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Research Article

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Chemistry Laboratory Safety Signs Awareness Among Undergraduate Students in Rivers State

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Abstract

Chemistry laboratory instructions do not only provide students with practical experiences but also teaches students on hazardous materials/chemicals as well as laboratory safety signs so as to prevent or minimize harm in the laboratory. Consequently, the purpose of this research study was to investigate Rivers undergraduate students' awareness level of safety signs in Chemistry laboratory. To this end, three research questions and two hypotheses guided the study. The study adopted analytic descriptive survey design. A total of 60 year three undergraduate students studying Chemistry Education (B.Sc. Ed) and Pure Chemistry (B.Sc.) were randomly drawn from three universities namely; University of Port Harcourt (Uniport), Rivers State University (RSU) and Ignatius Ajuru University of Education (IAUE) with each university contributing 20 students. A well validated and researchers constructed test instrument, titled, Chemistry Laboratory Test on Safety Signs (CLTSS) which had an internal reliability index of 0.94 via Cronbach Alpha was used for data collection in the study. The relevant data collected were subjected to simple percentages, mean, standard deviation, t-test and analysis of variance (One-way ANOVA) as statistical tools. The results of the study revealed that majority of the students misunderstood the definition of chemical hazards. In addition, they experienced confusion in matching chemicals commonly found in Chemistry laboratory (i.e., sodium hydroxide) and the meaning of chemical safety sign. An indication that students' awareness level of safety signs is low. A second finding of the study showed that there is a difference in the awareness level of safety signs between Chemistry Education (B.Sc. Ed) students and their pure Chemistry (B.Sc.) counterpart, however, the difference was not significant statistically. Also, the finding showed that the awareness levels of safety signs among undergraduate Chemistry students are not significantly dependent on institutional types. Based on the findings of the study and the fact that the findings from this study provide basic information for teaching and learning, it was recommended among others that, lecturers in the course of teaching should promote students' awareness of the proper handling, storage and disposal of hazardous materials/chemicals vis-à-vis their safety signs.

Keywords: Undergraduate Students, Chemistry Laboratory, Safety Signs, Rivers State.

Introduction

Chemistry like every other pure science discipline is experiential and experimental in nature and so requires practical experiments to be carried out in order to transfer knowledge from concepts, principles, and theories to tangible results that can be observed, measured, controlled and re-tested in different conditions and according to new variables. As a result, foster better understanding of the subject under study in many ways. Nevertheless, for Chemists and scientist in general to work effectively and efficiently they require a room popularly called laboratory. No wonder the saying, "the laboratory is the heart of science education" a true and unchangeable remark.

The laboratory has maintained its status as the most important characteristic of teaching Science than other fields of knowledge. It also plays a clear and tangible role in advancing this field of knowledge and making it more interesting and enjoyable for students, teachers, and researchers alike. What then is laboratory?

May probably be a question an un-scientific mind may ask.

Laboratory is a room or building or even a period of time equipped and set apart for experimental studies to take place [1]. Igwe defined the laboratory as a facility for learning what science is and how scientists work, it can be indoor such as sufficiently designed and equipped room found in most schools or outdoor involving such places as riverside, workshop field or under a tree [2]. The laboratory is an instructional facility used by the science teacher to help the student learn about science and how the scientist investigates the world around them [3]. It is a school building set aside for scientific discovery/inquiry. The laboratory is a place where students experience and participate in the demonstrating activities which provides opportunity for students to develop understanding of practical and theoretical concepts through solutions of problems. Laboratory inquiry process develops students' abilities and skills such as posting scientifically oriented quest ions forming hypothesis designing and conducting scientific explanation and communication and defending scientific arguments [4]. The laboratory is a place where learners acquire science process skill of observing carefully and thoroughly:

a. Reporting completing and accurate what is observed
b. Organizing information acquired by observation
c. Generalizing on the basis of acquired information
d. Predicting as a result of these generalization
e. Designing experiments including controls where necessary to check these predictions.
f. Using models to explain phenomena where appropriate
g. Continuing the process of inquiry when new data do not conform to predictions [5].

