IOSR Journal Of Humanities And Social Science (IOSR-JHSS)
Volume 28, Issue 3, Series 1 (March, 2023) 17-23
e-ISSN: 2279-0837, p-ISSN: 2279-0845.
www.iosrjournals.org

Covid-19 Pandemic and Safety in Teaching and Learning in Experimental Chemistry Classrooms

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Abstract:
School activities were temporarily suspended in several countries as a preventive measure against the spread of the pandemic caused by Covid-19, where approximately 1.5 billion students were left without face-to-face classes, including classes involving experimental activities. Teaching through online activities has become one of the main resources to ensure the continuity of school activities, being applied as an emergency. Regarding the experimental activities, the problems were accentuated due to the safety and biosafety conditions found in the different teaching laboratories. The university community (professors, technicians, students and outsourced workers) who may be in contact with the laboratories must be aware of the safety and biosafety conditions under these adverse conditions. This work, which was developed as an extension project, aimed to outline the safety and biosafety conditions of these learning environments and provide everyone involved with coexistence and learning situations with regard to safety in Chemistry teaching laboratories. The objective of the work of carrying out a diagnosis and analysis of the safety and biosafety conditions in the Chemistry teaching laboratories of Education and Health Center, Federal University of Campina Grande due to the conditions imposed by Covid-19 was effectively carried out. Through this extension activity, a survey was carried out and an opinion was issued on the conditions of safety and biosafety in the Chemistry laboratories through specific questionnaires applied to teachers and technicians, seeking to assess the existence of possible risks, a lecture was given on the standards of safety and biosafety for students, outsourced workers and professors involved in experimental classes and proposed a routine of norms that favor the development of experimental activities in a safe way.

Key Word: Science Teaching, Experimentation, Epidemic.

Date of Submission: 20-02-2023 Date of Acceptance: 03-03-2023

I. Introduction

According to a monitoring report, carried out by the United Nations Educational, Scientific and Cultural Organization, around 190 countries have suspended school activities as a preventive measure against the spread of the pandemic caused by the new coronavirus (COVID-19). With the interruption, approximately 1.5 billion students were left without face-to-face classes, and this problem is broader in classes that involve experimental activities. In Brazil, Provisional number 934/2020, established rules on the school year of Basic Education and Higher Education, due to the context of public health emergency caused by COVID-19, the same occurring for the 2021 school year. Thus, basic education teaching establishments are exempt, exceptionally, from the obligation to comply with the minimum of 200 days of effective school work, established by the Law of Guidelines and Bases of Education 9394/1996, however, the workload of 800 hours is maintained[1,2].

The temporary closure of schools and universities exponentially accelerated the role of students in their way of studying. School institutions quickly had to transform teaching into 100% remote, becoming hybrid in some institutions, in the face of the pandemic. In this way, each teacher is looking for alternatives to handle their pedagogical activities in this current reality, adapting to the situation, seeking to develop new methodologies, using digital educational resources. In this way, remote teaching, through online activities, has become one of the main resources to ensure the continuity of school activities, due to the COVID-19 pandemic, being applied as an emergency, to deal with a hitherto unexpected situation. . But with regard to experimental activities, the problems were accentuated mainly due to the safety and biosafety conditions found in the different laboratories of educational institutions.

According to Pereira and Lima[3] (2009), the risks offered by the lack of safety in teaching laboratories can be of different types and can be classified as: biological risks, mechanical risks, ergonomic risks, physical

risks and chemical risks. The set of practices and technical actions aimed at preventing, minimizing or eliminating these risks inherent to research, production, teaching, technological development and service provision activities, aiming to preserve the health of man, animals and the environment, is called biosecurity[4].

Safety in chemistry is something that, in order to be effective, has to be part of the natural procedures that the individual adopts when carrying out any experimental activity. That is, security has to be part of the experience itself and this should be imagined and prepared with a view to the necessary security precautions. In chemistry teaching laboratories there are dangers inherent to the activities carried out, which can affect their direct users (teachers, laboratory technicians, students) and indirect users (people linked to the maintenance of the place). For this reason, it is important that the application of preventive measures should be redoubled, given that safety and biosecurity in these places can be compromised due to some malpractice, negligence or even recklessness of those who use them directly or indirectly. The laboratory is an extremely hostile environment. Equipment, reagents, solutions, microorganisms, people, papers, samples, among other elements coexists in the same space. For this system to function properly and safely, it is necessary: discipline, respect for relevant standards and legislation when working in the context of quality and biosafety, conscience and ethics[5]. The laboratory environment must be understood as a complex system, where there are constant interactions between human, environmental, technological, educational and regulatory factors. These interactions often favor the occurrence of accidents[6]. Set of studies and actions aimed at preventing, controlling, reducing or eliminating risks inherent in activities that may compromise human, animal, plant and environmental health, contributing to the minimization of these occurrences. We must understand the concepts of danger, risk and accident. Danger is a possibility of causing damage, risk is the probability of this danger materializing and accident is the materialization of that risk.

