THE EFFECTS OF A MULTIMEDIA CONSTRUCTIVIST ENVIRONMENT ON STUDENTS' ACHIEVEMENT AND MOTIVATION IN THE LEARNING OF CHEMICAL FORMULAE AND EQUATIONS

by

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Penyelidikan ini dijalankan bagi mengkaji kesan persekitaran multimedia berasaskan konstruktivisme terhadap pencapaian dan motivasi pelajar Tingkatan Empat dalam pembelajaran 'Formula dan Persamaan Kimia'. Koswer Instruksi Multimedia Konstruktivis (MCI) dan Instruksi Multimedia Objektivis (MOI) telah dibangunkan. Seramai 80 pelajar menerima MCI manakala 89 pelajar menerima MOI. Kajian eksperimen kuasi ini menggunakan reka bentuk faktorial 2 x 2. Pembolehubah bebas melibatkan pendekatan multimedia, iaitu MCI dan MOI, manakala pembolehubah bersandar merupakan pencapaian serta motivasi pelajar. Tiga pembolehubah moderator telah digunapakai, iaitu tahap kebolehan pelajar (kebolehan rendah, LA atau kebolehan tinggi, HA), gaya kognitif (field-dependent, FD atau field-independent, FI) serta jantina (lelaki atau perempuan) .

Kajian ini mendapati (i) pelajar MCI memperoleh pencapaian lebih baik secara signifikan dan lebih bermotivasi secara signifikan pelajar MOI, (ii) pelajar HA mencapai pencapaian lebih baik secara signifikan dan lebih bermotivasi secara signifikan berbanding pelajar LA, (iii) pelajar FI tidak memperoleh pencapaian lebih baik secara signifikan tetapi lebih bermotivasi secara signifikan berbanding pelajar FD, (iv) pelajar lelaki juga tidak memperoleh pencapaian lebih baik secara signifikan tetapi lebih bermotivasi secara signifikan berbanding pelajar perempuan, (v) pelajar HA memperoleh pencapaian lebih baik secara signifikan dan lebih bermotivasi secara signifikan berbanding pelajar LA dalam MCI, (vi) pelajar HA menggunakan MCI memperoleh pencapaian lebih baik secara signifikan tetapi tidak bermotivasi secara signifikan berbanding pelajar HA menggunakan MOI, (vii) pelajar LA menggunakan MCI tidak

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ABSTRACT

THE EFFECTS OF A MULTIMEDIA CONSTRUCTIVIST ENVIRONMENT ON STUDENTS' ACHIEVEMENT AND MOTIVATION IN THE LEARNING OF CHEMICAL FORMULAE AND EQUATIONS

This study is conducted to examine the effects of a multimedia constructivist environment on Form Four students' achievement and motivation in the learning of "Chemical Formulae and Equations". Multimedia Constructivist Instruction (MCI) and Multimedia Objectivist Instruction (MOI) courseware were developed. The MCI was assigned to 80 students whereas the MOI was assigned to 89 students. This quasi-experimental study employed a 2 x 2 factorial design. The independent variables were the multimedia approaches, i.e. the MCI and the MOI, whereas the dependent variables were the students' achievement and motivation. Students' ability levels (high-ability, HA or low-ability, LA), cognitive styles (field-independent, FI or field-dependent, FD) and gender (male or female) were the moderator variables.

This study found that (i) the MCI students performed significantly better and were significantly more motivated than the MOI students, (ii) the HA students performed significantly better and were significantly more motivated than the LA students, (iii) the FI students did not perform significantly better but were significantly more motivated than the FD students, (iv) the male students did not perform significantly better but were significantly more motivated than the female students, (v) the HA students performed significantly better and were significantly more motivated than the LA students in MCI, (vi) the HA students using MCI performed significantly better but were not significantly more motivated than the HA students using MOI, (vii) the LA students using MCI did not perform significantly better but were significantly more motivated than the LA students using MOI, (viii) the FI students performed significantly better and were significantly more motivated than the FD students in MCI, (ix) the FI students using MCI performed

significantly better but were not significantly more motivated than the FI students using MOI, (x) the FD students using MCI did not perform significantly better but were significantly more motivated than the FD students using MOI, (xi) the male students did not perform significantly better but were significantly more motivated than the female students in MCI, (xii) the male students using MCI performed significantly better but were not significantly more motivated than the male students using MOI, and (xiii) the female students using MCI also performed significantly better but were not significantly more motivated than the female students using MOI. Overall, these findings support the positive effect of multimedia constructivist environment on the learning of "Chemical Formulae and Equations".

CHAPTER 1

INTRODUCTION

1.0 Introduction

Malaysia, as a fast developing nation, is moving towards realising her vision to be a progressive and fully developed country by the year 2020. One of the challenges of Vision 2020 is "to establish a scientific and progressive society, a society that is innovative and forward-looking, one that is not only a consumer of technology but also a contributor to the scientific and technological civilisation of the future" (Information Department of Malaysia, 1997). The emphasis on science and technology has introduced multimedia as one of the delivery systems in schools.

