# Safety Training Needs and Problems Encountered in the Safety Management of the Chemistry Teaching Laboratory

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***Abstract*** *–The chemistry teaching laboratory is an essential arena for developing or improving students' comprehension of the chemical concepts. But the presence of hazardous chemicals puts them at considerable risk. The faculty members of the chemistry teaching laboratory are the primary supervisors in the chemistry laboratory, and they are responsible for maintaining safety. This study investigated the safety training needed and problems encountered in the safety management of chemistry faculty members in State Universities not offering (NBSC) and offering (BSC) the BS Chemistry program. Quantitative Cross-sectional Survey Design was used and data were collected using a prepared questionnaire. Among the nine investigated parameters on safety management, the two groups were found to encounter problems in safety management. The NBSC experienced more serious problems in Emergency Response, Chemical Storage and Labelling, and Waste Management as compared to BSC. The two groups are found to be significantly different in the problems they encountered in safety management and their safety training needs.*

***Keywords*** *–chemistry teaching laboratory, laboratory safety, safety management, safety training*

## INTRODUCTION

Chemistry is offered in universities, not only in BS Chemistry program or any chemistry-related courses, but also as a core subject or prerequisite in most science-related courses. It is most often offered with a lecture and laboratory component. The chemistry teaching laboratory provides experiences on using or manipulating materials and is found to be an effective strategy in improving the performance of students in Chemistry [1].

Despite the benefits of using the chemistry teaching laboratory to improve the learning of students, the use of hazardous chemicals and procedures in laboratory experiments can pose a risk to the students and so with the faculty members. Considering also that these experiments are performed by students inexperienced in handling chemicals and laboratory equipment, makes the likelihood of injuries and accidents to happen.

The faculty member of chemistry teaching laboratory in State Universities (SUs)are tasked with the responsibility to maintain and supervise safety in the laboratory and to foster among students "good attitudes toward rational risk assessment and safe habits" through continual education [2]. Because of their constant association with students, their role in promoting safety awareness and attitudes among students lies primarily in their management of safety of the chemistry teaching laboratory [3]-[8].

In the Philippines, there are laws regulating safety in the chemistry laboratory, like the Occupational Safety and Health Standard Law (RA 11058) and Toxic Substances and Nuclear and Hazardous Waste Control Act of 1992 (RA 6969). Still, the contents of the law are more directed to industrial chemical laboratories and chemical testing laboratories. No specific provisions in the laws regulate the chemistry teaching laboratories. In practice, only some provisions are adapted in the maintenance of safety in academic chemistry laboratories [9].

In the absence of formal regulations on the safe management of academic laboratories, SUs formulate different safety policies that would address the nature, the hazards, and the risks of their operations [5]. The SUs offering the BS Chemistry program use the chemistry laboratory safety guidelines set by the Commission on Higher Education, and those not offering the program only adopt some. In effect, SUs become diverse in their decision making process, and this presents unique challenges in the safety management of the chemistry teaching laboratories.

Safety parameters need investigation in the management of safety in the chemistry teaching laboratory,. These include Work Environment (WE), Lab Safety Documents (LSD), Emergency Planning and Emergency Equipment (EPE), Emergency Response (ER), Personal Protective Equipment (PPE), Chemical Storage & Chemical Labelling (CSC), Fume Hood and Chemical Handling (FHC), Waste and Management (WM) and Safety Training/ Awareness (STA)[2], [10]-[12]. In addition to the nine mentioned parameters, the safety management training of the faculty member needs to be investigated.

***Work Environment (WE)***

Work Environment is the physical aspect of the laboratory working area. It includes good housekeeping, furniture, physical arrangement, and proper behavior of users.

***Lab Safety Documents (LSD)***

Laboratory Safety Document (LSD) includes all documents and records that are necessary for managing safety in the chemistry teaching laboratory. Keeping records and documents is one of the 12 essential elements of the quality system [13]. It can give readily available information that can be used "to reduce or prevent errors, need to rework, incorrect results, time spent on fixing mistakes, and cost" [14].These documents (safety manual, incident report, SDS, etc.) should be available and maintained in the laboratory to have clear and uniform guidelines and information about safe laboratory operations.

***Planning and Emergency Equipment (EPE)***

Emergency planning includes activities that can prevent or minimize accidents from happening like fire and earthquake drills, posting of safety guidelines and signages, proper use of equipment, and planning laboratory activities. Emergency equipment like safety showers and eyewash are tools for emergency preparation. They are installed in the laboratory to facilitate quick responses during emergencies.

