International Journal of the Malay World and Civilisation 6(Special Issue 1), 2018: 11 - 16
(https://doi.org/10.17576/jatma-2018-06SI1-02)

Chemical Safety in School Laboratories Located In Urban and Rural Areas: A Case Study in Cameron Highlands, Malaysia

Keselamatan Makmal Kimia Sekolah di Bandar dan Luar Bandar: Satu Kajian Kes di Cameron Highlands, Malaysia

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ABSTRACT

School laboratory is one of the important facilities in enhancing teaching and learning particularly for science related subjects. Once students learned about science theories in the classroom, they can apply what they have learned by setting up relevant experiment in the school laboratories. However, potential risks occur in the laboratories, especially when dealing with chemicals. As this is unavoidable, hence, safety measures such as good ventilation system, personal protective equipment, emergency response plans are in place to safeguard the users and the environment. Nonetheless, existing safety measures in schools might vary among each other. A project was embarked to investigate if there have differences between secondary schools located in urban and rural areas, particularly on existing safety measures in laboratories, practices and awareness of students. This paper presents the preliminary findings of three aspects in chemical safety: level of knowledge, level of practices and level of perspective among the students in urban and rural areas in Pahang. The findings indicated that there were no differences between the levels of students' knowledge, practices and perspective of chemical safety in school laboratories. Majority of the students had average level of knowledge and practices of chemical safety. The study also revealed that they not so sure about the safety aspects in school laboratory. The findings from this study provide basic information for teaching and learning to enhance the knowledge and practice of chemical safety in school laboratories by taking considerations from students' perspective.

Keywords: Chemical safety; school laboratories; knowledge; practices; perspectives

ABSTRAK

Makmal sekolah adalah salah satu kemudahan penting dalam meningkatkan pengajaran dan pembelajaran terutamanya untuk mata pelajaran berkaitan sains. Apabila pelajar mempelajari teori sains di dalam bilik darjah, mereka boleh menggunakan apa yang telah mereka pelajari dengan membuat eksperimen yang relevan di makmal sekolah. Walau bagaimanapun, terdapat risiko yang berpotensi akan berlaku di dalam makmal, terutamanya apabila berurusan dengan bahan kimia. Memandangkan terdapat resiko yang tidak dapat dielakkan, dengan itu, langkah-langkah keselamatan seperti sistem pengalihudaraan yang baik, peralatan perlindungan peribadi, pelan tindak balas kecemasan disediakan untuk melindungi pengguna dan alam sekitar. Walau bagaimanapun, langkah keselamatan yang ada di sekolah mungkin berbeza antara satu sama lain. Satu kajian telah dibuat untuk menyiasat jika terdapat perbezaan di antara sekolah menengah yang terletak di kawasan bandar dan luar bandar, terutamanya mengenai langkah-langkah keselamatan yang sedia ada dalam makmal seperti amalan dan kesedaran pelajar. Makalah ini membentangkan penemuan awal tiga aspek dalam keselamatan kimia: tahap pengetahuan, tahap amalan dan tahap perspektif di kalangan pelajar di bandar dan luar bandar di Pahang. Penemuan menunjukkan bahawa tiada perbezaan antara tahap pengetahuan pelajar, amalan dan perspektif keselamatan kimia di makmal sekolah. Kebanyakan pelajar mempunyai tahap pengetahuan dan amalan keselamatan kimia yang tinggi. Kajian itu juga mendedahkan bahawa mereka tidak begitu yakin mengenai aspek keselamatan di makmal sekolah. Penemuan dari kajian ini memberikan maklumat asas untuk pengajaran dan pembelajaran untuk meningkatkan pengetahuan dan amalan keselamatan kimia di makmal sekolah dengan mengambil pertimbangan dari perspektif pelajar.

