STRUCTURED CHEMICAL SAFETY MULTIMEDIA COURSEWARE FOR SECONDARY SCHOOLS CHEMISTRY TEACHERS

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by

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LIST OF ABBREVIATIONS

Abbreviations	Description
2D	2 Dimension
32-Bit	4 Octets
3D	3 Dimension
64-Bit	2 Octets
ACKS	Acquired Cumulative Knowledge Score
ADDIE	Analysis, Design, Development, Implementation and Evaluation
ASQ	After Scenario Questionnaire
AVI	Audio Video Interleave
CBT	Computer Based Training
CD	Compact Disk
CD-ROM	Compact Disc Read Only Memory
CHH	Chemical Hazardous to Health
CHRA	Chemical Health Risk Assessment
CSDS	Chemical Safety and Data Sheet
CSUQ	Computer System Usability Questionnaire
CUSI	Computer User Satisfaction Inventory
DOSH	Department of Occupational Safety and Health
GHS	Globally Harmonized System
ICT	Information and Communications Technology
ID	Instructional Design
IMC	Interactive Multimedia Courseware
ISD	Instructional System Design

JAKIM	Jabatan Kemajuan Islam Malaysia
JPEG	Joint Photographic Experts Group
KAFA	Kelas Pengajian Al-Quran dan Fardhu Ain
KBSM	Kurikulum Bersepadu Sekolah Menengah
KBSR	Kurikulum Bersepadu Sekolah Rendah
LC50	Lethal Concentration when 50% of test animal dies upon the concentration treatment
LD50	Lethal Dose when 50% of test animal dies upon the dose treatment
MIDI	Musical Instrument Digital Interface
MP3/MPEG-1	Moving Picture Expert Group 1
MP3/MPEG-2	Moving Picture Expert Group 2
MRK	Morrison, Ross and Kemp
MSC	Multimedia Super Corridor
MSDS	Material Safety Data Sheet
MyChemiSOS	Chemical Safety Resource for Schools Teachers in Malaysia
NA	Not Applicable
NFPA	National Fire Protection Association
NIOSH	National Institute of Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Limits
PPE	Personal Protective Equipment
PSDS	Product Safety Data Sheet
PSSUQ	Post-Study System Usability Questionnaire
PUTQ	Purdue Usability Testing Questionnaire

QUIS	Questionnaire for User Interface Satisfaction
SDS	Safety Data Sheet
SPSS	Statistical Package for the Social Sciences
STPM	Sijil Tinggi Persekolahan Malaysia
SUMI	Software Usability Measurement Inventory
TIFF	Tagged Image File Format
TLV	Threshold Limit Value
UI	User Interface
UK	United Kingdom
USA	United Stated of America
USECHH	Use and Standard of Exposure of Chemicals Hazardous to Health
USM	Universiti Sains Malaysia
WAV	Waveform Audio File Format
WMV	Windows Media Video

LIST OF SYMBOLS

Symbols	Description
%	Percentage
®	Registered
&	And
ºC	Celsius
°F	Fahrenheit
CO_2	Carbon Dioxide
O_2	Oxygen
H_2	Hydrogen
mg/m^3	Milligrams per Cubic Meter
pH	Measure of the molar concentration of hydrogen ions in the solution
M	Mean
SD	Standard Deviation

LIST OF CONFERENCE PRESENTATION

1 **Prabadevi N**, Jahangir K, Jamilah R, Amin Z, Mohd Adib O & Norita M. 2012. A Multimedia Application of Chemical Safety Resource for Schools Teachers in Malaysia (MyChemiSOS). The University-Community Engagement Conference 2012. 9 – 12 January 2012. Chiangmai, Thailand. (Abstract)

2 Jahangir K, **Prabadevi N**, Jamilah R, Amin Z, Mohd Adib O & Norita M. 2012. A Gap Analysis on the Facility for Safety at Chemistry Laboratory. The University-Community Engagement Conference 2012. 9 – 12 January 2012. Chiangmai, Thailand. (Abstract)

3 Jamilah R, Jahangir K, Norita M, Mohd Adib O, Amin Z & **Prabadevi N**. 2012. Transforming the Millennium Generation towards Safe Use of Chemicals for Sustainable Tomorrow. The University-Community Engagement Conference 2012. 9 – 12 January 2012. Chiangmai, Thailand. (Abstract)

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PERISIAN KURSUS MULTIMEDIA KESELAMATAN KIMIA YANG BERSTRUKTUR UNTUK PARA GURU KIMIA SEKOLAH MENENGAH