***Emergency Response (ER)***

Emergency responses are practices that can mitigate incidents in the lab. According to Meyer [15], an emergency is more related to the training on how to behave and act correctly during cases of accidents. Emergency responses are very critical in mitigating incidents and, chemistry laboratory faculty members should behave in the same manner in every situation. It can help lessen the effect of incidents because it can provide the necessary actions or interventions in the form of safety equipment and immediate responses designed for a specific incident.

***Personal Protective Equipment (PPE)***

The practice of using PPE during laboratory activity is one of the most common safety practices implemented in the laboratory. PPEs are clothing and gadgets worn to protect any exposed area of the body from spills and splashes. Examples of PPEs are laboratory gowns, gloves, face masks, and closed shoes.

This parameter includes the availability and wearing of PPE. It is expected that most chemistry faculty should adhere to PPE wearing to ensure the protection of their students and themselves.

***Chemical Storage & Chemical Labelling (CSC)***

This parameter is about guidelines on how to store chemicals in the laboratory, based on their hazard properties. It takes into consideration the space available in the storage area and correct physical set-up, chemical hazard properties, and classification (using SDS) of chemicals stored, incompatibilities of stockpiled chemicals and proper labeling of containers.

***Fume Hood and Chemical Handling (FHC)***

The fume hood is an engineering control that protects laboratory users from hazardous fumes and volatiles and procedures that could result to some form of explosion. This parameter includes the proper use of the fume hood.

***Waste and Management (WM)***

Managing wastes, especially wastes from hazardous chemicals, is one exceptional component of the safe management of a chemistry laboratory.

The issue of safety lies in the kind and amount of wastes produced and the manner of disposing of hazardous chemical wastes. Because of the hazardous nature of the chemicals used in experiments, good practices in the handling and minimization of their wastes are important in maintaining safety in the laboratory [12].

***Safety Training Awareness (STA)***

Safety training awareness is the giving and acquiring of the necessary training to maintain safety in the chemistry laboratory. Faculty members of the

chemistry teaching laboratory have to be trained in the safety management of the laboratory [16] for them to easily handle the responsibility to provide safety education to their students [17]-[18]. Training makes a laboratory user more cautious, confident and prepared in any emergency in the laboratory [5], [19].

Problems encountered in the management of safety from these different parameters can negatively affect safety management [3], [20]. Identifying these problems can be used as a basis for future interventions that can make any faculty member of chemistry teaching laboratory be more effective in managing safety in the laboratory, whether they are faculty members of SUs not offering the BS Chemistry program (NBSC) or faculty members of SUs offering the BS Chemistry program (BSC). Likewise, the importance of safety training of faculty members of the chemistry laboratory has proven to play an important role in safety management [16]. Considering the importance of addressing problems encountered in safety management and the need to train the faculty of teaching laboratory on safety, this study was conducted.

## OBJECTIVES OF THE STUDY

This study was conducted to find out if the problems encountered in the safety management of the chemistry teaching laboratory and the safety training needed for safety management are different between the NBSC and BSC.

The following null hypotheses were tested at .05 level of significance: there is no significant difference in the problems encountered in the safety management of the chemistry teaching laboratory between the NBSC and BSC; there is no significant difference in the safety training needs between the NBSC and BSC.

## MATERIALS AND METHODS

### *Research Design*

This design of the study is a Quantitative Cross-sectional Survey Design. Survey-based evaluation collects responses from a statistically valid sample of the population to arrive at an inference. The cross-sectional nature of the study is due to the collection of information at one point in time [21]. The quantitative aspect of the design is the numerical scale behind the quantities that respondents are asked to reveal in the survey. This numerical scale can be as simple as expressing a degree of agreement or disagreement over a scale of ordinal intensities. This is a design that enables the researcher to extract information from a sample of the population and to study quantitatively specific characteristics of a population. The objective of conducting a survey is to draw reliable and valid data in a structured form that will be easy to analyze and report [22].

The survey collected information from the respondents (Chemistry faculty) through their answers in the questionnaire. Their responses gave information on their management of safety in the chemistry teaching laboratory in the university based on their problems encountered in safety management and their safety training needs. It is quantitative because items in the questionnaire were rated numerically. A 5-point Likert scale was used in rating their responses.

### *Sources of Data*

In this study, nine SUs in Central Luzon were surveyed. Among the nine universities under the study, three universities are offering the BS Chemistry program, and six do not offer the BS Chemistry program.