Kata kunci: Keselamatan kimia; makmal sekolah; pengetahuan; amalan; perspektif

INTRODUCTION

In the education system, laboratories are one of the school facilities used by teachers and students, particularly during teaching and learning of science subjects. Students practice theories they have learned in the classroom via conducting experiments in the laboratories. This is one of the important ways

to develop the scientific skills of the students in science. Tsung, C.W., Chi, W.L. & Mu, C.L. (2007) stated that places like experimental laboratories, testing grounds or practice factories are the arenas for student to learn skills or verify scientific theories. However, conducting experiments in laboratory are associated with risks. The risks may lead to the accident and injury to the students as well as people surroundings. Moreover, currently there are several case reported in newspaper, journal, media regarding the accident and injuries in school laboratories. Majority cases that are reported caused many levels of injuries and even deaths to the students or instructor (Tsung et al. 2007). Besides, the study by Leggett, D.J. (2012) revealed that reported data on incidents in academic chemistry laboratories indicates that the accidents rate is 10-50 times higher than that in industrial laboratories. These accidents and reports manifested the importance concerning safety issues in all high school, college, and university science curricula (Ritch, D. & Rank, J. 2001; Tsung et al. 2007).

The cause of laboratory accidents is based on various factors. These factors normally come from the individuals, behaviour, equipment etc. Each individual conducting experiment in laboratory must have basic knowledge on laboratory safety to avoid any undesired circumstances. For example, experiments involving hazardous volatile chemicals should be carried out in fume hood. It is also the responsibility of teacher and laboratory assistant to inform students all precautionary measures before and during students conducting their experiments. Besides that, if the laboratory users are lack of knowledge, tendency of the accidents to happen is high. For example Sarquis, M. (2003) that high school teachers have indicated that they were not getting adequate safety education training that enable them to effectively manage a teaching laboratory or stockroom or to prepare their student to safely conduct experiments. Herrington, D.G. & Nakhleh, M.B. (2003) in their studies revealed that in enhancing laboratory safety, both students and teaching assistant must have sufficient knowledge, particularly on laboratory procedures, techniques and safety measures.

In addition, one's behaviour can also become cause of failure to a system. If someone already has basic of knowledge about the safety measures, hence they will follow the rules and safety procedures in the laboratory. However, the main problem is the failure of student to obey safety rules in laboratory, which often causes the accidents to happen. Behaviour of the laboratory users ignoring safety rules in laboratory might lead to accident. For example, the tragic incident that happened in December 2008 in the laboratory in University of California, Los Angeles where a research assistant experienced almost the entire body burns when conducting experiments using chemical sensitive to air and he died 18 days after the incident. According to the reports, he was not wearing a lab coat when handling experiments (Noorden 2011). If the research assistant put on lab coat on when conducting the experiment, the possibility of fatal incident will not going to happen.

Apart from that, laboratory infrastructure is also an important component in enhancing laboratory safety. School laboratory's infrastructure refers to all facilities, equipment and materials available in school laboratories. Good infrastructure management makes the process of teaching and learning in science laboratory work efficiently and safely. Therefore, it is important to ensure all infrastructures available in their school laboratory are in good condition and safe to use. Hence, periodic inspection is one of the important control measures to ensure all facilities are in good condition and safe to use. For example, if there are chemicals that has expired and equipment that cannot be used were found during periodic inspection, laboratory assistants should report to the management for further action. Eguana, et al., (2011) reported that an accident occurred in Metro Manila when wall-mounted storage shelves collapsed and it was reported that the shelves contained various acids, ammonia, sulphur and even mercuric oxide. These kinds of accidents can be avoided if the storage shelves are well managed. Nurzatulshima Kamarudin & Lilia Halim (2011) emphasizes that management of equipment and materials in laboratory is important where it covers the planning, conducting, directing, monitoring and control.

Every problem that occurred needs to be addressed so that it does not get worse and thus disable the actual function of laboratory. There are some suggestions on how to improve laboratory safety and one of it is through financial support. However, throughout the years this approach is not very effective. Tsung, et al., (2007) discover that many organization have tried to improve workplace safety by providing additional financial resources but at the end they realized that it is not very effective to solve the problem that are related

to behaviour and management. On the other hand, Carder, B. & Ragan, P.W. (2003) used the incidents rate in evaluating safety system revealed that the incident rate is not always useful for process improvement because the cause of incident could not be identified. Due to that, researchers recommended that perception survey is an important tool in evaluating safety programs and improving safety performance by providing solutions to the problems (Petersen, D. 2005; Tsung et al. 2007).

This study focused on chemical safety in school laboratory based on the knowledge, practices and perspectives among the students located in urban and rural areas. The researchers anticipated same level of understanding in chemical safety between students located in urban and rural areas as all schools received the same directives from Ministry of Education.

METHOD

RESEARCH OBJECTIVES

Objective of the study is to identify and compare understanding of chemical safety in school laboratory based on the knowledge, practices and perspectives among the students located in urban and rural areas.

