# CHAPTER 5

## SUMMARY AND CONCLUSIONS

In this chapter, the researcher shall first present a summarized account of the entire study. This is followed by some recommendations for further research and the conclusion of the study.

### Summary

The purpose of this study was to develop and evaluate an IMM programme in Electrochemistry. The IMM programme was termed as ELEKTROKIMIA programme. This programme was developed as a self-directed, self-paced and learner-centered instructions in Electrochemistry. It can also be used to complement and supplement teacher's teaching in schools for this particular topic. This IMM programme has also been developed to cater to those students who wish to perform better in their examinations. It is both a tutorial and drill and practice-type of programme which focussed on the important concepts that the student should know in order to answer questions that can be found in the national examinations.

The ELEKTROKIMIA programme served as a concrete model of how an IMM programme can be developed and evaluated. This could facilitate other multimedia programmes in other subject areas to be developed. The use of this programme would be consistent with the other studies which stated that a computer can be used as a cognitive tool which can support, guide and extend the thinking processes of their uses (Derry, 1990).

A systematic approach based on research findings, learning theories as well as instructional theories were used to develop the ELEKTROKIMIA programme. A courseware programme which was developed based on these principles would be ensured to be instructionally and technically sound (Burkhardt, 1992; Fluoris, 1989; Jonassen, 1988; Smith,1988). Specifically, behaviouric learning theories like Skinner's reinforcement theory, cognitive learning theories like information processing theories and Gagne's nine events of instructions have been used as a guide to design and develop the content of the programme. Other learning theories like Paivio's Dual Coding Theory, Bruner's constructivist theory, Mager's Criterion Referenced Instructions and Hull's Drive Reduction Theory have also been utilized in the development of the ELEKTROKIMIA programme.

The entire development of the programme was basically divided into four stages: preparation stage, development stage, evaluation stage and finally revision stage. Within the preparation stage, the major instructional design principles were adapted from the various instructional design models. This included the design models of Dick and Carey, Hannafin Peck, Jerold Kemp, Gerlach and Ely and finally Rapid Prototype design model. This approach was chosen for its logical sequence and simplicity towards the novice developer.

The ELEKTROKIMIA programme was subjected to three types of evaluation; (a) field testing by teachers (b) field testing by students (c) observation and interview. An achievement test was also conducted on ten low-ability students to gauge the effectiveness of the programme. The purpose of the three evaluations was to identify the strengths and weaknesses of the programme based on the feedback given by both teachers and students. The findings from these evaluations was used as a basis to revise the final version of the ELEKTROKIMIA programme. The results of the achievement test on the low-ability students would indicate the effectiveness of the programme itself. A summary of the evaluation results were summarized in the next section.

## Summary of Findings

The findings of this study was summarized into four main categories namely the ELEKTROKIMIA programme developed, the evaluation of the programme by the teachers, the evaluation of the programme by the students and the achievement test by low-ability students.

**The ELEKTROKIMIA programme**

The ELEKTROMIA programme was in the form of a CD. In introducing the user to Electrochemistry, the image of three different fruits capable of working a calculator, electric bulb and a clock respectively were shown as an induction set to gain attention to the user of how chemicals in fruits can be used to produce electrical energy. This was followed by a welcoming video clip where a brief overview of the programme was presented by the researcher.

The programme had a Main Menu where the students could either browse through the *PENGENALAN* (INTRODUCTION) section, the *TOPIK* (TOPIC) section, the *EKSPERIMEN* (EXPERIMENT) section, the *LATIHAN* (EXERCISE) or the *UJIAN* (TEST)section. Within the *PENGENALAN* (INTRODUCTION) and the *TOPIK* (TOPIC)sections, narrated questions on the important aspects of Electrochemistry were presented simultaneously with the text. However, answers to these questions were in text form only. Multimedia elements like still pictures, graphics and animations were incorporated within these two sections to aid understanding of electrochemical concepts. The *EKSPERIMEN* (EXPERIMENT) section was a video tape of the demonstrated experiments found in this topic. Assessment questions were not only found in the *LATIHAN* (EXERCISE) and *UJIAN* (TEST) sections but also at the end of every section in the Main Menu. These questions were largely the multi-choice type of questions.