### *Population Sampling*

The respondents of the study were the faculty members who are holding chemistry laboratory classes in the nine SUs in Central Luzon during the time of the study (January to March 2019). Sampling was not employed because the number of the population is manageable. Data gathered came from the responses of 37NBSCs and 31 BSCs.

### *Instrumentation and Data Collection*

The survey on the problems encountered by the teachers in the management of safety in the chemistry teaching laboratory is composed of nine parameters, namely, WE, LSD, EPE, ER,PPE, CSC, FHC, WM, and STA. Problems were rated from 1 (not serious) to 5 (very serious). The survey on safety training needs is composed of 11 trainings. Training needs were rated from 1 (not needed) to 5 (much needed).

This study was conducted using a modified questionnaire and adapted from the works of Abbas et al [11] and Anza et al [20]. The prepared questionnaire was validated by three experts in the field of research and the area of study – a chemistry faculty member in an SU in Ilocos Region, another from a private university in the National Capital Region, and a Registered Chemist who had some experience teaching in the University. The prepared questionnaire got a weighted mean of 4.567 in its

validation. Comments and suggestions were used in improving the instrument before distribution.

Permissions from concerned authorities were secured before the distribution of the questionnaires. The questionnaires were personally distributed to the respondents and were collected personally after 1-2 weeks. All information were handled with utmost confidentiality.

***Tools for Data Analysis***

Weighted means, one-way anova on ranks and two-sample z-test were utilized as statistical tools for analysis. Anova was used to determine which parameter and what factors in each parameter do these faculty members encounter more problems.

To compare the problems encountered and safety training needs of faculty from SUs offering the BS Chemistry program and faculty from SUs not offering the BS Chemistry program, the z-test was used. .

The z-test was used because the study satisfies these requirements for conducting a z-test: 1) sample sizes (n) are both more than 30, and 2) population are independent from each other.

**Table 1. Differences in the Problems Encountered in Safety Management of Work Environment(WE)**

| Parameter WE | Weighted Mean NBSC | BSC | Sig. |
|---|---|---|---|
| 1. Laboratory area is small for the class size. | 1.73bcd | 1.58bc | NS |
| 2. Poor illumination of the work area | 1.6cd | 1.48bc | NS |
| 3. Poor ventilation of the work area | 1.70bcd | 1.61bc | NS |
| 4. Aisles and passageways are not clear and obstructed | 1.30d | 2.19a | **S** |
| 5. Food or drink allowed in active laboratory areas | 1.95abc | 1.29c | **S** |
| 6. Laboratory area is not clean and orderly. | 1.84abc | 1.58bc | NS |
| 7. Storage of combustible materials minimized | 2.19a | 2.26a | NS |
| 8. Lack of continuous water flows in the chemical lab rooms. | 2.14ab | 1.87ab | NS |
| ***Average weighted mean*** | 1.80 | 1.73 | NS |

*at 0.05 level of significance; where: S – significant difference and NS – no significant difference*

Among the eight indicators (Table 1), both NBSC and BSC encountered the most serious problem in the storage of combustible materials. The BSC also encountered serious problems on obstructed aisles and passageways. It can also be seen that NBSC do not encounter serious problem in obstructed aisles and passageways while the BSC do not encounter serious problem in allowing food in active laboratory areas.

Comparing the responses of the two groups on this parameter, there is a non-significant difference in the problems encountered by the NBSC and BSC in this parameter. The highly significant difference is on their response on indicators 4 and 5. The BSC regard the problem on obstructed aisles and passageways more seriously than the NBSC. On the other hand, the NBSC take the problem on food and drinks being allowed inside the laboratory more seriously than the BSC. This indicates that though they regard the problems in this parameter with no significant difference, there are indicators that need to be considered to iron out the differences.

**Table 2. Differences in the Problems Encountered in Safety Management of Lab Safety Documents (LSD)**

| Parameter LSD | Weighted Mean NBSC | BSC | Sig. |
|---|---|---|---|
| 1. Lab safety Manual is not available | 1.76b | 1.84a | NS |
| 2. Updated Emergency action plan is not available | 1.68b | 1.77a | NS |
| 3. There is no Spill response guide. | 2.19a | 2.03a | NS |
| 4. Lab accidents and injuries records are not maintained | 2.46a | 1.81a | **S** |
| 5. Safety data Sheets are not available (SDS) | 1.76b | 1.74a | NS |
| 6. Lab chemicals inventory are not updated | 1.62b | 1.23b | **S** |
| 7. An incident report form is not available | 2.46a | 2.19a | NS |
| ***Average weighted mean*** | 1.98 | 1.80 | NS |

*at 0.05 level of significance; where: S – significant difference and NS – no significant difference*

## RESULTS

As seen on Table 2, the NBSC and BSC takes the non-availability of spill guide response, laboratory accident records and incident report form as their most serious problems among the seven indicators in LSD. The BSC faculty, in addition, encounters problem in the same level in the non-availability of Lab Safety Manual, updated emergency action plan, and Safety Data Sheets.