ABSTRAK

Perisian multimedia interaktif adalah salah satu kaedah berasaskan teknologi maklumat yang digunakan dalam pengajaran kendiri dengan ciri-ciri prihatin yang dibangunkan berdasarkan pembelajaran yang menarik dan berkesan. Kajian ini bertujuan untuk membina sebuah perisian khas untuk para guru kimia di sekolah menengah kebangsaan Malaysia bagi meningkatkan pengetahuan mereka mengenai keselamatan kimia di makmal sekolah. Dalam mencapai matlamat ini, tiga objektif telah dikenal pasti, iaitu (1) mengenali latar belakang para guru kimia, (2) mentaksir pengetahuan guru kimia berkenaan keselamatan kimia dan kemudahan untuk mengendalikan kimia berbahaya dan (3) membangunkan sebuah perisian kursus (MyChemiSOS) multimedia interaktif sehingga versi alfa untuk pendidikan keselamatan kimia di kalangan para guru kimia. Model ADDIE telah digunakan dalam membangunkan prototaip MyChemiSOS. Pengetahuan keselamatan kimia di makmal di kalangan 46 orang guru kimia dari 44 buah sekolah menengah di Kedah yang menyertai kajian ini dengan keizinan bertulis, didapati sangat lemah (61%) dan lemah (26%). Perisian MyChemiSOS telah dinilai oleh bakal pengguna dan dwi-kepakaran, dengan keputusan penilaian kebolehan sebesar 4.13±0.35 dan 5.67±0.48 masing-masing, yang menunjukan persetujuan mereka bahawa perisian kursus MyChemiSOS adalah memuaskan bagi tujuan pendidikan keselamatan kimia di kalangan para guru kimia.

Kata Kunci: Perisian kursus multimedia, Guru kimia, Keselamatan kimia, Model ADDIE

STRUCTURED CHEMICAL SAFETY MULTIMEDIA COURSEWARE FOR SECONDARY SCHOOLS CHEMISTRY TEACHERS

ABSTRACT

Interactive multimedia courseware is one of the modalities that being implemented in self-teaching with attentive features which make adult learning interesting and effectives. The study aims is to establish interactive multimedia courseware that empowers national secondary schools chemistry teachers with adequate knowledge for safe conduct of chemistry practical's by students. In achieving the aim, three specifics objectives were identified, i.e. (1) to profile chemistry teacher's background, (2) to gauge chemistry teachers' knowledge of chemical safety and knowledge of facility for handling hazardous chemical and (3) to develop an interactive multimedia courseware for chemical safety education for chemistry teachers (MyChemiSOS) up to alpha version. The ADDIE model was adapted in developing the MyChemiSOS prototype. Chemistry teachers' knowledge in chemical safety at laboratory was gauged to be very poor (61%) and poor (26%) among the 46 chemistry teachers from the 44 secondary schools in Kedah that participated in the study with informed consent. The MyChemiSOS was evaluated by double-experts and users, whereby the overall usability scores were 5.67±0.48 and 4.13±0.35 respectively, which indicate agreement of the double-experts and the users that the courseware was satisfying for the intended purpose of chemical safety education among chemistry teachers.

Keyword: Multimedia courseware, Chemistry teachers, Chemical Safety, ADDIE model

CHAPTER ONE

INTRODUCTION

1.0 Introduction

In our daily life, we often use chemical products such as soap, shampoo, toothpaste, detergent, face cream and etc. These products contain many kinds of chemical substances. These chemical substances are used to improve the quality of life without harming the environment or human health. However, some chemicals have the potential to cause harm, in certain amounts and should only be used when the potential risks are appropriately managed.

A chemical that is determined to be hazardous can be either a physical or health hazard or both in some cases. A chemical that poses a physical hazard is one which there is scientific evidence that it is a flammable, combustible or explosive material, compressed gas, organic peroxide or an oxidizer (United Nations, 2011). These are chemicals that could cause damage to the physical surroundings through fire or explosion. Health hazards arise from chemicals with significant evidence that either through brief exposure or long-term exposure can cause health effects in those that have been exposed. These hazards are not always obvious; workers may not see, feel or smell the danger. For examples, chemicals like benzene and formaldehyde, which are known cancer-causers, toxic agents like insecticides and arsenic compounds, irritants like bleaches or ammonia, corrosives like battery acid or caustic sodas and sensitizers like creosote or epoxy resins (Keller, 2013).