Laboratory containment aims to reduce the exposure of the team of professionals working in a laboratory, whether on the bench or even cleaning, to biological, chemical and physical risks. In order to define the necessary containment, it is important to carry out a risk analysis of the activity to be carried out in that location, that is, which chemical, biological and physical agents will be handled. Associated with each material with which you are going to work, being able to consult the protocol of the experiment to be carried out, the chemical product safety data sheet and/or the biosafety manual. According to the Ministry of Health, containment can be classified as primary, which aims to guarantee the protection of the laboratory's internal environment, and secondary, which is related to protections of the external environment and is provided by the combination of laboratory infrastructure and operational practices[7].

The permanent search for total quality in scientific activities leads to the need for training, acquisition and mastery of knowledge to carry out activities with a view to ensuring accuracy, validity, quality of results and maintaining the integrity of people, facilities, of machines, instruments and equipment. In order to guarantee the application of these principles, one of the instruments used in the laboratories are the Standard Operating Procedures, a document that expresses the work planning with a view to standardizing and minimizing the occurrence of deviations in the execution of activities and thus guaranteeing users services or products free of undesirable variations, regardless of who performs them. A standard operating procedure aims to ensure that the quality of exams is the same at all stages of the process at any time[8].

Laboratory equipment requires appropriate environmental conditions for proper operation, in addition to interference-free installation locations (vibrations, air currents, sunlight, humidity and heat) and, with regard to installation in the electrical network, must be connected to properly grounded outlets. As far as operation is concerned, the equipment must be operated by trained personnel. The equipment must be in usable conditions and must follow a rigorous validation, qualification, calibration and maintenance plan. As for the materials, they must be of known origin and have their quality assured. To this end, it is necessary to re-establish supplier control procedures, that is, to demand from them a set of operations that establish, under specified conditions, the relationship between the values indicated by a measuring instrument or measurement system or values represented by a materialized measure or a reference material, and the corresponding values of the magnitudes established by standards. When it comes to the storage of materials, some rules must be established and followed at risk, in order to maintain their integrity. For each material, a defined and identified place must be reserved, as well as an identification and coding system established for each product[9]. Every laboratory must be signposted in order to facilitate the orientation of users and to warn about the potential risks present in the place. Correct use and respect for safety signs are understood as primary barriers to containment measures. The colors do not dispense with the use of other forms of accident prevention and must be accompanied by conventional signs or word identification. It is the responsibility of informing, training and even qualifying subjects potentially exposed to risks, in order to avoid health problems and prevent accidents. Environmental risks are considered to be physical, chemical and biological agents existing in the work environment, which, depending on their nature, concentration or intensity and exposure times, are capable of causing[10].

The university community (professors, technicians, students and outsourced workers) who are somehow able to maintain contact with these laboratories must be aware of safety and biosecurity conditions,

especially in adverse situations caused by the pandemic. This extension proposal aims to outline the safety conditions of these learning environments and provide everyone involved with coexistence and learning situations with regard to safety in Chemistry teaching laboratories.

II. Material And Methods

The work was developed within the framework of the UFCG Education and Health Center, involving professors, laboratory technicians, students and outsourced workers, where the proposed activities were developed in a methodology that provided an interdisciplinary, educational and scientific process that promoted the transforming interaction between the Federal University of Campina Grande and other sectors of society. The team responsible for the project worked mostly remotely. All activities listed were accompanied and monitored by the project coordination, scholarship holders and volunteers and other collaborators involved in the project, where monthly reports were prepared and project evaluation meetings were held with the project team and coordination. The activities were carried out remotely, lasting twelve hours a week, eight hours of preparation and four hours of development of activities, from July to December 2021, with their methodological procedures described below:

i. Presentation of the proposal with the project team: virtual meeting;

ii. Conducting a survey on safety and biosafety conditions in Chemistry teaching laboratories through specific questionnaires applied online to teachers and laboratory technicians;

iii. Issuance of an opinion on safety and biosafety conditions in Chemistry teaching laboratories through the results expressed in specific questionnaires.

iv. Preparation and presentation of a virtual lecture on safety and biosafety standards in chemistry laboratories for students and teachers involved in experimental classes making a correlation with the proliferation of COVID-19;

v. Presentation of a virtual lecture on safety and biosecurity standards in laboratories for outsourced employees involved in cleaning and sanitizing the environments of experimental classes, making a correlation with the proliferation of COVID-19.

vi. Proposition of a set of norms (routine) in the e-book format that favor the development of experimental activities in a safe way during the pandemic period;

vii. Evaluation of the proposed activities through an online questionnaire applied to the community involved in the project;

viii. Assessment of skills acquired by students involved in the extension project;

ix. Elaboration of the Final Report jointly.

