STUDENTS' AT--RISK BEHAVIOR AND SAFETY CULTURE IN BASIC CHEMISTRYLABORATORY

Rose Marie O. Mendoza, Divina F. Palacio & Elizabeth B. Calara

Far Eastern University--Nicanor Reyes Medical Foundation, General Education Department, Quezon City, Philippines

Abstract

An academic laboratory such as the General and Organic Chemistry Laboratory were given less priority as to safety due to the perception that the quantity of materials would not give a significant hazardous impact to students or the environment. This study evaluated the at--risk behaviors of the Basic Chemistry students as well as the present Safety Culture in the laboratory. A total of 918 Basic Chemistry students officially enrolled during the A.Y. 2016--2017 in the host institution participated the study. New findings in the at--risk behaviors were recorded such as the use of gadgets and tablets not associated with the lab activity, half--glove use, ¾ sleeved-- and unbuttoned laboratory gowns, limited working area, messy and unorganized working area, going out of the laboratory in their lab gowns and gloves on top of not properly and untied hair for girls and dangling bangs for boys, incomplete safety gears, horse--playing and unfamiliarity to experimental procedures. The laboratory safety has been found to be better among first year students than that of the second--year students. It was also found that majority of the students are not aware of the different nature of chemicals being handled in the laboratory. Significant relationship was found between the at--risk behavior of the students and their laboratory safety culture, indicating that students who are in the high--risk level exhibits lower laboratory culture. Integration of safety orientation into the laboratory curriculum was found to be an attractive solution to the existing laboratory issues observed.

Keywords: Laboratory Safety, Safety Culture, At--Risk Behavior, Basic Chemistry Lab

1.0 INTRODUCTION

Safety should always be the primary consideration in Basic chemistry laboratories. Since the experiments are easier, less toxic and hazardous as compared with university research laboratories, some students tend to ignore its importance on the routine activities performed in the laboratory. Paying attention to the potential hazards in chemicals as well as the working environment becomes very important in any laboratory whether it is a basic or a research lab.

Academic laboratories particularly in Basic Science laboratory such as the General and Organic Chemistry Laboratories are not usually given top priority as to safety due to the perception that quantity materials would not give a significant hazardous impact to the people and environment. Schultz (Schultz, 2005) in his interview with Michael J. Halligan, Associate Director of Environmental Health and Safety at the University of Utah, stressed that academic laboratories, have more accidents, but goes unnoticed and are non--alarming because it is observed in a smaller scale. In addition, he opined that that quantity of materials being used and handled in an academic laboratory is not as huge as that of an industrial or a research laboratory. Benderly (Benderly, 2009) added that in Du--Pont, Jams Kauffman estimated that the rate of opportunities of laboratory accidents in the schools and colleges is 100--1000 times greater. However, the injuries that resulted are minor to very minor to cause significant hazards to students.

In the Philippine setting, there are very seldom studies being undertaken with regards to the practice and safety inside the Basic Chemistry Laboratory. One of these few studies was that of Daclan (Daclan, 2013) who claimed of improving the student's practice and safety in the laboratory when exposed to an online social networking--based health education. While most literature reported more of incidents involving laboratory burn down (Botial, 2010), toxic fumes release (National Research Council of the National Academies, 2011) and chemical spills (US Environmental Protection Agency, 2008), there is not much studies that focus on the actual assessment and evaluation of the behaviors of students in the basic laboratory as well as their safety. Thus, this study was deemed timely due to its capability of adding up to the information and data base of laboratory behavior studies, most particularly in FEU--NRMF.

Over the years, accidents and incidents related to safety are being recorded in the incident logbooks in the Chemistry Laboratory in FEU--NRMF. Though what was observed in terms of the nature of injuries conforms to what was reported to be "simpler and with lesser threat", this study aimed to assess and evaluate the level of laboratory safety culture and the at--risk behaviors of students in the General and Organic Chemistry Laboratory for this School Year 2016--2017. This study also attempts to correlate the at--risk behaviors of the students and their laboratory safety culture.

2.0 LITERATURE REVIEW

In Bridgewater College, VA, USA, Crockett, (2010) reported that students were not always following the rules in the laboratory and had to be reminded too often to obey the safety rules, read safety precautions and safety labelling. This is because most people have perceived that academic laboratories are a safe place to work and study (Shariff, A.M., Norazahar, 2011;; Ponnet, K., Reniers, G., Kempencers, 2013). Artdej (2012) in his investigation on the undergraduate students' scientific understanding of laboratory safety, mentioned that safety in the laboratory relies mainly on the instructor's ability to give students practical safety orientation, information on material hazard identification and laboratory protocols. Another study stressed that reading and following warnings can be considered as effective safety behaviors that can prevent students from ending up in unsafe laboratory circumstances which will most likely lead to injury (Argo, J., Main, 2004).