1.1 Background

Accidents in the chemical substances process arise mostly from human error. Preventing accidents with chemicals involve two aspects. First is knowledge and the second is the habit of safety precautions (SACL, 2003). Knowledge entails understanding the characteristics of a particular chemical substance that will be used in the experiment. The knowledge also covers information on what to do and what to avoid when handling a chemical. For example, handling of flammable and corrosive would differ due to their different physical chemistry (Brun, 2009). The most important knowledge pertinent to chemical safety is characteristics described in the Safety Data Sheet (SDS). In order to instil techniques of safe handling of chemical, it requires practicing the process of handling which best trained by allowing teachers or laboratory staff to construct the experience. The process is known as constructing knowledge (SACL, 2003).

Laboratory safety is imperative similar to any other subjects taught in the high school and it is part of the science curriculum. Everyone at school is involved, the principal, teacher, laboratory staff and student, together develop a constructive approach in creating a safe working environment in the laboratory. The enforcement of safety regulations in the science laboratory requires everyone to assume their appropriate share of responsibility. Safety and health should be an integral part of the planning, preparation and implementation of any science program. The importance of laboratory safety has been recognized for many years in the industry (Brundage & Palassis, 2006). However, educational institutions seem to be slower in adopting such safety practices and programs. Many chemicals used in school laboratories are hazardous and they need to be stored and used safely in accordance with hazardous substances regulations. In order to minimize chemical hazards at school laboratory, the school management, laboratory staff and teachers should take appropriate actions in making a safe environment for teaching and learning chemistry especially in educating awareness of chemical safety among the staff and students.

Courseware is a software package to supplement or replace traditional course activities. The courseware contains useful information on chemical safety. This proposed courseware is developed for the secondary school chemistry teachers. Some of the advantages are to provide learning which is immediately available to every teacher in 24 hours a day. There is no need to track books, asking a working colleague and it provides easy navigation and interaction throughout the attractive content. Besides that, the information provided will be useful to chemistry teachers. The information provided in courseware is more interesting and adhere to the international standard of the United Nation Global Harmonized System for Classification and Labelling of Chemicals (United Nations, 2011) and the Malaysian Occupational Safety and Health Act 514 (ILBS, 2006) compare to the books. Other than that, the chemistry teachers can watch videos related to chemical safety.

1.2 Importance and Impact

This project will make the chemistry teachers have motivation to learn and understand the chemical safety course. If they are not getting proper guideline of chemical safety, they can use this propose interactive multimedia courseware to increase their understanding because various multimedia elements are included in the system such as video and text. Other than that, adults are very pragmatic learners. They learn best when faced with actual problems that have real consequences

(Hofstein, 2004). In traditional formal education usually takes two forms, either through reading a book or listening to someone's lecture on the topic. But by using the propose courseware, the chemistry teachers only need the software and a computer where we know that each laboratory has a computer at school. It is capable of presenting true-to-life situations that learners face every day (Hofstein, 2004). According to Jahangir *et al.* (2012), preliminary discussion showed that the chemistry teachers and laboratory staff were very receptive to the idea of using multimedia in educating themselves on chemical safety, which leads to the development of Chemical Safety Resource for Schools Teachers in Malaysia (MyChemiSOS).

1.3 Problem Statement

A preliminary study conducted on chemistry teachers who are managing chemical laboratory on secondary schools showed the facility for safe handling of chemicals at school laboratory was much lacking. In addition, the chemistry teachers depending only on the printed experimental booklet as the main source of information for safety of chemical substance used in the practical session without referring to chemical safety data sheet (SDS) of the chemical substances used (Jahangir *et al.*, 2012). Up to date SDS was also not available in the chemical substance storage area. These situations fail to adhere to the minimum international standard of the United Nation Global Harmonized System for Classification and Labelling of Chemicals (United Nations, 2011) and the Malaysian Occupational Safety and Health Act 514 (ILBS, 2006). In recognition of the serious safety and health problems at the work place in Malaysia, the Occupational Safety and Health Act 514 were legislated to reduce the rates of injury and fatality due to occupational accidents (ILBS, 2006). There is great need to build a resource material by means of self-learning tool for the teachers to be able to refer and uplift their knowledge and practice of chemical safety.

