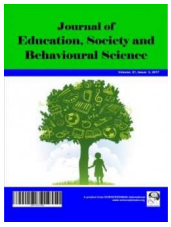

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Science Education Undergraduate Students' Level of Laboratory Safety Awareness

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Authors' contributions

This work was carried out in collaboration between both authors. Author OSO designed the study, wrote the protocol, wrote the first draft of the manuscript and managed the literature searches. Author BAE performed the statistical analysis and managed the analyses of the study. Both authors read and approved the final manuscript.

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ABSTRACT

Science faculties simply don't consider instruction in laboratory and chemical safety to be important enough to devote a whole course to the topic. This can be detrimental to the development of safety awareness among science students. Hence the need to investigate science education students' laboratory safety awareness, since the society looks up to them to impart the secondary school students with right scientific knowledge, skills and attitude. This study employed the descriptive survey design, with the aim of determining the current level of laboratory safety awareness among science education undergraduate students of Lagos State University, Nigeria. Fifty second-year science education students in the second semester of their degree program participated voluntarily in this survey. A self- developed questionnaire titled "Science Laboratory Safety Awareness Test" (SLSAT) was used for data collection. Percentages, mean frequency and t-test statistics were used to answer the research questions. The findings of this study revealed that awareness was

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demonstrated in students' responses to those questions relating to good/safe practices (96%), appropriate attire (80%) and emergency procedure (72%) by the students. However, the study revealed two important safety issues where student awareness was alarmingly lacking; clean-up of spills (38%) and recognition of laboratory signs/symbols (0%). The study also revealed that there is no significant difference in the level of safety awareness of both male and female students (t = .781, df = 48, p = .439). Based on the findings of this study, recommendations were made, among which are that science-based faculties and students should bear in mind that knowing and following safety practices are part of learning in science.

Keywords: Laboratory; safety awareness; science education; undergraduate students.

1. INTRODUCTION

Science education is a field of study concerned with producing a scientifically literate society, through laying the foundation for future work in science and science related fields by imparting the students with certain basic knowledge, skills and attitudes. A country's scientific and technological development depend largely on the type of science education available in such country (Aydoğdu, [1] in Burak, [2]). Olatoye [3] stresses that science education lays the foundation for work in science related fields by acquainting learners with certain knowledge, skills and attitudes.

Science curricula have developed over many decades with a focus on the Sciences, Technology, Engineering and Mathematics. The topic laboratory safety has been mostly taught much more in a small way as introduction in various laboratory experiments and procedures. But it is still not considered by most as "mainstream content area" of science. Many science faculties simply don't consider instruction in laboratory and chemical safety to be important enough to devote a whole course to the topic (Hill and David, [4]). This can be detrimental to the development of safety awareness among science students. Hence the need to investigate science education students' laboratory safety awareness, since the society looks up to them to impart in the secondary school students scientific knowledge, skills and attitude.

Safety perhaps, is an important prerequisite in science and science education. Having a safe and secure laboratory environment is a prime concern while conducting practical work and investigations in science. Laboratory safety is a requirement to establish conditions for meaningful science learning. This is the reason why it is expected that appropriate safety skills need to be developed in students and safety procedures observed in laboratory classes, for their own safety, the safety of others and the learning environment.

The school laboratories are essential venues for science learning. However, these laboratories are endowed with hazards which can lead to the occurrence of accidents and jeopardize the safety of all its users, especially the students (Benedict, [5]; Weigmann & Shappell, [6]). According to Hill and David [4], a hazard is a potential source of danger or harm. The word potential means something that is capable of being dangerous or harmful. Many chemicals may have inherent hazardous properties and these hazardous properties never change. The practice of safety is really about minimizing, managing, or controlling these hazards. Hence, to be safe in the laboratory or elsewhere requires four steps: Recognize hazards; assess the risks of hazards; minimize the risks of hazards and prepare for emergencies (Hill, and David, [4]).

Three factors have been identified by Geller ([7]) that contributes to safety:

(1) Environmental factors including facilities, location, equipment, procedures, and standards;
(2) Personal factors including attitude, beliefs, personality, knowledge, skills, and abilities; and
(3) Behaviour factors including safe and risky practices.