The science process skill enables learners to process the scientific attitude of curiosity, open mindedness, objectivity, intellectual honesty, rationality, willingness to suspend judgement, humility and reverence for life all these are nurtured in the laboratory. All these attitudes are cultivated in the individual in the course of practical involvement with scientific experiences. Hence, teaching in the laboratory makes the learner learn about the nature of science and technology in order to foster the knowledge of human enterprise of science and this enhance the aesthetic and intellectual understanding of the learner.

The laboratory enables students learning to appreciate and in part emulate the role of the scientist through acquisition of manipulative skills. Learning major scientific concept, models, principles and theories and understanding their tentative nature is aided through laboratory experience [1]. The laboratory gives the student the opportunities to gain exposure to facts in scientific phenomena. However, in the course of carrying out their work in the laboratory, Chemist and scientist use materials and chemicals that could be harmful or toxic to them and others working with them. Thus, the need for safety measures to be ahead to in the course of carrying out laboratory works becomes a sine-qua-non in laboratory activities.

Safety is the state of being safe, free from the occurrence of risk of injury, danger or loss. It is the quality of averting or not causing injury, danger or loss. It can also be seen as a deliberate step taken to avoid or reduce risk, making wise choices and actively managing your health [6]. The laboratory is said to be safe when it will design, has proper access, layout of conducive to the free movement of personnel in the event of emergency [7]. The foundation of laboratory safety is clean and tidy habit adoption of good laboratory practices, good discipline, the strict prohibition of unauthorized practical work, the teachers' knowledge and understanding of the hazard involved. Laboratory safety is a shared responsibility of the school staff and students.

Ottander and Grelsson reiterated that one purpose of science laboratory is to encourage the development of analytical and critical thinking skills and encourage interest in science [8]. Direct laboratory experience also fosters scientific habits of mind and promote the excitement and enjoyment of learning, thereby debunking the general belief that science is a complex field of study. Knowledge gained from science lessons with strong laboratory components enables students to understand in more practical and concrete terms the functioning of the natural world around them.

Types of Laboratories

Klimovski, Cricenti and But J classified laboratory types into three, namely: traditional or real laboratory, simulated or virtual laboratory and remote laboratory [9].

a. Traditional or real laboratory is the physical room where the learners interact with the laboratory equipment in the same time and space. This is a typical example of conventional laboratory used in secondary schools in Nigeria.
b. Stimulated or virtual laboratories have real equipment replaced with computers using certain scientific software for the purpose of experimental activities.
c. Remote laboratories are characterized by mediated reality where the students are not physically present in the same space as the physical equipment.

Table 1: Comparative Advantages and Disadvantages in the Different Types of Laboratories

Laboratory Type	Advantages	Disadvantages
Traditional or Real	Realistic Data Interaction with real equipment Collaborative work Interaction with Supervisor	Time and place restrictions Requires scheduling Expensive Supervision required
Simulated or Virtual	Good for concept explanation No time and place restriction Low cost	Idealized data Lack of Collaboration No Interaction with real equipment
Remote	Interaction with real equipment Calibration Realistic Data No time and place rest Medium cost	Only "virtual presence" in the laboratory

Poor Laboratory Management and Safety

This is another cardinal issue in science laboratory in Nigeria. Science laboratory facilities are expected to be properly utilized and managed to serve the purpose for which they were acquired. But in most Nigerian secondary schools, there is poor maintenance culture: improper arrangement and labelling of reagents, lack of regular cleaning of some laboratory apparatus, lack of periodic inventory taking etc. Affirming this, Nbina asserts that poor laboratory management culture could hinder effective practical activities [3]. On the other hand, most of our schools lack safety equipment like fire extinguishers, sand bucket, etc. in the science laboratory. It is important to also point out that all science laboratory users should comply to safety rules and regulations in order to avoid laboratory accidents.