1.4 Research Objectives

In view, the teachers were receptive to the idea of using interactive multimedia courseware on chemical safety as a practical medium for them to improve their knowledge and practice of chemical safety. The overall aim of this study is to establish interactive multimedia courseware that empowers national secondary schools chemistry teachers with adequate knowledge for safe conduct of chemistry practical's by students. To achieve the stated aim of the study, three specific objectives of the study were developed as follows:

a. To profile chemistry teacher's background

b. To gauge chemistry teacher's knowledge of chemical safety and knowledge of facility for handling hazardous chemical

c. To develop an interactive multimedia courseware for chemical safety education (beta version) for chemistry teachers

1.5 Approach

MyChemiSOS is an interactive multimedia courseware for chemical safety, which is provided on a CD-ROM. This interactive multimedia courseware only focuses on chemical safety knowledge in the aspect of occupational safety and health at school laboratory. This study not endeavour into the chemistry learning because the Ministry of Education has selected the FSBM Holdings to produce interactive multimedia courseware (FSBM, 2005). Adobe Flash CS4, Adobe Premiere and

Adobe Photoshop CS4 utilized in developing the application to allow the application to run on a common operating system available in the schools, i.e. Windows® and Macintosh®. Though the project is not seen as cutting edge research in ICT, it would be a pragmatic initiative to study the role of ICT as a sustainable educational tool in the area of chemical safety and health. Furthermore, the project would be a starting point for studying the determinant factors in changing human behavior towards safer working practices.

1.6 Expected Contribution

The uniqueness of interactive multimedia courseware (CD-ROM), it is a custom-made chemical safety resource for the chemistry teacher of secondary school in Malaysia. In addition, it contains video clips based on actual secondary school experiments which enable better visualization of the important skills of laboratory safety techniques. This courseware is designed to help teachers create a safe environment when conducting experiments or doing work in science laboratories. It provides a simulated learning experience of the school laboratory environment that closely resembles actual practices.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

A review of current literature was conducted to understand the importance of chemical safety education and training and the effectiveness of chemical safety multimedia education programs for secondary school teachers. In addition, a review of interactive multimedia programs identified the components that make these programs successful. The results of the literary query are presented in this chapter.

2.1 Chemical Safety in Schools

The chemical safety in school resource promotes the development of effective workplace practices and details procedures which must be implemented by schools in response to the Occupational Safety and Health.

2.1.1 Chemistry at Schools

Chemistry plays an important role in human civilization. Throughout the modern period of its development, chemistry has contributed enormously both to broad improvements in human wellbeing, including enhancements of health and quality of life and to wealth creation for individuals and nations (Stephen *et al.*, 2011). Therefore, people with good knowledge of chemistry are always needed. Laboratory practices are an important component of chemistry teaching and learning. As expressed by Beach and Stone (1988) "*chemistry education without laboratory is like painting without colours and canvas*" (Tezcan *et al.*, 2004). Similarly expressed by Tezcan and Bilgin (2004) "*learning how to ride a bike by* *reading its operating manual*". Laboratory classes are integral and essential components of science subjects at secondary school and tertiary level education systems of every country, regardless of its stage of development (Hofstein, 2004). One of the main reasons is that exposure to laboratory classes' helps students to understand the theories and principles of sciences courses that are complex and abstract otherwise. These classes also offer opportunities for students to learn the skill of handling chemical safely and with confidence and gain experience in using chemical apparatus (Stroud *et al.*, 2007).

In Malaysia, Chemical Education has been in the mainstream of the national education system since the day of independence. Chemistry was first taught at the secondary level; but was introduced in the primary level as part of "Man and his Environment Subject" when the New Primary School Curriculum (KBSR) was introduced in 1982. Chemistry was extended in the Integrated Secondary School Curriculum (KBSM) in the combined science curriculum for Form 1 to Form 3 students and as part of general science and additional science or chemistry for forms four and five. For the Form 6 science students, chemistry taught as a subject in both the Higher School Certificate (STPM) and the "A" levels. For Form 4 and 5, the syllabus presents the aims, objectives and the outline of the curriculum content for a period of two years for elective science subjects. Hands-on practical skills series allows students to perform scientific activities as they learn and acquire understanding of the physical universe in which they live in.

Various engaging experiments and activities were crafting carefully, enabling students to refine their scientific skills continuously.

The chemistry curriculum aims at producing active and critical thinking learners. To this end, students are given numerous opportunities to engage in scientific investigations through hands-on activities and experimentations. In all experimental work, safety should be a major concern. Students must carry out the mandatory experiments included in the syllabus. In addition, the students' practical work should be supplemented by teacher demonstrations where indicated throughout the syllabus.

