THE EFFECTS OF SCIENCE WRITING HEURISTIC APPROACH TO IMPROVE CONCEPT UNDERSTANDING OF STOICHIOMETRY AND ATTITUDE TOWARDS LEARNING CHEMISTRY AMONG UNDERGRADUATE STUDENTS

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by

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LIST OF ABBREVIATIONS

SWH	Science Writing Heuristic
TOSRA	Test of Science Related Attitudes
SCT	Stoichiometry Concept Test
SPSS	Statistical Package for Social Sciences

KESAN PENDEKATAN PENULISAN SAINS HEURISTIK BAGI MENINGKATKAN PEMAHAMAN KONSEP STOIKIOMETRI DAN SIKAP TERHADAP PEMBELAJARAN KIMIA PELAJAR SARJANA MUDA

ABSTRAK

Kajian ini menyiasat penggunaaan pendekatan sains penulisan heuristik (SWH) terhadap pemahaman topik stoikiometri dalam kimia dan peningkatan sikap pelajar universiti terhadap pembelajaran kimia. Pendekatan SWH adalah strategi 'writing-to-learn' yang menggabungkan penyelidikan berpandu dan kerja kolaborasi. Pendekatan SWH telah diintegrasikan dan disesuaikan dengan pengajaran stoikiometri dalam kelas tutorial. Seramai 78 orang siswa universiti terlibat dalam kajian ini dalam dua kumpulan iaitu kumpulan eksperimen (N=36) dan kumpulan kawalan (N=42). Kumpulan eksperimen (EG) diajar berasaskan pendekatan sains penulisan heuristik (SWH) dan kumpulan kawalan (CG) diajar secara pendekatan tradisional. Ujian Konsep Stoikiometri (SCT), soal selidik berhubung sikap terhadap sains (TOSRA), dan temubual separa berstruktur digunakan untuk memungut data. Data kuantitatif dianalisis dengan menggunakan *Independent Samples T-test*. Hasil daripada data kuantitatif menunjukkan bahawa terdapat perbezaan yang signifikan dari pemahaman pelajar EG dibandingkan dengan pemahaman CG ($t = 7.78$; $p<0.05$). Dapatan kuantitatif disokong oleh dapatan kualitatif melalui temu bual yang menunjukkan peningkatan pemahaman stoikiometri kumpulan eksperimen berbanding dengan kumpulan kawalan. Kumpulan eksperimen juga menunjukkan peningkatan yang signifikan bagi sikap terhadap pembelajaran kimia ($t = 4.01$; $p<0.05$). Respons bagi temu bual sikap terhadap pembelajaran sains menyokong dapatan kuantitatif. Kajian

ini menunjukkan bahawa pendekatan SWH adalah salah satu pendekatan efektif yang boleh digunakan dalam pengajaran dan pembelajaran stoikiometri.

THE EFFECTS OF SCIENCE WRITING HEURISTIC APPROACH TO IMPROVE CONCEPT UNDERSTANDING OF STOICHIOMETRY AND ATTITUDE TOWARDS LEARNING CHEMISTRY AMONG UNDERGRADUATE STUDENTS

ABSTRACT

This study investigated the use of the science writing heuristic (SWH) approach on undergraduate university students' understanding on the topic of stoichiometry in chemistry and to improve attitude on learning chemistry. SWH approach is a writing-to-learn strategy that incorporates guided inquiry and collaborative work. SWH approach was integrated and adapted in the teaching of stoichiometry in the tutorial classes. There was a total of 78 undergraduate university students participated in this study. These students were randomly assigned into experimental (N=36) and control (N=42) groups. For the experimental group (EG) the lessons on stoichiometry was instructed using SWH, while for the control group (CG) students the same lessons were instructed using more traditional teacher centred instruction. A Stoichiometry Concept Test (SCT), Test of Science-Related Attitude (TOSRA) questionnaire and semi-structured interviews were employed to collect the data. The quantitative data was analysed using independent sample t-tests. The outcome of the quantitative data indicated that there was a significant difference of the EG students understanding as compared to the CG's understanding ($t = 7.78$; $p<0.05$). The quantitative findings are supported by the qualitative findings from interviews which indicate an improvement in the students' understanding of stoichiometry apparently from the exposure to the SWH approach. The EG also showed a significant difference in improvement of attitude to learning chemistry ($t = 4.01$; $p<0.05$) compared with CG. The responses from the interviews on attitude toward learning science supported the quantitative findings. This study implies that SWH approach is one of the viable approach to be used in teaching and learning of stoichiometry.