RESPONDENTS

Two secondary schools in Pahang, which located in urban and rural areas, were selected. Respondents of the survey were science students from both schools.

SURVEY INSTRUMENT

This survey was carried out using a multiple-choice questionnaire method. The questionnaire item used in this study was designed to ask about the matters regarding safety aspect in school laboratories such as work procedure, equipment, handling experiment, waste management and emergency response. All the items were based on the chemistry textbook. Questionnaire has been divided into four parts, namely Part A for the demography questions; Part B contains the chemical safety questions related to students' understanding; Part C questions are about students' practice in chemical safety; and Part D contains questions pertaining to students' perspective related to chemical safety. In total, there are 82 questions in the questionnaire.

DATA COLLECTION

The survey questionnaire was administered during the teaching and learning activities. Respondent took approximately 40-45 minutes to complete the questionnaire.

DATA ANALYSIS

Student's responses from the questionnaire were analysed by the researcher. For the Part B and C, a correct answer which indicated students have knowledge and practiced wisely aspect of chemical safety were coded one and an incorrect answer were coded zero. For Part D, subjects rated items were using a Likert scale (5-strongly agree, 4-agree, 3-not sure, 2-not agree, 1-strongly not agree). Then, the score were transforming into awareness and lack of awareness on chemical safety. The frequency, percentage and mean score of students' responses were calculated.

RESULT AND DISCUSSION

STUDENT'S KNOWLEDGE IN CHEMICAL SAFETY

Data from the administration of the questionnaire showed that most of the students from urban and rural area had average scores with a mean of knowledge respectively (i.e. 0.68). This implies that students can correctly answer most of the questions. Mean score indicates that the level of knowledge of secondary school students in urban and rural areas is the same. However, there are few questions that majority of urban and rural students could not answer correctly. Analysis of these questions is shown in Table 1.

TABLE 1. Student's knowledge in chemical safety

List of items	Urban area				Rural area			
	Correct answer		Incorrect answer		Correct answer		Incorrect answer	
	f	(%)	f	(%)	f	(%)	f	(%)
Apparatus and equipment of the experiment can be placed on top of the cabinet/ cupboard.	28	27.5	**74**	**72.5**	45	45.5	**55**	**54.5**
In the science laboratory, safety glasses (goggle) and laboratory coat are provided	16	15.7	**86**	**84.3**	24	28.8	**77**	**76.2**
The molten Naftalena ($C^{10}H^8$) cannot be thrown into the sink, as it will form clog in the sink. Therefore, for other molten chemicals, which will not form clog in the sink, they can be thrown into the sink directly.	34	33.3	**68**	**66.7**	49	48.5	**52**	**51.5**
I know how to use "eyewash station" (showers/ eye wash).	21	20.6	**81**	**79.4**	18	17.8	**83**	**82.2**

The results indicated that most of the student did not know that apparatus and equipment of the experiment could not be placed on the top of cabinet or cupboard. This is to avoid items fall from the top of cabinet and injured people who are nearby. All of these items should be placed inside cabinet or cupboard. In addition, students are also not aware that the school must provide goggle and a laboratory coat to students while they are handling the experiment. They also are not aware that cannot be discharge via the sink. Most of the students did not know how to use eye washer and most likely this is due to the absent of eye washer in the laboratory.

STUDENT'S PRACTICES RELATED TO CHEMICAL SAFETY

Based on the result, it shows that the level of practice related to chemical safety between the students from urban area and rural area are almost the same, i.e. 0.76 (urban area) and 0.75 (rural area). However, there are two questions that majority of urban and rural students could not answer correctly. Analysis of these questions is shown in Table 2.

TABLE 2. Student's practices related to chemical safety

List of items	Urban area				Rural area			
	Correct answer		Incorrect answer		Correct answer		Incorrect answer	
	f	(%)	f	(%)	f	(%)	f	(%)
I wear safety glasses (goggle) and gloves when handling alkaline metals	40	39.2	**62**	**60.8**	43	42.6	**58**	**57.4**
I wear safety glasses (goggle) and lab coat at science lab when carrying out experiments involving heating or chemicals.	16	15.7	**86**	**84.3**	25	24.8	**76**	**75.2**

The result reveals that most of the students did not wear goggle and gloves when handling alkaline metals during the experiment. In fact, most of the alkaline metals are very reactive and can cause harm to the users. In addition, students also exposed themselves to the danger when they did not wear goggle and lab coat while conducting experiments such as heating or dealing with chemicals. However, the reason for students not having goggle and lab coat might due to inadequate supplies provided by the school.

