

Comprehension of Chemical Laboratory Safety and Hazard Warning Signs Among Chemistry and Biology Department Students in Wolaita Sodo University, Southern Ethiopia

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Abstract

Chemical accidents mostly occur due to the neglect of safety precautions or the absence of related precautionary symbols on the chemicals. The present study was aimed to assess students' comprehensibility of chemical laboratory safety and hazard warning signs among biology and chemistry department students in the Wolaita Sodo University during January to May, 2016. The total population of this study was 500 students. Sample size was determined by purposive sampling. Among the total population 72 respondents were selected to respond to the questionnaire. Data were collected using structured questionnaires and observation. The collected data were analyzed using simple quantitative analysis. The results of the study revealed that the majority (75 % and 61.11%) of the respondents were well aware with chemical laboratory safety and hazard signs of laboratory chemicals, respectively. However, the majority of the respondents (61.11% and 56.94%) were low familiarity with chemical laboratory safety and hazard signs of laboratory chemicals, respectively. Also the respondents were requested to match chemical characteristics with the corresponding hazard signs (pictograms). Only 23.61%, 15.28% and 11.1% of the respondents were able to match chemical hazard warning signs of flammable, explosive and harmful, respectively with their associated signs. The responses given to the rest of properties (oxidizing, dangerous to the environment, corrosive, radioactive, chronic health hazards and toxic) were not as such significant. The results also indicate that comprehensibility of hazard warning signs is low among the students. This necessitates organization of education / training programs to help students to get familiarized and increase their comprehensibility about chemical laboratory safety and hazard warning signs. Thus, it is recommended that warning students to follow safety rules is not sufficient and they should be educated to understand and recognize the signs in order to avoid the possible happening of chemical accidents on them and their environment.

Keywords: Laboratory safety, Hazard warning signs, Chemical labels, chemical accident

1. Introduction

Laboratories are described as secure environments with adequate experimental material where open-ended activities can be carried out; the rules to be followed are clearly defined; designed properly for both individual and cooperative studies of students [1, 2]. The culture of laboratory safety depends ultimately on the working habits of individuals and their sense of teamwork for protection of themselves, their neighbours, and the wider community and environment. Safety in the laboratory also depends on well-developed administrative structures and supports that extend beyond the laboratory's walls within the institution [3]. However, achieving the goal of balancing the economic and social benefits of chemicals with their health and environmental risks is a highly complex problem since managing the risks of chemicals is interconnected with many other issues, including wastes and pollution, global warming, resource depletion, agriculture, biotechnology, loss of biodiversity, poverty, etc [4]. Safety is an integral part of all laboratory operations but it requires that the laboratory worker consider this every time they start work [5]. Safety is, therefore, of prime importance in laboratory practices. Individuals must be informed about the risks of a laboratory environment and the necessary precautions must be taken [6-9].

Most of the laboratories in natural science fields widely use chemicals of different types and hazard levels. Chemistry and Biology are two of the fields that intensively and extensively use chemicals for laboratory classes and other experimentations. These chemicals might be organic or inorganic and may be encountered in solid, liquid or gaseous form. Moreover, these chemicals may be corrosive, explosive, irritant, flammable, harmful, oxidizing, toxic, environmentally harmful or radioactive. Those who work in laboratories must, therefore, be aware of the hazards and risks associated with chemicals. They should be aware that, for instance, acids and bases that are ordinarily used in chemical laboratories are irritants. Upon contact with the eye, skin and respiratory organs, they have a burning effect. There are several chemicals used in laboratories that are easily flammable and pose threat of fire. On the other hand, there are explosive chemicals in a laboratory, as well. If released, some chemicals can have harmful effects on human beings and the environment [10].

