

Chemical Safety Awareness for Undergraduate Analytical Chemistry Students: A Case Study at Baghdad University, Republic of Iraq

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Abstract

The objective of this study was to assess the chemical safety awareness for undergraduate analytical chemistry students. Data were collected from years one (First year) and four (final year) students in February 2018 using structured questionnaires (Multiple choices) designed for this purpose with chemical safety in mind, e.g. hazard warning symbols (signs), first aid, Material Safety Data Sheets (MSDS), waste handling and the use of safety equipment. The results of the study revealed that year four students have an average grade of below average (%51.1) which is significantly low and not encouraging compare to year one students who have an average grade of good (%79.2). Results of this study also showed that there isn't much noticeable difference between female students' average grades than their male colleagues. Based on the results of this study, researchers recommend that year four student should get some sort of chemical safety training or asked to complete a chemical safety course prior to their graduation in order to avoid the possible happening of chemical accidents on them, their future work colleagues' and the environment.

Keywords: Analytical Chemistry, Laboratory Safety, Hazard Warning Signs, MSDS, Iraq.

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INTRODUCTION

Many analytical chemistry graduates go on to work in analytical laboratories as analysts, analytical chemists for example in industry, academia, and government. They must take responsibility of experimental work and risks involved with it as well as being able to deal with the increasing regulatory actions designed to minimize hazardous situations on a day to day basis as part of their responsibilities.

Chemistry laboratories can have more hazardous than any other science laboratories [1]. According to National Research Council, "the new culture of laboratory safety implements the priority of 'safety first' through a greatly increased emphasis on experiment planning" [2]. Therefore, safety must be instilled early with students and developed continually throughout their course of study as it can have a big impact on all members of the laboratory community. Safety education in chemistry in some universities has been delegated primarily to a few regulatory documents at the beginning of a laboratory course, or an occasional

warning in the description of a specific experiment. Moreover, safety issues are rarely raised in lecture-based chemistry courses.

It is so important for chemistry students to get more involved in laboratory classes as this will help them understand complex theories and principles of chemistry courses. These classes will surely motivate students to develop scientific attitude toward research and offer opportunities for them to learn how to handle chemicals safely and gain experience in using chemical apparatus and also to develop ranges of skills in chemistry knowledge and conceptual understanding [3, 4]. All the facts mentioned above indicate that laboratory classes are integral and essential components of chemistry at higher education level [5].

It is well understood that Chemistry is the field that intensively and extensively uses chemicals for practical laboratory classes and experiments. These chemicals can be inorganic or organic in their natures and could be in the form of gases, liquids or solids. Moreover, they could be corrosive, explosive, easily

oxidizing, flammable, harmful, irritating, radioactive or toxic to human being and also pollute environment [6]. Thus, employees working in these laboratories are highly exposed to many types chemicals with high risk compare to people working elsewhere.

Accidents due to laboratory chemicals are highly likely in the case of employees and students who are not well aware of the risks associated with the majority of chemicals in their laboratories. Even very experienced laboratories staff may be at risk, if they don't follow proper safety precautions while working with hazardous chemicals [7].

Hazard and risk warning signs (labels) of chemicals are something that anyone entering in to laboratories should be familiar with. They are commonly assigned to each chemical in order to draw the attention of users and to classify chemicals according to their characteristics [8, 9].

Lack of proper chemical warning signs (labels) of the chemicals in use and neglectation of safety precautions can be considered the main causes of most accidents happen in analytical chemistry laboratories [8]. This indicates that knowledge of potential hazards and risks of chemicals and understanding their labels would help to make correct choices and safe utilization and handling of chemicals.

According to the American Chemical Society ACS which is the accreditation body for all chemistry programmes in the United States of America, "Approved chemistry programs should promote a safety-conscious culture in which students understand the concepts of safe laboratory practices and how to apply them. Programs should train students in the aspects of modern chemical safety appropriate to their educational level and scientific needs. A high degree of safety awareness should begin during the first laboratory course, and both classroom and laboratory discussions must stress safe practices. Students should understand responsible disposal techniques, understand and comply with safety regulations, understand and use material safety data sheets (MSDS), recognize and minimize potential chemical and physical hazards in the laboratory, and know how to handle laboratory emergencies effectively" [10].

The objective of this study was to assess the understanding of undergraduates' analytical chemistry students of laboratory safety at Baghdad University as the graduates of this department can work in various agricultural, medical and industrial fields and serve their country in many governmental establishments like ministry of oil, ministry of industry, ministry of health and ministry of environment etc. To the best of our knowledge, there are no similar studies in the university and other universities and colleges of the country. These facts prompted us to carry out the present study. The results of the study would (i) provide information about understanding of undergraduate chemistry students of laboratory safety; (ii) help chemistry departments at all Iraqi universities to take correct measures (if there are gaps or problems) in understanding laboratory safety; (iii) serve as a baseline for other researchers who want to conduct similar studies and finally (iv) promote safety culture amongst academic staff, university management and undergraduate analytical chemistry students.