Based on the checklists attached to the questionnaire, 35 out of the 68 (51.47%) respondents claimed not to have SDS, 43 (63.23%) have no

incident report form, 25 (36.76%) do not have a laboratory safety manual and 52 ( 76.47%) have no spill guide. In spite of these, the response indicates that they do not see the non-availability of these documents as a serious problem in safety management.

There is no significant difference in the problems encountered in the safety management in LSD between the NBSC and BSC as shown in Table 2. The difference is shown in indicators 4 and 5 of this parameter. The NBSC gave more serious impression on the non-maintenance of records of lab accidents. It can be noted that the absence of laboratory incident report is the most serious problem of the NBSC in this parameter. The NBSC have their most serious problems encountered in the updating of chemical inventory.

**Table 3. Differences in the Problems Encountered in Safety Management of Emergency Planning and Emergency Equipment (EPE)**

| Parameter EPE | Weighted Mean NBSC | BSC | Sig. |
|---|---|---|---|
| 1. Emergency exits in the laboratory are not clearly marked. | 1.68cd | 1.23d | **S** |
| 2. Emergency instructions in case of exposure to chemical hazards are not posted in the labs. | 1.76cd | 1.81a | NS |
| 3. Emergency equipment *not labeled* with highly visible signs | 2.24ab | 1.77a | NS |
| 4. Emergency contact numbers are not posted. | 2.35a | 1.68ab | **S** |
| 5. No regular Earthquake and Fire drill offered by the institution | 1.84bc | 1.39abc | **S** |
| 6. Laboratory doors cannot be locked properly | 1.3d | 1.32bc | NS |
| 7. Safety Equipment not available because it's too expensive | 1.60cd | 1.77a | NS |
| 8. Safety Shower is not functional | 1.70cd | 1.52abc | NS |
| 9. Fire extinguishers are not strategically located in the work area | 1.76cd | 1.45abc | NS |
| ***Average weighted mean*** | 1.80 | 1.55 | NS |

*at 0.05 level of significance*
*where: S – significant difference and NS – no significant difference*

As shown in Table 3, the NBSC regarded the non-posting of emergency contact numbers as the most serious problem among the indicators and laboratory doors that can't be closed as the least serious problem. The BSC ranked indicators 2, 3, and 7 as their most serious encountered problems in this parameter – non-posting of emergency instructions, not clearly labeled emergency equipment, and the non-availability of safety equipment because of their price. Their least serious problem is on emergency exits not being clearly marked.

The responses of the NBSC and BSC in Table 3 show that both groups did not exhibit significant difference in their response to the problems encountered in the safety management in EPE.

The difference is in their response to indicators 1, 4, and 5 of this parameter. The NBSC encounter more serious problems in the emergency exits not being clearly marked, non-posting of emergency contact numbers and the non-regular offering of fire and earthquake drill by their University compared to the BSC.

**Table 4: Differences in the Problems Encountered in Safety Management of Emergency Response (ER)**

| Parameter ER | Weighted Mean NBSC | BSC | Sig. |
|---|---|---|---|
| 1. Eyewash unit and safety shower not within reach in 10 seconds | 2.24b | 1.32b | **S** |
| 2. Safety equipment are not regularly inspected | 2.16b | 1.65ab | **S** |
| 3. First Aid kit materials are not complete. | 2.00b | 1.58ab | NS |
| 4. Safety equipment are not checked regularly | 1.97b | 1.87a | NS |
| 5. Use of spill kit was not oriented to staff | 2.76a | 1.94a | **S** |
| 6. No formal training on first-aid measures | 2.19b | 1.68ab | **S** |
| 7. Not confident on responding to incidents such as fire and explosion | 1.79b | 1.87a | NS |
| ***Average weighted mean*** | 2.16 | 1.70 | NS |

*at 0.05 level of significance*
*where: S – significant difference and NS – no significant difference*

The non-orientation on the use of spill kit is regarded as the most serious problem of the NBSC among the indicators in this parameter, while the BSC, together with the mentioned indicator, regards the not regular checking of safety equipment and their not confident response to fires and explosions as their

most serious problem in ER (Table 4). It can be noted that the BSC do not regard the location of the eyewash and safety shower as a serious problem.

