Chapter 1

INTRODUCTION

Computers are now an integral part of our lives, be it in business, home entertainment, games, education and training, research and development, administration and many other fields. Multimedia is another word used synonymously with computers, where in many organizations special sections have been set up to cater to the growing demand in developing multimedia application. Multimedia and interactive multimedia (IMM) systems are increasingly making an impact especially in educational training settings. IMM is seen as a new technology with the potential to change the way we learn, the way we acquire information and the way we entertain ourselves (Philips,1997).

Background of Study

Reform in classroom practices is taking place around the globe. Educationists worldwide have come to realize that schools and their traditional classroom instructions have not produced students who are adequately prepared for the information age. It has been generally agreed that a workforce who is knowledgeable about mathematical, scientific and technological aspects of the emerging information age need to be produced in order to compete in today's global economic environment (NCISLA, October Communications, 1998). However, there appears to be a gap between the expected outcome of the human resource and the one currently available. The American National Center for Improving Student Learning and Achievement in Mathematics and Science (NCISLA) had reported that the failure to educate students in science and mathematics, in general, was seen as a product of the "traditional" teaching commonly practiced in schools throughout the United States. Instructions in most schools follows a mechanistic sequence wherein the job of teaching primarily involves planning, presenting, assessing students and keeping order in the classroom. Teacher's responsibility often ends when students are told what they must know and memorize . This is especially so in countries which places a high degree of emphasis on public examinations and their achievement results (NCISLA, October Communications, 1998).

Hence, a change in the instructional procedures in science and mathematics is sought in order to promote a better understanding of the subjects. One of the strategies to meet this objective is through the use of information technology -based teaching and learning. Information technology (IT) should in theory benefit all aspects of science teaching and learning (Frost, 1997). Through IT, teachers and learners can tap into a growing wealth of educational resources outside the school where one of these educational resources can be in the form of multimedia.

In the Information Age, knowledge will be the basis for power, wealth and influence where the information and multimedia technology acts as a valuable input in the different aspect of life (Mahathir,1998). Malaysia, with the realization to keep up with the changing world, has come up with a vision called Vision 2020, the purpose of which is to attain a developed-nation status by the year 2020. Within this Vision is Malaysia's IT-Agenda which defines the content as the creation of a civil society; meaning a community which is self-regulating and empowered through the use of knowledge, skills and values inculcated within the people.

The underlying creative force to achieve a knowledge-based society will be provided by digital technology. The National Information Technology Council (NCIT) created in 1994 was set up to ensure the commitment of the government to the development of IT and multimedia in the country (Mahathir,1998).

One of the ways for this Vision to be realized is to transform the educational system from memory-based learning designed for the average student to an education that stimulates thinking, creativity, and caring in all students where individual abilities and learning styles will be based on more equitable access (Ministry of Education,Malaysia 1, 1997).

Malaysia needs to produce a new generation that can think, process, analyze and manipulate data in the ever-increasing avalanche of information. This new generation need also be equipped with problem-solving skills and be responsible for any decisions made based on ethical and moral values embedded in the education system. In this regard, the Ministry of Education has formalized, in 1995, a mission statement which is as follows, "To develop a world class quality education system which will realize the full potential of the individual and fulfill the aspirations of the Malaysian nation" (Ministry of Education,Malaysia 1,1997).

One of the ways to fulfill this mission statement, will be through the implementation of the Malaysian Smart Schools. The Smart School is one of the seven flagship applications of the Malaysian Multimedia Super Corridor (MSC). The MSC briefly, is a giant test-bed for experimenting with multimedia technology and the evolution of a new way of life in the unfolding age of information and technology (Mahathir, 1998). The Malaysian Smart School Conceptual Blueprint defines the Smart School as a learning institution which is systematically reinvented to prepare children for the Information Age.

The main feature of the infrastructure of these Smart Schools will be the presence of technology as an important integration in each classroom. The electronic structure will allow information to be two-way where access and input of data and information will be made available. Emphasis in the Smart Schools will be students' self-learning and student-centered learning based on technology and applications of multimedia while teachers are facilitators and counselors in the process of learning (Ministry of Education,Malaysia 2, 1997). In Smart Schools, besides the conventional educational materials, a wide variety of multimedia electronic teaching-learning materials using computers, CD-ROMs, the Internet, electronic mail, school web-sites, video and tele-conferencing and others would be used. These leading-edge technology to be used in the Smart Schools should make learning more interesting, stimulating and meaningful.