CHAPTER ONE
INTRODUCTION

1.0 Introduction

The value of science education, perceived as the vehicle for economic development and technological modernization, has been widely acknowledged (Brown-Acquaye, 2001; Walberg, 1991). Science and technology are often perceived as fundamental forces behind economic development in industrialized countries. This view is shared by many developing as well as industrialized nations. As one of the developing nations that aspire to attain a fully developed nation status by 2020, Malaysia too, subscribes to this view. This is evidenced by the national vision statement that calls for, amongst others, an establishment of a scientific and progressive society, and by the national policies that place much emphasis on science education such as the 60:40 policy, which aims to achieve a ratio of 60:40 for science versus arts-based students by 2020. However, students enrolled in science courses at the undergraduate level as well students opting for science subjects at the secondary level reported to be far below the ratio aspired by the government.

It was reported that the percentage of students at the upper secondary level in government and government-aided schools enrolled in the science and technical streams declined from 22.8% in 1990 to 21.3% in 1995 (STEM in Malaysia, 2017). This situation further deteriorates as in 2010 students' enrollment into science stream dropped to below 20% (New Strait Times, 2016). At the rate things are going, it will be tough for the government to increase the number of research scientists and engineers (RSEs) in the country. The government's target of 50 RSEs per 10,000 workers by 2020 does not look achievable. This can have serious repercussions on the country's innovation plan. Since, only those students, who take science, or science and mathematics, can pursue further a scientific education and scientific careers, the decline in the number of science-based students has raised concerns about the nation’s economic future (Dearing, 1996; Roberts, 2002).

Studies done in the UK has shown that there are three times more arts and humanities specialists as compared to science specialists (Osborne, Simon & Collins 2003). In our modern society, science and technology play a prominent role and the success of a nation is pivotal on that. So, if more arts specialists are produced how can the nation move to be successful economically? Moreover, survey of comparisons of countries or regions as to the number of engineers and scientists per million of the population shows existence of strong co- relation between economic performance of a society and the numbers of engineers and scientists (Kennedy, 1993). Education in science is important in a society which is increasingly rich in science and technology (Walczak & Walczak, 2009).

Chemistry is an important subject in science. It is a compulsory subject at upper secondary level, pre-university and undergraduate level. Additionally, for the students enrolled in the professional courses such as medicine, pharmacy and engineering, chemistry concepts are fundamental for these students to pursue their studies in these fields. On the contrary, chemistry knowledge assists people to understand the natural phenomena and happenings around them (Sirhan, 2007). Studies indicate that understanding of chemistry involves many steps and it is multilevel (Johnstone, 1991). Johnstone (1991) asserted that firstly understanding of chemistry involves observing the particulate nature and then translating this into equations.

Decline in the enrollment in science courses is mainly due to students' attitude towards learning science reported to be minimal (Osborne et al., 2003) and in some instances it is reported students to have negative attitude towards learning science (Seymour & Hewitt, 1997). One probable reason for the students to have minimal or negative attitude towards learning science is because of the teaching methods employed in the classroom to deliver the subject matter (Pollock, 2004). The instructional method appeared to be centered on the teachers, whereby the teachers deliver the lesson and the student's role is as an audience listen to the speech delivered by the teacher.

Review of literature indicates that it is possible to improve students' understanding of science concepts using SWH (Cronje, Murray, Rohlinger & Wellnitz, 2013). Science Writing Heuristic (SWH) is an argument-based inquiry approach developed to facilitate science learning (Keys, Hand, Prain & Collins, 1999). SWH successfully applied in parts of the United States and Korea to improve students' conceptual understanding (Nam, Choi & Hand, 2011). Hence, in the context of this study, SWH will be integrated as part of teaching and learning of stoichiometry to improve students understanding of stoichiometry concepts and attitudes towards learning science.

1.1 Background of the study

Malaysia is dedicated to achieving a greater unity of all her peoples; to maintain a democratic way of life; to creating a just society in which the wealth of the nation shall be equitably shared; to ensuring a liberal approach to her rich and diverse cultural traditions; to building a progressive society which shall be orientated towards modern science and technology. Science education in Malaysia in nurturing a science and technology culture focuses on the development of individuals who are competitive, dynamic, robust and resilient and able to master scientific knowledge and possess technological competency. In tandem with this policy, there is a great need for educators to move in developing effective ways of teaching and learning science. Scientific literacy is an important goal in moving toward a technologically advanced nation. This is also expressed in many countries (Millar & Osborne, 1998; National Research Council, 1996). Many methods have been introduced such as the use of computer assisted teaching to enhance the learning of science. These methods to certain extent have enhanced students understanding of scientific concepts and the performance in science subjects appear to be improved in the last two years as indicated in Figure 1. However, TIMSS (2010), Malaysia is placed at the 20th place for grade 8 and were at 21st place in 2007. Despite some significant improvement was noticed in the TIMSS (2015) result. The results show that Malaysian students' performance is still minimal and lagging Asian countries like Hong Kong, Korea, and Singapore.