The results show that there is a significant difference in the seriousness of the problems encountered by the NBSC and BSC in this parameter. The NBSC indicated more serious problems encountered in ER compared to the BSC faculty. Their difference is also evident in indicators 1, 2, 5, and 6 with the NBSC encountering more serious problems on the location of eyewash and safety shower, non-regular inspection of safety equipment, non-orientation on the use of spill kit, and no formal training on first aid kits. The implication of this finding is the two groups are not in the same level of readiness in cases of emergency.

**Table 5. Differences in the Problems Encountered in Safety Management of Personal Protective Equipment (PPE)**

| PARAMETER | Weighted Mean | | Sig. |
|---|---|---|---|
| **PPE** | **NBSC** | **BSC** | |
| 1. Wearing of PPE is not strictly implemented | 2.16 | 1.37c | **S** |
| 2. Most laboratory teachers do not wear PPE | 2.24 | 1.65c | **S** |
| 3. Only wearing of Lab gowns and goggles are implemented. | 2.05 | 2.06b | NS |
| 4. PPE is not provided by the university (personally bought by user) | 2.86 | 3.55a | **S** |
| ***Average weighted mean*** | 2.33 | 2.17 | NS |

*at 0.05 level of significance*
*where: S – significant difference and NS – no significant difference*

From Table 5, the NBSC gave ratings that are not significantly different in the four indicators. The BSC rated the non-provision of PPE by the university as their most serious problem among the indicators and regard the strict implementation of PPE wearing a not serious problem. The provision of PPE by the employer to its staff to protect them from possible hazardous exposure is specified in the Occupational Health and Safety Standards of the Department of Labor and Employment (RA 11058).

The NBSC and BSC gave a non-significant difference in their rating in this parameter, as shown in Table 5. Considering their responses on the four indicators in this parameter, the NBSC gave indicators 1, 2, and 3 of this parameter a more serious impression compared to the BSC group. The NBSC encounters more serious problem in the implementation of PPE wearing, the non-wearing of PPE by the faculty, and the non-provision of PPE by their University. A significant difference regarding the seriousness of these problems is worth note-taking in the formulation of a uniform policy.

**Table 6. Differences in the Problems Encountered in Safety Management of Chemical Storage & Chemical Labelling (CSC)**

| Parameter | Weighted Mean | | Sig. |
|---|---|---|---|
| **CSC** | **NBSC** | **BSC** | |
| 1. Reactive chemicals and reagents and samples are not labelled with the following information: name, date, storage temperature, expiry date | 2.60ab | 2.06ab | **S** |
| 2. Chemical containers are not clearly labelled | 2.35b | 1.45c | **S** |
| 3. Chemicals are segregated in alphabetical order | 2.32b | 1.9abc | NS |
| 4. There is only one area for storing all chemicals | 2.86ab | 1.97ab | **S** |
| 5. Chemical Storage does not have its own ventilation | 2.43ab | 2.13ab | NS |
| 6. Flammable materials are not kept in Flammable storage cabinets | 2.89ab | 2.32a | **S** |
| 7. Teacher are not oriented on using SDS (safety data sheets) | 2.30b | 1.74bc | **S** |
| 8. Teachers are not aware of regulations/ laws on chemical safety | 2.78ab | 1.94ab | **S** |
| 9. No agency does inspection on the safety status of the university | 3.00a | 1.9abc | **S** |
| ***Average weighted mean*** | 2.62 | 1.93 | **S** |

*at 0.05 level of significance*
*where: S – significant difference and NS – no significant difference*

The proper storing and labeling of chemicals, according to Abbas et al [11], are necessary in the proper prevention and response to accidents in the laboratory involving chemicals.

From Table 6, the problems encountered by the NBSC, indicator 9 is their most serious problem among the nine listed indicators. The BSC regards the non-storing of flammable chemicals in the flammable cabinet as their most serious problem among the indicators. It can also be noted that the BSC group takes the not clearly labeled chemical containers as a not serious problem.

The difference in the responses of the NBSC and BSC on the problems encountered in the safety management in CSC are significant. Among the nine indicators of this parameter, the NBSC gave indicators 1, 2, 4, 6, 7, 8, and 9 (7 out of 9 indicators) a more serious rating on the problems compared to the BSC. This implies that the NBSC's problem on this parameter have to be addressed.