The Ministry of Education has emphasized that the main focus of these schools is to produce students that are creative, can generate information, a "thinker", flexible when faced with new situations and can analyze and make decisions. The Malaysian Smart Schools give emphasis on the individual development holistically and give priority to the intellectual as well as the affective domains. It is hoped that the setting up of these technology-supported schools will help jump-start the change in the education system and help foster the development of a work force prepared to meet the challenges of the future of which IT plays an important role (Wan Zahid, 1997).

Since multimedia, specifically interactive multimedia (IMM) will play an increased role in these Smart Schools, it would be interesting to see whether an IMM programme developed for the purpose of teaching and learning, would live up to the promises and advantages of smart learning as claimed worldwide.

Smart learning in science is vital to allow the nation to compete with others around the world in the Information Age. One way to boost science education is to take advantage of the advances in computer technology to enable the concepts in science be presented for easy understanding. Science and IT need to go hand in hand for personal, social and economic development.

Purpose of study

Part of the teaching and learning materials to be used in the Smart Schools and eventually in all Malaysian schools, will be in the form of courseware materials which are technology-based. Schools are encouraged to use technology-driven teaching and learning aids to enhance students' learning. In response to this need, this study was undertaken to develop and evaluate an IMM programme in Electrochemistry, a Form Four topic in the Malaysian Chemistry syllabus. The programme developed is termed as ELEKTROKIMIA programme.

An IMM programme is a course module which empowers a user to interact within the content. The programme itself has integrated the various multimedia elements like text, graphics, sound, images, video and animation where the user is allowed control over the links, determine the path of navigation, set their own speed of information and construct the content in accordance to their respective needs.

This ELEKTROKIMIA programme is to be used as a supplement or revision courseware to chemistry instructions within the setting of a Malaysian Secondary Schools. The programme can be considered as a drill-and-practice Computer-Assisted-Instructions (CAI) courseware since it is meant to assist the learner in reviewing, reinforcing and over-learning previously learned concepts. The presentation of the courseware however, follows the CAI tutorial mode. The ELEKTROMIKIA programme was also designed as a self-paced, self-directed and a learner-centered learning instruction.

This IMM programme was developed so that it can be used in schools or at home either by Form Four Science students or Form Five students. This was accomplished through four major stages of instructional development: needs analysis; design, production and development; formative evaluation and finally revision.

Rationale of the study

Current research on the learning effects from multimedia is on the increase. Based on multiple-channel research from the past, it can be implied that when the channels provided complementary information, learning might increase (Jonassen, 1996). In Malaysia there has been relatively few materials to explore the effects of an IMM programme on students' learning. Some important questions need to be answered about the effect of IMM in teaching and learning. Could the use of an IMM programme help students understand better, motivate students to learn, increase students' achievement scores and enhance students' learning? In short, how effective is an IMM programme in an educational setting?

The *Kurikulum Bersepadu Sekolah Menegah* or *KBSM*, fully implemented in 1989 has brought about major changes in the curriculum. One of these changes was to diversify the teaching and learning strategies. However, from the researcher's observation and discussions with colleagues over the last fifteen years, teaching and learning have mainly concentrated on the senses of sight and sound where the chalk and talk method of presenting a lesson is still the main mode of delivery. Teaching is usually a one-way flow where students listened passively while teachers taught. A casual observation in most schools would indicate that the use of chalk and talk, textbooks and rote learning for examinations still seemed prevalent till today. How then, can teachers be encouraged to use these technology-based teaching and learning materials advocated in the Smart Schools?

Compared to the traditional method , the use of computers in education would entail a much higher budget allocation in terms of acquiring the hardware, the various software , maintenance, personnel, and general upkeep of computers. Moreover, computers need to be upgraded periodically to keep up with the times, all of which will incur a great amount of financial budget.

Where the teaching and learning materials are concerned, the cost of producing hese coursewares can be staggering. As an example, the Education Ministry has spent an initial amount of RM53 million for its Education Technology Division to develop emporary (interim) multimedia courseware alone to be used in the 80 Smart Schools and these are only for the subjects of Bahasa Malaysia, English, Mathematics and Science. These courseware are currently being used until the actual courseware are made available later in the year (Gan, 1999).

