

## Risk Management at the Institute of Chemistry of the State University of Rio de Janeiro

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The present work aims to evaluate the perception of students in relation to the risk of activities carried out in the laboratories (academic and research) of the Institute of Chemistry of the State University of Rio de Janeiro. In laboratories, equipment operating under pressure and hazardous chemical compounds can harm human health or result in accidents, some fatal. Risk assessments were carried out in the laboratories, using nationally accepted risk management standards, to identify the risks that the laboratories are exposed to in relation to fire and explosion safety, as well as to understand the history, causes and consequences of previous accidents. In a simplified way, it was concluded that the perception of risk by students and employees of the Institute of Chemistry is low. Thus, the need for improvements in laboratories was pointed out, to mitigate or eliminate existing risks, in addition to help foster a strong safety culture, through which laboratory risks can be identified and properly managed by all working in such environments. Consequently, the frequency and severity of laboratory accidents is expected to be reduced or even eliminated.

### 1. Introduction

Higher Education Institution (HEI) play an important role in the technological context of developed and underdeveloped countries. Although they are basically teaching and research institutions focused on training people, universities also interact with other institutions and companies.

On the part of the students, there is a lack of risk perception in academic laboratory activities, where it is believed that when handling chemical products in low quantities, the risk of accidents is minimized. The increased role of universities in research associated with companies brought a diversity of products and process conditions, which were previously only found in large research centers. Work is being carried out with oil and its derivatives, studies with polymers involving the use of ethylene or butadiene, or even characterization tests of composites involving high pressures. The main issue is to identify whether students know and are informed about the risks that exist in the different laboratories at the HEI and whether the laboratories are suitable for these activities. Thus, these questions encourage the realization of this work, which is mainly about the analysis of the safety conditions of the laboratories of the Institute of Chemistry.

In this line, Gibson et al. (2014) developed a set of actions to increase the culture of safety and risk monitoring at the University of California at Los Angeles (UCLA), after a fatal accident involving a researcher. As a result of this event, university senior management proposed a comprehensive laboratory safety program.

The concern with risk management in HEI laboratories is evidenced in the work prepared by Budihardjo and Rizaldianto (2019), where the authors sought to analyze all the activities carried out, assessing the level of severity for each one of them, the possibilities of accidents occurring, as well as defining the risk priority matrix. This work showed that the main occurrences involved the handling of products with heavy metals and problems in the hoods' exhaust systems and that the personal protective equipment used was not sufficient to deal with the identified risks. Along the same lines, Eighmy et al. (2020) analyze the accident that occurred in January 2010 at the University of Texas from a historical perspective seen through the eyes of professors, administrators and researchers who were primarily involved. The accident involved a graduate student who was grinding an energetic material in a quantity greater than that normally used and was not using personal

protective equipment such as a lab coat, gloves and goggles. Suffering serious injuries. The authors interviewed several people, including professors, researchers and employees. The reflections obtained show that the fact contributed to a significant change in the safety culture of the place, incorporating the actions that must be considered in the work routine of a laboratory.

With regard to the perception of risk Álvarez-Chávez et al. (2019) carried out a survey involving 521 university students, seeking to identify the perception of risk. As a tool, the Spanish standard NTP 578 was used, which allowed characterizing the perception of risk by nine dimensions (1. Voluntary exposure to the source of the risk; 2. Immediacy of its effect; 3. Control over it; 4. Severity of its consequences; 5. Knowledge on the part of those exposed to risk 6. Knowledge attributed to specialists; 7. Novelty; 8. Catastrophic potential; 9. Fear generated by the risk) and the overall risk for three risk factors, namely: work of laboratory, chemical splashes, and chemical inhalation. Based on the research, it was possible to identify concerns with the splash of chemicals on the skin and eyes, the risk of burns resulting from the use of hot products, the risk of cutting and the inhalation of chemical substances. Due to the different perceptions between students and professors, the work indicates the importance of increasing the culture of safety and good practices in laboratories.

Still in line with the assessment of culture and safety in academic laboratories, the work carried out by Ayi and Hon (2018) sought to identify the level of compliance with safety items in a medium-sized Canadian university. The work involved 56 students who indicated that the level of risk associated with laboratory work was low or very low but considered that safety is a very important item and that it is fundamental to have training programs before carrying out the activities.