For purposes of the study, three typical chemistry experiments taught to form 4 and 5 students were reviewing during this study. The examples of experiments are: (1) study on the hardness, density and melting point of alkali metals, (2) study of the chemical properties of lithium, sodium and potassium and (3) study on the heat of combustion of various alcohols. The three experiments were choosing to give examples of an experiment involving solid, liquid and gas form of chemical as demonstrated by chemistry teachers. The experiment also described the class of hazardous chemicals. For examples, lithium, sodium and potassium are very reactive metals, and they react actively with air or water. Lighting up a mixture of hydrogen, H_2 gas and oxygen, O_2 gas will cause an explosion. Asbestos fibers are very harmful. Alcohols are very flammable and volatile.

2.1.2 Chemical Hazards in the School Experiments

The chemicals utilized in secondary schools are inorganic and organic in their natures and could be in the form of gases, liquids or solids (in powder form, flakes or particulate). Some of these chemicals are corrosive, explosive, easily oxidizing, flammable, harmful, irritating, radioactive or toxic to human being and pollute environment (Kan, 2007). Example of hazardous chemicals that are available at school chemistry laboratory are hydrochloric acid, sulfuric acid, acetic acid, natrium hydroxide, hydrogen sulfate, ammonium sulfate, hydrogen peroxide, ethanol, propanol and acetone (Low, *et al*., 2005). These chemicals are classified as hazardous chemicals to health under the Malaysia Occupational Safety and Health (Use and Standards of Exposure of Chemical Hazardous to Health) Regulations 2000.

In view of their hazardous characteristics, the government through the Department of Occupational Safety and Health regulates labelling and packaging of these chemicals. A specific law pertaining to these hazardous chemicals, the Occupational Safety and Health (Classification, Packaging & Labelling of Hazardous Chemicals) Regulations 1997 (MDC, 2005), was established under the Occupational Safety and Health Act 1994 later revised based on the Globally Harmonized System of Classification and Labelling of Chemicals to enforce the regulation. The chemicals are classified as hazardous based on their physicochemical characteristics and toxicity to human. Oxidizing and flammable chemicals have the potential to cause fire while corrosive and toxic chemicals have the potential to cause external and internal body injuries. For example, volatile organic compound such as acetone, ethanol and formaldehyde have been suggesting causing a nervous system disorder experienced by workers known as “solvent syndrome”, due to prolonged exposure to organic solvents (Stephen *et al*., 2011).

Malaysian Occupational Safety & Health (ILBS, 2006) and Occupational Safety & Health Regulation 2000 (Use and Standard of Exposure to Chemicals, Hazardous to Health) specify the permissible exposure level (PEL). The PEL is the maximum time-weight average concentration of hazardous chemicals in the air of working area that workers can be exposed without the need to wear personal protective equipment and the PEL for acetone, ethanol and formaldehyde are 1187.0, 1880.0 and 0.4 mg/m^3, respectively (MDC, 2005).Thus, students or employees working in these laboratories are exposed to many kinds of chemicals making them more vulnerable to potential hazards and risks caused by these chemicals more than people working elsewhere (Kan, 2007).

2.1.3 Safety Precautions

Accident involving laboratory chemicals is most likely to occur in the case of inexperienced employees and students, due to lack of knowledge of the danger and risk associated with the chemicals at their laboratories. Even very experienced laboratory individuals may be at risk, if they fail to follow safety precautions while working with hazardous substances (Fivizzani, 2005). There are several reports from different parts of the world showing chemical incidents at science laboratories happened due to wrong handling and misuse of chemicals. For an example, a chemistry professor at Dartmouth College in the United State of America (USA) died from mercury poisoning after a small drop of dimethyl mercury apparently seeped through her latex gloves. Investigations showed that the latex gloves were not appropriate for work with dimethyl mercury (Clarkson *et al*., 2006).

A United Kingdom (UK) researcher was testing the pH of a four-litre container of hazardous waste when the bottle fell and burst. The researcher fell in the slippery liquid, hitting his head extremely hard on the floor. The entire side of his body was saturating in the liquid solution. He suffers from lacerations and eye burns. These are some of the typical examples that can serve, as sobering reminders for all laboratory chemical users everywhere. Based on the reports, it shows the importance of understanding safety precautions while handling chemical substances especially during conducting experiments. In view of the physical and health hazards of the chemicals, it requires the implementation of a safety precaution and hazard control is required to reduce the risk of exposure to the chemical hazards (Richards-Babb *et al.*, 2010). The School Chemistry Laboratory Safety Guide (Brundage & Palassis, 2006) is an example of guide for the implementation. Safety precaution differs based on the type of the chemical hazards. General safety precaution is personal hygiene whereby the user is advised to:

1. Wash hand
2. Wear lab coat/ protective clothing

3. Avoid eating and drinking at laboratory

4. Wear covered shoes

5. Wear eye protection (goggles)

A label with the words contacts must be placed on the goggles if contacts are worn. Aprons are used to protect from chemical splashes. Gloves are available, with requirements for use in some experiments. Safety procedures are documented for working with electrical apparatus. Use of a gas burner and other dangerous laboratory equipment should be managed by giving clear instructions and warning about the hazards. Labelling requirements are described in chemical bottles and in the NFPA diamond information chart. Glassware handling emphasis on avoiding breakage and handling sharps of broken glass. The location and use of the shower, fire blanket and fire extinguisher are detailed. The section of the manual on Chemical Hazards gives sources of information on chemicals, general precautions, exposure limits and hazard categories. Maps of the General Chemistry labs and a general evacuation plan are posted on the lab. A safety pledge must be signed before in-lab chemical work is started.

2.1.4 Responsibility of Chemistry Teachers

The teacher is a key figure in implementing the teaching of chemical science because, without a teacher, students cannot carry out the science practicum well (Sedghpour *et al.*, 2013). These students would have had no scientific competence, no skill in conducting experiments, and they would not be able to make observations and analyse experimental data

(Copriady *et al.*, 2012). Schools very much rely on chemistry teachers and laboratory staff, which are laboratory assistants and technicians in managing the chemistry laboratory. Their tasks include the inventory, storage, repackaging, preparation of experimental reagent, conducting a practical curriculum, cleaning of the apparatus and waste collection. Therefore, they play a considerable role in the practice and regulation of chemical safety in the school chemistry laboratory.

Furthermore, chemistry teachers must also provide information and training to the students at every stage of experiment planning and be there to observe, supervise, instruct, and correct during the experimentation (Brundage & Palassis, 2006). Teachers and teacher-aides should lead by example – they should wear personal protective equipment, follow and enforce safety rules, procedures and practices, as well as demonstrated safe behavior and promote a culture of safety (Brundage & Palassis, 2006). They should be proactive in every aspect of laboratory safety and make, safety a priority. This is a general safety checklist and should be periodically re-evaluated for updates (Brundage & Palassis, 2006).

- Upkeep of Laboratory and Equipment
- Recordkeeping
- Safety and Emergency Procedures
- Maintenance of Chemicals
- Preparing for Laboratory Activities
- Ensuring Appropriate Laboratory Conduct

2.1.5 Chemical Hazard Symbols

Hazard symbols form part of the Globally Harmonized System of Classification and Labelling of Chemicals (GHS), (United Nations, 2011). GHS is an especially important programme to harmonize national systems worldwide to improve chemical safety across all sectors (United Nations, 2011).In referring to the GHS regulation, each package of chemical and the respective storage place should be clearly labelled with the relevant hazard symbols. These symbols communicate the related hazard, subsequently to reduce risk of chemical exposure of the incident. Each chemical should be labelled clearly to draw the attention of users and to classifying chemicals according to their characteristics. As can be seen from Table 2.1 and Table 2.2, chemical hazard symbols consist of different colours, pictures and intended to provide information about properties of chemicals such as flammability, toxicity, explosive, corrosive, oxidizing, irritating and harmfulness. Understanding or becoming familiar with the symbol of these properties would help to avoid unwanted but preventable hazards of laboratory chemicals.

Therefore, for safety reasons, individuals working in chemistry laboratories and in other laboratories that involve the use of chemicals are supposed to be aware of the potential hazards of laboratory chemicals and become familiar with the symbol of each chemical in use. Chemical storage areas can be the most dangerous places in any facilities. Placing the correct chemical hazard symbols around chemicals is essential in maintaining workplace safety. Hazard symbols are designed to warn about hazardous

Table 2.1: Physical Hazards

Hazard classes	New Symbol	Old Symbol	Signal Word	Hazard Statement
Explosives			Danger	Explosive; mass explosion hazard
Flammable gases			Danger	Extremely flammable gas
Flammable aerosols			Danger	Extremely flammable aerosol
Flammable liquids			Danger	Extremely flammable liquid and vapor
Flammable solids			Danger	Flammable solid
Oxidizing gases			Danger	May cause or intensify fire; oxidizer
Oxidizing solids			Danger	May cause fire or explosion; strong oxidizer
Oxidizing liquids			Danger	May cause fire or explosion; strong oxidizer
Gas under pressure		No Classification	Warning	Contains gas under pressure; may explode if heated

Source: Globally Harmonized System of Classification and Labelling of Chemicals (GHS), United Nations, New York and Geneva, 2011.