III. Results And Discussion

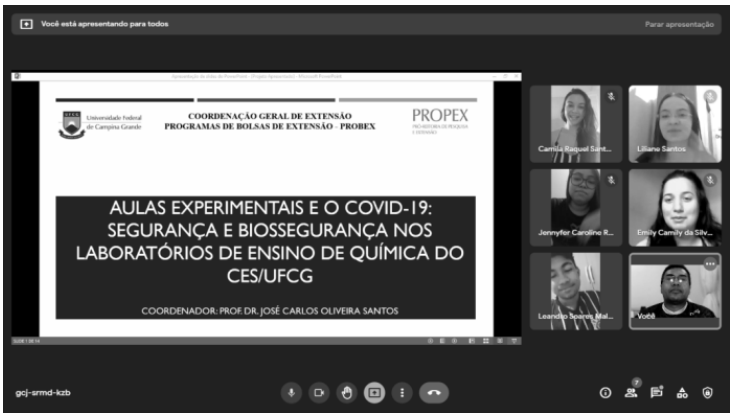
The various activities developed within the scope of the extension project triggered the main results summarized and listed below:

I. Presentation of the proposal with the project team: virtual meeting: Several virtual meetings were held between fellows and between fellows and advisor. In these meetings, the actions developed and their impacts on the university community of CES/UFCG were discussed (Figure 1).

II. Conducting a survey on safety and biosafety conditions in chemistry teaching laboratories through specific questionnaires applied online to teachers and laboratory technicians: Teachers, technicians and undergraduate students were able to assess the safety conditions in chemistry teaching laboratories, where it was noticed that most of the safety and biosafety standards were being fulfilled in carrying out the experimental activities remotely, and that these laboratories were prepared to receive students in person.

III. Issuance of an opinion on the safety and biosafety conditions in chemistry teaching laboratories through the results expressed in the specific questionnaires. After analyzing the answers about the safety conditions made by professors and technicians, it was verified that the Physical-Chemistry Laboratory is less prepared in safety conditions (50%), while the Organic Chemistry Laboratories, Analytical Chemistry and General and Inorganic Chemistry had average scores of 55%, 69% and 74%, respectively. In this way, laboratories must adapt to receive face-to-face classes.

Figure 1. Virtual meeting with the project team.



IV. Preparation and presentation of a virtual lecture on safety and biosafety standards in chemistry laboratories for students and teachers involved in experimental classes, making a correlation with the proliferation of COVID-19: The lecture was prepared using powerpoint© and was made available on the official youtube channel of Education and Health Center (Figure 2), through the link https://www.youtube.com/watch?v=AN_39ORqTR4, where it was verified that there were 189 views and 32 comments.

Figure 2. Lecture available on the YouTube platform.

V. Evaluation of the proposed activities through an online questionnaire applied to the community involved in the project: The community involved mainly students and outsourced technicians, answered a questionnaire, and emphasized the importance of this project to study and work safely in the Laboratories' premises of Chemistry at CES/UFCG.

VI. During the analysis of safety conditions through the photographic study, the following items were observed: laboratory facilities, unprotected machinery and equipment, probability of fire and explosion, inadequate physical arrangement, inadequate storage, etc. A certain vulnerability to the safety risks of professionals working in laboratories was found, since in most cases it was possible to observe:

- ***Laboratory of General and Inorganic Chemistry***: Door that facilitates the entry and exit of students; Safety notice such as not to remove products from the laboratory; In addition to being used as a teaching laboratory, it is also used in research, where only students authorized by supervisors and laboratory coordination can enter; Separate counters containing reagents and glassware in specific locations; Absence of sinks at the ends of the central bench; Adequate windows, however, impeded by benches; Inadequate disposition of materials below the central bench; Benches are prepared for team work; Absence of plastic or rubber mats in the sink; Used and not cleaned glassware; Availability of PPE such as masks, goggles and gloves; Availability of sockets for all equipment, however without the voltage being specified; security lamps; Safety cabinet for flammable and combustible solvents; EPCs such as hood, extinguishers, shower, eyewash, signage; Telephone; Refrigerator containing material for analysis and chemical reagents; Container for unidentified waste; Expired reagent without proper disposal.