Laboratory Accidents

When laboratory accidents do occur, they can sometimes be attributed to sheer bad luck, lack of awareness, lack of control, and lack of right attitude. Lack of awareness and control of student behaviour are usually encountered by many inexperienced teachers. The consequences of the problem can be serious in the laboratory, particularly if the situation is worsened by lack of control of an experiment. Teachers need to be on the lookout for the appearance of this problem and be ready to help. Two groups of people who lack knowledge of laboratory hazards are inexperienced teachers (including students, teachers, probationers and those teaching outside the area in which they qualified) and unqualified laboratory technicians. The latter is sometimes appointed to wash up, fetch water and carry equipment by which they can easily and unknowingly encounter hazards.

A study in the United Kingdom indicates that the general attitude of school science staff to safety is excellent [10]. However, within a satisfactory general picture there are extremes. An example is the disregard of precaution by allowing the mouth pipetting liquids as toxic as oxalic acid and as corrosive as molar caustic soda. Some of the consequences of extreme attitudes are obvious while others are less. Insufficient care can lead to injury to students, staff and damage to equipment. Over carefulness can waste time and money and reduce students' experience. It can also divert attention from real to imaginary hazards and produce undesirable student attitudes. Chemicals entering the eye are frequently reported and so eye protection (glasses) should be worm more often. Electric shock is seldom reported but because of its consequence, it can be serious. Therefore, care should be taken to avoid it.

Preventing Accidents in the Laboratory

Several measures are usually taken or put in place to prevent accidents from occurring in the laboratory. One of such measure is the presentation safety orientation and signs.

Safety Orientation

All new staff and students should be oriented to accident preventive measures before using the laboratory. The following measures are recommended.

I. Safety signs and devices such as alarms, danger signs, warning lights etc. should be prominently displayed in the laboratory and all those who use the laboratory must observe and respect such signs.

II Smoking should not be allowed in the laboratory.

III Unnecessary running, throwing objects etc. should be avoided.

IV Horseplay is strictly prohibited in the laboratory.

V Sophisticated equipment is to be operated only by trained and authorized personnel.

VI Protective clothing such as overall, eye shields, gloves etc. should be used where necessary.

VII Food and drinks should not be taken to or eaten in the laboratory.

VIII Do not taste any chemical in the laboratory, as it may be fatal.

IX For safe handling of corrosive liquid irritants such as trioxonitrate (V) acid (HNO_3), tetraoxosulphate (VI) acid (H_2SO_4), Hydrochloric acid (HCl), etc. students should wear sufficient protective materials to prevent accidental contact e.g., rubber gloves, safety goggles and face shield.

X For safe handling of solid irritants such as sodium trioxocarbonate (IV) (Na_2CO_3), potassium trioxocarbonate (IV) (K_2CO_3), copper (II) tetraoxosulphate (VI) ($CuSO_4$) and copper cyanide etc., students should put on gloves, respirator and protective clothing.

XI For safe handling of gaseous irritants such as ammonia (NH_3), sulphur (IV) oxide (SO_2); Chlorine (Cl_2), etc. use respiratory protective equipment and ensure that eyes and skin are protected.

XII For safe handling of flammable materials, ensures that one of the three (3) components of the fire triangle is absent. For fire to occur, three components, namely, (i) Fuel (ii) Air (containing O_2) (iii) source of ignition; must be present. These components make up a fire triangle as shown below.

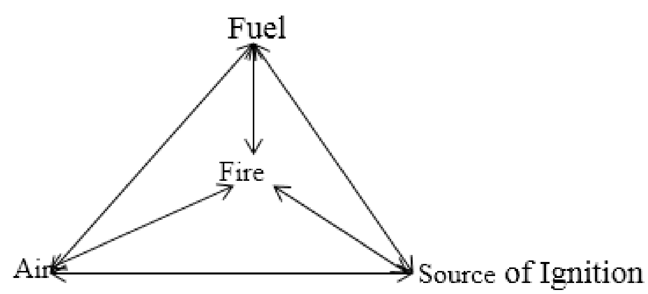


Figure 1: The Fire Ignition Triangle

Therefore, the surest way to avoid fire outbreak in the laboratory is to prevent the fire triangle from being completed by ensuring that at least one of the three components is absent at any given time.