Chemicals are dangerous and risky. It should always be remembered that they are beneficial provided that they are used appropriately [11]. Even experienced individuals might be exposed to several hazards unless

they follow certain precautions while working in the laboratories. Students of all age groups (secondary school, high school, undergraduate or graduate degree levels) might be exposed to several hazards unless they follow certain precautions while working at laboratories [12]. Moreover, these hazardous properties (information) of chemical accidents in science laboratories that happened chemicals must be due to mishandling or misusing of chemicals [13, 14]

It is wrong to conclude that chemicals are totally hazardous or risky. They are beneficial if they are properly utilized [11]. The benefits of utilization of chemicals in different research activities and laboratory classes in science subjects of higher institutions can be considered as typical examples in this regard. Chemical accidents mostly occur due to the neglect of safety precautions or the absence of related precautionary symbols on the chemicals [15]. So as to classify chemicals and draw users' attention, each chemical should be labelled with precautionary symbols indicating its features [6]. These symbols (flammable, corrosive, irritant, environmentally harmful, radioactive, oxidizing, toxic or harmful) include different colours and images and are designed to inform users about the features of the chemicals [14]. These hazard and risk precautionary symbols must be known by everybody who enters the laboratory and knowing the meanings of these hazard symbols on chemicals aid the safe use of chemicals [16].

Ethiopia is one of those developing countries aggressively working on expansion of higher institutes to increase yearly enrolment of students in different fields including natural sciences to meet the demand of skilled, well-qualified, scientifically literates and competent educated human power [17, 18]. The current concern of the Ethiopian Education Policy is to produce quality and large number of graduates year after year in different fields of science. Moreover, the researches in the field of science widely use varieties of chemicals. In most of the higher institutes practical classes are conducted in a group of students that consisting of up to 5 students / group particularly those in undergraduate level ones. This is a worry that students could face health risks due to mishandling or misuse of chemicals or failures to understand chemical hazard signs labels) and to comply with safety measures.

In the histories' of laboratories of higher institutes of the country, there are no reports on chemical accidents. However, from our experience and preliminary observation for the study when students in their tenure on these departments, students who are more exposed with chemicals give a little attention for chemical laboratory safety and chemical hazard warning signs. The present study aimed to assess the comprehension of chemical laboratory safety and hazard warning signs among chemistry and biology department students in case of Wolaita Sodo University. The results of the study provide information about chemical laboratory safety and hazard warning sign comprehensibility of students and help the departments (Biology and Chemistry) and other science field to take correct measures as regards laboratory management.

2. Methodology of the Study

2.1. Description of the study area

The study was conducted at Wolaita Sodo University, southern Ethiopia from January to May, 2016. Wolaita Sodo University is one of the 33 public high institutions in Ethiopia located in Wolaita Sodo town, 315 km faraway from Addis Ababa capital city of Ethiopia. Currently, the university functions in three campus premises (Gandaba, Ottona and Dawuro Tarcha). The university also involved in divergent mainstreaming research & community services and has gained considerable achievements. Biology and chemistry departments are two of the eleven departments at college of natural and computational science enrolling totally 500 undergraduate (year I, year II and year III) students during the study period.

2.2. Research design

Design of a study considers as a road map/blue print of a research work through a descriptive survey method. To collect data on the participants view, standard structured questionnaire and observation were used. The questionnaire assessed the degree of agreement of the respondents with items concerning familiarity and understanding of laboratory safety rules and hazard chemical signs.

2.3. Study Population and sample size

The population for this study is undergraduate Chemistry and Biology department students of year I, II and III. The students of these departments were chosen for present study because of their frequent exposures to different chemicals of various hazard levels during their practical / experimental classes as well as conducting project works. During the present study there were 500 students in those departments. Among these students, by purposive sampling methods, 36 from each departments totally 72 students were participated in the study. The profiles of the respondents were given in (Table 1). A standard method was used to determine sample size [19].

Table 1: Profiles of respondents participated in the study

Year	Biology			Chemistry			Total respondents
	F (%)	M (%)	Total	F (%)	M (%)	Total	
I	6(8.33)	6(8.33)	12(16.67)	6(8.33)	6(8.33)	12(16.67)	24(33.34)
II	6(8.33)	6(8.33)	12(16.67)	6(8.33)	6(8.33)	12(16.67)	24(33.34)
III	6(8.33)	6(8.33)	12(16.67)	6(8.33)	6(8.33)	12(16.67)	24(33.34)
Total	18(25)	18(25)	36(50)	18(25)	18(25)	36(50)	72(100)

F=Female, M=Male, NI= No idea, Res=Responses

2.4. Data collection and analysis

A standard structured questionnaire, prepared in English, and observation checklists were used for the data collection. The questionnaire was distributed to the respondents to be filled- in immediately without any discussion among themselves. The primary data gathered were then analyzed using simple quantitative analyses such as frequency count and percentage.