The user was given the choice and freedom to go to any of the sections in the Main Menu. Within each section, the user could go back and forth (except for the video clips on the demonstrated experiments) or exit from the programme at any time. Feedback was given to all the assessment questions. A correct response was rewarded with a music hit and further explanation in text. An incorrect response on the other hand, would result in the correct answers be given. Students were allowed one attempt to answer all the assessment questions. Navigation within the programme was made possible by clicking the mouse on buttons found at the bottom of the computer screen. Hypertext was made available by clicking on the underlined words while animations were accessed by clicking on any part of the screen or as directed in the programme.

**Students' evaluation of the ELEKTROKIMIA programme**

There were two parts to the students' evaluation. The first was the results from the Evaluation Form Of A Multimedia Programme For Students (Appendix 1). Second was the results of the observation and interview of the students.

The results of the students' evaluation obtained from the questionnaire in the Evaluation Form Of A Multimedia Programme For Students (Appendix 1) would indicate that the students found the programme easy to use. The level of language used was satisfactory and the multimedia elements, specifically the graphics and animations, have helped them to visualize the processes of electrochemical cells. It has been seen in other studies that computer simulations and animations have helped students to visualize chemical reactions at the molecular level (Sanger and Greenbowe, 1997).

By observing and interviewing these students, any problems connected with the usage of the programme by other computer-illiterate users could be identified in greater detail. Observations made during the field test have thus yielded information regarding the adequacy of the content and presentation style of the material. In addition, information was collected on the quality of the programme and adequacy of the instructor's performance. Students' behaviour and attitude, gleaned from the observation and interview have also yielded valuable information that can be used to improve the programme.

**Teachers' evaluation of the ELEKROMIKIA programme**

The results of the teachers' evaluation obtained from the questionnaire in the Evaluation Form Of A Multimedia Programme For Teachers (Appendix 2) indicated that they found the ELEKROKIMIA programme to be fairly excellent with an average rating value of eight from a scale of one to ten. The content of the programme was found to be consistent with the requirements of the *KBSM* Form Four Chemistry syllabus.

It was noted that the programme has achieved its stated objectives. The teachers were in agreement that the educational value, the presentation, content, usability, documentation and overall perception of the programme were satisfactory. Comments from the teachers indicate that they found the multimedia elements have helped motivate students in this topic and increase their understanding in the concepts in Electrochemistry.

## Results of the Achievement Test on Low-ability Students

Ten low-ability students were selected to do the achievement test. These students had scored less than 50% in their schools' semester Chemistry test. Although they went to schools in the Petaling Jaya district, these students were from the rural areas. They were also selected because they had no experience with computers.

The achievement test was conducted by students answering the questions in the *UJIAN* (TEST) section of the ELEKTROKIMIA programme first before going through the rest of the programme. The students were then asked to repeat the same questions in the *UJIAN* section at the end of the programme. The scores for the two tests constituted the pre-test and post-test scores. A statistical test to determine the significance of the two results showed that the increase in the mean score of the post-test over the pre-test was significant at the 0.5% level.

Results of the achievement test reveal that the ELEKTROKIMIA programme seemed to have helped increase the achievement scores of low-ability students in Electrochemistry. Other studies have also shown that there was an increase in the average scores of students exposed to multimedia compared to others who were not (Kris,1996). Thus, an IMM programme like the ELEKTROKIMIA programme appear to have helped students achieve a better conceptual understanding of the processes occurring in electrochemical cells based on the results of these achievement test. Only the low-ability students were asked to do the achievement test. The assumption here was that if the programme could help these students with the understanding of the concepts in Electrochemistry, then the effect would be similar to the other medium and high-ability students.

## Discussions

The development of an IMM programme like the ELEKTROKIMIA programme was a very time-consuming process. In this study, the development of the three hour programme took a total sum of 6000 hours. Some of the considerations that were deliberated during the development of the programme were the principles of Instructional Design (ID) to be used as a guide. In addition, learning theories and instructional theories have helped shape the ELEKTROKIMIA programme. The inclusion of all these theories was to strengthen the instructional and academic background of the study.