EXPERIMENTAL

The study was conducted at Baghdad University, Baghdad, Iraq, and March 2017. Baghdad University is the largest and oldest university of the country's 35 public universities. The College of Science was established on 27/3/1949, as a part of the college of Arts and science. The department of chemistry is one of eight departments and was founded with the establishment of the College of Science in 1949 and currently enrolling about 150 undergraduate students per year. The department established central laboratory containing advanced research equipment's and well qualified staff to carry out various laboratorial works for postgraduate students and other relevant institutions [11].

The population of this study were undergraduate's chemistry students. The number of students who participated in this study were 65 students of first year (total number is 105) and 60 students of 4th year (total number is 80). A structured multiple choices questionnaire designed with chemical safety in mind, e.g. hazard signs, first aid, MSDS's, the use of safety equipment and waste handling, prepared in English and translated to Arabic language was used for the data collection. The profile of the respondents is given in Table 1. Analysis of the collected data was carried out using simple quantitative analysis.

Table-1: Profile of respondents participated in this study.

Year	No. of Female Students	No. of Male Students	No. of Unspecified Students	Total No. of Students
1 st Year	28	10	27	65
4 th Year	33	27	-	60

RESULTS AND DISCUSSION

One should expect that final year undergraduate chemistry students to achieve a superior

grade to their junior first year undergraduate students in a basic chemical safety test as senior students usually have more laboratory experiences from attending more practical classes. This however wasn't the case in the

results of this study. Surprisingly results showed that the average grade for final year students was (%51.1) compare to (%79.2) achieved by first year students (Figure 1). When investigated, the better average grade

achieved by first year students was found to be due to the introducing of new course titled “Chemical Safety” in the academic year 2015 /2016 in which year 4th year students didn’t have the chance to take.

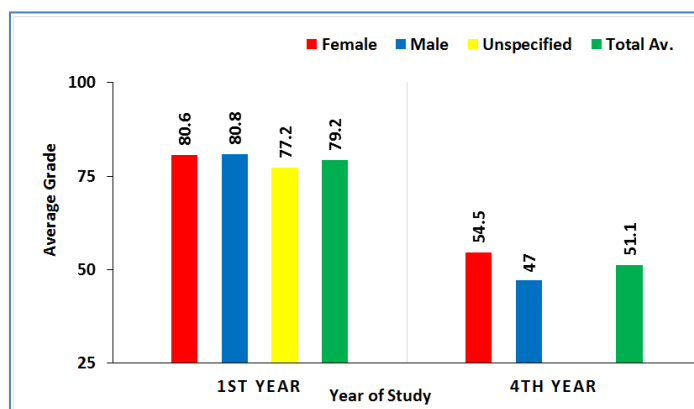


Fig-1: Shows average grade per year for undergraduate's chemistry students in Science College at Baghdad University for the academic year 2017/2018

Profile of grades achieved by both 1st year and 4th year students is shown in Table 2. No significant differences were observed in grades achieved by girls or

boys in both years were noted. Figures 2 and 3 show grades achieve by both first year and fourth year undergraduates' students respectively.

Table-2: Profile of grades achieved by first year and fourth year students in Science College at Baghdad University for the academic year 2017/2018.

Year	Students	No. of Students Achieved Grades									Avg. Grade per Student Gender	Avg. Grade per year
		Less than %20	%20 - 29	%30 - 39	%40 - 49	%50 - 59	%60 - 69	%70 - 79	%80 - 89	%90 - 100		
1 st Year	Female			1		1	2	2	18	4	80.6	79.2
	Male						1	2	6	1	80.8	
	Unspecified					2	4	7	13	1	77.2	
4 th Year	Female	2	1	1	6	6	12	4	1		54.5	51.1
	Male	4	1	2	6	2	8	4			47.0	

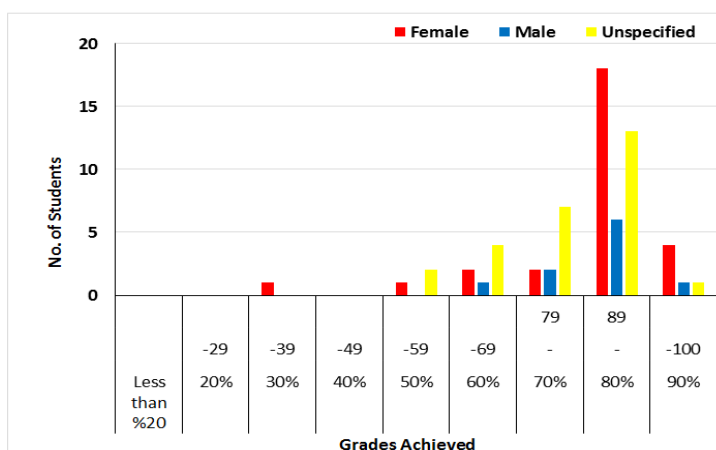


Fig-2: Shows Grades achieved by first year undergraduates' chemistry students in Science College at Baghdad University for the academic year 2017/2018