These factors are interconnected so that each factor influences others. According to him, being safe requires attention to all the three factors since they have significant influence on safety.

Osang, Obi & Ewona, [8] traced the history of laboratory users as being replete with cases of fatal accidents which occurred due to neglect, carelessness or ignorance of laboratory or workshop safety and precautions in cases of accidents. Also, according to Adedayo & Owolabi

[9], the history of science revealed that the lives of great scientists of old were cut short as a result of hazards in laboratory work. People like Liebig, Curie, Scheele, e.t.c. died young from health hazards experienced in the laboratory In a special report by Amber [10] on laboratory hazard, the following scenarios were documented:

- A research assistant died in January 2009 from burns sustained in a university chemistry laboratory in California;
- Sheharbano Sangji had worked in the laboratory for only a few months when the plunger popped out of the syringe she was using to transfer tert-butyl lithium. This ignites spontaneously in air, causing her gloves and jumper to catch fire.

Adedayo & Owolabi [9] investgated the hazards that are prevalent in a typical secondary school science laboratory and safety condition of science laboratories in Ekiti state. They reported that there are hazards in the science laboratories with little or no precaution being taken. Alaimo, Langenhan, Tanner, and Ferrenberg [11] reported that student laboratory practices and attitudes were lacking when traditional approaches to safety training were followed. These traditional methods include: introductory presentations to laboratory safety rules in the first class, weekly presentations by instructors of experiment specific safety concerns, and brief safety quizzes based on assigned readings. The authors noted that students were "bored by the litany of laboratory safety rules and brief pre-laboratory safety notes" delivered through traditional methods. Consequently, while students followed the rules regarding the use of personal protective equipment on the one hand, they often removed goggles in the lab, or wore gloves outside the laboratory. Also, Romklao [12] investigated undergraduate students' scientific understanding of laboratory safety. His findings indicated that majority of the students misunderstood the definition of chemical hazards. In addition, they experienced confusion in matching chemicals commonly found in school science laboratory (i.e., sodium hydroxide) and the meaning of chemical safety signs.

The increasing prevalence of accidents in the science laboratory calls for efficient measures to eradicate, or lessen accident occurrences. One of such measures is the development of awareness and practice of laboratory safety. Harvard University [13] emphasized, "….awareness is the most fundamental rule of safety". Hence, the provision of information on the awareness and practice of laboratory safety among students is seen as a primordial step in the attainment and maintenance of an accident-free laboratory. This study was therefore, carried out to determine the level of laboratory safety awareness among science education undergraduate students.

1.1 Research Questions

This study sought to answer the following questions:

(i) What is the current level of laboratory safety awareness among science education undergraduate students?
(ii) Will there be any significant differences between male and female students' current level of laboratory safety?

2. METHODOLOGY

The Bachelor of Science Education degree in Lagos State University, Nigeria offers specializations in three science disciplines: Biology, Chemistry, and Physics. Students can choose to specialize in any of these science disciplines. This is a four year degree with a common first year and a choice of sub-specializations in the latter three years. The degree is Education- industry focused, offers an intensive hands-on laboratory experience, provides opportunities for teaching practices during the course of the programme and, overall, prepares students for careers in the science teaching profession.

The study was a descriptive survey type of research. Fifty (50) second-year undergraduate students who enrolled for chemistry (26) and biology (24) education programme, at the Faculty of Education, Lagos State University, Nigeria, voluntarily participated in this study during the second semester of their degree programme. This survey was carried out using a multiple-choice questionnaire method. A questionnaire titled "Science Laboratory Safety Awareness Test" (SLSAT) was developed by the researchers for data collection. The SLSAT was a thirty eight- item multiple choice objective test with four options per item, meant to measure the students level of safety awareness with regard to good/safe practices, appropriate attire, emergency procedures, recognition of laboratory signs/symbols and clean-up of spills. For each of the items, participants were required to tick the

correct option, with a score of 1 for correct option and zero score for wrong option. The lowest score was one (1) for each of the safety issues tested and the highest score was seventeen (17) for good/safe practices, five (5) for appropriate attire, five (5) for emergency procedures, eight (8) for recognition of laboratory signs/symbols and three (3) for Clean-up of Spills.