XIII For safe handling of explosive substances, shut off all possible sources of ignition. Wear breathing apparatus and gloves. Transport the explosive substance in a safe, open area for atmosphere evaporation or burial of volatile substance.

XIV Always handle chemicals with care.

XV Always keep a first aid box in the laboratory for emergencies

Some Common Laboratory Safety Signs and Symbols

In a bit to ascertain the awareness level of students as far as laboratory safety signs are concerned, Oludipe and Etobro investigated science education undergraduate student's level of laboratory safety awareness [11]. The study was carried out in Lagos state University, Nigeria. The study adopted the descriptive survey design. The population of the study was fifty-second-year science education students. The instrument for data collection was a self-developed questionnaire titled Science Laboratory Safety Awareness Test (SLSAT). Frequencies, percentages, mean and t-test statistics were used to answer the research question. The result of the study revealed 100% of the respondents are not aware of the laboratory sign and symbols. The study also revealed that there is no significant difference in the level of safety awareness between male and female students. The study recommends that science-based faculties, staff and students' safety practices should be part of teaching and learning of science.

Adebayo and Owolabi studied the hazards that are prevalent in a typical secondary school science laboratory and safety condition of science laboratories in Ekiti State [12]. Two research questions guided the study. They found out that there are hazards in the science laboratories with little or no precaution are taken. Romklao studied undergraduate students' scientific understanding of laboratory safety [13]. The findings of the study revealed that majority of the students have misconception of chemical hazards. The students also have difficulty in matching chemical commonly found in school science laboratory and meaning of chemical safety signs.

Duban, Aydogdu and Yuksel investigated Classroom Teacher's Opinion on Science Laboratory Practices. The study was carried out in Turkey [14]. The study adopted the phenomenological study design. Six research questions guided the study. The sample size consisted of 18 teachers (9 females and 9 males) working in public schools. The instrument for data collection was an in-depth interview with open-ended questions. The data obtained were evaluated by qualitative data analysis. The findings of study revealed that some teachers stated that science laboratory were not available. The teachers were forced to use in the material in the storage room to teach science. There is no responsible laboratory practice. However, the finding also revealed that safety precautionary measures such as wearing gloves and goggles were taken.

In order to carry out this investigation in line with the topic of interest, the following research questions and hypotheses guided the study.

Research Questions

1. What is the percentage awareness level of safety signs among undergraduate Chemistry students?
2. What is the difference in awareness level of safety signs between undergraduate Chemistry Education students and Chemistry Science students?
3. To what extent do the awareness levels of safety signs among undergraduate Chemistry students depended on Institutional types?

Hypotheses

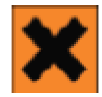
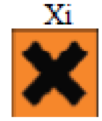
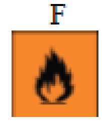
1. There is no significant difference in awareness level of safety signs between undergraduate Chemistry Education students and Chemistry Science students.
2. The awareness levels of safety signs among undergraduate Chemistry students are not significantly dependent on Institutional types.

Methodology

The study adopted analytic descriptive survey design. A total of 60 year three undergraduate students studying Chemistry Education (B.Sc. Ed) and Pure Chemistry (B.Sc.) were randomly drawn from three universities namely; University of Port Harcourt (Uniport), Rivers State University (RSU) and Ignatius Ajuru University of Education (IAUE) with each university contributing 20 students. A well validated and researchers constructed test instrument, titled, Chemistry Laboratory Test on Safety Signs (CLTSS) which had an internal reliability index of 0.94 via Cronbach Alpha was used for data collection in the study. The questions in the test required the students to match a list of 20 chemicals in column A and of nine safety signs accompanied with a short description in column B. This aimed to reduce the wrong response because the students incorrectly considered only the symbol.

In addition, to the main questions, students were also asked to state what they understand about chemical hazards and chemical safety signs. The test was administered in the initial schedule of Chemistry laboratory instruction course prior to getting started teaching and learning activities. Students took approximately 30-40 minutes to respond to the test items. Students' responses from the test were analyzed by the researcher. A correct answer which indicated students could match a chemical name with its safety sign were coded one and an incorrect answer which indicated students could not match a chemical name with its safety sign were coded zero. The relevant data collected were subjected to simple percentages, mean, standard deviation, t-test and analysis of variance (One-way ANOVA) as statistical tools. An example of the test sheet is as shown in Table 2.