Table 2.2: Health Hazards and Environmental Hazards

Hazard classes	**New Symbol**	**Old Symbol**	**Signal Word**	**Hazard Statement**
		Health Hazards		
Corrosive to metals			Warning	May be corrosive to metals
Skin corrosion			Danger	Causes severe skin burns and eye damage
Acute toxicity			Danger	Fatal if swallowed (oral) Fatal in contact with skin (dermal) Fatal if inhaled (gas vapour, dust, mist)
Skin irritant			Warning	Causes skin irritation
Carcinogenicity		No Classification	Danger	May cause cancer (state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard)
		Environmental Hazards		
Acute hazardous to the aquatic environment			Warning	Very toxic to aquatic life

Source: Globally Harmonized System of Classification and Labelling of Chemicals (GHS), United Nations, New York and Geneva, 2011.

materials or locations. The use of hazard symbols is regulated by law and directed by standards organizations.

2.1.6 Chemical Safety Data Sheet

Safety Data Sheet (SDS) also known as Chemical Safety data Sheet (CSDS), Material Safety Data Sheet (MSDS) or Product Safety Data Sheet (PSDS) is an important component of product stewardship and workplace safety (United Nations, 2011).The CSDS, prepared by a chemical manufacturer or distributer, contains comprehensive information about the chemical safety (Microbial ID, 2009).

The CSDS is a document that contains information on the potential health effects of exposure to chemicals, or other potentially dangerous substance, and on safe working procedures when handling a chemical product (ILBS, 2006). It is an essential starting point for the development of a complete health and safety program. The document contains the findings of the evaluation on the use, storage, handling and emergency procedures related to a specific chemical. The purpose is to communicate the hazards of the product, safe use of the product, possible consequences if the recommendations are not followed, actions to take if accidents occur, as well as symptoms of overexposure and steps to follow if such incidents occur.

In Malaysia, as specified in Classification, Packaging & Labelling Regulation 1997, chemical suppliers must supply CSDS as part of the requirement for a sale. The recent USECHH Regulation 2000 also requires all chemical industry users to have each chemical's CSDS on hand prior to the use of the chemical in their workplace. Therefore, a CSDS is a very useful source of safety and health information that will help to create a safer practice when dealing with chemicals. The information in the CSDS is divided into sixteen sections as follows (Microbial ID, 2009):

- **Section 1: Identification**

  Provide specific identification of the chemicals substances. Example: Synonyms, CAS Number, Molecular Weight, Chemical Formula, and Product Codes.

- **Section 2: Hazards identification**

  Outlines the degree of hazard with reference to:

  a) Health rating

  b) Flammability rating

  c) Reactivity rating

  d) Contact rating

  Additional information may include the potential health effects and symptom through inhalation, ingestion, dermal contact, eye contact, chronic exposure and aggravation of pre-existing conditions.

- **Section 3: Composition / information on ingredients**

  Describe the composition, percentage or concentration of the chemical substance. Some may provide additional hazard information such as Permissible Exposure Limit (PEL), Threshold Limit Value (TLV) and etc. Therefore, the seriousness of the chemicals hazard can be determined.

- **Section 4: First-aid measures**

  Describe the first aid attention to be given prior to the treatment by a physician when an accident takes place. The information provided may refer to the chemical intoxication due to:

  a) Inhalation

  b) Ingestion

  c) Dermal Contact

  d) Eye Contact

- **Section 5: Fire-fighting measures**

  Detailed information on the Flash point, Auto Ignition Temperature, Flammability of the chemical product and Explosion capability information. Additional information may include the proper methods of using fire extinguishing media (dry chemical, foam, water or carbon dioxide) and type of suitable fire fighting protective clothing used during a fire emergency.

- **Section 6: Accidental release measures**

  Recommends the appropriate response to spills, leaks, or releases in order to prevent or minimize the adverse effects on persons, property and the environment in this section. Distinguish between responses for large and small spills where the spills volume has a significant impact on the hazard.

- **Section 7: Handling and storage**

  Recommends procedure to handle and store the chemical substance in a safe condition. It may include:

  a) To protect the chemical.

b) To store chemicals (environment factors consideration).

c) Compatible with other chemicals when stored together.

d) To use it in a safer way.