The hazard control hierarchy (Haddon, 1973;; Laughery, K., Wogalter, 2014) or so--called safety hierarchy is the theoretical framework used by this study to define the priorities for addressing safety in the laboratory. This framework stressed that the most preferable approach to eliminate hazards is by several hierarchal approaches starting from safe alternative designs (Sanders, M., Mc Cormick, 1993) where safety will be implemented, and a safety curriculum be constructed based on technological or economic reasons. Second is to deal with hazards by "guarding" (Smith--Jackson, T., Hall, 2002) which is the setting up of physical or procedural barricades such as protective clothes or a step--by--step process of avoiding such hazard. The third is the "warning" (Cox, E., Wogalter, 1997;; Argo, J., Main, 2004) which is communication tool consisting of warnings intended to provide information for students which allows them to make informed decisions about how to maintain safety while working in the laboratory.

The safety in the laboratory is greatly influenced by the teachers. They play an important role in enforcing safety inside the laboratory through student encouragement on a considerable attention to the hazards of the chemicals they use in the lab and to support safe habits while working in the laboratory (Artdej, 2012). The students, in the everyday setting follows all the suggestions given by the teachers, which makes safety as the primary concern of both students and teachers (Alaimo, P.J., Langenhan, J.M., Tanner, M.J., Ferrenberg, 2010). As such, laboratories must not only provide students with skills and technical knowledge but also must be able to allow students, by themselves, to identify hazards and recognize their social responsibility to their fellow students and the whole laboratory setting.

Famous Laboratory Accidents in the History

The film Experimenting with Danger released by the US Chemistry Safety Board in 2011 a 24--minute video that focused on three (3) serious laboratory accidents: first is the death of a laboratory research assistant in 2008 in a flash fire at the University of Los Angeles California (UCLA);; second is the death by accidental poisoning of a highly regarded Professor from Darmouth College Professor in 1997;; and the 2010 explosion at Texas Tech University (TTU) that severely injured a graduate student who lost three fingers and suffered permanent eye damage in the blast. The CSB in summary calls on Universities not only in United States to do everything that is possible to provide safe working environments in their laboratories (Lawhorne, 2011).

In the Philippines, several laboratory accidents also were documented such as the the burning down of the Biochemistry Laboratory located in a 100--year old building in the University of the Philippines--Diliman (Botial, 2010) in 2010. Prior to this, the release of toxic fumes from the science laboratory from San Isidro High School in Makati also made the news in 2006 which resulted in rushing 10 teachers and staff to the hospital after episodes of vomiting and skin rash (National Research Council of the National Academies, 2011). Another recorded incident also in 2006 was the mercury spill that took place in St. Andrews School in Paranaque, where 10 students were admitted to the Philippine General Hospital for reported symptoms of mercury exposure and poisoning(US Environmental Protection Agency, 2008).

3.0 METHODOLOGY

The study is a cross--sectional study involving a total of 918 students of General, Analytical and Biochemistry officially enrolled for the first and the 2nd semester of Academic Year 2016--2017. This study also included students who have been taking the course for the 2nd or 3rd time. Attendance to the initial safety orientation allows the respondents to continue their participation in this study. Inclusion of the students to the study commenced after the signing of informed consent and their attendance to the initial safety orientation conducted by the laboratory Professor within the first few weeks of the start of the laboratory class. Students who refuse to participate or wish to withdraw from the study were excluded from this study.

The study collected numeric data using a validated survey tool adopted from the 2012 Laboratory safety culture report of Bioraft, NPG and UCCL (2014) and was modified to suit the objectives of this study. In general, this study involves the collection of the at--risk behavior data preliminarily from the Incident Logbook to come up with a list of the top (10) most frequently occurring/accident in the laboratory, which was converted to an at--risk behavior checklist. Then the level of laboratory safety culture was measured using the modified and validated survey tool by Bioraft, NPG and UCCL

Research Instruments

At--risk Behavior Checklist. This tool was constructed based on the Incident Logbook used and kept in the chemistry laboratory. An Incident Logbook keeps records on incidents or accidents occurring in the Basic Chemistry Laboratory located at Room M510. The records included the name, course, year of the student, background of the incident/accident and the action taken. The checklist was updated through an informal focus group discussion (FGD) participated by chemistry professors before the start of the 1st semester to account for the other at--risk behaviors of the students in the laboratory. A final checklist included the top ten (10) incidents recorded over the past 5 years and other at--risk behaviors discussed during the FGD. The at--risk behavior checklist is composed of 12 safety indicators answerable by Yes or No. The Kuder--Richardson (KR--20) coefficient for the at--risk behavior checklist was found to be 0.9075.