Table 2: Test instrument for the investigation

Item	Column A	Answer		Column B
A	Toluene	....		T
B	Hydrochloric acid	....	1	 Toxic
C	Chlorine water	....		Xn
D	Colloid suspension of polychloroprene	....	2	 Harmful
E	Styrene	....		C
F	Oils and greases	....	3	 Corrosive
G	Ammonium hydroxide	....		Xi
H	Methyl ethyl ketone	....	4	 Irritating
I	Turpentine	....		E
J	Sodium hydroxide	....	5	 Explosive
K	Epoxy resin	....		O
L	Trichloroethylene	....	6	 Oxidative
M	Hydrogen peroxide	....		F
N	Dichlorodifluoromethane	....	7	 Flammable
O	Phenol	....		
P	Lead oxide	....	8	No sign
Q	Sodium cyanide	....		N
R	Petrol	....	9	 Dangerous to the environment
S	Sodium chloride	....		
T	Mercury (II) fulminate	....		

Results and Discussion

Research Question 1: What is the percentage awareness level of safety signs among undergraduate Chemistry students?

The answer to this question is shown in the frequency and percent age of students' responses (e.g., correct and incorrect answer) to the 20 questions of the test as presented in Table 3. Figures in bold indicates the majority of students' responses.

Table 3: Frequency and Percentage of Students' Responses (n = 60)

Chemical names	Correct answers		Incorrect answers	
	F	(%)	f	(%)
Toluene	13	22.2	**47**	**77.8**
Hydrochloric acid	**60**	**100.0**	0	0.0
Chlorine water	7	11.1	**53**	**88.9**
Colloid suspension of polychloroprene	4	7.4	**56**	**92.6**
Styrene	20	33.3	**40**	**66.7**
Oils and greases	18	29.6	**42**	**70.4**
Ammonium hydroxide	22	37.0	**38**	**63.0**
Methyl ethyl ketone	7	11.1	**53**	**88.9**
Turpentine	4	7.4	**56**	**92.6**
Sodium hydroxide	18	29.6	**42**	**70.4**
Epoxy resin	4	7.4	**56**	**92.6**
Trichloroethylene	16	25.9	**44**	**74.1**
Hydrogen peroxide	11	18.5	**49**	**81.5**
Dichlorodifluoromethane	0	0.0	**60**	**100.0**
Phenol	0	0.0	**60**	**100.0**
Lead oxide	18	29.6	**42**	**70.4**
Sodium cyanide	**33**	**55.6**	27	44.4
Petrol	**40**	**66.7**	20	33.3
Sodium chloride	0	0.0	**100**	**100.0**
Mercury (II) fulminate	20	33.3	**40**	**66.7**

The findings in Table 3 indicated that most students were unable to match 17 chemicals (e.g., ammonium hydroxide, sodium hydroxide, and sodium chloride) with their safety sign correctly. There were only three chemicals (i.e., hydrochloric acid, sodium cyanide, and petrol) that most students were able to match with their safety sign correctly. Three of these chemicals were commonly found in laboratory school science. Surprisingly, sodium hydroxide and sodium chloride were also available in laboratory but the students misunderstood their meaning of safety sign. Most students incorrectly considered that sodium hydroxide was not corrosive. In fact, solid or solution of sodium hydroxide can cause severe burns if students contact without safety equipment such as goggles and gloves. Therefore, it should be labeled as corrosive.

Most students also incorrectly thought that sodium chloride is not dangerous to their health. This could be as result of the fact that they may be using it daily in their life, and so, are not aware of general hazard information. Actually, sodium chloride is slightly hazardous in case of skin and eye contact (irritant). Additionally, the data gather qualitatively, demonstrated that some students understood the meaning of all safety signs but they had no ideas what chemicals appropriately match to their safety signs. Moreover, they did not pay attention to safety signs labeled on containers during conducting experiments. Concerning the use of chemicals occurred when the laboratory direction was clearly explained. For these reasons mentioned above, students' awareness level of safety signs is considered low in this study.