This tremendous increase in the budget allocation on the learning and teaching material alone should commensurate the promises and advantages of a technology-based education system especially where students' learning are concerned. In addition the high cost of producing an IMM programme should also be compensated by a substantial increase in students' understanding of the concepts delivered.

In this study, the considerations and the experience involved in the development and evaluation of this IMM programme could help teachers or even students to develop their own software for teaching and learning. Research has shown that about 69.4% of teachers has expressed great interest in learning more about computers in education and a high proportion of 85% of them were interested in learning software development (Razak, and Rashid, 1999). Another research by Hussin and Maarof (1998) have suggested that teachers should involve themselves directly as software designers and producers which would help narrow the poor congruency between teacher's knowledge in applying the technology with that of an active learning participation in a Smart School environment.

The findings from this study could form another basis for the rationale by the Ministry of Education on the use of multimedia in the teaching and learning in the Smart Schools and eventually in all Malaysian schools. Since a large amount of money has been invested in the use of information technology in these Smart Schools, of which multimedia being one of the components, it would be interesting to see whether the learning and teaching process could be enhanced by the use of multimedia. In addition, this IMM programme would serve as an example for many more courseware programmes to be developed for other difficult topics in the curriculum.

Based on this study, teachers would realize that a self-paced, self-directed and learner-centered programme can be developed to cater to the different types of learners. If the programme is proven to be effective and can increase students' performance, then perhaps both teachers and parents can be encouraged and convinced to use these programmes.

The ELEKTROKIMIA programme was developed as a revision course, based on the concepts found in Electrochemistry, a fourth topic in the Malaysian Syllabus for Chemistry. One of the reasons this topic was chosen was because it is related to three other topics in the syllabus. The concepts, found in the first three topics, form part of the prerequisite concepts in the understanding of Electrochemistry. The main concepts found in this topic, will in turn help students to understand another concept in a topic in Form Five. Thus, Electrochemistry indirectly encompassed four topics in the Chemistry syllabus.

Electrochemistry is one of the topics which provided a lot of opportunities for multimedia elements like video clips, audio, images, graphics and animations to be incorporated within the programme. Animations of the movement of ions and electrons during electrolysis and in chemical cells, for example, might help students to visualize what is actually happening at the microscopic level of Electrochemistry.

Another reason why Electrochemistry was chosen to develop the IMM programme was because it is one of the easiest topic that students can relate to, due to its everyday application. Almost everyone is familiar with torch lights, alarm clocks, calculators, and other electrical gadgets which use batteries. Different kinds of batteries like dry cells, alkali batteries, car batteries, mobile phone batteries, are being used every day. Other applications of Electrochemistry like gold or silver-plated kitchenware and costume jewelry are some of the things that also utilize the principles of Electrochemistry. Perhaps this aspect of the application of Electrochemistry might spur students to enjoy chemistry and kindle their interest in the subject. By showing the relevance of chemistry in their lives, the students can be given a purpose and the motivation to further study the subject and pursue Chemistry at the higher level.

Since most students found Electrochemistry difficult to understand, it would be a challenge to see how an IMM programme could make the concepts within the topic easier for students to understand and visualize the happenings of an electrochemical cell. This, in turn, might help students to retain the concepts of Electrochemistry better and helped the students to achieve a higher score in their Chemistry examinations relating to the topic Electrochemistry.

Significance of study

To date, one of the main problems of computer-assisted instruction (CAI) is its poor quality. Only a handful of the CAI courseware were effective and fulfilled the students' needs. Ideally the educational software development should involve experts in each of the following fields: an instructional developer, a content specialist and a computer programmer (Zoraini , 1993).

A poor CAI or courseware could be due to incompetency in computer-related expertise or a lack of understanding of the instructional theory during the development. Poor pedagogical design, inappropriate use of feedback can make CAI lessons ineffective (Zoraini, 1993). Carrier and Sales (1983) have found that a great deal of dissatisfaction with some of the available computer courseware were centered on flaws in their designs and presentation strategies used. Other courseware reviewed provided no results of formative evaluation use before the product was marketed (cited in Roblyer, 1988).

