Chapter 4

RESULTS

The purpose of this study was to develop and evaluate an IMM programme for Form Four students in Electrochemistry. This programme was termed as ELEKTROKIMIA programme. Three results were obtained from this study. The first result was the description of the ELEKTROKIMIA program developed which was in the form of a CD, the second was the evaluation results from the teachers and from the students and finally the achievement test performed by the ten low-ability students.

Presentation of the content in the ELEKTROKIMIA programme was based on the nine events of instructions, the information processing theory and also on several learning theories associated with the development of a courseware.

The evaluation results were analyzed using the Statistical Program for Social Sciences (SPSS) (Norusis,1997). The analysis was divided into two parts, one for the teachers and the other for the students. Both analyses were based on the results obtained from the Evaluation Form Of A Multimedia Programme For Students (Appendix 1) and the Evaluation Form Of A Multimedia Programme For Teachers (Appendix 2).

The ELEKTROKIMIA programme

The ELEKTROKIMIA programme, in the form of a CD was designed as a supplement to classroom teaching where Form Four Science (and Form Five Science) students could use it as a revision or as an enrichment programme in Electrochemistry. The programme was also designed to be an interactive, self-paced, self-directed system to assist individualized learning.

The content of the programme, which was the instructions of external events was designed based on the information processing theory and the internal learning process The instructional events, according to Gagne, Wager and Briggs (1992) are:

1. gaining attention to ensure reception of patterns of neural impulses
2. informing the learner of the objective which would activate a process of executive control
3. stimulate recall of pre-requisite learning for retrieval of prior learning to working memory
4. presenting the stimulus material to emphasize features of selective perception
5. provide learning guidance for semantic coding or as cues for retrieval
6. eliciting the performance to activate response organization
7. provide feedback about performance correctness to establish reinforcement
8. assessing the performance to activate retrieval or to make reinforcement possible

9. enhancing retention and transfer by providing cues and strategies for retrieval.

In the ELEKTROKIMIA programme, the concepts of Electrochemistry would be found in text form. The combined multimedia elements of text, audio, graphics, images, video and animations have been used to guide learning by utilizing the various senses during semantic encoding for storage in the long-term memory (LTM). Demonstrations of the experiments found in this topic were delivered using video clips whereas assessment questions on Electrochemistry were in the form of multiple-choice questions.

The programme began with a traditional Malay music, *gamelan* with the words *Selamat Datang Ke Dunia Elektrokimia* (see Appendix 8) ('Welcome To The World of Electrochemistry") appearing on the screen. Three images chosen to represent Electrochemistry were then brought onto the screen. One was an image of an electric bulb attached to two electrodes stuck into an apple, another was an image of a calculator attached to two electrodes stuck into a lemon and the third image was a clock attached to two electrodes stuck into an orange. These three images then moved across the screen seemingly following the rhythm of the *gamelan*. The fruits attached to the electrical appliances were used to replace normal batteries and served as a means to attract student's attention on how chemicals from the three fruits could be converted to electrical energy to enable the three appliances to function. These images were used as a stimulant to gain attention to ensure the reception of stimuli as well as registration of information by the sensory registers (Gagne *et al.*, 1989).

The next screen was a video clip of the researcher giving an overview and explaining the content of the program. This section was to establish appropriate expectancies where learners were informed of the learning objectives of the programme (Gagne,1989). The goal task analysis as developed by Mager's Criterion Referenced Instructions (CRI), where students could identify what needed to be learned in the programme was also presented (Mager, 1988). The performance objectives outlined in this clip also determined the exact specification of the outcomes to be accomplished and how students' understanding of Electrochemistry were to be evaluated (Mager, 1988). The video clip of the researcher herself explaining the programme was to personalize the presentation and provided an impression that a teacher was there to help the students revise the topic.

The application of electrochemical principles in everyday life was also shown in the video clip. A variety of batteries together with various electrical appliances like torch light, calculator, clock, watch and mobile phone were shown together with gold-plated ornaments, gold-plated and silver-plated jewelry and silverware to highlight the applications of Electrochemistry. All the applications shown were things which students were familiar with. This approach would be parallel to Bruner's constructivist principle which stated that instructions must be concerned with the experiences and contexts that make students willing and ready to learn (Bruner,1966).