Research Question 2: What is the difference in awareness level of safety signs between undergraduate Chemistry Education students and Chemistry Science students?

Hypotheses 1: There is no significant difference in awareness level of safety signs between undergraduate Chemistry Education students and Chemistry Science students.

To answer this research question and test the corresponding hypothesis, scores gathered on the test items as it relates to Chemistry Education (B.Sc. Ed) students and their counterpart in Chemistry Science (B.Sc.) were subjected to mean, standard deviations and t-test analysis and the result is as shown in Table 4.

Table 4: Mean, Standard Deviations and t-test of the Students' Awareness According to Programme

Programme	n	$\bar{x}$	Sd	df	t	Sig	Remark
Chemistry Education (B.Sc. Ed)	30	5.97	1.564				
				58	-.786	.435	NS
Chemistry Science (B.Sc.)	30	6.27	1.388				

NS = Not Significant, p (.435) > 0.05 level of Significance

The mean and standard deviations of Chemistry Education (B.Sc. Ed) Students and Chemistry Science (B.Sc.) Students are 5.97 (1.564) and 6.27 (1.388) respectively. This shows that there is slight difference in awareness of laboratory safety sign. However, the t-test(58) value (-.786) shows no significant difference since the p-value is greater than the chosen alpha value 0.05 level of significance, hence the stated null hypothesis is retained. The result is that, there is no significant difference in awareness level of safety signs between undergraduate Chemistry Education students and Chemistry Science students.

Research Question 3: To what extent do the awareness levels of safety signs among undergraduate Chemistry students depended on Institutional types?

Hypothesis 2: The awareness levels of safety signs among undergraduate Chemistry students are not significantly dependent on Institutional types.

To answer this research question and test the corresponding hypothesis, scores gathered on the test items as it relates to institutional types (University of Port Harcourt-Uniport, River State University-RSU and Ignatius Ajuru University of Education-IAUE) subjected to mean, standard deviations and analysis of variance (ANOVA) analysis and the result is as shown in Table 5.

Table 5: Mean, Standard Deviations and ANOVA of the Students' Awareness Level of Safety Signs According to Institution

Institutional Types	n		$\bar{x}$		Sd
Uniport	20		5.85		1.387
RSU	20		6.55		1.432
IAUE	20		5.95		1.572
Source of Variation	**SS**	**df**	**MS**	**F**	**Sig**
Between Groups	5.733	2	2.867		
				1.334	.271
Within Groups	122.450	57	2.148		
Total	128.183	59			

Table 5 shows that F (2, 57) = 1.334, p (.271) > 0.05 level of significant. That is the F-ratio is not significant statistically hence, the stated null hypothesis is retained. The result is that, the awareness levels of safety signs among undergraduate Chemistry students are not significantly dependent on Institutional types. Since, the test result was not significant, post-hoc comparisons becomes unnecessary.

Conclusion and Recommendations

The findings from this study showed that a great majority of students misunderstood the meaning of safety signs. This study provides information for further research to find out teaching strategies to improve students' understanding of safety signs. Also, this study raises a question about adjusting teaching and learning in a chemistry instruction course to promote students' awareness of safety signs. It is an important thing for teachers to do all the time in the science laboratory and should be encouraged together with enhancing scientific understanding. Consequently, the following are recommended:

1. Lecturers in the course of teaching should promote students' awareness of the proper handling, storage and disposal of hazardous materials/chemicals vis-à-vis their safety signs.
2. A comprehensive review of the program of Science teacher preparation in Universities to include continuous activities in order to increase students' awareness of the safety measures practiced in school laboratories.
3. Practical aspect of laboratory practices and first aid skills a special attention to be acquired and evaluated through the process of teaching in lectures and while making experiments.
4. Incorporating activities in the practical education study plan

to develop pre-service Science teachers' knowledge and skills in safety measures in school laboratories.
5. Designing and testing a safety skills development program in school laboratories for both students and staff.

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