**Table 7. Differences in the Problems Encountered in Safety Management of Fume Hood and Chemical Handling (FHC)**

| Parameter | Weighted Mean | | Sig. |
|---|---|---|---|
| **FHC** | **NBSC** | **BSC** | |
| 1. Fume hoods are not properly installed | 1.86c | 1.58a | NS |
| 2. Fume hood is not functional | 2.54ab | 1.71a | **S** |
| 3. Chemicals are stored in fumehood | 1.97bc | 2.03a | NS |
| 4. The university do not promptly act on requests to purchase fumehood. | 2.59a | 2.03a | **S** |
| 5. No budget for the purchase of fumehood. | 2.27abc | 2.06a | NS |
| ***Average weighted mean*** | 2.25 | 1.88 | NS |

*at 0.05 level of significance*
*where: S – significant difference and NS – no significant difference*

Table 7 shows that all chemistry faculty in SUs in Region III encounter slightly serious problem in the safety management of FHC. The NBSC rated the indicator "University does not promptly act on requests to purchase fume hood' as their most serious problem in this parameter. They also regard the non-functionality of the fume hood as a moderately serious problem. The BSC group did not give significant difference in the rating of the five indicators.

In this parameter, the result shows that there is no significant difference in the problems encountered by the NBSC and BSC faculty in safety management in FHC. But, the two groups are different in their response to indicators 2 and 4 of this parameter. The NBSC regarded their problems on the non-functional state of their fume hood and their request to purchase fume hood not being acted upon promptly by the University as more serious than the BSC faculty.

***Waste and Management***

The NBSC gave no significant difference in their rating on the six indicators in this parameter, but they regard indicators 4 and 6 as moderately serious (Table 8). With the BSC faculty giving a significantly different ratings on the six indicators, rated the absence of a second party that collects hazardous wastes as their most serious problem in this parameter and rated indicators 3 and 5 as their least serious problems.

**Table 8. Differences in the Problems Encountered in Safety Management of Waste Management (WM)**

| Parameter | Weighted Mean | | Sig. |
|---|---|---|---|
| **WM** | **NBSC** | **BSC** | |
| 1. There is no waste disposal policy and regulation in the institution. | 1.92 | 1.61bc | NS |
| 2. No staff in the university can handle hazardous waste | 2.49 | 2.00b | **S** |
| 3. Chemical waste containers are not identifiable, labeled, dated, and sealed. | 2.49 | 1.55c | **S** |
| 4. Acid waste, basic waste, and solvents are not stored in separate containers. | 2.78 | 1.61bc | **S** |
| 5. Containers for sharp and cutting waste are not properly handled and disposed of. | 2.16 | 1.55c | **S** |
| 6. There is no second party that collects hazardous waste in the university | 2.76 | 2.48a | NS |
| ***Average weighted mean*** | 2.43 | 1.80 | **S** |

*at 0.05 level of significance*
*where: S – significant difference and NS – no significant difference*

The seriousness of the problems encountered in safety management in WM is different between the NBSC and BSC. The NBSC experience more serious problems in this parameter than the BSC faculty. The difference is highly emphasized in indicators 2, 3, 4, and 5 of this parameter. It shows that the NBSC encounter more serious problems than the BSC in the following - no staff to handle hazardous waste; chemical waste containers are not labeled and

identified; acid waste and base waste containers not separated; and glass and sharp wastes not properly handled. These problems in waste management, if not corrected, can pause risks on the safety of the laboratory users [2].

**Table 9. Differences in the Problems Encountered in Safety Management of Safety Training Awareness (STA)**

| Parameter | Weighted Mean | | Sig. |
|---|---|---|---|
| **STA** | **NBSC** | **BSC** | |
| 1. Time is a constraint in introducing safety in pre-lab activity | 1.65b | 1.61a | NS |
| 2. The university does not provide safety training. | 2.27a | 2.23a | NS |
| 3. Training records are not documented | 2.24a | 2.06a | NS |
| 4. Trainings on safety is not a priority of the school. | 2.49a | 1.84a | **S** |
| 5. There is no standard policy in implementing safety in the university. | 2.05ab | 2.00a | NS |
| 6. Safety rules vary from one discipline to another | 2.14a | 2.23a | NS |
| 7. Staff do not know where to get training on chemistry laboratory safety | 2.11a | 2.00a | NS |
| ***Average weighted mean*** | 2.14 | 1.99 | NS |