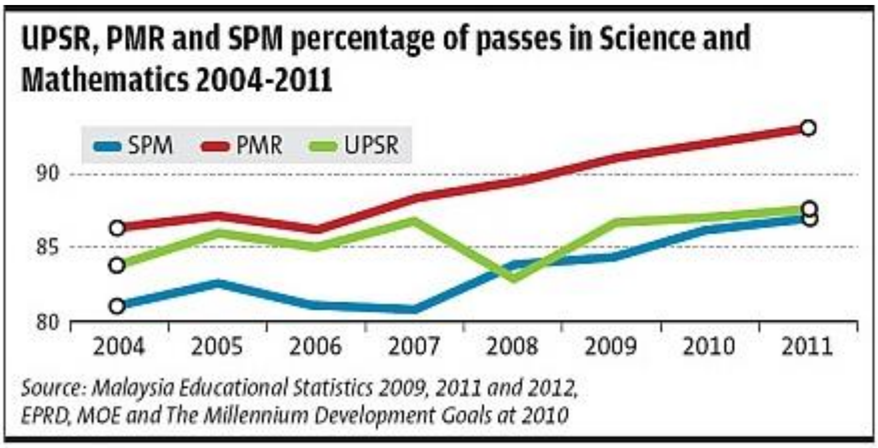

Figure 1 UPSR, PMR and SPM percentage of passes in Science and Mathematics 2004-2011(Star, 2012)

Chemistry is a compulsory science subject for upper secondary school science stream students. Chemistry is perceived as a difficult subject to be mastered (Childs & Sheehan, 2009). Chemistry concepts are perceived as abstract and students find it is beyond their ability to internalize and understand the chemistry concepts (Bodner, 1991). Among various chemistry concepts, stoichiometry is an important undergraduate chemistry subject which is identified as difficult for the students to understand (Frazer & Servant, 1986; 1987; Schimdt, 1990; Huddle & Pillay,1996; Boujaoude & Barakat, 2000; Arasasingham, Taagepera, Potter & Lonjers, 2004). This is also a basic concept whereby understanding of stoichiometry is a prerequisite for other concepts such as reactant ratios, balancing equations which are necessary in problem solving. Stoichiometry is a foundation for all types of calculations in chemistry, which includes laboratory work of diluting solutions and it is imperative for all other work in biology, analytical and applied chemistry. It centers on chemical reactions and writing balanced chemical equations and thereby correlating these equations with masses and a way to connect masses would be to calculate the moles of substances involved. In this process it would involve recognizing the substances which are in sufficient amounts for the reactions to proceed and a substance that is lacking, would be the limiting reagents for the reaction to proceed. Stoichiometry has been found to be one of the difficult topics in chemistry in a semi-longitudinal study by Childs and Sheehan (2009), on Irish students from ages 15/16 years through to University. The difficulties were found to be greater with topics that required more mathematical abilities. Gauchon and Meheut (2007), in their study on learning about stoichiometry and specifically on students' preconceptions on limiting reagents, it was found that students were not clear to this concept in grade 10 students.

Generally, students' level of engagement in learning subject and interest in learning the subject is frequently associated with students' attitude towards the subject (Sirhan, 2007). For chemistry specifically and science generally students attitude appears to be minimal (Johnstone, 1991). Osborne et al. (2003) had done a review of literature for the past 20 years on attitude to science and their implications. Osborne says that there have been investigations done because of a decline in interest in young people pursuing scientific careers and the overall scientific ignorance of the general populace. Various aspects of attitudes were researched in Osborne's review of literature.

Attitudes to science was initially categorized by Klopfer (1971) as manifestation of favorable attitudes towards science and scientists, the acceptance of scientific enquiry as a way of thought, the adoption of "scientific" attitudes, the enjoyment of science learning experiences, development of interests in science and science-related activities and the development of an interest in pursuing a career in science or science related work. Other categories were developed as sub-constructs of the above such as perception of the science teacher, anxiety toward science, value of science, self-esteem of science, motivation towards science, enjoyment of science, attitudes of peers and friends towards science, nature of the classroom environment, achievement in science and fear of failure on course.

Following Klopfer's (1971) initial work decline, in numbers of students choosing to study science permitted more investigation to be performed on attitude (Osborne et al., 2003). According to Osborne et al. (2003) there is therefore a need for more research to be conducted on the attitude of students to science to remediate the already critical situation. Osborne also states that there is a greater need for research to identify those aspects of school science to make it more engaging for the students. Profoundly, researching attitude towards learning chemistry is significantly important as attitude plays an important part to predict the actual performance in a general chemistry course (Xu & Lewis, 2011).