With the advent of the knowledge-economy (k-economy) and globalisation, an effective instructional design is pivotal. Kumar and Helgeson (2000) noted that science education reform emphasised the need for integrating computer technology into learning, teaching and assessing. They felt that there are possibilities of providing a better education in science by modifying the teaching and learning of science, with special emphasis on computer technology such as computer-based laboratories, interactive videos, simulations, intelligent tutors, the Internet and the World Wide Web. Since Malaysia is committed to developing and providing world-class educational systems, an effective instructional medium, with the incorporation of an appropriate learning environment in various fields, is needed.

This study intended to design and develop a multimedia constructivist environment to solve the learning difficulties in chemistry. It has been reported that chemistry is a subject that contains many abstract concepts that are difficult to understand (Chan, 1988; Gabel, 1999; Muth & Guzman, 2000; Yalcinalp, Geban & Ozkan, 1995). The mole concept is the fundamental concept in quantitative chemistry that poses understanding difficulties among students and has been identified as a difficult concept in chemistry (Cervellati et al., 1982; Friedel &

Maloney, 1992; Gabel & Sherwood, 1984; Gabel, Sherwood & Enochs, 1984; Yalcinalp et al., 1995).

1.1 Background of Research

Chemistry has been documented as a difficult subject and chemistry courses are generally taught at a level of abstraction (Chan, 1988; Gabel, 1999; Muth & Guzman, 2000; Yalcinalp et al., 1995). The abstract knowledge of chemistry is said to have an influence on the learning difficulties of students (Yalcinalp et al., 1995).

In Malaysia, the report on the performance of Sijil Pelajaran Malaysia (SPM) 2003 and 2004 (Lembaga Peperiksaan, 2003, 2004) concluded that the topic "Chemical Formulae and Equations", "The Atomic Structure", "The Periodic Table" and "Chemical Bonding" are the basics in chemistry that need to be emphasised. The mole concept is the main concept that is taught in the topic of "Chemical Formulae and Equations". Therefore, the teaching and learning of chemistry should be improvised to enhance a better understanding of the mole concept because it involves the concrete foundation in chemistry.

The Ministry of Education has taken steps to improve the teaching and learning of science in the schools. These include the introduction of the Multimedia Super Corridor (MSC) in 1997 to accelerate Vision 2020, that is, to transform Malaysia into a knowledge-based society (Ministry of Education, 1997). The need for Malaysia to make the transformation from an industrial to an information-based economy led to the Smart School Flagship Application (Ministry of Education, Malaysia, 1997). This was to produce a technologically-literate thinking workforce who is able to perform in a global environment as well as to use information age tools and technology to improve productivity. The Smart School is also a learning institution that has been systematically reinvented in terms of its teaching-learning practices and school management in order to prepare students to practise self-assessed and self-directed learning focusing on individual achievements and development (Ministry of Education, Malaysia, 1997). Thus, the introduction of multimedia has become significant in order to achieve the objective of the Smart School Flagship Application.

In Malaysia, the application of computers is now infiltrating all levels and areas of education. Computers, as the technology in the multimedia stream, have long been introduced to Malaysian schools but students use these computers as a tool. Many schools use computers for documentation purposes only but in this age of information technology, the usage of computers as an instructional medium in schools is more imperative due to the huge volume of information that is changing rapidly. Thus, most schools are equipped with computer laboratories but they are hardly used as instructional mediums.

Educators should integrate computers as an instructional medium to facilitate the teaching and learning process. Multimedia instruction is possible since many schools are now equipped with computer laboratories. Students are not only encouraged to be computer literate but are also allowed to surf the Internet to gather more information to construct their own knowledge. Educators are needed to facilitate students' construction of knowledge in a very exciting, presentable and practical method. Multimedia instruction not only contains the expected components but also instructs students on an individual basis. This differs from the traditional instruction used in classrooms where the teacher has to deal with a large number of students.

Like other science courses, chemistry courses have undergone several changes in the past few years both in terms of what is taught and how it is taught. The latest change took place in the year 2000 with the reorganisation of the Malaysian chemistry syllabus and the integration of the constructivist learning method. One of the objectives of this reorganisation of the syllabus was to incorporate the constructivist approach with the learning and teaching of science. There are various constructivist learning methods that are being introduced, such as inquiry learning, mastery learning, problem-solving and discovery learning. Although teachers have been provided with a substantial amount of introduction on the various constructivist learning methods to facilitate the teaching and learning process, they have not been provided with expertise training to implement these methods. These teachers still lack constructivist materials and readily accessible models of instruction that are in line with the student-centred models of instruction to enable novice teachers to reflect on and change their science teaching praxis.

The reorganisation of the syllabus is also followed by the usage of laptops in classrooms. The aim of the Ministry of Education is to encourage teachers to use the laptops to facilitate the teaching and learning process. So, science teachers are now using the provided laptops as a teaching aid. However, the students still have not been given a chance to be hands-on with computers. To overcome this problem, the Ministry of Education had decided to provide all schools their own computer laboratories. The main intention is for the schools to use computers as an instructional medium, but the use of computers as a learning tool is left much to be desired.