To identify the risks, Brazilian standards that apply to chemical laboratories were used. Initially, the Regulatory Standards established by the Ministry of Labor and Social Security can be mentioned. Table 1 presents the most relevant ones.

*Table 1: Brazilian Regulatory Standards*

Standard	Identification	Function
NR 1	General Provisions and Occupational Risk Management	It shows the obligation to carry out analyzes of work accidents and the implementation of the emergency response plan.
NR 6	Personal Protective Equipment	Addresses the obligation of companies to provide personal protective equipment free of charge.
NR 9	Evaluation and Control of Occupational Exposures to physical, chemical and biological agents	Defines the requirements for evaluating occupational exposures to physical, chemical and biological agents when identified in the Risk Management Program, provided for in NR 1.
NR 10	Safety in Electricity Facilities and Services	It establishes the minimum requirements for control measures and preventive systems in electrical installations.
NR 20	Safety and Healthy at Work with Flammables and Combustibles	It establishes minimum requirements for the management of safety and health at work against risk factors for accidents arising from the activities of extraction, production, storage, transfer, handling and manipulation of flammable and combustible liquids.
NR 25	Industrial Waste	It establishes the ways in which companies that deal with industrial waste must handle and dispose of this waste at the appropriate destination.
NR 26	Safety Signs	It establishes measures regarding signaling and safety identification to be adopted in the workplace.

In addition, the standards of the Brazilian Association of Technical Standards (ABNT) were also used as the basis for this work. The main ABNT standards that apply to this research can be seen in Table 2.

Table 2: Brazilian Standards

Standard	Identification	Function
NBR 12779	Fire Hoses - Inspection, Maintenance and Care	It specifies the minimum requirements for the or inspection, maintenance and care necessary to keep the fire hose approved for use.
NBR 5419	Protection of Structures Against Atmospheric Discharges	It specifies the requirements for protection of a structures against physical damage by means of a lightning protection system.
NBR 17505	Storage of Flammable and Combustible Liquids	Apply to storage, handling, and use of flammable and combustible liquids, including waste liquids, as herein defined and classified.
NBR IEC 60079-10-1	Explosive Atmospheres - Part 10-1: Area Classification - Explosive Gas Atmospheres	It is concerned with the classification of areas where flammable gas or vapour hazards may arise and may then be used as a basis to support the proper selection and installation of equipment for use in hazardous areas.
NBR 12962	Fire Extinguishers - Inspection and Maintenance	It establishes the requirements for periodic verification and inspection services and maintenance of portable fire extinguishers.
NBR 16704	Stationary Pump Sets for Fire Protection Systems - Requirements	It deals with the necessary requirements for the selection and installation of stationary pump sets for automatic fire protection systems.
NBR 10897	Fire Protection Systems for Automatic Sprinklers - Requirements	It specifies the minimum requirements for the design and installation of automatic sprinklers for fire protection, including water supply characteristics, selection of automatic sprinklers, fittings, piping, valves and all materials and accessories involved.
NBR 16981	Fire Protection in Storage Areas in General, through Automatic Sprinkler Systems - Requirements	It establishes the requirements for the design of automatic sprinklers for the protection of storage areas.
NBR 15219	Fire Emergency Plan - Requirements	It deals the minimum requirements for the elaboration, implantation, maintenance and revision of a fire emergency plan.
NBR 14276	Fire and Emergency Brigade - Requirements and Procedures	It establishes the minimum requirements for the composition, formation, implantation and recycling of fire brigades.
NBR 9050	Accessibility to buildings, furniture, spaces and urban equipment	It specifies criteria and technical parameters to be observed when designing, building, and proceeding installation and adjustment of urban buildings to the conditions of accessibility.

## 2. Methodology

This research is being carried out in two stages, the first of which aims to assess the perception of risks by students who attend the Institute of Chemistry and involves sending questionnaires, seeking to identify the level of information regarding the risks present in laboratory activities. The second stage involves a risk assessment by the author of this work, based on existing standards in Brazil.

## 2.1 The case study

The University object of this work is installed in the municipality of the State of Rio de Janeiro. It occupies a total area of 289,629 m<sup>2</sup>. The campus has 18,606 students, 2,251 professors and 4,080 employees. It includes 33 academic units, 156 departments and 557 laboratories (2019 data). The Institute of Chemistry, occupies two floors, has about 30 laboratories (including research and teaching laboratories), 570 students, 86 professors and 20 laboratory technicians. The building where the Institute of Chemistry operates has 5 floors and two elevators.