Osborne et al. (2003) has said that even though there has been vast research conducted at identifying the problem of attitude, but little done on the remediation of attitudes towards science. When the attitude towards science is not there the motivation and interest in the subject goes down as well. Research by Wallace et al. (1996) about students' outlook on learning indicated that there was a need for pupils to take control of their learning and greater pupil autonomy. This was further supported by Osborne and Collins (2001) where pupils preferred more practical work and discussions which point to more personal autonomy. Traditional teaching methods gave little opportunity for personal autonomy of the students. Traditional teaching methods, thus, failed to improve students' attitude towards learning science.

Various initiatives were taken to improve the attitude towards learning. This includes CLASS (Colorado Learning attitudes about Science Survey) (Milner-Bolotin, Antimirova, Noack & Petrov, 2011). Milner-Bolotin et al. (2011) conducted the survey in a large physics course at a midsize, metropolitan Canadian university. This study explored students' attitudes about science and how much they had learnt in an introductory physics course. Overall it was found that students' conceptual understanding increased and their attitudes improved across the course (Milner-Bolotin et al., 2011).

Welch (2010) in her study investigated high school students' attitude towards science and achievement in science. She found that programs that involve students in authentic science related learning activities significantly improved students' attitudes and views of science. The intervention in this study involved about 130 students who participated in a robotic completion which is designed to build awareness and interest in science and engineering in high school students. They are engaged in learning activities in a setting that will inspire them to pursue careers in science and technology. The parallel scenario is in professional sport, where young people can pursue a career as professional athletes. Among various approaches, teaching strategy used in the classroom is a key factor that needs to be taken into consideration. In the current situation, the teaching method is mainly teacher-centered. SWH (Science Writing Heuristic) is an analytical writing tool which is gaining importance as an alternative way to teach chemistry. In a study by Rivard and Straw (2000), it was found that analytical writing is a useful tool for transforming students' primary ideas to a more coherent and structured form. It was also found that talk combined with writing enhances the retention of science learning over time.

Prain and Hand (1996) who developed the Science Writing Heuristic (SWH) approach, is applied here in this study, which is a shift from the traditional teacher centered learning to the student-centered learning. The use of SWH approach as a writing to learn tool to understand science concepts (Keys et al., 1991). This SWH approach involves writing-to-learn tasks which are framed around five critical elements which *are topic, type, audience, purpose and method of text production.* When writing, the students must explain the science concept that they have learnt. So, the audience would be the group of people that the writing would address like secondary students, adults or younger brothers and sisters, and type would refer to a letter format or writing to the newspaper (like a brochure, narrative or power point production). They had to communicate in a language that the audience would comprehend. In this process, they must paraphrase and explain in a way that the audience could understand. This process helps them to understand the concepts better. The method of test production could be handwritten or typed out.

In writing, the students must explain what they learnt in this topic. The writing must be addressed to different audiences, through different writing types for example to a newspaper or a letter. In this study the audience the students addressed were either secondary school students or to their younger brothers or sisters. It was essential that the students were able to re-represent the chemistry language to a form that the participating audience can understand it and make meaning from it. The fact of having a real audience to respond to the writing was purposeful unlike just writing for the tutor to read. Here the fact of translating scientific matter or language to a simplified language involves the students getting a deeper understanding of the topics to be able to express it in a simpler language to the required audience and having the audience provide feedback on written texts proves to make the students to do it diligently unlike other traditional writing methods. They had to engage in a language that their audience would understand. This involved them understanding the topic and content knowledge and switching it from scientific terms to something that the audience could make meaning of it. This required that the student would be more actively involved in the process. And they also were very apt in giving realistic analogies to explain the seemingly difficult concepts

There are several cases in literature, where SWH has been successfully implemented especially in the laboratory classes. In a previous study, the SWH approach was implemented in a South Eastern town in the USA to eighth grade students in their laboratory class (Keys et al., 1999). The topic covered at this school was based on an established curriculum by National Geographic, “Is our Water at

Risk?" (National Geography Society, 1997). The implementation consequently resulted in the students "generating meaning from data collected, connect procedures, data, evidence and claims and engage in metacognition" (Keys et al., 1999). Initially this group of students was not clear about the nature of science and because of the SWH approach they were able to comprehend more complex and specific understandings.