Since 2003, the Ministry of Education has supplied laptops to all schools in Malaysia to enable teachers integrate their usage into the teaching and learning process. Computer laboratories were installed in many schools and this clearly shows that the Ministry of Education is emphasising the usage of computers in education. At present, in most primary and secondary schools in Malaysia, computers are used primarily to improve literacy and as a teaching aid.

Very few schools have started utilising computers as an instructional medium due to the inaccessibility of appropriate courseware. The courseware that is now being widely used at present by government schools in Malaysia is from the Curriculum Development Centre, Ministry of Education, Malaysia. Based on the researchers' expertise in teaching of science and chemistry, these courseware are used as teaching aids and are developed in a linear manner. If students are provided courseware designed in a constructivist environment, they will be encouraged to explore on their own and at their own pace to construct knowledge.

1.2 Statement of the Problem

Chemistry, as a discipline, has a bright future, and chemistry education delivers a truly broad scope and integral position of chemistry, not only among the sciences but also in daily life and human activities in general (Price & Hill, 2004). However, chemistry has been reported as one of the most difficult subjects to learn (Chan, 1988; Muth & Guzman, 2000; Stieff & Wilensky, 2002). Stieff and Wilensky (2002) expressed the view that learning chemistry imposes great demands on students and teachers; instructors often have to use mathematical formulae, chemical symbols and scientific measurements simultaneously to illustrate the non-visible scenario in chemistry. Gabel (1999) also documented that chemistry is a very complex and difficult subject, and this imposes implications for its teaching. Many researchers reported that chemistry is an abstract and a formal subject (Chan, 1988; Gabel, 1999; Muth & Guzman, 2000; Yalcinalp et al., 1995) and thus, it often results in learning difficulties of students.

Johnstone (2000) noted that much effort has been expended to design demonstrations, microchemistry, computer-assisted learning, CD-ROMs, units on societal issues and a plethora of textbooks. All these were associated with the transmission of chemical knowledge only rather than to the nature and desirability of the content or to the nature of the learning process. According to Johnstone (2000), the International Journal of Science Education had devoted over a third of its space to work on "Alternative Frameworks" and this had encouraged an approach to research which was negative and offered few solutions to the problems that were exposed.

New theories and a change of paradigms play an important role in improving and also overcoming learning difficulties in chemistry. The Malaysian Form Four students who are still at the concrete operations level or early formal operations level will experience difficulty in understanding and applying a formal subject. Since they are in the transitional position from concrete operations to formal operations according to Piaget's (1970) perspective on thought processes, it is vital for educators to design an instruction that will enable them to learn chemistry in a formal setting. The instruction designed for this study should be able to elevate these students to the formal operations level that promotes hypothetical-deductive reasoning, scientific-inductive reasoning and reflective abstraction.

A shift in the dominant theory of learning from behaviourism to constructivism has had a significant impact on chemistry education research over the past 50 years (Johnstone, 2000). He expressed that the changes in chemistry education research that have emerged from these two perspectives seemed dichotomous. Behaviourist-based research attempt to narrow things down. Learning is placed under the microscope in order to identify salient variables that could assure improvement in performance. In contrast, constructivist-based research reverses that focus, using a telescope to broaden the view of learning.

All along, the teaching and learning in Malaysia has been conducted in an objectivist environment. The objectivist approach is basically pouring information into the learner. The most basic assumption is that knowledge is external to humans, and the meaning of the world exists independent of the human mind (Jonassen, 1992). The educator identifies the knowledge to be imparted to learners and this knowledge is identified via specific behavioural objectives. Jonassen also stated that all learners are expected to achieve learning objectives in the same manner. The evaluation procedure entails using an objective evaluation method to determine whether the objectives have been met and to what degree (Jonassen, 1992).

When the education reformation took place in the year 2000, the constructivist environment was introduced into the Malaysian education system. In this environment, knowledge is constructed in the mind from experience. Merrill

(1991) noted that in a constructivist environment, learning is a personal interpretation of the world and is an active process in which meaning is developed on the basis of experience. The conceptual growth comes from the negotiation of meaning, the sharing of multiple perspectives and the changing of our internal representations through collaborative learning (Merrill, 1991). According to Merrill, learning should also be situated in realistic settings and testing should be integrated with the task and not as a separate activity.

Since the mole concept has been reported as a difficult, abstract and formal topic, the chemistry educators have devoted considerable time in developing curricula that help students visualise the molecular world and connect classroom concepts to the world outside school (Stieff & Wilensky, 2002). Hence, it is necessary to develop a constructivist learning environment incorporating the instructional strategies to enhance the learning of abstract chemistry concepts. The students will be able to visualise the molecular world and construct their own knowledge in a more meaningful manner. They will also have to deploy hypothetical-deductive and logical reasoning to solve problems in authentic situations.