*at 0.05 level of significance*
*where: S – significant difference and NS – no significant difference*

Problems encountered in Safety Management of Safety Training Awareness (STA) are time constraints and non-availability of safety trainings. Based on the weighted means in this parameter (Table 9), the two groups encounter slightly serious problems in STA. The NBSC, with significantly different ratings on the seven indicators, regarded the non-provision of safety trainings by the University, non-documentation of safety trainings, absence of a standard policy on safety, the diverse nature of safety rules and not knowing where to get safety training as their most serious problems in this parameter and their least serious problem is time constraint in introducing safety in pre-lab activity. The BSC gave no significant difference in their rating on the different indicators of this parameter.

The NBSC and BSC responded on this parameter with the results shown in Table 9.Results show that there is no significant difference in the problems encountered by the NBSC faculty and BSC faculty in the problems encountered in the safety management in STA. Both NBSC and BSC encounter slightly serious problems in this parameter.

The two groups are different in terms of their responses on indicator 4 of this parameter. Though this indicator was described as slightly serious for both groups, their responses were found to be statistically different. It shows that the NBSC encounter more serious problem on their University's low priority on safety training.

**Table 10. Differences in the Problems Encountered in Safety Management**

| Parameter | Weighted Mean | | Sig. |
|---|---|---|---|
| | **NBSC** | **BSC** | |
| Work Environment | 1.80d | 1.73bc | NS |
| Laboratory Safety Documents | 1.99cd | 1.80bc | NS |
| Emergency Planning and Emergency Equipment | 1.80d | 1.55c | NS |
| Emergency Response | 2.16bcd | 1.70bc | **S** |
| Personal Protective Equipment | 2.33abc | 2.17a | NS |
| Chemical Storage & Chemical Labelling | 2.62a | 1.94ab | **S** |
| Fume Hood and Chemical Handling | 2.25abc | 1.88ab | NS |
| Waste Management | 2.43ab | 1.80bc | **S** |
| Safety Training/ Awareness | 2.14bcd | 2.00ab | NS |
| ***Average weighted mean*** | 2.17 | 1.84 | **S** |

*at 0.05 level of significance*
*where: S – significant difference and NS – no significant difference*

From all the results on the problems encountered by the NBSC and BSC on the problems encountered in safety management in the different parameters, Table 10 gives the summary. Parameters WE, LSD, EPE, PPE, FHC and STA are not different between the two groups. Both groups encounter problems in these parameters on the same level.

The difference between the NBSC and BSC is evident in three parameters - ER, CSC, and WM. Their difference is highly significant (at p=0.05), with the NBSC having more serious problems than the BSC in the mentioned parameters.

The table shows that (using z-test at 0.05 level of confidence), the second null hypothesis of the study is rejected. It means that, overall, the problems encountered by the NBSC and the BSC in safety management are significantly different, with the NBSC encountering more serious problems.

**Table 11. Difference in the Safety Training Needs**

| Safety Training | Weighted Mean | | Sig. |
|---|---|---|---|
| | NBSC | BSC | |
| 1. Using SDS (safety data sheets) | 4.65 | 3.77 | **S** |
| 2. First aid response on basic injuries like burns, chemicals on skin, inhalation and ingestion of chemicals. | 4.73 | 3.77 | **S** |
| 3. Strategies on emergency response | 4.62 | 4.32 | NS |
| 4. Understanding State Laws, regulations and policies on safety in the chemistry laboratory | 4.65 | 3.81 | **S** |
| 5. Proper handling of chemicals based on properties and hazards. | 4.73 | 3.60 | **S** |
| 6. Methods and observations used to detect the presence or release of hazardous chemicals | 4.62 | 4.03 | **S** |
| 7. Hazardous chemical waste segregation | 4.68 | 3.65 | **S** |
| 8. How to manage chemical spills | 4.73 | 3.61 | **S** |
| 9. Handling Compressed Gas & Liquid Nitrogen | 4.70 | 3.68 | **S** |
| 10. Maintenance of laboratory safety devices | 4.59 | 3.74 | **S** |
| 11. Response to Evacuation & Crisis Management | 4.57 | 3.39 | **S** |
| ***Average weighted mean*** | 4.66 | 3.77 | **S** |

*at 0.05 level of significance*
*where: S – significant difference and NS – no significant difference*