SWH was also successfully implemented in the second biggest city in Korea, on eighth grade students involved in a general science course in three middle schools (Nam et al., 2011). The results indicated that a greater implementation of the SWH approach by the teachers would result in a better student achievement and improved learning of subject matter. SWH has also been implemented in an undergraduate biology laboratory course (Cronje et al., 2011). This was a foundation laboratory course for all biology majors enrolled at the University of Wisconsin. It was found that the positive trends observed in the study can justify additional experimentation with SWH approach to develop science writing competence in other disciplines as well. This SWH tool holds promise to improve students' understanding and attitude towards science. This is important to develop a society that is competent in science.

As mentioned earlier on, stoichiometry is a foundation for all types of calculation in chemistry, deeming it an important topic to be understood well SWH approach developed by Prain and Hand (1996), is based on constructivist theory and encourages student centered learning. It involves writing to learn methods which helps improve understanding. As such , SWH approach has been applied on the topic of stoichiometry in the undergraduate inorganic course to measure the effectiveness in improving students' understanding on the topic and attitude towards learning chemistry.

1.2 Statement of the problem

Due to abstract presentation and multistep required to understand the concepts, learning chemistry is frequently identified as irrelevant and not valuable (Childs & Sheehan, 2009). In a study involving Irish chemistry pupils from junior certificate all the way to university level students were asked to identify topics that were difficult or simple using a six-point Likert scale (Childs & Sheehan, 2009). Each group of students, Junior Certificate pupils, Leaving Certificate pupils and University students had different questionnaires according to the chemistry topics covered in their syllabus. The results show the overlap of topics right from junior certificate till university chemistry students. The difficult topics at junior certificate level were structure of the atom, bonding and chemical equations and symbols. Majority of leaving certificate level students found, organic chemistry, chemical equilibrium calculations and volumetric calculations as difficult. University chemistry students listed volumetric calculations, redox reactions and concentration of solutions as difficult concepts to learn. The outcome of this study indicates that students tend to face problem in understanding the concepts from early stage and the problem persisted through tertiary level education.

There were similarities in the findings of studies carried out in the UK by Ratcliffe (2004) and in Scotland by Johnstone (2006). Johnstone (1974) reported that difficult areas in chemistry from the pupil's perspective continued until university. He identified mole concept, chemical formulae and equations and, in organic chemistry, condensation and hydrolysis as the difficult topics. Stoichiometry involves understanding of mole concept, reaction ratios, concept of limiting reagents and balancing chemical equations. This is the foundation of all other problem solving in other topics of chemistry. If this concept is not clear, then the students will face difficulty in understanding of all other topics. Despite being a crucial topic, according to Childs and Sheehan (2009) the problems associated with stoichiometry and other topics has never been truly addressed. This really puts the student in a big disadvantage when concepts are not understood and persists right through the tertiary levels. It was reported also, that in Malaysia, students have difficulty understanding abstract science concepts (Halim & Meerah, 2016).

Besides understanding, attitude to learn chemistry appears to be one major concern among Malaysian students. In another study involving Malaysian students, it was reported that these pupils have a poor attitude towards science (Aziz, Nor & Rahmat, 2011). Chua and Karpudewan (2015) investigated Malaysian pre-university students' attitude towards learning chemistry and documented that these group students tend to dislike and at extend avoided learning chemistry. Pre-university students when enrolled in first year university course the next following probably this situation will be sustained. Generally, stoichiometry also has been taught in a traditional method which is teacher centered. In the first-year inorganic course, stoichiometry is taught very much in a rote manner which resulted in poor understanding of the concepts among the students. Generally, students tend to learn in a rote manner and have difficulties applying the concept in different contexts. Year 2020 has been targeted as the year to achieve a complete developed status through the education blueprint (MOE, 2013), and as such this shift of teaching approach to a more student-centered learning must be effectively implemented.

In the past, SWH has been an approach to enhance students understanding of several science concepts. Cronje et al. (2011) in their study using SWH to improve undergraduate writing in biology had found that this approach had improved students' ability to express their scientific understanding in a writing assignment. In another study by Keys et al. (1999), students in a secondary school laboratory class were able to understand the data and translate their understandings to more complex situations as an outcome of this SWH approach.

Some studies also deliberately indicated SWH approach has resulted in the students becoming effective in learning. As such here in this study, the SWH approach is adopted to a tutorial class of undergraduate students in their study of a topic in chemistry, stoichiometry. This research was concluded to bridge the gap, lack of information on integration of SWH approach in learning stoichiometry and possibly how this method or approach inculcates improved attitude towards learning chemistry.

1.3 Purpose of the study

This study aims to determine the effects of SWH approach on undergraduate students' understanding of stoichiometry concepts and their attitude towards learning chemistry

1.3.1. Objective of study

To measure the effect of SWH approach integrated into the teaching and learning of stoichiometry in promoting specifically

i. undergraduate students' understanding on stoichiometry concepts.

ii. undergraduate students' attitude towards learning chemistry.