3. Results And Discussion

3.1. Awareness of students about hazards of laboratory chemicals

As shown in (Table 2), the majority of respondents (61.11%) replied that they are aware of budding hazards of laboratory chemicals on them and their environment. On other hand, the small percentage of respondents (33.33 % and 5.56 %) said that they are not aware and even have no idea of hazards of these chemicals respectively on them and their environment. The data obtained from respondents revealed that totally 38.89% of students were without awareness exposure to chemicals in their tenure. Moreover, the respondents replied, through open ended question that the chemical hazard warning signs were not displayed inside the laboratory rooms as well as they were not continuously encouraged to pay attention toward potential hazards and risks of laboratory chemicals. These could attribute to their low awareness about hazards of laboratory chemicals. No significant differences were observed within departments and different year levels (I, II and III) of the respondents regarding awareness of potential hazards and risks of laboratory chemicals (Table 2). It needs further work to create awareness towards potential hazards and risks of laboratory chemicals to the students and their environment.

Table 2: The responses to the items “are you aware of hazards of laboratory chemicals?”

Res	BIOLOGY						CHEMISTRY						Total
	Year I		Year II		Year III		Year I		Year II		Year III		
	F (%)	M (%)	F (%)	M (%)	F (%)	M (%)	F (%)	M (%)	F (%)	M (%)	F (%)	M (%)	
Yes	5 (6.94)	3 (4.16)	2 (2.78)	2 (2.78)	3 (4.16)	3 (4.16)	3 (4.16)	5 (6.94)	5 (6.94)	4 (5.56)	4 (5.56)	5 (6.94)	44 (61.11)
No	1 (1.39)	1 (1.39)	4 (5.56)	4 (5.56)	3 (4.16)	3 (4.16)	2 (2.78)	0 (0.00)	1 (1.39)	2 (2.78)	2 (2.78)	1 (1.39)	24 (33.33)
NI	0 (0.00)	2 (2.78)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (1.39)	1 (1.39)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	4 (5.56)

F=Female, M=Male, NI= No idea, Res=Responses, P=0.004

3.2. Familiarity of Students with Hazard Warning Symbols of Laboratory Chemicals

The majority (56.94%) of respondents claimed that they are not familiar with hazard warning symbols of laboratory chemicals. Among 43.06% of the respondents who are familiar with hazard symbols, 27.78% and 25.00% were biology and chemistry department students, respectively. The number of year III biology department students who are not familiar with the hazard warning symbols were very low (4.06%) as compared to year I (11.12%) and year II (12.50%) students. Regarding familiarity of hazard warning signs among chemistry department students, though similar degree of familiarity was observed among all the batches in the current study, the first year and second year students showed better familiarity than the corresponding batches of biology department. However, the third year chemistry students showed less familiarity than biology department students of the same batch. This might be attributed by difference in the students' initiation to know more about the chemical hazard warning symbols and background of the respondents. Moreover, the possible reason given by those respondents for their low familiarity: they do not pay much attention to the labels of chemicals except using the chemicals for specified purposes; most of chemical hazard warning symbols are not displayed in and around the entrances of laboratory rooms; and most of the symbols are difficult to understand and remember. These findings were agreed with the results reported by Adane and Abeje [20]. There is a significant difference observed from year to year and department to department in their familiarity with chemical hazard symbols. Among the respondents the biology department students are relatively well familiar than chemistry department students (Table 3).

The finding indicated that the majority of respondents claimed that they are well aware of potential

hazards of laboratory chemicals but showed low level of familiarity with hazard warning signs. These results indicates that the direction of the necessity a lot of works to be done to help students of the institute in general and biology and chemistry students in particular to become familiar with warning symbols (signs) of laboratory chemicals in order to avoid preventable hazards of chemicals on the students and the wider environment. Students in these departments are frequently exposed to chemicals in their laboratories. Therefore, it is recommended that the signs should be displayed in the laboratories as well as cover pages of the manuals and laboratory note books to help students get familiarized with them.

Table 3: The responses to the item “are you familiar with hazard warning signs of laboratory chemicals?”