STUDENT'S PERCEPTION ON CHEMICAL SAFETY IN SCHOOL LABORATORIES

From the analysis of students' perception on chemical safety in school laboratories, it indicates that there were obviously differences perceptions among the students from urban and rural area. This is due to several reasons, which will discuss later.

TABLE 3. Student's perception on chemical safety in school laboratories

Perceptions	Urban Area		Rural Area	
	f	(%)	f	(%)
Awareness on chemical safety	**69**	**67.6**	35	34.7
Lack of awareness on chemical safety	33	32.4	**66**	**65.3**
TOTAL	102	100	101	100

This result indicated that most of the students from urban area have better perception regarding chemical safety in their school laboratories compared to the students from rural area. This is due to some reasons such as the access for the facilities and the availability of the safety program. For example, majority of the students in rural area stated that they were never briefed about emergency response techniques. Due to that, they did not know how to handle if spilled with the chemicals. Besides, from the answers that returned, the researcher recognized that most of the students from rural area had problems regarding some safety equipment in the school laboratories. For example, students not sure either their science laboratory provides safety coat laboratory and goggle with enough quantity. This situation happened probably due to the failure of the schools to provide the personal safety equipment as required. The schools should aware that this simple requirement will lead to the severe impact if its use is negligible. Additionally, the students from both areas failed to recognise the eye washer either it was provided in their science laboratory or not. It can be said that the students do not know what is eye washer because the equipment not provided by the school.

CONCLUSION AND IMPLICATION

The findings from this study showed that majority of the students had average knowledge regarding chemical safety in school laboratories. However, their practiced regarding chemical safety was better while the perspectives were average. This study provides information for the better research and find out teaching strategies to improve students' knowledge and practices of chemistry safety in school laboratories. In addition, this study provide the information regarding the perspective of the students regarding the safety aspects in their school laboratories to promote the importance of perspectives on the behalf of students' itself. It is an important thing for school administration to understand really, what the core issues of problem that facing by the students to do some action in order to enhancing the chemical safety knowledge among the students in school laboratories. With the well knowledge, then students were able to practice accordingly.

ACKNOWLEDGEMENT

The authors would like to acknowledge research grant XX-06-2012 funded by Ministry of Higher Education and research grant GGPM-2011-058 funded by Universiti Kebangsaan Malaysia.

REFERENCES

Carder, B. & Ragan, P.W. 2003. A Survey-based system for safety measurement and improvement. *Journal of Safety Research* 34: 157-165.

Eguana, M.T., Suico, M.L.S. & Lim P.J.Y. 2011. Learning to be safe: Chemical laboratory management in a developing country. *Journal of Chemical Health & Safety* 18(6): 5-7.

Herrington, D.G. & Nakhleh, M.B. 2003. What Defines Effective Chemistry Laboratory Instruction? Teaching Assistant and Student Perspectives. *Journal of Chemical Education* 80(10): 1197-1205.

Leggett, D.J. 2012. Lab-HIRA: Hazard identification and risk analysis for the chemical research laboratory. Part 2. Risk analysis of laboratory operations. *Journal of Chemical Health & Safety* 19(5): 25-36.

Noorden, R. V. 2011. A death in the lab. *Nature* 472: 270-271.

Nurzatulshima Kamarudin & Lilia Halim. 2011. Konsep Pengurusan Alatan dan Bahan Untuk Pembelajaran Sains di Makmal. *Jurnal Teknologi* 60: 65-70.

Petersen, D. 2005. Safety Improvement: Perception surveys can reveal strengths & weaknesses. *Professional Safety*: 45-48.

Ritch, D. & Rank, J. 2001. Laboratory Safety in the Biology Lab. *Journal of Bioscene* 27(3): 17-22.

Sarquis, M. 2003. Building student safety habits: Barriers and recommendations. *Journal of Chemical Health & Safety* 10(2): 10-12.

Tsung, C.W., Chi, W.L. & Mu, C.L. 2007. Safety climate in university and college laboratories: Impact of organizational and individual factors. *Journal of Safety Research* 38: 91-102.

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Received: 18 April 2017
Accepted: 09 July 2017