1.4 Research Questions

1. Is there any significant difference between the post-test means scores of the stoichiometry concept test (SCT) of the control group taught in traditional instruction and the experimental group taught using SWH approach in the understanding of stoichiometry?

   1.a. Is there any significant difference between the post-test means scores of items on limiting agent in the stoichiometry concept test (SCT) of the control group taught in traditional instruction and the experimental group taught using SWH approach?

   1.b. Is there any significant difference between the post-test means scores of items on balancing equations in the stoichiometry concept test (SCT) of the control group taught in traditional instruction and the experimental group taught using SWH approach?

   1.c. Is there any significant difference between the post-test means scores of items on calculating molar masses the stoichiometry concept test (SCT) of the control group taught in traditional instruction and the experimental group taught using SWH approach?

2. Is there any significant difference between the post-test means scores of TOSRA of the control group taught in traditional instruction and the experimental group taught using SWH approach?

   2.a. Is there any significant difference between the post-test means scores of items on social implications of science in TOSRA of the control group taught in traditional instruction and the experimental group taught using SWH approach?

2b. Is there any significant difference between the post-test means scores of items on normality of scientists in TOSRA of the control group taught in traditional instruction and the experimental group taught using SWH approach?

2.c. Is there any significant difference between the post-test means scores of items on scientific inquiry in TOSRA of the control group taught in traditional instruction and the experimental group taught using SWH approach?

2.d. Is there any significant difference between the post-test means scores of items on adoption of scientific attitudes in TOSRA of the control group taught in traditional instruction and the experimental group taught using SWH approach?

2.e. Is there any significant difference between the post-test means scores of items on enjoyment of science lessons in TOSRA of the control group taught in traditional instruction and the experimental group taught using SWH approach?

2.f. Is there any significant difference between the post-test means scores of items on leisure interest in science in TOSRA of the control group taught in traditional instruction and the experimental group taught using SWH approach?

2.g. Is there any significant difference between the post-test means scores of items on career interest in science in TOSRA of the control group taught in traditional instruction and the experimental group taught using SWH approach?

1.5 Hypothesis

Ho1. There is no significant difference between traditional and SWH groups' SCT post-test mean scores.

H_o1a There is no significant difference between traditional and SWH groups' SCT post-test mean scores of items on limiting reagent.

Ho1b There is no significant difference between traditional and SWH groups' SCT post-test mean scores of items on balancing equations.

Ho1c There is no significant difference between traditional and SWH groups' SCT post-test mean scores of items on calculating molar masses.

Ho2 There is no significant difference between traditional and SWH groups' TOSRA posttest mean scores.

Ho2a There is no significant difference between traditional and SWH groups' TOSRA posttest mean scores of items on social implications of science.

Ho2b There is no significant difference between traditional and SWH groups' TOSRA posttest mean scores of the items on normality of scientists.

Ho2c There is no significant difference between traditional and SWH groups' TOSRA posttest mean scores of the items on scientific inquiry.

Ho2d There is no significant difference between traditional and SWH groups' TOSRA posttest mean scores of the items on adoption of scientific attitudes.

Ho2e There is no significant difference between traditional and SWH groups' TOSRA posttest mean scores of the items on enjoyment of science lessons.

Ho2f There is no significant difference between traditional and SWH groups' TOSRA posttest mean scores of the items on leisure interest in science.

Ho2g There is no significant difference between traditional and SWH groups' TOSRA posttest mean scores of the items on career interest in science.

1.6 Significance of the study

It was stated in the Star on the 7th.Nov 2011 by the Deputy Prime Minister, who is also the Education Minister, that less than 20 percent of students who took SPM in the past year were from the Science stream. The goal of the country is to achieve 60 percent of students in SPM to be in the Science stream. We are far behind our target.

As a compromise the Government is hoping that there will at least be an increase of 10 percent by 2014. This being the case, there is more urgency in conducting this study to improve attitude by the implementation of this SWH. When attitude towards science improves, performance will improve and that will motivate more to go to the science stream and remain there.

When this SWH approach is introduced through professional training for teachers and this can help shift learning for students from teacher orientated to student centered and thereby empower the students learning This especially so in this topic of understanding stoichiometry, proves to be so important not only in chemistry but in other fields of science as well.

This SWH will also help students to improve their writing skills, and their ability to express their views. It has been mentioned in the study by Nam et al. (2011) that this implementation of SWH is relevant in an Asian context where because of the inherent cultural environment, students are inactive in participation in discussions. As such this SWH approach can draw the students to this question, claims, and evidence structure and writing-to-learn approach to build their confidence. The SWH approach with the question, claims, and evidence will also help students to improve their argumentation skills. They will be more confident to argue over any fact with the relevant claims and evidence.