Res	BIOLOGY						CHEMISTRY						Total
	Year I		Year II		Year III		Year I		Year II		Year III		
	F (%)	M (%)	F (%)	M (%)	F (%)	M (%)	F (%)	M (%)	F (%)	M (%)	F (%)	M (%)	
Yes	2 (2.78)	2 (2.78)	2 (2.78)	1 (1.39)	5 (6.94)	4 (5.56)	3 (4.16)	2 (2.78)	3 (4.16)	2 (2.78)	2 (2.78)	3 (4.16)	31 (43.06)
No	4 (5.56)	4 (5.56)	4 (5.56)	5 (6.94)	1 (1.39)	2 (2.78)	4 (5.56)	3 (4.16)	3 (4.16)	4 (5.56)	4 (5.56)	3 (4.16)	41 (56.94)
NI	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)

F=Female, M=Male, NI= No idea, Res=Responses P=0.011

3.3. Awareness of Students with Chemical Laboratory Safety

Out of the total 72 respondent in the study, the majority (75%) of the respondent said that they are well aware with laboratory safety rules. Those respondents who were asked how they are get aware of chemical laboratory safety in open ended question said that (i) they obtained awareness from previous learning experiences in high school level courses; (ii) fresh man courses and laboratory manuals incorporated contents about laboratory safety rules; (iii) at the beginning of semester of their first experiment class, students are briefed by their instructors about laboratory safety rules to pay attention to safety precautions and to read / identify labels of chemicals before use or opening containers. On the other hand, about (25%) of respondents claimed that they are not well aware with the Laboratory safety rules.

Table 4: The responses to an item “are you aware with the laboratory safety rules?”

Res	BIOLOGY						CHEMISTRY						Total
	Year I		Year II		Year III		Year I		Year II		Year III		
	F (%)	M (%)	F (%)	M (%)	F (%)	M (%)	F (%)	M (%)	F (%)	M (%)	F (%)	M (%)	
Yes	5 (6.94)	5 (6.94)	4 (5.56)	4 (5.56)	3 (4.16)	5 (6.94)	4 (5.56)	5 (6.94)	6 (8.33)	5 (6.94)	5 (6.94)	3 (4.16)	54 (75.00)
No	1 (1.39)	1 (1.39)	2 (2.78)	2 (2.78)	3 (4.16)	1 (1.39)	2 (2.78)	1 (1.39)	0 (0.00)	1 (1.39)	1 (1.39)	3 (4.16)	18 (25.00)
NI	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)

F=Female, M=Male, NI= No idea, Res=Responses, P=0.053

3.4. Familiarity of Students with Laboratory Attire and Personal Protective Equipments (PPE)

When the respondents were asked about their familiarity with laboratory attire and personal protective equipments, majority (80.55%) of the respondents claimed that they are not familiar with laboratory attires and personal protective equipments (Table 5). During the observation made to collect the information for the present study, it was observed that majority of students conducting their tenure without laboratory attires and personal protective equipments, which is an indication for their low familiarity of laboratory attire and personal protective equipments (PPE). There is also no significant difference among students of the two departments and duration of stay in the university with regard to familiarity of students with laboratory attire and PPE. On the other hand, a small percentage of students who participated in the study (19.45 %) said that they are well familiar with laboratory attire and PPE.

The finding indicated that the majority of respondents claimed that they are well aware of chemical laboratory safety but showed low level of familiarity in chemical laboratory safety, laboratory attire and PPE. Since it is difficult to anticipate the happening of chemical accidents in laboratories, the departments and instructors as well as technical assistances should take the initiative to enforce student to use or develop the habit of using these equipments and encouraging students to feel responsibility to their safety and strictly follow safety rules. This can be done using different approaches such as (i) use of computer game-based training and safety-related visual aids that have been found to be equally effective with that of safety briefing at the beginning of each semester or laboratory session in communicating science safety to students and other visual aids [21,22];

and (ii) the instructors are expected to be good role models in following safety procedures as this has a significant impact on the students' attitude to develop safety behavior[23].

Table 5: The responses to an item “are you appropriately using laboratory attire and personal protective equipments while performing experiments?”