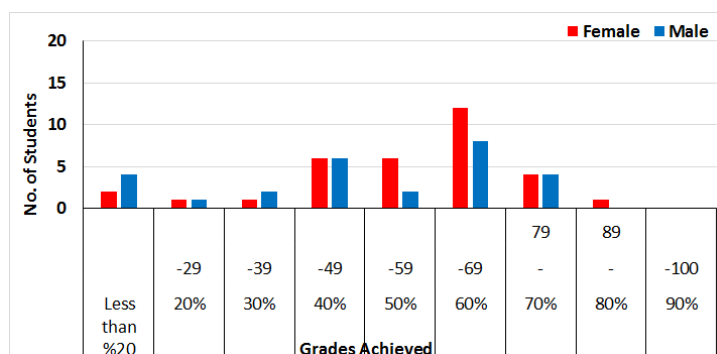


Fig-3: Shows Grades achieved by fourth year undergraduates' students in Science College at Baghdad University for the academic year 2017/2018

The unacceptable grades achieved by final year undergraduate chemistry students has attempted the researchers to analyze their answers in more details in order to learn about the level of their understanding of laboratory safety as they only few months away from graduation.

Worst correct answers percentage was achieved by year four students when asked if “they should use pipette by mouth”, only %3.3 answered this question correctly!





Other examples of low percentage of correct answers by year four students when asked “Are there any conditions under which a student may work alone in the laboratory?” and “If you catch on fire, you should:” were %18.3 and %26.7 respectively.






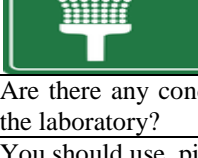
The highest correct answers percentage amongst year four students regarding identifying

laboratory safety symbols were noted for Flammable sign (%85) and Explosive sign (%75) while the worst percentage were for Oxidizing sign (%25), Hot Surface sign (%25), Environmental Hazard sign (%26.7) and Biohazard sign (%26.7). This can be explained by the fact that symbols are not well displayed in and around laboratories or are not well referred to through practical sessions. Therefore, hazard symbols understanding of the students may be enhanced through; (i) chemical safety and hazard symbols quizzes (ii) training through organizing group discussions at a regular basis; and (iii) displaying the internationally adopted symbols and relevant information as well as posters showing chemical accidents.

All correct answers percentage for each safety symbol/question answered by year four undergraduate's students is shown in Table 3.

Table-3: Percentage of correct answers for year four undergraduates' chemistry students

No.	Safety Symbols/Questions	Percentage of Correct Answers
1		85.0
2		60.0
3		75.0
4		50.0

5		50.0
6		26.7
7		25.0
8		26.7
9		25.0
10		71.7
11	Are there any conditions under which a student may work alone in the laboratory?	18.3
12	You should use pipette by mouth:	3.3
13	When diluting an acid with water:	75.0
14	If you catch on fire, you should:	26.7
15	There is a container on the lab bench containing some unknown chemical. You should:	58.3
16	You see someone in your lab engaged in a safe laboratory practice. You should:	76.7
17	If you do not understand a direction or part of a lab procedure, you should:	43.3
18	You are heating a substance in a test tube. Always point the open end of the tube:	83.3
19	Working in the lab is making you severely thirsty, you should:	76.7
20	You spill a little acid on your hand. You should:	53.3
21	When disposing of chemicals, it is appropriate to:	40.0
22	Before using gloves for protection, one should check them for:	41.7
23	Compressed gas cylinders must have a cap in place before being transported.	75.0
24	A fume hood is used:	31.7
25	When should you look up a chemical's MSDS?	36.7

CONCLUSION AND RECOMMENDATIONS

This study was conducted on first and final year undergraduate's chemistry students of Science College at Baghdad University to assess their understanding of laboratory safety. Results indicated that despite the good effort taken by the chemistry department through introducing a new course titled

"Chemical Safety" which greatly helped first year undergraduate's students still much to be done especially for final year undergraduate's students who are few months away from graduation.

The researchers, however, strongly recommend that year four student should get some sort

of chemical safety training or asked to complete a chemical safety course introduced by the chemistry department in Science college at Baghdad University prior to their graduation in order to avoid any possible happening of chemical accidents on them and the environment.

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