In this study, this SWH approach was confined to just the tutorial classes and by its effectiveness it can be introduced to the lecturers who are teaching this course of KTT111. As this approach is empowering to the students and it will enliven the lectures as well. Many of the lecturers are new to teaching and this will be a good strategy to introduce this SWH approach.

If this approach is introduced by the lecturers to teach the whole course with this SWH approach, it will immensely benefit the students and their learning as well. With the traditional approach, students are grappling to understand their work and not really interested in chemistry. And with the shift of attitude, they will be more interested in chemistry.

Another aspect would be to improvise and adapt this SWH to the curriculum of the School of Chemistry in the teaching of other courses besides this first-year course.

1.7 Limitations of the study

It may seem that one of the limitations of this study is that the limit to a time frame of only six weeks. However, in a similar study by Cronje et al. (2011), this application of SWH was done on only one out of the six laboratory classes which is a limited time yet the SWH cohort was more likely to have a higher score when compared to the control group. As such the intervention in this study is possible based on the result of the study by Cronje et al. (2011).

Another limitation is this implementation of the SWH approach has been conducted in the confines of the tutorial classes and only on the topic of stoichiometry This is because the topic of stoichiometry is only one of the many topics in this first-year undergraduate course. The course is a year one inorganic chemistry subject, course code, KTT111. The study was conducted on first year undergraduate students.

The diffusion effect could prove to be a limitation because both the groups are from the same institution. However, both the classes take place at the same time and undergraduate students are too busy with their respective courses and activities to interact and discuss about the different approach of teaching. Another limitation would be the tutor who had conducted the SWH approach group may not have had sufficient time in the training of this approach since it was over one week, but the tutor has over 20 years of teaching experience.

1.8 Operational Definitions

Following are the keyword definitions of this research topic:

i. Science Writing Heuristic (SWH)

The Science Writing Heuristic is a new tool designed for learning (Prain & Hand, 1996). This SWH approach involves writing-to-learn tasks which are framed around five critical elements which are topic, type, audience, purpose and method of text production. Topic referred to the science concept under study, type was the writing outcome as a narrative; brochure, or powerpoint; audience referred to the audience to which the writing addressed; purpose refers to the particular goal of the activity and method of test production would imply handwritten or trpewritten(Prain & Hand, 1996). It is a framework that can be used for teaching to design classroom activities. It contains a teacher and student template for structuring relevant activities.

Here in this study this SWH was adopted in the tutorial session of the undergraduate students specifically on the topic of stoichiometry. The first tutorial session was the tutors' input of the brainstorming session and providing the guideline for the students to work in groups. These groups of students' discussions went in stages, to get the evidences and discuss in the groups and write their conclusions and present to the larger group as an audience type. In the process of the stages, they would go through their understanding of the topic of stoichiometry and the subheadings and apply that knowledge through different questions on the topic posed to them.

ii SWH integrated into stoichiometry

This SWH was originally framed for use in laboratory activities in secondary science. The SWH was designed to promote connections between investigation questions, procedures, data, evidence and knowledge claims. Here in this study, there is also two templates, the teacher template and another for the student. The teacher template had a list of activities that will involve students on brainstorming, reading, writing and presentations on stoichiometry. The student template involves the student as a group to make an explanation or generalization from their data and present it to give their understandings to audience.

iii. Stoichiometry

Stoichiometry is a branch of chemistry that deals with the quantitative relationships that exist among the reactants and products in chemical reactions and is founded on the law of conservation of mass. One can use stoichiometry to calculate masses, moles, number of products that can be produced and percentages within a chemical equation. It is a mathematical method to calculate quantitative information from chemical formulae or equation of chemical reaction (Jesperson, Brady & Hyslop, 2011). Here in the topic of stoichiometry, it would encompass sub-categories of balancing chemical equations, calculating molar masses and identifying the limiting substance or reagent.

iv. Attitude towards learning chemistry.