## 2.2 Questions regarding the assessment of risk perception

As defined in the objective of the work, the first stage sought to assess whether students, regardless of the period studied, are able to identify the university's position in relation to the issue of safety in laboratory activities, if professors inform about the risks associated with experiments and if they know the norms or legislation pertinent to the activities carried out in laboratories. If they are familiar with protection equipment, how does the HEI inform the student that the issue of safety risk management, how does it work with the different departments that make up the Institute of Chemistry and how does it act in the event of accidents in its laboratories. The questionnaire was prepared in four parts, namely:

Part 1: Identification of the participant's profile. At this stage, we sought to identify age (years), level of education, area of study and training, and weekly frequency in (hours) of academic laboratory activities.

Part 2: Performance of the HEI. In this way, the student was asked if the HEI provides a guide or manual with guidelines regarding the functioning of the campus, the areas of health, safety and emergency procedures in case of accidents. If the HEI, through its competent bodies, provides information, organizes lectures, workshops with themes that include health, safety or risk management. If via its portal or other form of communication, it periodically shows the behavior of indicators related to both safety and risk management. It provides or informs about collective personal accident insurance for students. If a subject related to good laboratory practices and industrial safety were included in the 1st period, would the students consider that this would help both in the practical activity in the laboratories and in the understanding of the dangers inherent to the chemical and chemical engineering professional.

Part 3: HEI performance with the departments that make up the Institute of Chemistry in relation to practical classes in laboratories. In this part, it was questioned whether the HEI informs about the existence of internal protocols and security measures for practical classes held in academic laboratories. Whether operating instructions are available for use by students during practical classes. If, before the practical classes, training is carried out on techniques/procedures for handling laboratory glassware, chemical products, chemical compatibility and other materials that will be used. Whether the time allocated to practical classes is sufficient for all planned experiments to be carried out and concluded safely. Whether all experiments in practical classes carried out in academic laboratories are supervised. Whether training is provided related to the different standards associated with the theme of risk in activities carried out in the laboratory. Whether, through the department responsible for the laboratory, compliance by students with the internal protocols and security measures established for academic laboratories is monitored. If the student is informed by the professors and technicians that the academic laboratories present an updated risk map prepared by the university's work safety engineering area. If you were informed by teachers and technicians about what a risk map is, how it is prepared and what its usefulness is. If periodic inspections are carried out in the work safety engineering area, where chemical reagent storage sites, gas cylinders and hood efficiency are checked. Whether training exercises are carried out on how to act in an emergency during practical classes in academic laboratories (start of fire, explosion, spill of chemical products). Whether the HEI provides personal protective equipment free of charge for use in practical classes held in academic laboratories and whether the student has been trained to use them. Whether academic laboratories have a file containing Material Safety Data Sheets (MSDS) available for consultation of all substances used in practical classes. Whether there are emergency kits available to be used in case of accidental spillage of chemicals in practical classes. If the HEI has a fire brigade.

Part 4: Regarding the performance of the HEI in relation to the occurrence of accidents/incidents in its laboratories. In this sense, the student was asked if the HEI disseminates through its channels (internal network, murals or lectures), an annual survey of accidents/incidents that occurred in its facilities. Whether accident investigations are carried out in laboratories to identify possible causes. If corrective measures are adopted, according to recommendations of investigations of accidents that occurred in the laboratories and if the student considers it important to investigate and report the accidents that occurred in the laboratories to prevent future occurrences.

### 2.3 Issues assessed in relation to risk assessment

Risk inspections were carried out in the laboratories of the Institute of Chemistry to identify the risks. As a methodology, risk elements of great importance were defined for analysis, in accordance with market practices. The main elements evaluated are subdivided into the following groups: layout and construction, protection, special hazardous and human element. Among these elements, the following points were considered: emergency exits, constructive characteristics and compartmentation of areas, fire protection systems, fire brigade, emergency plan and procedures, storage practices for combustible or flammable chemicals, preventive maintenance procedures and periodic inspections of facilities.