Lab Safety Culture Survey. The Lab Safety Culture Survey was adopted and patterned from 2012 Laboratory safety culture report of Bioraft, NPG and UCCL (2014) and was modified to suit the objectives of this study. Initially, the survey form covers eight areas of Laboratory Safety namely;; (1) Awareness and Responsibility;; (2) Use of PPEs;; (3) Injuries and Accidents;; (4) Overall Safety;; (5) Importance of safety. These areas were retained with substantial changes on the construction of each indicator to fit with the objectives of this paper. Internal consistency (Cronbach Alpha) was used to statistically validate the Laboratory Safety Culture Survey tool. An overall Cronbach alpha coefficient of 0.9233 was obtained for the Laboratory Safety Culture tool. This is comprised of Cronbach alpha coefficients of 0.9233 for Awareness and Responsibility, 0.9518 for use of PPEs, 0.8529 for Injuries and Accidents, 0.8884 for Overall safety, and 0.8794 for the Importance of Safety.

All statistical calculation is performed using MINITAB statistical software version 17. Both studentized t--test and chi--square test is performed at 0.05 level of significance. Cramer's V coefficient was used to determine association between the at--risk behavior and the laboratory safety culture. The null hypotheses are significant at p--values less than 0.05.

4.0 FINDINGS

Student's At--Risk Behaviors in the Laboratory

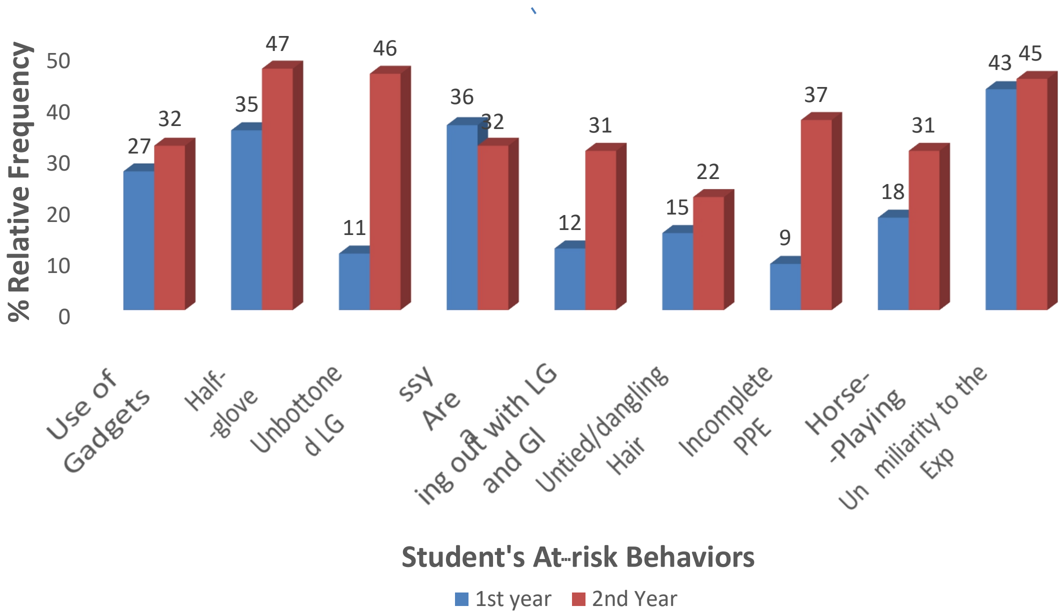

Figure 1: Student's At--risk Behaviors in the Basic Chemistry Laboratory

Figure 1 indicates that the 2nd year students are more at--risk as compared to the first year students. This is illustrated by relatively high percentage of incidences of the at--risk behaviors being displayed by the sophomores as compared to that of the freshmen. The figure also indicated several new at--risk behaviors that were not documented in the previous studies (Crockett, 2010;; Artdej, 2012). Among the 2nd

year students' new at--risk behaviors are half--glove use during experiments, unbuttoned laboratory gowns, use of gadgets on activities not related to the lab activities and going out of the laboratory in their lab gowns and gloves while new at--risk behaviors among 1st year students are messy area, half--glove use and use of gadgets on tasks not related to the laboratory activity.