The Ministry of Education in Malaysia emphasises the usage of multimedia to facilitate the teaching and learning process in schools. They have provided laptops to teachers, computer laboratories to schools and courseware to be utilised in the teaching and learning process. The question is, "Are the computers and laptops being used as teaching aids to facilitate the teaching and learning process or are they being used as instructional medium?"

However, there are problems that have arisen such as the lack of sufficient computers to enable students to be "hands on". Most school computer laboratories consist of about 20 computers only and there are usually an average of thirty students in a class. Therefore, some of the students have to share the computers with fellow students. This will hinder them from being self-paced and much time will be wasted due to the sharing. However, to persuade the Ministry of Education to provide each student with a computer, research must prove that it is essential to improve the students' achievement and enhance their motivation.

Although there are many local researchers (Fong, 2000; Fong & Ng, 1996, 1998, 1999, 2000; Kong, 2002; Norizan, 2002; Toh, 1995, 1998; Toh, Abdul Rahim & Ng, 1998) conducted multimedia studies but as far as the researcher is aware, no research on multimedia constructivist environment in chemistry was reported. Thus, there is a need for a study in Malaysia to discover the effects of the multimedia constructivist environment towards the students' achievement and motivation.

There is no readymade courseware designed in a constructivist environment in the Malaysian education system. The courseware provided by the Curicullum Development Centre, Educational Technology Department and Pelangi Mind-edge is generally based on the objectivist model. There might be some constructivist elements embedded within the courseware but on the whole the courseware is designed in an objectivist manner. The teachers might not have resources and the time to prepare their own courseware using the constructivist environment due to the lack of expertise and knowledge on courseware development. Thus, the Ministry of Education must ensure that readymade courseware is provided to schools to assist teachers implement their teaching and learning processes effectively in a constructivist environment.

Malaysia as a fast developing nation is moving towards excellence through education. Greater involvement and a bigger work force in science and technology are required for the knowledge-economy and globalisation. Therefore, the root factor will have to start from school level. More students are encouraged to enrol in the science stream to congregate the work force required in the field of science and technology. In order to achieve a developed country by the year 2020, the Ministry of Education has set target to achieve the ratio 60:40 for the science stream students compared to the arts stream students by the year 2010 (Pusat Perkembangan Kurikulum, Kementerian Pelajaran, 2001). This has indirectly encouraged many students with average and below average results to be accepted in the science stream (Kong, 2002). Kong expressed that these students are the main challenge for educators since most of them are weak in the science subjects. She also mentioned that teachers have to deal with students of different levels of science skills and the weaker groups might develop a negative attitude and the lack of interest in learning pure science subjects. This practice had also indirectly created an environment where the class will be of a mismatch of high-ability students and low-ability students in this scenario. The low-ability students will be poorly motivated and might be subjected to low achievement in the pure sciences. To hinder this, it is important for the Ministry of Education to resolve this problem and provide a learning environment and an instructional design that are suitable for the students to improve their achievement and increase their motivational level.

Based on the Third International Mathematics and Science Study, TIMSS Report (Appendix A), the average for Malaysia's mathematics and science achievement of eight graders in 1999 was higher than the international average. However, Malaysia's mathematics achievement was at the 16^{th} position and science achievement was at the 22^{nd} position. In the year 2003 (Appendix B and Appendix C), the TIMSS Report also showed a similar result for Malaysia. The average scale score for mathematics and science was higher than the international average but it fell to the 10^{th} position for mathematics and 20^{th} position for science. This shows that Malaysia is still far behind Singapore (top position) and therefore, need to strive very hard to improve its performance of mathematics and science. Hence, this implies that the teaching and learning of science and mathematics need to be improved in order to elevate the achievement in the two subjects to a higher level.

Since the introduction of Keller's (1987) ARCS model of motivation, many studies have been carried out to investigate students' perceived motivation towards instructional material and chemistry using the Instructional Materials Motivation Scale (IMMS) instrument. Many foreign studies (Duchastel, 1997; Hykle, 1993; Malone, 1984; Mistler-Jackson & Songer, 2000; & Pulist, 2001) as well as local studies (Kong, 2002; Toh, 1998; Toh, Abdul Rahim & Ng, 1998) have documented the effects of students' perceived motivation towards multimedia. However, information on the effects of the student's perceived motivation towards instructional material and also towards chemistry in the multimedia constructivist environment are relatively lacking, especially, in Malaysia. Thus, this study intends to investigate whether students are better motivated towards chemistry and also the multimedia instruction in a constructivist environment.

Computers in education may provide their greatest potential for disadvantaged students, those of low-ability and the concrete operational students. Cavin and Lagowski (1978) investigated the effects of computer simulated or laboratory experiments and student aptitude on achievement and time in a college general chemistry laboratory course. They reported that computer-simulated experiments are useful especially for low-aptitude students, both as a laboratory experiment substitute and as a supplement, while being a satisfactory means of instruction for higher-aptitude students. So, it is important to investigate the effect of the multimedia constructivist environment on the low-ability as well as high-ability students.

