprehensive training programs for laboratory managers to ensure a safe working environment. It underscores the importance of implementing access systems and inspection protocols, which are essential components of training programs to equip laboratory managers with the necessary skills to enforce safety measures effectively.

5.3.3. Laboratory Safety Education Programs

Table 9. Respondents' Descriptions About Laboratory Safety Education Programs

Respondent No.	Respondents' descriptions
10	The school should conduct regular inspections of the safety management of the training room, focusing on fire safety. And give advice and recommendations.
12	Develop a system of safety inspections. Regular inspections of laboratory safety management.
13	Establishment of specialized waste disposal stations.
15	Conduct a variety of laboratory safety education programs to increase student safety awareness.
23	Universities need to emphasize safety management in laboratories.
26	The university should have a general document on laboratory safety management.

Most of the informants highlighted the significance of

regular inspections, safety education programs, waste disposal stations in maintaining a safe working environment and preventing accidents and injuries in the laboratory.

Similarly, the paper of Wu et al [12] focuses on the importance of laboratory safety in universities, especially in "double first-class" universities, to enhance educational strength and national power. The research emphasizes the need to build a comprehensive laboratory safety education system to raise awareness among teachers and students and create a positive safety culture. It discusses the importance of consistent safety education for all students and teachers, regardless of their major or grade level, to ensure a uniform understanding of safety protocols.

6. Conclusion

Based on the results of the study the following conclusions are presented:

(1) The problems of safety management in civil engineering laboratories are occupational risks, inadequate safety training and improper operation and equipment maintenance.

(2) The causes of safety management problems in civil engineering laboratories in public universities are low level of safety awareness and facilities and systems inadequacy.

(3) Methods of solving safety management problems in civil engineering laboratories in public universities are financial and technical support, training programs for laboratory managers and laboratory safety education programs.

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