- **Section 8: Exposure Controls/ Personal Protection**

Within this guidance, the term "occupational exposure limits" refers to limits in the air of the workplace or biological limit values. In addition, for the purposes of this document "exposure control" means the full range of specific protection and prevention measures to be taken during use in order to minimize worker and environmental exposure. Engineering control measures that are needed to minimize exposure to and risks associated with the hazards of, the substance or mixture should be included in this section.

- **Section 9: Physical and chemical properties**

Describe detail of some of the properties of chemical, for instance:

a) Appearance (clear, colourless, milky etc)

b) Odour (type of "smell" of product)

c) Odour threshold

d) pH

e) Melting point/freezing point

f) Initial boiling point and boiling range

g) Flash point

h) Evaporation rate

i) Flammability (solid, gas)

j) Upper/lower flammability or explosive limits

k) Vapour pressure

l) Vapour density

m) Relative density

n) Solubility (Water soluble, slight solubility and etc.)

o) Partition coefficient n-octanol/water

p) Auto-ignition temperature

q) Decomposition temperature

r) Viscosity

- **Section 10: Stability and reactivity**

  Provide details on:

  a) Stability and reactivity of the chemical during storage.

  b) Type of hazardous decomposition products, e.g. release of gases such as CO_2 when heated.

  c) Compatibilities with other chemicals, e.g. acrylic acid are incompatible with strong oxidizing agents.

- **Section 11: Toxicological information**

  This section refers to the toxicity of the chemical with reference to the LD 50 and LC 50 of the chemical substance against rabbit or rat. The lower the value of the LC the more hazardous will be the chemical.

- **Section 12: Ecological Information**

  Details on the ecological impact of the chemical when it is used or discharged into the air, water or soil. Therefore, the user should take precautions to control environmental exposure when handling the chemical substance.

- **Section 13: Disposal Considerations**

  Applies for the chemical substance that could not be recycled or recovered. Waste considered as hazardous shall be disposed in accordance to national regulatory requirements.

- **Section 14: Transport Information**

  This section provides basic classification information for the transportation/shipment of a hazardous substance or mixture by road, rail, sea or air. Where information is not available or relevant this should be stated.

- **Section 15: Regulatory information**

  Describe any other regulatory information on the substance or mixture that is not provided elsewhere in the SDS (e.g. whether the substance or mixture is subject to the Montreal Protocol, the Stockholm Convention or the Rotterdam Convention).

- **Section 16: Other information**

  Provides additional information relevant for the national regulations,

  a) NFPA rating in term of health, flammability and reactivity rating.

  b) Label hazard warning, e.g. Danger! may be fatal if swallowed

  c) Label pre-cautious, e.g. Do not breathe vapour or mist

  d) Label of first aid, e.g. Do not induce vomiting, give large plenty of water

  e) Chemical substance application

An example of CSDS (Microbial ID, 2006) of the chemical substance used in the study is described in Appendix 1.

2.2 Interactive Multimedia Courseware (IMC)

With the development of technology, computer technology has been used in all areas of people's lives, especially internet technology, multimedia technology and artificial intelligence technology to bring a very profound impact for communicating knowledge. The interactive multimedia courseware is the courseware that runs in computer or network terminal, with a strong interactive and multimedia character (Zhen *et al.*, 2011).

2.2.1 Multimedia

Technology based learning is one of the "hottest" disciplines not only in the educational research but also in computer science research. The change of technology is rapid, it was estimated that 55% of the training programs in 2002 would be technology-based. The use of computer-based training (CBT), especially multimedia CBT is still perceived as more advantageous than its web-based counterpart (Zaini *et al.*, 2011). The use of technology in training has been discussed in various types of organizations: for instance in large organizations (Mishra *et al.*, 2005), small organizations (Mishra *et al.*, 2005), microbiology (Abdul Manap *et al.*, 2013), telecommunications (Gasco *et al.*, 2004), higher education (Poon *et al.*, 2004), banking (Vaugan *et al.*, 2004), sports (Lvhua, 2011), military training (Vaughan 2006), transportation industry (Zhen *et al.*, 2011), parental guide (Mohamed Noor *et al.*, 2011) and public sector (Wagner *et at.*, 2004). In education multimedia is used to produce computer-based training program for example, Kelas Pengajian Al-Quran and Fardhu ain (KAFA) organized by Jabatan Kemajuan Islam Malaysia (JAKIM) has been