The design and development of the multimedia constructivist environment must accommodate both low-ability and high-ability students. The rationale is to ascertain that both groups of students will benefit equally when exposed to a multimedia constructivist environment. Each individual (low-ability and high-ability) is expected to perform differently (Cronbach & Snow, 1977) and this study intends to find out whether both low-ability students and high-ability students can adapt easily to a multimedia constructivist environment. A certain learning environment might only motivate either the higher ability students or the lower ability students (Cavin & Lagowski, 1978). It is also vital to know whether there are any differences in the higher ability and lower ability students' motivation towards the constructivist environment and objectivist environment, as it is more appropriate to design an instruction that motivates both groups of students.

Many psychological moderator variables affect students' achievement. Amongst them are the locus of control, spatial ability, students' computer anxiety, and field dependency. Previous studies undertaken on multimedia instruction (Kong, 2002; Irfan, 2000; Ng, 1996, 1998; Ng & Fong, 1996; Ng & Toh, 1996) showed that field dependency stands out as the strongest among the various psychological moderator variables. However, the effects of field dependency on students in the multimedia constructivist environment are relatively unknown and still not well researched especially in Malaysia.

This study also intended to predict whether the field-dependent or the field-independent students would perform better in a constructivist environment. The students thinking and learning styles have to be considered in designing an appropriate multimedia instruction. This has an important implication on the development of the courseware that is adaptive and customised to the psychological profile of learners. The field-independent students are expected to learn better in an unstructured and non-linear environment (Constructivist Learning Environment) whereas the field-dependent students are expected to learn better in a more structured and linear environment (Objectivist Learning Environment). However, it is vital to design an instruction that would increase the achievement for both groups. Therefore, Multimedia Constructivist Instruction should be appropriately designed to suit both field-dependent and field-independent students.

Kahle and Meece (1994) reported gender differences in science achievement while carrying out research on gender issues in the classroom. While investigating the gender difference in attitudes, achievement and use of computers, Hattie and Fitzgerald (1988) also found that there is a gender difference in the usage of computers that is more evident at the secondary level than in the elementary years. Therefore, an investigation into gender differences in terms of achievement and also motivation would provide useful insight into this research. The rationale is to determine whether boys and girls perform equally well when exposed to a multimedia constructivist environment. There are a number of studies reported that they show a significant difference in their formal operational level and learning abstract concepts and therefore, a significant difference in their achievement score was reported (Andersen & Nielsen, 2003; Turner & Lindsay, 2003; Yea Ru Chuang, 1999). However, other studies reported that there is no significant difference in their formal operation level and learning abstract concepts, and thus, both male and female students show no significant difference in their achievement score using multimedia instruction. Therefore, it is significant to design a multimedia constructivist environment that enhances the achievement of both the male and female students and elevates their motivation towards the instructional materials and chemistry.

This study developed a constructivist environment for the students to learn the mole concept. It also employs multimedia instruction as a medium of instruction to investigate their achievement in chemistry and its effect on their motivation towards chemistry and multimedia instruction. As many researchers have documented that the mole concept is taught and learned using the problem-solving method (Gabel & Bunce, 1994; Hollingworth, 2001; Johnstone, 1993b; Nurrenbern & Pickering, 1987; Reid & Yang, 2002), the multimedia instruction for the constructivist environment will be based on the problem-solving component.

For this purpose, the researcher designed a Multimedia Constructivist Instruction that is expected to enhance the achievement of the students and elevate their motivation towards chemistry and the instruction. The researcher also examined whether the students' ability levels (low-ability and high-ability), cognitive styles (field-dependent and field-independent) and gender (male and female) affect their achievement in chemistry as well as their motivation towards chemistry and multimedia instruction.

1.3 Research Objectives

The objectives of this research are:

a) To investigate the effects of the Multimedia Constructivist Instruction (MCI) approach compared to the Multimedia Objectivist Instruction (MOI) approach in the learning of "Chemical Formulae and Equations" (the mole concept) on the students' achievement score (as measured by the pretest and posttest)

b) To investigate the effects of the MCI approach compared to the MOI approach in the learning of "Chemical Formulae and Equations" (the mole concept) between

   (i) the low-ability and high-ability students

   (ii) the field-dependent and field-independent students

   (iii) the male and female students

   towards their achievement score

c) To investigate the effects of the MCI approach compared to the MOI approach in the learning of "Chemical Formulae and Equations" (the mole concept) on the students' IMMS score (as measured by the Instructional Materials Motivation Scale)

d) To investigate the effects of the MCI approach compared to the MOI approach in the learning of "Chemical Formulae and Equations" (the mole concept) between

   (i) the low-ability and high-ability students

   (ii) the field-dependent and field-independent students

   (iii) the male and female students

   towards their motivation as indicated by the IMMS score.

1.4 Research Questions

1 (a) Is there any significant difference in the achievement score (as measured by the pretest and posttest) of the students in the

Multimedia Constructivist Instruction (MCI) approach as compared to the Multimedia Objectivist Instruction (MOI) approach?