The ELEKTROKIMIA programme was subjected to three types of evaluation namely, questionnaire method, direct observation and interview method and an achievement test. The questionnaire to evaluate the programme was developed separately for the teachers and for the students. The teachers' feedback constituted the expert review while the students' evaluation would be seen as a feedback from the users' point of view. The evaluation from both groups would give a broader perspective to the evaluation of the programme. The main aspects of the programme evaluated were the usability, language, content, navigation, effects of multimedia elements, interactivity and to a certain extent, attitude towards the programme.

One of the contradictory results obtained from the evaluation results of teachers and students was the extent of the electrochemical concepts presented in the programme. While all the teachers agreed that the programme has presented all the concepts in Electrochemistry only 54% (19) of the students totally agreed with this statement. The rest of the students indicated that they were not sure. One of the reasons that can be attributed to this difference is the possibility that some of the students might have missed or overlooked certain sections of the content during navigation of the programme. It must be noted that the quality of interaction is usually determined by the skills and experience of the students in an IMM programme. Thus it may take some practice for the student to be familiar with the progarmme. Another plausible reason is that students have not mastered the topic Electrochemistry in the Chemistry syllabus.

It is evident that from the comments made by both teachers and students that the programme could motivate students in this topic. It is encouraging to note that both groups agreed that the programme should be recommended to other students. It must be noted that this programme is used as a self-paced, self-directed and learner-centered revision tool. The student can exit from the programme and re-enter at any point in the programme or the student can also repeat any part of the programme that he or he wishes. These features of the programme has been made possible by the navigational buttons, directional buttons, interface and hypertext. Although instructions have been placed throughout the programme, it is still possible for a user to become 'lost' in the programme. It is also possible that the user might have skipped certain sections of the sub-menu in the programme. This problem can be overcome by printing the concept map of the programme on the cover of the CD casing.

The programme was also designed to be interactive. Interactivity helps the learner to actively select instructions which have been arranged in such a way that when selected by the learner, will result in meaningful learning and attainment of the learning needs. It is believed that this feature of interactivity which empowers the learner will eventually result in increased motivation to learn (Szabo, 1996). However, it was not possible to ascertain the extent of meaningful learning that might have occurred by the students in this study. This was because the design of the programme did not permit this type of feedback.

The achievement test was conducted on ten low-ability students. The inclusion of these low-ability students was to represent other low-ability, computer-illiterate students from the rural areas. If the ELEKTROKIMIA programme can be seen to help increase the performance of these student, then it can probably be assumed that a similar effect will be obtained for other students. The significant results of the achievement test by these students however, may not necessarily been due to the use of the ELEKTROKIMIA programme. The increase in the average score of the post-test could have been due to over-learning or repeated learning in the topic. It is possible that a similar increase in the achievement results would be achieved if the students were subjected to revision by other learning aids or with a teacher. Other factors which might have contributed to the increment in the achievement tests of these low-ability students were the differing capacity for short-term and long-term memory of each students.

Another limitation to these results was the assumption that these low-ability students had similar background knowledge prior to the achievement test.

The achievement test was based on the 40 multiple-choice questions answered by the low-ability students in the ELEKTROKIMIA programme. The assumption in this study was that the higher the score of the achievement test, the higher the level of students' understanding of the electrochemical concepts. However, there is a possibility that the students might have memorized the answers to some of the questions that they have answered in the pre-test. One way to ascertain that the increase in the achievement test was due to their increased understanding of the electrochemical concepts is to administer another test . This test could be an open-ended type of questions or an essay-type of questions. Alternatively the students can be interviewed to gauge their actual understanding of the topic.

## Recommendations to the study

The findings of this study have shown that the ELEKTROKIMIA programme developed possesses many features of a well-designed IMM courseware programme. The weaknesses of the programme, identified by experienced teachers and representative students both from the rural and urban areas have been rectified in the final revision of the programme. While the findings were sufficient for the improvement of the instructional and technical design of the programme, it does not show how well it will work in other instructional settings.