Gardner (1975) in his work has defined attitude towards science as “a learned disposition to evaluate in certain ways, objects, people, actions, situations or dispositions involved in learning science” (p. 2). Here the attitude would be examined as following what is given in the seven sub-scales of the TOSRA questionnaire as follows: -Social Implications of Science (S), Normality of Scientists (N). Attitude to Scientific Inquiry (I). Adoption of Scientific Attitudes (A), Enjoyment of Science Lessons (E), Leisure Interest in Science (L) and Career Interest in Science (C). The questions were taken per se without any change in the word science to chemistry. As such these seven sub-scales are covering several aspects of attitude to science and used here interchangeably to be the same as attitude towards learning chemistry, since chemistry is in the field of science.

v. Understanding of Stoichiometry

This is an understanding that goes beyond memorization of facts. It involves the ability to apply the facts in different situations or unfamiliar situations of problem solving (Nakhleh & Mitchell, 1993). Here the understanding will involve going beyond rote memorization of definitions of for example a mole but being able to understand and apply these concepts in very different situations with relative ease.

vi. Chemistry undergraduate

This research will focus on undergraduate students in Universiti Sains Malaysia, Penang, who are enrolled for the first-year course on inorganic chemistry, course code KTT111. One of the topics in this course is about stoichiometry.

vi. Test of Science Related Attitudes (TOSRA)

Fraser (1981) designed this questionnaire to measure secondary students' attitude towards science. There are seven scales or sub-constructs which measures attitude and the seven constructs are: -Social Implications of Science (S), Normality of Scientists (N). Attitude to Scientific Inquiry (I). Adoption of Scientific Attitudes (A), Enjoyment of Science Lessons (E), Leisure Interest in Science (L) and Career Interest in Science (C). Here Social Implications of Science (S) will be a result of studying stoichiometry, how the students would relate to chemistry in society. Normality of Scientists (N) would imply how chemists are viewed generally after the study of SWH approach on stoichiometry. Attitude to Scientific Inquiry (I) would refer to this inquisitive quality a result of the intervention of SWH approach. It will be examined Adoption of Scientific Attitudes (A) construct was a result of the intervention. Was there Enjoyment of Science Lessons (E) as an outcome of this intervention? The last 2 constructs of Leisure Interest in Science (L) and Career Interest in Science (C), where we can see the students interest in chemistry during their leisure time and if they would pursue a career in science as a result of this SWH approach in the study of stoichiometry.

1.9 Summary

This chapter consists of background of study, statement of problem, purpose of study, research questions, objectives, limitations of study and operational definitions. This study was conducted to explore the effects of SWH approach on undergraduate students understanding of stoichiometry and their attitudes towards learning chemistry.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

Students generally enrolled into chemistry courses at the undergraduate level as a routine subject since chemistry is prerequisite course to other advance level courses. Due to this reason students' commonly lack real interest to learn the subject and understanding of chemistry concepts appears to be minimal. Review of literature indicates that students lacking interest in taking science mainly chemistry because the teaching approach used failed to deliver the subject matter effectively. The 2020 Human Capital Road Map documents that Malaysia needs a total of 500,000 science and technology graduates to provide enough human capital for the country to achieve developed nation status by year 2020 (Second National Science and Technology Policy, 2003). However, the current report indicates that enrollment of the students in science subjects is less than 20 % (NST, 2011).

In this study SWH will be integrated into teaching and learning of stoichiometry as an approach to improve understanding of the relevant concepts as well as improve the undergraduate students' attitude towards learning chemistry. For this purpose, in this chapter complete review of literature on chemistry teaching and learning focusing on the topic of stoichiometry will be provided. Following this students' acquisition of the concepts related to stoichiometry and attitude towards learning chemistry will be described. The theoretical and conceptual framework of the study will be provided in this chapter as well.

2.1 Undergraduate Chemistry Program

The Bachelor of Science program majoring in chemistry and the Bachelor of Applied Science majoring in analytical chemistry or industrial chemistry are both three years program offered at the School of Chemical Sciences. Students enroll into these programs aftercompleting pre-U education at the matriculation or Sijil Tinggi Pelajaran Malaysia (STPM) level. To graduate with a degree in Bachelor of Science majoring in chemistry students were required to complete a total of 100 units. These 100 units comprises of core courses on chemistry (65units) as well as university level course (18 units) which are compulsory for all students to take up. Students have an option to minor (16 units) in any other areas offered by the university. This includes courses in management, computer sciences, English language and journalism. Aside from that, students minoring is required to take an additional 4 units of elective courses related to chemistry. Those who are not opting for any minors needed to take an additional 20 units of elective courses which are also relevant to chemistry.

Students enrolled in the Bachelor of Applied Science program are required to major either in analytical chemistry or industrial chemistry. They need to complete 105 units to graduate of which 60 units are core courses in chemistry. Those who minor in other subjects need to take 16 units of those minor papers and the full major students enroll for 20 units of additional chemistry courses.

The major courses for the students enrolled for both these programs are inorganic, organic, physical and analytical chemistry. These courses are compulsory to be completed in their first academic year. Basic laboratory courses are compulsory and cover inorganic, organic, physical and analytical chemistry.