(b) Is there any significant difference in the achievement score between the low-ability and high-ability students in the MCI approach as compared to the MOI approach?

(c) Is there any significant difference in the achievement score between the field-dependent and field-independent students in the MCI approach as compared to the MOI approach?

(d) Is there any significant difference in the achievement score between male and female students in the MCI approach as compared to the MOI approach?

2 (a) Is there any significant difference in the IMMS score (as measured by the Instructional Materials Motivation Scale) of the students in the MCI approach as compared to the MOI approach?

(b) Is there any significant difference in the IMMS score between the low-ability and high-ability students in the MCI approach as compared to the MOI approach?

(c) Is there any significant difference in the IMMS score between the field-dependent and field-independent students in the MCI approach as compared to the MOI approach?

(d) Is there any significant difference in the IMMS score between male and female students in the MCI approach as compared to the MOI approach?

1.5 Research Hypotheses

The level of significance, α, used for this study was 0.05. The hypotheses of this study that corresponded to the above research questions were stated in the alternate form with reference from the past research conducted in multimedia instruction as well as constructivist learning environment and were as follows:

$H_1$1: The students who are using the MCI approach will show a significant difference compared to the students who are using the MOI approach in their achievement score (as measured by the posttest minus the pretest).

$H_1$2: The high-ability students will show a significant difference compared to the low-ability students who are using the multimedia instruction approach in their achievement score (as measured by the posttest minus the pretest).

$H_1$2a: The high-ability students will show a significant difference compared to the low-ability students who are using the MCI approach in their achievement score.

$H_1$2b: The high-ability students who are using the MCI approach will show a significant difference compared to the high-ability students who are using the MOI approach in their achievement score.

$H_1$2c: The low-ability students who are using the MCI approach will show a significant difference compared to the low-ability students who are using the MOI approach in their achievement score.

$H_1$3: The field-independent students will show a significant difference compared to the field-dependent students who are using the multimedia instruction approach in their achievement score (as measured by the posttest minus the pretest).

$H_1$3a: The field-independent students will show a significant difference compared to the field-dependent students who are using the MCI approach in their achievement score.

$H_1$3b: The field-independent students who are using the MCI approach will show a significant difference compared to the field-independent students who are using the MOI approach in their achievement score.

$H_1$3c: The field-dependent students who are using the MCI approach will show a significant difference compared to the field-dependent students who are using the MOI approach in their achievement score.

$H_1$4: The male students will show a significant difference compared to the female students who are using the multimedia instruction approach in their achievement score (as measured by the posttest minus the pretest).

$H_1$4a: The male students will show a significant difference compared to the female students who are using the MCI approach in their achievement score.

$H_1$4b: The male students who are using the MCI approach will show a significant difference compared to the male students who are using the MOI approach in their achievement score.

$H_1$4c: The female students who are using the MCI approach will show a significant difference compared to the female students who are using the MOI approach in their achievement score.

$H_1$5: The students who are using the MCI approach will show a significant difference compared to the students who are using the MOI approach in their IMMS score (as measured by the Instructional Materials Motivation Scale).

$H_1$6: The high-ability students will show a significant difference compared to the low-ability students who are using the multimedia instruction approach in their IMMS score (as measured by the Instructional Materials Motivation Scale).

H_16a: The high-ability students will show a significant difference compared to the low-ability students who are using the MCI approach in their IMMS score.

H_16b: The high-ability students who are using the MCI approach will show a significant difference compared to the high-ability students who are using the MOI approach in their IMMS score.

H_16c: The low-ability students who are using the MCI approach will show a significant difference compared to the low-ability students who are using the MOI approach in their IMMS score.

H_17: The field-independent students will show a significant difference compared to the field-dependent students who are using the multimedia instruction approach in their IMMS score (as measured by the Instructional Materials Motivation Scale).

H_17a: The field-independent students will show a significant difference compared to the field-dependent students who are using the MCI approach in their IMMS score.

H_17b: The field-independent students who are using the MCI approach will show a significant difference compared to the field-independent students who are using the MOI approach in their IMMS score.

H_17c: The field-dependent students who are using the MCI approach will show a significant difference compared to the field-dependent students who are using the MOI approach in their IMMS score.

H_18: The male students will show a significant difference compared to the female students who are using the multimedia instruction approach in their IMMS score (as measured by the Instructional Materials Motivation Scale).

H_18a: The male students will show a significant difference compared to the female students who are using the MCI approach in their IMMS score.

H_18b: The male students who are using the MCI approach will show a significant difference compared to the male students who are using the MOI approach in their IMMS score.

H_18c: The female students who are using the MCI approach will show a significant difference compared to the female students who are using the MOI approach in their IMMS score.

1.6 Significance of the Study

The problems in the mole concept are not a new phenomenon and are of a major international concern. Many relevant studies have been carried out in various parts of the world such as Italy, Israel, Turkey, USA, Canada and Malaysia. The review of literature reveals very few international studies in chemistry with regard to the Constructivist Learning Environment and based on the survey of the literature, no specific study has been conducted in Malaysia related to teaching the mole concept in this environment. Hence, this study is expected to provide some useful information for instructional designers to create more multimedia instruction in the constructivist environment that will enhance and provide some resources for CD-ROMs and web-based learning.