The survey also asked if and where the students had studied laboratory safety rules. The SLSAT was given to two lecturers of Faculty of Science, Lagos State University for its face and content validity. SLSAT was administered on 20 undergraduates in their third year in Science and Technology Education Department in order to determine its psychometric properties. After the pilot testing, thirty-eight items were finally selected after the validation exercise. The result of the trial-out was analyzed using Kuder-Richardson formula (KR-20) to establish the reliability coefficient of the SLSAT which gave a measure of .83. The instrument was thereafter administered to the second year pre-service teachers. The data obtained were analyzed with frequency counts and the t-test.

3. RESULTS

This section is presented in two sections according to the research questions raised:

3.1 Research Question 1

(i) What is the current level of laboratory safety awareness among Science Education Undergraduate students?

With reference to Table 1, awareness was demonstrated in responses to those questions relating to good/safe practices (96%), appropriate attire (80%), emergency procedure (72%), clean-up of Spills (38%) and no awareness demonstrated in recognition of laboratory signs (0%) in the survey.

As observed on Table 2, N = 48 (*96%) of the respondents scored above 50% (i.e., 9/17 to 15/17) in safe practices. Among this 96%, it is noteworthy that only N = 1 (2%) out of the 48 participants scored 15/17 on safe practices.

Table 3 shows that N = 40 (*80%) of the respondents scored above 50% (i.e. 3/5 to 5/5) in the awareness of appropriate attire in the laboratory. This shows that a good number of the participants in this study are aware of the correct dress code in the laboratory.

Table 4 revealed that N = 36 (*72%) of the respondents scored above 50% (i.e. 3/5 to 5/5) in emergency procedures questions. Among this 72%, it is worthy to note that only N = 4 (8%) out

Table 1. Summary of level of laboratory safety awareness

S/N	Safety issue tested	Percentage level of awareness among students
1	Good/safe practices	96%
2	Appropriate attire	80%
3	Emergency procedures	72%
4	Recognition of laboratory signs/symbols	0%
5	Clean up of Spills	38%

Table 2. Response rate (in %) to questions involving good/safe practices as represented in a total of 17 items on the questionnaire. n indicates the total number of students who had specific safe practices scores

Students' safe practices scores (17)	Mean	N	% of Total N
5	10	1	2
8	16	1	2
9	18.33	3	6*
10	18.71	7	14*
11	19.50	14	28*
12	19.50	10	20*
13	23.00	10	20*
14	22.67	3	6*
15	24.00	1	2*
Total	20.04	50	100

of the 36 participants scored 5/5 on emergency procedures.

Table 5 shows the level of awareness of the participants in this study in recognition of laboratory signs/symbols. 21 (42%) could not identify correctly all the eight symbols presented in the survey. 24 (48%) was only able to identify one out of eight symbols presented, and 5 (10%) could identify just two. Thus, it is alarming to discover that *100% of the respondents are not aware of the laboratory signs and symbols.

As observed on Table 6, nineteen (*38%) of the respondents scored above 50% (i.e. 2/3 to 3/3), demonstrating an awareness in cleaning up spills during experiments in the laboratory. Twenty eight (56%) of the participants scored just 1/3 and three (6%) showed total ignorance in this regard.

3.2 Research Question 2

(ii) Will there be any significant differences between male and female students' current level of laboratory safety?

The data on Table 7 which represent the result of the t-test between two independent means shows that male respondents have better (20.53) safety knowledge than their female counterparts (19.83), however, there is no significant difference in the safety awareness of both male and female respondents ($t = .781$, $df = 48$, $p = .439$).