Table 11 shows the responses of the NBSC faculty and BSC faculty on their needs for safety trainings. The result shows that the NBSC rating on the 11 trainings presented is described as much needed, and the BSC regarded them as needed. Both their ratings on the 11 safety trainings are not significantly different, which shows that these trainings have to be taken by the chemistry teaching laboratory faculty of the nine SUs under this study to make them more confident in performing their task as safety managers in the chemistry teaching laboratory. The difference in the safety training needs of the NBSC and BSC was analysed using z-test at 0.05 level of confidence. Statistical analysis of the respondents' trainings needs resulted at a p-value of 0.000 as shown in Table 8, which means that the third null hypothesis is rejected. It indicates that there is a highly significant difference in the safety training needs of the NBSC and BSC. The NBSC needed the trainings listed more than the BSC. Among the 11 safety trainings listed, only the training on Strategies on Emergency Response is needed in the same level (no significant difference) by the two groups.

## DISCUSSION

Based on the results, there are problems encountered in safety management by both NBSC and BSC . This result can be attributed to the lack of safety organizational structure in the SUs that overlooks safety implementation and policies that regulate safety management. Because of minimal resources, he SUs under this study do not have principal investigators, or safety officers tasked to handle and monitor safety in their universities. Instead, the SUs designate the chemistry faculty members to craft and implement guidelines and policies to manage safety in their laboratories, and at the same time, monitor its implementation. The problems arise if there is rare if not a lack of strict supervision and investigation if these guidelines and policies are implemented. These findings corroborated with the conclusions of Lestari et al. [10], Schroder et al., [5] and Marendaz et al. [23] that regular inspection, supervision, and evaluation of the safety management of the chemistry teaching laboratory have a positive impact on its safety management.

The lack of a regulatory instrument that can be a basis for managing safety in the chemistry teaching laboratory can lead to differences in problems encountered. The safety policies and guidelines of the SUs vary according to how they see it fit in their situations. The BSC works in a higher risk environment than the NBSC because they handle more chemicals for their BS Chemistry program. This situation requires them to be more cautious or safety

conscious. Also, the Commission on Higher Education requires stricter compliance with the safety management of chemistry teaching laboratories from universities offering Chemistry courses. This resulted in the BSC encountering less serious problems than the NBSC.

Both NBSC and BSC needed safety trainings. This confirms the report of the National Research Council [24] that the trainings undergone by most staff in the University are "not sufficient to ensure knowledge, skills, qualifications, and abilities to perform safely in a laboratory environment and to establish a strong, positive safety culture". Likewise, those that have undergone safety training have to go through routine retraining to make them abreast with regulatory changes [4].

The difference in their safety training needs could have been a result of the different safety trainings offered by the Integrated Chemists of the Philippines (ICP), their latest training was on Chemical Waste Management held last February 18, 2019 (https://www.icp.org.ph/). The trainings offered by ICP are attended mostly by registered chemists, which is a basic requirement of a BSC. So far, most of the trainings given or attended by NBSC (as per trainings given by the Philippine Association of Chemistry Teachers and Organic Chemistry Teachers Association) are more concerned with content and pedagogy concerning chemistry education.

## CONCLUSIONS AND RECOMMENDATIONS

The NBSC encounter more serious problems in safety management compared to the BSC faculty. Likewise, the NBSC needed more safety trainings than the BSC.

These differences suggest that a uniform chemistry laboratory safety manual should be developed. The manual can be used by the chemistry teaching laboratory faculty members of SUs in Central Luzon as a starting document to establish a uniform safety policy and guideline in the chemistry teaching laboratory. Second, it is also recommended that all faculty members of the chemistry teaching laboratory in SUs in Central Luzon undergo laboratory safety trainings. If the University cannot provide the training, they can seek the assistance of the Integrated Chemists of the Philippines and the Environmental Management Bureau of the Department of Environment and Natural Resources (DENR) in the conduct of the training. It is further recommended that safety training should be a regular undertaking of the University especially if a novice chemistry teacher is present. Retraining is also recommended to update the chemistry teaching laboratory faculty with new policies and regulations.

The findings of this study should be considered by policy makers to realize that there is a need to develop regulatory materials specially designed for the safe management of chemistry teaching laboratories. The chemistry faculty members are workers exposed to hazardous materials and procedures. The University administrations are their employers, therefore, a regulation that specifically addresses the occupational safety of the chemistry faculty members and the role of the University in providing them a safe working environment is a need of the time.

Lastly, this study was done only in Central Luzon, and it is recommended to conduct it on a broader scope, which includes SUs in different regions of the country.

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