The study was intended to suggest an alternative to the traditional learning environment in schools. Although teachers were exposed to the constructivist elements in the teaching and learning process during the revised curriculum of 2000, they still use the "note-book" to facilitate the teaching and learning process and therefore, one-to-one instruction is not possible. The multimedia constructivist learning environment employed in the present study will enable students to learn and construct knowledge on their own and the teacher will become the facilitator. Each student will be provided with a computer and they will be able to construct their knowledge according to their own experience at their own pace. The outcome of this study is expected to benefit the educators, curriculum experts and other researchers.

One of the main objectives of the study was to test the efficacy of the MCI compared to the MOI amongst the students' achievement and motivation towards the learning of chemistry and the usage of multimedia instruction. The results from this investigation would indicate the effects of the constructivist environment in the students' chemistry learning outcome.

The study also aimed to seek the difference between the low-ability and high-ability students, the field-dependent and field-independent students and the male and female students in their achievement and motivation towards the MCI and MOI. The findings from this study will contribute insightful information on the ability levels of the students, different learning styles (FD/FI) and gender preferences. This can be used as a basis for educators to improve the teaching and learning among Form Four chemistry students. The students will benefit in the sense that they will be provided with better learning environments and facilities. The instructional designers will also be provided with useful insights into the aptitudes and psychological profiles of the students in the constructivist environment.

One of the difficult transitions for new secondary science teachers is that from novice teacher to master teacher. This is because there is a major revamp in the teaching of science and mathematics where the medium of instruction is changed from the Malay medium to English medium to enable Malaysia to compete in the global economy. As a result, a large number of teachers who have been teaching these subjects using the Malay medium find it difficult to adjust this shift. Therefore, there is a dilution in the quality of teaching from those advocated by the curriculum standards. This study provides adjunct instructional materials to meet these needs.

The majority of the cited research in the literature review on the mole concept was conducted using the problem-solving approach. This concept involved extensive calculations and problems to be solved. So, this study developed a multimedia instruction for the mole concept using the problem-solving approach for the constructivist environment.

1.7 The Theoretical Framework

The theoretical base for this study originated from Jonassen (1999), Clark and Mayer (2003) and Keller (1987). Jonassen presented a macro model for the learning environment; whereas Clark and Mayer proposed the instructional design model for multimedia and Keller developed a framework for motivation as the micro model.

Jonassen (1999) proposed the Constructivist Learning Environment model that consists of a problem, question or project as the central focus of an environment. The goal of the learner is to interpret and solve a problem or complete a project. The environment would be filled with five interpretative and intellectual support systems as guidance for the learner and to assist him/her to solve the problems. The support tools or system for this Constructivist Learning Environment are related cases, information resources, cognitive tools, conversation/collaboration tools and social/contextual support.

Clark and Mayer (2003) introduced an instruction delivered on a computer by CD-ROM and the Internet and this is called e-learning. e-Learning consists of content (information) relevant to the learning objectives. It uses instructional methods (techniques) such as examples and practice to help learning. It also uses media elements such as words and pictures, to deliver the content and methods. e-Learning builds new knowledge and skills linked to individual learning goals. In general, e-learning courses include both content and instructional methods to help students learn the content. Learning courses are delivered via the computer using words in the form of the spoken or printed text and pictures such as illustrations, photos, animation or video. The objective of e-learning courses is to help learners reach personal learning objectives. In short, the goal of e-learning is to build knowledge and skills to help individuals achieve personal learning goals.

Keller (1987) developed the ARCS model of motivation that was used in this study as a measure of motivation among the Form Four students to investigate their motivation towards chemistry and multimedia instruction. This model identifies four essential strategy components for motivating instruction:

(i) A – Attention strategies for arousing and sustaining curiosity and interest.

(ii) R – Relevance strategies that are linked to learner' needs, interests and motives.

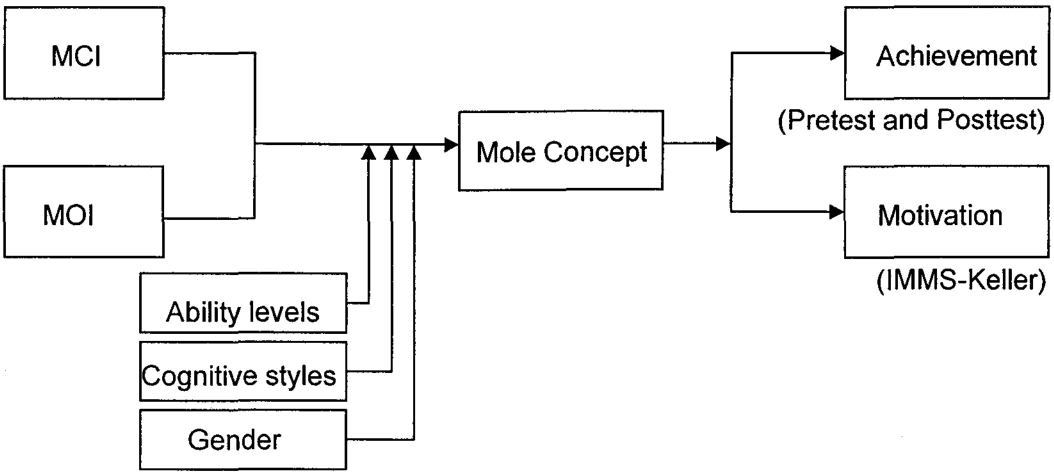
(iii) C – Confidence strategies that help students develop a positive expectation for successful achievement.