Several causes contributing to the overall lack of quality courseware have been identified as developers' unfamiliarity with (a) the syllabi, (b) the instructional design, and (c) the theories of learning. Most of the courseware were developed by those who had little background in learning theories or pedagogy or they were developed by educators who lack instructional skills (Carrier and Sales, 1987;Fluoris, 1989; Bullough and Beatty, 1991). The lack of adequate programme evaluation prior to its application in the classroom (Schwarz and Lewis, 1989) and the use of wrong or lack of development methods to produce a courseware (Jonassen, 1988) have also contributed to the poor quality of some of these courseware.

Some of the computer-based courseware available in the present Malaysian market have mainly targeted those in the primary schools and the lower secondary schools. These courseware were mainly of the 'tutorial' or the 'drill and practice' type . Some courseware were available in Chemistry in the form of compact discs (CD) but these were in English and the contents did not meet the requirements of *KBSM* .

The development of this IMM programme was timely as the Smart Schools concept has already been launched for the Form One students in the eighty pilot Smart Schools in January 1999 beginning with the four subjects of English, Malay Language, Mathematics and Science. The current practice of supplying the learning courseware to the pilot Smart Schools was through the Conceptual Request For Proposals (CRFP) by several private companies or consortium. This consortium was given a guideline by the Ministry of Education on the development of the learning courseware (Ministry of Education, Malaysia 2,1997).

The conceptual selection and evaluation guidelines for the teaching and learning materials covered five main criteria: cosmetic adequacy, instruction adequacy, technical adequacy, curriculum adequacy and cost-effectiveness (Ministry of Education,Malaysia 2, 1997). One of the computer-based teaching and learning materials that were needed for the Smart Schools would be individual, self-paced learning materials. Based on the above guidelines, the consortium was expected to develop the teaching and learning materials that would conform to the expectations and requirements of the Ministry of

Education. It is assumed that these courseware were developed based on some principles of instructional design and learning theories, and that these courseware had been subjected to some form of rigorous evaluation.

Thus, based on the present *KBSM* syllabus the subject Chemistry (hence the topic Electrochemistry) will be taught to the Form Four students within the next three years. This would mean that more courseware will be needed for use in the Smart Schools in all the other subjects. This study then would serve as a concrete example of how an IMM programme could be developed and evaluated based on sound theoretical principles.

The results of this study, specifically the evaluation technique utilized, could be used as one of the guidelines by the decision-makers to evaluate and select the computer-based courseware for the Smart Schools. The quality of instructions can be assured through the use of instructional design and development models, which are based on valid learning theories and principles of instructional psychology. This can ensure that high-quality standards are maintained in the design, development, implementation and evaluation of the courseware (Fluoris, 1989).

This ELEKTROKIMIA programme would be relevant to both teachers and students. Teachers could supplement this programme in their teaching for use as a revision and reinforcement or enrichment programme in Electrochemistry after the topic has been taught. Alternatively, teachers could utilize the multimedia elements found in the programme to help students visualize the processes occurring in the electrochemical cells. In several ways, the ELEKTROKIMIA programme developed in this study would contribute to the availability of multimedia courseware for all schools at present and in the future.

The multimedia approach in an IMM programme like ELEKTROKIMIA could inject a new sense of enjoyment in the learning and teaching process . This in turn would enhance the understanding of the concepts involved and would lead to a better achievement in a topic like Electrochemistry. In addition, the use of the ELEKTROKIMIA programme could enhance students' understanding of other related concepts like atoms, ions and redox.

The ELEKTROKIMIA programme developed could cater to students with different learning abilities, different learning styles and students who were either computer-literate or otherwise. The only prerequisite needed for anyone wishing to use this programme is a multimedia computer with a compact-disc (CD)-ROM player. This programme would allow learning to be individualized, student-centered and self-paced which in turn would make learning more interesting, stimulating and meaningful.

Research Questions

This study would look into the considerations and the design mode during the development of the IMM and the evaluation of the final product of the IMM programme. Specifically, this study would like to identify the following:

1. What were the principles of instructional design applied in the development of the ELEKTROKIMIA programme?

2. Based on the students' evaluative feedback, what were the strengths and weaknesses of the ELEKTROKIMIA programme?
3. Based on the teachers' evaluative feedback, what were the strengths and weaknesses of the ELEKTROKIMIA programme?
4. Would the use of the ELEKTROKIMIA programme by the low-ability students result in a significant increase in their achievement in Electrochemistry?