Table 3. Response rate (in %) to questions involving appropriate attire as represented in a total of 5 items on the questionnaire. n indicates the total number of students who had specific appropriate attire scores

Students' appropriate attire scores (5)	Mean	N	% of Total N
1	13.00	1	2.0
2	17.44	9	18.0
3	19.38	16	32.0*
4	20.68	16	32.0*
5	23.38	8	16.0*
Total	20.04	50	100

Table 4. Response rate (in %) to questions involving emergency procedures as specified in a total of 5 items on the questionnaire. n indicates the total number of students who had specific emergency procedure scores

Students' emergency procedures scores (5)	Mean	N	% of Total N
1	18.00	2	4.0
2	19.25	12	24.0
3	19.84	19	38.0*
4	20.15	13	26.0*
5	24.00	4	8.0*
Total	20.04	50	100

Table 5. Response rate (in %) to questions involving recognition of laboratory symbols/signs as represented in a total of 8 items on the questionnaire. n indicates the total number of students who had specific symbols recognition scores

Students' symbols/signs recognition scores (8)	Mean	N	% of Total N
0	18.43	21	42.0*
1	20.88	24	48.0*
2	22.80	5	10.0*
Total	20.04	50	100

Table 6. Response rate (in %) to questions involving cleaning up spills as represented in a total of 3 items on the questionnaire. n indicates the total number of students who had specific clean up spills scores

Students' clean up spills scores (3)	Mean	N	% of Total N
0	17.00	3	6.0
1	19.71	28	56.0
2	20.29	14	28.0*
3	23.00	5	10.0*
Total	20.04	50	100

Table 7. t-test for the difference between male and female students' current level of laboratory safety?

Level	N	Mean	SD	df	Sig. (2-tailed)	t-value
Male	15	20.53	2.560	48	.439	.781
Female	35	19.83	3.063			

4. DISCUSSION

4.1 Current Level of Safety Awareness

To determine the current level of student awareness with respect to laboratory safety, a survey was administered to second-year science education students in the second semester of their degree program. Fifty (50) participated voluntarily in the survey.

Forty (80%) of the students claimed not to have studied laboratory safety rules as a course or subject before entering the science education degree, but indicated that they studied safety rules either in secondary school or while obtaining other post-secondary qualifications such as Certificate in Science or Foundation Studies. Overall, students responded to the survey questions at different levels, as can be observed in Tables 2 to 6.

Awareness was demonstrated in responses to those questions relating to good/safe practices (96%), appropriate attire (80%) and emergency procedure (72%) in the survey. These findings contradicts the findings of Alaimo, Langenhan, Tanner, and Ferrenberg [11] that reported that student laboratory practices and attitudes were lacking when traditional approaches to safety training were followed. According to their study, these traditional methods include: introductory presentations to laboratory safety rules in the first class, weekly presentations by instructors of experiment specific safety concerns, and brief safety quizzes based on assigned reading. However, the present survey revealed two important safety issues where students' awareness was alarmingly lacking. In the survey, only 38% of respondents scored above 50% in questions related to cleaning up of spills. The poor responses (0%) to the recognition of laboratory signs/symbols questions are a cause of concern especially as the participating students had completed three semesters of Chemistry, Physics and Biology classes before completing the survey. This corroborates the findings of Romklao [12], who investigated Thai undergraduate students' scientific understanding of safety signs. His findings indicated that a majority of the students misunderstood the definition of chemical hazards and the meaning of chemical safety sign. These findings can be said to support Hill [14] position on the issue of students' safety training. Hill [14] points out that one of the biggest challenges of better educating students in safety is to teach them to "understand and recognize hazards" (p. 18) rather than just to follow safety rules.

5. CONCLUSION AND RECOMMENDA-TIONS

This study provided evidence that science education undergraduate students are not adequately aware of laboratory safety rules with regard to recognition of laboratory signs and symbols in the context of this study and how to respond to chemical spills.

Based on the results of this study, it was recommended that:

1) Science- based faculties should devote a whole course to laboratory safety, particularly at the first year of all science-

based courses, to remind students the importance of laboratory safety, and the general safety practice and precautions in the laboratory, with the fact that well-entrenched safety awareness and practice will keep the number of laboratory accidents to a minimum.

2) Stakeholders should bear in mind that knowing and following safe practices are part of learning in science.

CONSENT

As per international standard or university standard, consent has been collected and preserved by the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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