- ***Laboratory of Analytical Chemistry***: Door that facilitates the entry and exit of students; Security notice; Identification of students who have access to the laboratory; Counter, cabinets and equipment organized and distributed with free space; Absence of plastic or rubber mat in the sink; Availability of sockets next to the sink faucet, without indication of specific voltage and without socket protection; Guidance on cleaning glassware;

Unmarked waste containers; Refrigerator with excess materials; Laboratory with occurrence notebook availability; Absence of telephone, sandbox, first aid kit; EPC's such as hood, fire extinguishers, showers, eyewash and signage available; Chapel is being used improperly, with inadequate equipment being placed inside the chapel; Side bench with equipment and cabinets all containing identification; Adequate windows, however, impeded by benches and equipment; Cabinet with reagents identified and properly separated; In the central workbench availability of outlets for all equipment, however without the specified voltage; Central bench with organization for division of groups with adequate space; Equipment in the central bench improperly, as they are not being used.

- ***Laboratory of Organic Chemistry***: Door that facilitates the entry and exit of students; Security notice; Identification of students who have access to the laboratory; Absence of sink at the end of the central bench; Central bench with dispersed materials; Side bench with organized and distributed equipment; EPCS such as hood, extinguishers, shower, eyewash, signage; Central bench with available outlets for equipment, but without specified voltages; Equipment on the central stand, which should be on the side stand; Central workbench with safety notices to prevent Reagents from being removed from their proper place; Counter below the sink with cleaning materials and undue glassware; Absence of rubber mats in the sink; Availability of sockets next to the sink without indication of specific voltage and without socket protection; Dispersed cloths on top of the distilled water storage; Availability of first aid kits and litter box and PPE; Unmarked waste container; Equipment for individual use placed in an inappropriate location; Fridge without materials and without cleaning, and apparently unused; At the bottom of the central bench we have the availability of benches for group division; Equipment properly distributed at the bottom of the central stand; Counter with reagents containing identification; Side bench containing reagents and boxes next to Equipment; Organized top closet; Counter with well distributed glassware; Absence of notebook of occurrences and telephone.
- ***Physical-Chemistry Laboratory***: Door that facilitates the entry and exit of students; Security notice; Identification of students who have access to the laboratory; Counter, cabinets and equipment organized and distributed; Signaled cabinets; Well-equipped side bench, with availability of a greenhouse; Laboratory containing chapel; Absence of rubber mats in the sink; Available from sink-side outlets with no specific voltage indication and no outlet protection; Damaged sink faucet; Reagents in an improper place, next to the sink; Waste deposit with identification; Inadequate materials on top of Waste deposits; Refrigerator containing material for analysis and chemical reagents; Counter under the sink with scattered glassware; Counter with reagents containing identification; Lower part of the central bench containing unidentified reagents, improperly placed; Availability of sockets for all equipment, but without voltage identification on the top of the central bench; Objects improperly scattered on the central bench; Security cabinets with solvents organized and properly flagged; Organized top closet; EPC fire extinguishers, shower, eyewash, signage; Absence of occurrence notebook, telephone, sandbox, and first aid kit.

In the Laboratory Block (Figure 3), the concern with the safety and biosecurity conditions imposed by Covid-19 is evident, where it was possible to observe that the laboratory block with a double-door entrance facilitates the entry and exit of students and professors, entrance containing hand and foot sanitizer and alcohol gel deposit, to prevent Covid-19, corridors with fire extinguishers and signs available, booklet for better control of access to laboratories, whether for teachers or students.

Figure 3. Some situations observed in the central block.

During the analysis of the risks of accidents and possible proliferation of COVID-19, the following items were observed: unprotected machinery and equipment, probability of fire and explosion, inadequate physical arrangement, inadequate storage, etc.

IV. Conclusion

Through the study carried out, it can be verified that there are several positive situations in the analyzed laboratories, considering that there are an infinity of security measures to be followed, however the fundamental factor for the minimization of the security risks is the awareness and permanent education of the professionals adopting the opportunity for reflections, critical discussions, update and adoption of correct preventive measures. The attitude that each individual can adopt in the laboratory is the most important prevention, especially in the analyzed period, which was a pandemic period.

The development of this project provided the students involved with the experience of Extension activities, as well as an opportunity to share the acquired knowledge with other members of society. The project aimed, in addition to serving the target audience, to share with society lectures on topics related to safety and biosafety in Chemistry teaching laboratories during experimental classes during the Covid-19 pandemic period.

The attitude that each individual will adopt after this project is the most important prevention of Covid-19, thanks to an educational process, since the people who work in the laboratory have difficulty in adhering to safety measures and, in this case, also the measures of biosecurity. Evaluating this fact, it is important to be concerned about the way in which these professionals will be trained in educational institutions on the subject under study.

Acknowledgment

The authors would like to thank the University Extension Program of the UFCG for financial support.

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Leandro Soares Malaquias, et. al. "Covid-19 Pandemic and Safety in Teaching and Learning in Experimental Chemistry Classrooms." *IOSR Journal of Humanities and Social Science (IOSR-JHSS)*, 28(3), 2023, pp. 17-23.