Res	BIOLOGY						CHEMISTRY						Total
	Year I		Year II		Year III		Year I		Year II		Year III		
	F (%)	M (%)	F (%)	M (%)	F (%)	M (%)	F (%)	M (%)	F (%)	M (%)	F (%)	M (%)	
Yes	1 (1.39)	1 (1.39)	2 (2.78)	1 (1.39)	3 (4.16)	1 (1.39)	1 (1.39)	1 (1.39)	1 (1.39)	0 (0.00)	2 (2.78)	0 (0.00)	14 (19.44)
No	3 (4.16)	3 (4.16)	3 (4.16)	4 (5.56)	2 (2.78)	4 (5.56)	3 (4.16)	5 (6.94)	4 (5.56)	5 (6.94)	3 (4.16)	5 (6.94)	44 (61.11)
NI	2 (2.78)	2 (2.78)	1 (1.39)	1 (1.39)	1 (1.39)	1 (1.39)	2 (2.78)	0 (0.00)	1 (1.39)	1 (1.39)	1 (1.39)	1 (1.39)	14 (19.44)

F=Female, M=Male, NI= No idea, Res=Responses, P=0.678

3.5. Students' Ability to Comprehend Hazard Warning Symbols of Chemicals

The student respondents were requested to match chemicals characteristics with the corresponding labels or pictograms in order to evaluate their knowledge of hazard warning signs of commonly used laboratory chemicals. The properties of the laboratory chemicals presented to the students were flammable, oxidizing, harmful, dangerous to the environment, corrosive, radioactive, chronic health hazards, explosive and toxic. They were provided a matching item asking them to match each these properties with the correct signs (pictograms). As shown on (Fig 1) only 23.61 %, 15.28% and 11.1% of the respondents were able to match (comprehension) towards chemical hazard warning signs of flammable, explosive and harmful, respectively. These properties, with the highest percentage of matched answers, suggest that the student respondents have low level of understanding of chemical hazard warning signs. This finding supports the result of Adane and Abeje [20] that only 26.5%, 6.02% and 8.43% of the respondents were able to correctly match flammable, explosive and harmful, respectively, with their associated signs. Furthermore, in the present study the number of respondents who were able to match the rest of the properties with the corresponding symbols/labels was not as such significant (Fig2). The data obtained from our study also indicated no significant differences among students of the two departments and duration of stay in the university with regard to comprehension of warning signs of laboratory chemicals.