In this study, the effectiveness of the programme was measured based on the achievement test on ten low ability students. It is possible that different results be obtained in different educational settings. The ELEKTROKIMIA programme then, should be exposed to the general student population in other settings. The first recommendation is to conduct a comparative study to see the effect on the achievement test of students viewing the programme individually at home with the programme being used in schools. Due to insufficient computers to cater for every student in schools, it can be assumed that the programme has to be shared if used in the school setting. Would the group discussion that would take place have any effect on the achievement tests of these students in this particular study? Another study can also be conducted to compare the effect of this programme on the achievement of low-ability students in a rural school and those in an urban school. The results from such studies would permit conclusions to be drawn about how well the programme has worked in different settings.

Another area that is recommended for further research is the effectiveness of the multimedia elements, specifically the effect of animations in the conceptual understanding of electrochemical cells. In relation to this study, the ways in which knowledge in the different modalities are linked to the development of conceptual understanding can also be examined. In addition, the effect of the programme in the retention of the concepts in Electrochemitry can be studied.

Based on the results of this study, more use of IMM programmes should be advocated in schools whereby such programmes be developed by utilizing a set kind of proceedings of which this ELEKTROKIMIA programme is an example of. An IMM programme like the ELEKTROKIMIA programme has been shown to be enjoyable to use where students' learning has been enhanced.

## Proposal to the study

The development of this ELEKROKIMIA programme has incorporated some findings from misconception studies done in Electrochemistry. However these findings were mainly based on those studies that were from other countries. Some of these misconceptions might be different from the misconceptions of local students. To identify misconceptions in Electrochemistry of Malaysian students, this study would propose that a similar study be conducted on students' misconceptions in Electrochemistry based on the Malaysian syllabus. The main difference between the local syllabus and the foreign syllabus is the exclusion of the Faraday's Law, the concept of redox and the calculations of potential difference at the Form Four level when the topic is first introduced to the students.

In a related study, Greenbowe ( 1996) found that students' answers to test questions about the molecular events improved significantly after viewing animations. The initial study suggested that using computer simulations to depict chemical reactions at the molecular level and using teaching approaches that confronted student misconceptions can decrease the proportion of students consistently demonstrating these misconceptions. Kozma and Russel (1997), in their research however, argued that it would be interesting to study whether Chemistry students understand these representations to mean what chemists intend or whether they need to have the necessary prior knowledge to begin to see the principles in the images.

This study could unearth information about the lack of understanding of certain basic concepts in Chemistry related to Electrochemistry and misconceptions in Electrochemistry itself. A study of this nature can be conducted at three levels; those in Form Four, those in Form Six or undergoing matriculation courses and those in the first year universities. In this study, investigations on how misconceptions that might have occurred at the introductory level affect students' understanding at the higher level of learning institutions. Further, a study on how an IMM progarmme like the ELEKTROKIMIA programme can be used to minimise these misconceptions can also be studied.

This ELEKTROKIMIA programme appeared to be effective as the results indicated that the performance of low-ability students have been significantly increased with the use of the ELEKTROKIMIA programme. It is assumed that the increase in the achievement scores is due to the increased conceptual understanding of the electrochemical concepts. Based on this assumption, students should be able to understand the topic faster by using the ELEKTROKIMIA programme.

In addition, the ELEKTROKIMIA programme can be used selectively by teachers to aid students' understanding of the processess in Electrochemistry. Specifically the multimedia elements like the video clips, graphics and animations can be shown to students during the actual teaching of the concepts. This strategy may be possible if the computer laboratory has a computer projector. Students can then immediately "see" the processes of the electrochemical cells when the teacher is explaining them the concepts. This will then imply that the time taken to teach the topic can be reduced. This would enable teachers to plan other projects for students which will utilize their creativity and application skills in some problem-solving projects, perhaps related to the environmentally-polluting electroplating industry or to research other applications of Electrochemistry from the Internet.

Based on favourable comments from teachers and students on this ELEKTROKIMIA programme, it is proposed that other multimedia programmes be developed in other topics and in other subject areas. However, because it involves sophisticated tools, teachers will need help from other agencies in the Ministry of Education and the cooperation of private multimedia companies.