(iv) S – Satisfaction strategies that provide extrinsic and intrinsic reinforcement for effort (Keller, 1983).

1.8 The Research Framework

The research framework of this study is depicted in Figure 1.1. The model postulated two independent variables that attempted to impose effect on the two dependent variables. The independent variables were the MCI and the MOI. These independent variables were expected to show a significant variance on the dependent variables. The dependent variables were achievement and motivation. There were three moderator variables present in this study and they gave a strong contingent effect on the independent and dependent variable relationship. The moderator variables were ability levels, cognitive styles and gender.

Multimedia Constructivist Instruction was expected to show a significant positive improvement among the students in the mole concept achievement test. From the past studies, multimedia instruction and the constructivist learning environment has proven to enhance learning especially in higher order. So, the combination of both would provide a better environment for a more meaningful learning. This independent variable was also expected to provide a significant positive result on the students' motivation towards chemistry and multimedia instruction. This study also intended to explain the relationships of ability levels, cognitive styles and gender towards achievement and motivation.



MCI	– Multimedia Constructivist Instruction
MOI	– Multimedia Objectivist Instruction
Ability Levels	– Low-Ability and High-Ability
Cognitive Styles	– Field-Dependent/Field Independent
Gender	– Male and Female

Figure 1.1 The Research Framework for Multimedia Instruction

1.9 Limitations

The study aimed to investigate the effects of the multimedia constructivist environment on achievement and motivation in the learning of "Chemical Formulae and Equations". The sample of this study consisted of Form Four Science students from two suburban secondary schools in Butterworth. Their ages ranged from 16 to 17 years old. This limited the generalisability of the study to non-science stream students and students from other states in Malaysia, including Penang island.

This study investigated one out of 13 topics in chemistry that made generalisation on chemistry impossible. The constructivist instruction was designed for the problem-solving component, this being only one component investigated out of many constructivist components. Thus, the results from this study could not be generalised for all the components in constructivist instruction.

1.10 Operational Definitions

For the purpose of clarification, the following terms used in this study were either adopted from other studies or were operationally defined as follows:

The Mole Concept

One mole is the quantity of a substance that contains the number of particles similar to the one found in 12.000 of carbon-12. The number of particles forms a constant number called the Avogadro number of Avogadro constant, N_A, which is 6.02×10^{23} (Eng, Lim & Lim, 2006). This concept is taught in the third chapter of chemistry, "Chemical Formulae and Equations" at the fourth level of secondary school in Malaysia.

Multimedia

This is combination of content and instructional methods that encourages learners to engage in active learning by mentally representing materials in words and pictures making connections between the pictorial and verbal representations (Clark and Mayer, 2003).

Multimedia Constructivist Instruction (MCI)

This is a courseware designed and developed based on Jonassen's Constructivist Learning Environment (1999) model, Clark and Mayer's (2003) multimedia learning and Allessi and Trollip's (1991) instructional systems design and development for multimedia. The discerning attributes are:

(a) The model consists of a problem as the central focus of the environment.

(b) Students are not guided on how to go about solving a problem but are expected to do so by exploring the courseware on their own.

(c) The problem statement is loosely defined.

(d) A variety of tools are provided for the students to construct knowledge such as:

(i) Related cases

(ii) Information resources

(iii) Cognitive tools

(iv) Conversational collaboration tools

(v) Social contextual support

(e) The learning activities, that provide instructional support in this courseware and enable students to construct knowledge are modelling, coaching and scaffolding.

Multimedia Objectivist Instruction (MOI)

This is a courseware designed and developed based on the tutorial approach, Clark and Mayer's (2003) multimedia learning, Allessi and Trollip's (1991) instructional systems design and development for multimedia and Gagne's (1985) nine events of instruction. The discerning attributes are:

(a) The courseware is designed in a highly linear manner. The students are given tutorials with definition, information, historical background, formulae, media and examples of cases in sequence according to the sub-topics.

(b) There are also summative evaluations at the end of each lesson.

(c) The students are guided and forced to follow the flow given in the courseware according to the sub-topics.

(d) The objectives are presented clearly in a behavioural manner.

Field-Dependent Students

Students scoring below the GEFT (Witkin, et al., 1971) calculated mean for a sample are considered field-dependent. The students having a score at the GEFT calculated mean value will be omitted. These individuals tend to have highly developed social