### 3. Results

Regarding perception, the data obtained show that 80 % of respondents are undergraduate students, and 20 % graduate students. In the case of undergraduate students, about 76 % are taking subjects above the ninth period, that is, they have already taken all subjects involving laboratory. Of the respondents, around 67 % took a technical course involving the use of laboratories. Only 3 % of respondents had access, by the university, to activities whose theme involved health, safety and risk management. About 74 % of the respondents do not know whether the university makes available, whether on its website or via another form of communication, information related to the issue of security or risk. They are unaware of the existence of personal or collective accident insurance that covers any occurrence within the facilities. About 63 % of respondents consider it important to include a discipline in the first period on industrial safety. Around 76 % answered that they had received information about operational procedures. 70 % of respondents claim to have been trained before carrying out the experiment and report that the time available for carrying out the experiment is sufficient to carry it out safely. 70 % of those surveyed are unaware of the existence of a risk map for the laboratory and 80 % responded that they were not informed about periodic inspections regarding the safety conditions of the laboratories, in the same way they are unaware of the existence of checks by the fire department of the laboratory facilities. 90 % of those surveyed believe it is important to hold a periodic event on internal accident prevention, as well as all (100 %) agree with the need to hold a cycle of lectures on the subject. Likewise, everyone considers it important to participate in laboratory safety training. 80 % are unaware of the existence of a file in the laboratories containing information data sheets on the chemical products used. 90 % of the survey participants are unaware of the existence of a first-aid kit in the laboratory. 100 % of respondents report that there is no disclosure, in any type of communication channel, showing a survey of accidents that occurred at their facilities and 90 % recognize that it is important to investigate and report Intercurrences that occurred in the laboratories.

As for the issue of facilities for action in the event of an accident or fire, after the interviews and visits to the laboratories, it was found that the existing fire protection systems are limited to fire extinguishers, even so, there is no adequate coverage and no training on their use. Although there are fire hydrants in the corridors outside the laboratories, the water supply system for the fire network does not provide flow and pressure to protect laboratories. Also, there is no evidence of periodic testing of fire fighting hoses. There is no formalized fire brigade. There are no sprinkler systems, fire alarms or smoke detectors installed on site. Not all laboratories have an adequate exhaust system and safety shower/eye wash stations. There is a need for improvements in storage practices for cylinders of gases and chemicals in laboratories. There are no special cabinets to store flammable, corrosive and combustible chemicals. In general, electrical installations are old and periodic inspections are not carried out to verify them. There are no formalized emergency procedures in case of accidents or the need to evacuate the building. There is no periodic training for emergencies. Currently, the building has an emergency lighting system on the stairs. There are no emergency exits. As personal protective equipment, HEI only provides the lab coat to students and staff. Additionally, the university does not have insurance for fire or any accident on its premises.

### 4. Conclusions

From the results presented, it was possible to conclude that the perception of risk by the students is low. Although the most experienced researchers consider their laboratories to be safe, sometimes the students who carry out the activities are not very familiar with the risks, with the equipment, or even with the personal protective equipment needed to carry out the activity. It is essential to know the risks in the area so that accidents can be avoided or minimized.

It is important to emphasize that safety inside a laboratory depends mainly on the human factor, that is, on the actions of the people who attend it. Therefore, it is essential to implement a training program in safety practices, develop solid emergency procedures, beyond to formalizing an emergency plan and a fire brigade.

After the inspections and interviews carried out in the laboratories, it was verified the need for a series of improvements to mitigate the existing risks. One of the main shortcomings is the absence of adequate fire protection systems. To improve risk quality, the following major improvements need to be implemented: installation of an adequate fire water supply system, adequacy of hydrants and fire extinguisher coverage, installation of sprinkler and smoke detection systems, adequacy of practices storage of cylinders for gases and chemical products and carrying out inspections of electrical installations.

Finally, proper handling of chemicals and flammables, along with the availability of adequate fire protection systems, as well as good storage and housekeeping practices, contribute to reducing the likelihood and severity of accidents.

With the support of the Board of the Institute of Chemistry, it is suggested the creation of a commission, formed by a member representing each laboratory department, with the objective of controlling and assisting in the implementation of an action plan to meet the recommendations proposed in this work, and with that, mitigate the risks existing in laboratories.

Considering the existing protection systems, it is important to emphasize that the implementation of a loss prevention program is fundamental for the laboratories of the Institute of Chemistry of the State University of Rio de Janeiro, because in the event of a fire or explosion, the consequences can be catastrophic, with the destruction of all assets in a short period of time.

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