Alternatively, teachers can be trained in another multimedia software called "CoMIL" or Computer Intergrated Learning which has been developed by the Malaysian Institute of Microelectronics (MIMOS) for the development of educational softwares. If teachers can be empowered in developing their own multimedia programmes using the softwares available, then it would help reduce the financial strain of the Ministry of Education in providing the learning materials for the Smart Schools from private companies.

Another interesting project that is proposed in this study is to develop a similar IMM programme for the Internet or some network-based media. This way, students can have access to the programme through for example, on-line library. Another IMM programme can also be developed for the purpose of a distance learning courseware. Alternatively, other computer-assisted instructions modules can concentrate on simulation games, problem solving computer games or even artificial intelligence modules (Ministry of Education,Malaysia 1, 1997).

## Concluding Remarks

To produce quality multimedia courseware, the design team must be knowledgeable in learning principles, communication theories, subject matter and computer programming. As it is quite impossible for one individual to be an expert in so many areas, a courseware should best be developed using a team approach which would include a computer specialist, instructional designer, a graphic artist, a communication specialist, content experts, audio and video specialist and a computer animator.

This study has demonstrated that an IMM programme like the ELEKTROKIMIA programme can be successively developed by utilizing a systematic and research-based approach capable of delivering effective and efficient instructions. CD-ROMs can provide a rich source of visual information for teaching chemistry which has been lacking in print textbooks (Brooks and Brooks,1996). However, it is a very slow and tedious process requiring a lot of time, resources and energy.

Formative evaluation is a very important and an essential step in the development of any good quality courseware. As is evident in this study, the use of instructional design principles and other research-based learning principles and theories does not preclude the existence of weaknesses in the courseware programme.

It is therefore crucial that evaluation be conducted on any courseware so that weaknesses can be identified and rectified accordingly.

Based on the feedback from teachers and students, the programme was shown to possess some of the characteristics of a good courseware which include; accurate content, well-defined purpose, presentation of content clear and logical, appropriate level of difficulty and appropriate use of multimedia elements. There was indication that the programme provided motivation, there was effective feedback to students' response, the learner can control rate and sequence of presentation, the programme could be operated easily and independently and was reliable in normal use. This would imply that the programme has been successively developed as a self-paced, self-directed and learner-centered revision tool which can enhance students' learning. Interactivity features in the programme, provided by the navigational buttons, user interface and hypertext, presented students with the tools to control the path of navigation, set their own speed of information and construct the content in accordance to their own needs.

Despite the length of the programme, students could exit at any time and return to any part of the programme easily. This particular feature of the programme would indicate that the students can do the programme independently. This could lessen the absolute dependence on teachers as the main source of knowledge. This would also imply that the programme can be used by students who have missed the lesson or for students who are considered slow learners or even for those who may have different learning styles.

One of the most important responsibilities of a teacher, suggested by Greeno (1983), is to provide learners with appropriate representations that will lead to the conceptual understanding. An effective representation will allow rapid recognition and retrieval of relevant information through a process of perceptional enhancement. This ELEKTROKIMIA programme can be considered as a concrete example of a learning aid to help students visualize the representations of the processes in electrochemical cells.

Finally, it is noted that the programme can be considered effective and at par with any commercial products in the market in terms of the quality. Using an IMM programme like ELEKTROKIMIA programme is in line with the trend of 'reinventing chemical education by means of the visual-spatial approach which is the way modern Chemistry is thought about and practiced' as proposed by Habraken (1996). This programme appears to be a viable pedagogical strategy as a remedy to overcome specific learning problems. The findings from this study can be used as a guide and a model for future development of an IMM programme in other subject areas. It is proven to improve the learning process, it is well designed, reliable and economical to use. This ELEKTROKIMIA programme appears to have lived up to the promises and expectations of an IMM courseware where students' motivation to learn, students' self-concept and students' achievement can be increased. This programme can be recommended to be used in all schools for smart teaching and learning. Students enjoy the programme, students understand the concepts and students' achievement can be increased.

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