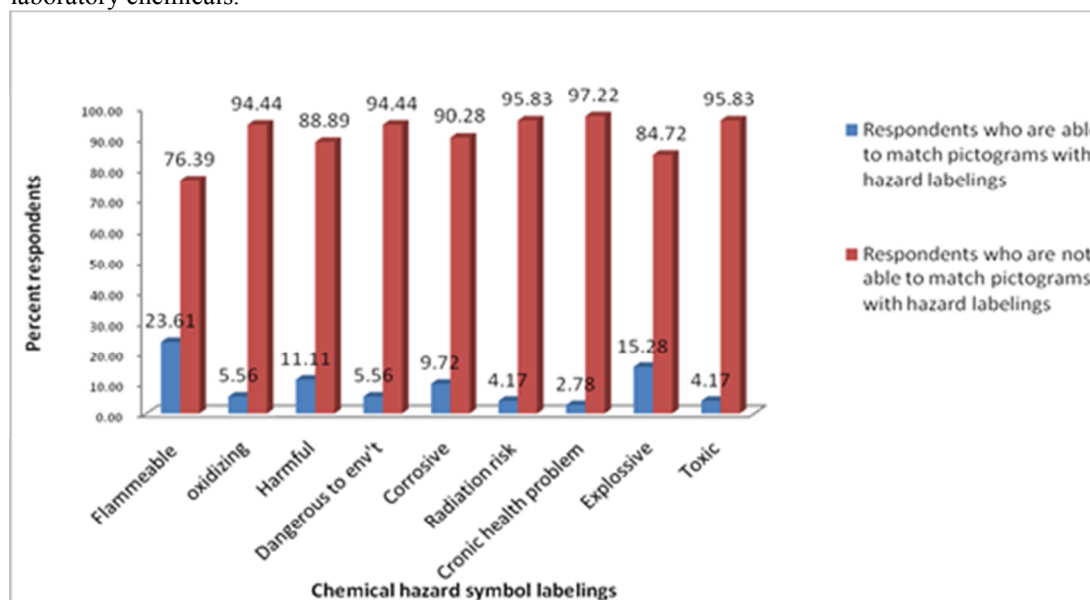


Figure1: Degree of matching hazard symbols with corresponding pictograms

3.6. Preferred ways to communicate effectively the potential hazards and risks of laboratory chemicals

The respondents' were requested their knowledge about Preferred ways to communicate effectively the potential hazards and risks of laboratory chemicals. The data obtained from the respondent indicated that majority of the respondents a combination of color and symbol (44.44%), symbols (29.17%), and color (23.61%) respectively, can be considered as better ways to communicate information about possible hazards of laboratory chemicals. This finding is consistent with the data obtained by Adane and Abeje [20] and Lunar *et al.*[24] that single color

or symbol alone are not sufficient enough to serve its purpose as the combination of such would more likely increase understanding and comprehensibility among students.

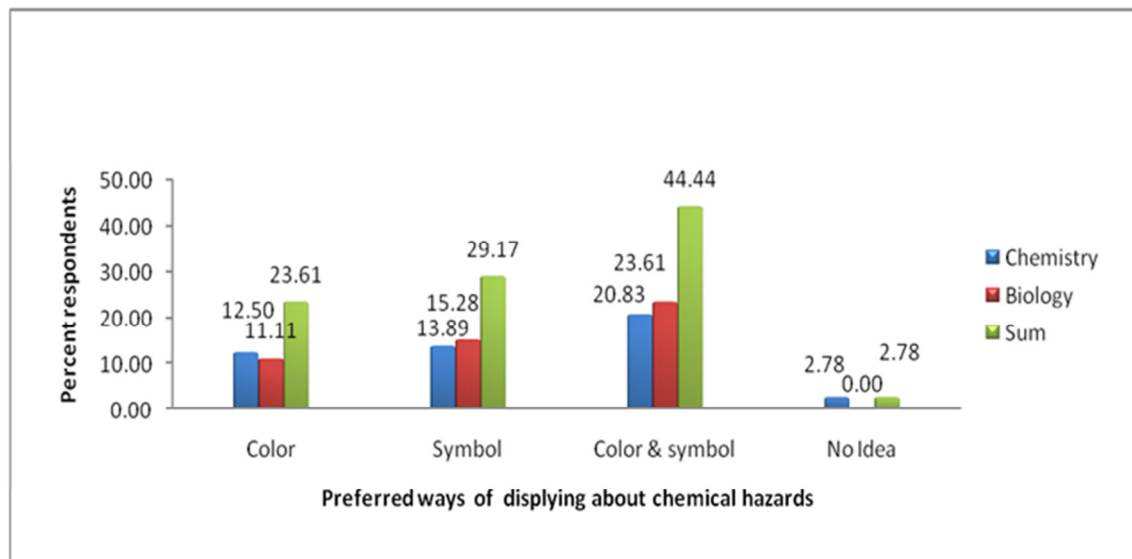


Fig.2: Preferred ways of getting information about hazards of laboratory chemicals

4. Conclusion

The present study is carried out to assess the comprehension of chemical laboratory safety and chemical hazard warning signs among the chemistry and biology department students in case of Wolaita Sodo University, Ethiopia. The result indicated that despite they claimed saying they have good awareness about chemical laboratory safety and hazards of laboratory chemicals, majority of respondents were not familiar with chemical laboratory safety, hazard signs and background colors of these signs. Moreover, only very few students were able to match hazard names with the corresponding signs (symbols).

The main reasons mentioned by the respondents for the observed low familiarity in laboratory safety and hazard sign were: chemical hazard signs were not displayed in the laboratories; students themselves are not paying attention to chemical laboratory safety; they are not paying attention for a few displayed symbols on the chemical containers about hazard chemical signs and safety precautions; orientations are not common in these laboratories to raise awareness of students and difficulties of these symbols to be remembered.

Further study is also needed to discover other important factors responsible for low level of familiarity and comprehension of chemical laboratory safety and hazard chemical signs. Thus, the departments and other concerned bodies of the university should take corrective actions to address these issues (problems). This would help to avoid possible happening of chemical hazards due to mishandling of laboratory chemicals not only in the chemistry and biology departments but also in other departments where chemicals are extensively used.

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