Student's Laboratory safety Culture

Report on the frequency of use of the substances in the lab. Table 2 presents the awareness of the students on the classification of substances being utilized in the lab.

Table 1. Comparison of the Students' Report on the Frequency of Use of the Substances in the Lab against the Laboratory Technician's Report

Substances Handled in the Laboratory	Lab. Tech. Report	Adjusted Weighted Student Response	
		1st Year	2nd Year
Pyrophoric	5	5	4
Human Samples	5	4	3
Highly Toxic/Mutagenic	5	4	3
Pathogenic Organisms	5	4	3
Viral Vectors	5	5	4
Highly Oxidizing agents	3	3	3
Concentrated Acids	2	2	2
Cyanides	5	5	4
Concentrated Bases	2	2	2
Highly Flammable solvents	3	3	3
Toxic Organic Materials	5	3	3
Nitrites/Nitrates	2	3	3

As shown in Table 1, it can be concluded that the 1st year students are more aware of the types of substances being use in the lab and the frequency of its use. The response or report of the 1st year students agrees better with the report of the Laboratory technician than that of the 2nd year students, indicating the 1st year students to be more aware of the types of chemicals or substances being used in the laboratory than the 2nd year students.

Laboratory Safety Culture Assessment

Shown in Table 2 is the comparative analysis of the Laboratory safety culture of the two group of students. It was found that the 2nd year students in general have higher risk than that of the 1sy year students. Statistical analysis proved that overall, there is no significant difference in the level of risk among the two groups of students, however, significant differences were observed on the level of risk of the two groups of respondents in terms of the use of PPEs. The negative t--value is statistically confirming the 2nd year students faces higher risk.

Table 2: Comparative Analysis of the Students' Laboratory Safety Culture

Source of Risk	Level of Risk		Statistical Test		
	1st Year	**2nd year**	**t--value**	**p--value**	**Interpretation**
Awareness and Responsibility	Very Low	Low	--1.63	0.140	Not Significant
Use of PPEs	Very Low	Moderate	--3.81	0.002	Significant
Injuries and Accidents	Low	Low	--0.01	0.988	Not Significant
Importance of Safety	Very Low	Low	--0.05	0.963	Not Significant
Overall Safety	Very Low	Low	--1.30	0.240	Not Significant

Table 3: Correlation Analysis on the Students' At--risk Behaviors and their Laboratory Safety Culture

Statistic	Very Low Risk	Low Risk	Moderate Risk
X^2	3.41	12.45	126.11
Sample size	35	93	189
p--value	0.014	0.008	<0.001
Interpretation	Significant	Significant	Significant
Cramer's V	0.213	0.249	0.317

Significant relationship was found between the student's at--risk behavior and their laboratory safety culture. This is implied by all p--values less than 0.05 indicated in Table 3. The association between at--risk behavior and the student's laboratory safety was indicated by the Cramer' 's V value which is used to measure the strength of association between the 2 variables. The Cramer's V values ranges from 0.213 to 0.317 indicating moderate to strong association between the at--risk behavior and the laboratory safety of the students, statistically indicating that the at--risk behavior becomes stronger as the level or risk becomes higher which corresponds to a low laboratory safety culture.

5.0 CONCLUSION

The student's at--risk behavior and laboratory safety culture in the Basic Chemistry Laboratory is assessed and evaluated. The prevalence of the new at--risk behaviors inside the chemistry laboratory was evident. These at--risk behaviors are rangers from infringement in the use of PPEs such as the half--glove use, use of unbuttoned laboratory gowns, going out or the laboratory in their lab gowns and gloved, messy working area and the use of gadgets on tasks not related to lab work. It was also found out that the 1st year students in general, have higher laboratory safety culture ranging from very low to low risk, than the 2nd year students whose laboratory safety culture ranges from very low to moderate risk. A strong significant relationship or association was found between the at--risk behavior and the student's lab safety culture. Since at--risk behavior and laboratory safety culture should always be kept low in the laboratory, safety should be the primary consideration in the laboratory. To achieve this, this study therefore suggests that a safety orientation be incorporated in the Chemistry Laboratory Curriculum and student's performance be strictly monitored and evaluated.

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