The first research question will be answered during the development of the IMM programme. The second and third research questions constitute the formative evaluation while the fourth research question will address the summative evaluation of the programme.

Operational Definition of Terms

The operational definition of the terms used in this dissertation are as follows:

Form Four Students — Students aged 15 to 16 years old in secondary schools administered by the Malaysian Ministry of Education who are taking Chemistry as part of their elective subject. These students are also called Form Four Science students.

Electrochemistry	The fourth topic found in the Form Four Chemistry syllabus taught to students in Form Four. Two main concepts are taught in this topic; electrolysis and galvanic or chemical cell.
ELEKTROKIMIA programme	The Interactive Multimedia programme on Electrochemistry being developed and evaluated.
KBSM	*Kurikulum Bersepadu Sekolah Menengah* or Integrated Curriculum for Secondary Schools.
Low-ability students	Form Four students who scored less than 50% in their schools' semester Chemistry examination. These students were from the rural areas but studying in schools in the Petaling district. They have no experience with computers.

Assumptions and Limitations of Study

The limitation to this study was due to several assumptions made on the students chosen as the subject of study. These students were assumed to have been taught by an experienced Chemistry teacher in their respective schools. This would mean that the students would have similar levels of knowledge to evaluate the programme.

The second limitation was that the teachers and some students were allowed to bring home the CD ELEKTROKIMIA for evaluation. This did not allow the researcher access to the problems that were encountered when these teachers and students were using the programme. It was assumed that they would have noted down all the problems and inadequacies of the programme in their respective evaluation forms (see Appendix 1 and Appendix 2).

Third, an achievement test was conducted on ten low-ability students selected based on their score of less than 50% in their respective schools' semester test in Chemistry. These students went to various schools in the district of Petaling Jaya. It was assumed that the Chemistry test conducted by each of the schools was of similar standard and level of difficulty. This would mean that the students selected had comparable weaknesses in the subject.

Fourth, the development of the content and instructional design in this programme was carried out entirely by the researcher . The programme was developed partly based on the researcher's fifteen years' experience of teaching, tutoring and attending to students who had problems with their Chemistry lessons in general and specifically in Electrochemistry. The students, whose problems in Chemistry were attended to by the researcher, ranged from those who went to boarding schools all over the country and those from the day-schools in the district of Petaling Jaya. This single perspective approach to the design of the programme may not be ideal because it was based on one person's experience and perceptions. Input from other experienced teachers and perhaps former students on the presentation of the programme could probably make the programme more wholesome and given a wider perspective.

Another limitation of the programme was that the assessment questions provided were mainly the multiple-response type of questions. Other forms of assessment, like simulations, games, crossword puzzles, structured-type of questions, open-ended type of questions or problem-solving questions were not provided due to the constraint of time on the part of the computer programmer and the multimedia company. Although these other forms of assessments could make the programme more exciting and varied, the amount of time, energy and resources needed to develop them were beyond the capacity of both the researcher and the multimedia company involved.

The development of the ELEKTROKIMIA programme has been mainly influenced by the technical limitation to the software environment. The ELEKTROKIMIA programme, which was in the form of a Compact Disc (CD), would require the user who evaluated the programme to possess a multimedia-ready computer. For optimum viewing of the programme, the minimum specifications of the computer are as follows: at least 166MHz processor and a Compact Disc Read Only (CD-ROM) drive of at least 32K. A computer which has a lower specification than the above would affect the quality of the presentation of the programme. It was assumed that any technical problems encountered by teachers and students who evaluated the programme were due to specification problems of the computers being used and not due to the CD itself.

Lastly, although this research was primarily concerned with the developmental aspect of the IMM programme, this ELEKTROKIMIA programme was also subjected to three types of evaluation: (a) quality review or expert appraisals, (b) pilot testing with a sample from the target users and (c) field testing on thirty-five target users. The programme was further revised and modified based on feedback from the target users (students). However, the final revised programme was not subjected to further evaluation. The sample size for evaluation of the ELEKTROKIMIA programme was small and the setting of the evaluation was also limited, that is, evaluation was only done at home or where they were staying. If the evaluation was conducted in schools, this might have yielded a different feedback. Furthermore, the programme was only subjected to individual evaluation by the students. No group evaluation was conducted because the researcher wanted to find out as many weaknesses as possible in the programme if the user was using the programme individually.