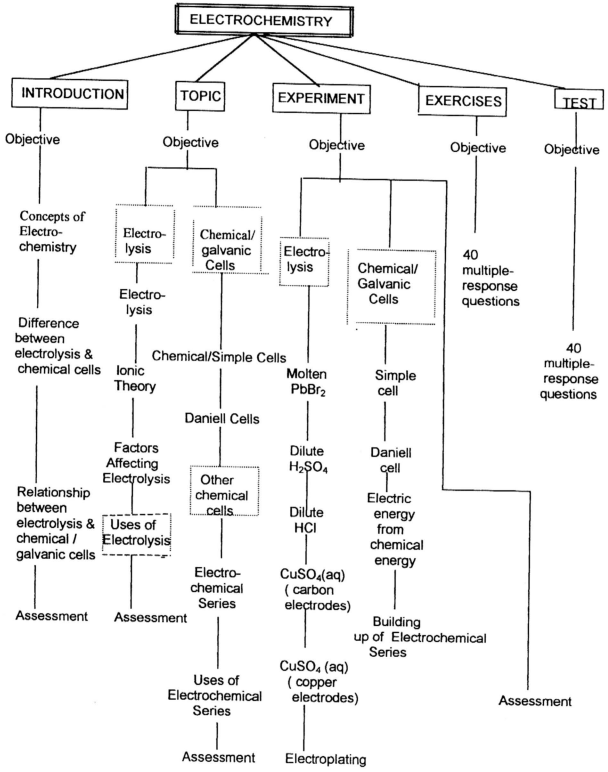
Overall, this introductory video clip utilized Gagne's first three events of instructions which is; stimulation to gain attention to ensure the reception of stimuli, informing learners of the learning objective in order to establish appropriate

expectancies and reminding learners of previously learned content for retrieval from LTM (Gagne, Briggs and Wager, 1992).

The Main Menu appeared next on the screen to show the user the five sections that he or she could go into in the program. They are the *PENGENALAN* (INTRODUCTION)section, *TOPIK* (TOPIC)section, *EKSPERIMEN* (EXSPERIMENT) section, *LATIHAN* (EXERCISE) section and *UJIAN* (TEST)section (see Appendix 9). These sections represented the stimulus materials to be presented for selective perception. The user could go to any of the five sections by clicking the mouse on any particular section in the menu. Each section in the Main Menu has been made into a "hot" spot. For example, a click on the word *PENGENALAN* or *TOPIK* would bring the user to the intended section. A text of the objective statement was provided in each of the five sections to brief the user about the content of that particular section. The content in each of the five sections provided learning guidance for semantic coding.

At the end of each section, assessment questions were provided to elicit students' performance which would activate response organization. Feedback about performance correctness were provided after each response to the assessment questions which would activate the retrieval process. The forty questions in each of the Exercise and Test sections could also be used to enhance retention and transfer by providing cues and strategies for retrieval. The entire content of ELEKTROKIMIA programme was summarized and represented in the concept map in Figure 8.

Figure 8 :
CONCEPT MAP OF ELEKTROKIMIA programme



In the INTRODUCTION section, the first screen would present the user with the objective statement (see Appendix 10). A series of narrated questions accompanied by the actual questions in text appeared on the following screens to introduce to students the concepts in Electrochemistry. Answers to these questions appeared in text form after the questions have been read out. The user need to click on the forward button to go the next screen.

The INTRODUCTION section briefly described the two major concepts found in Electrochemistry; electrolysis and the conversion of chemical energy to electrical energy in chemical or galvanic cells. The main difference between these two concepts was that the former involved the conversion of electrical energy to chemical energy instead.

Assessment questions on the INTRODUCTION section were found at the end of this section. Students' scores could be obtained at the end of all the assessment questions. These assessment questions were a combination of multiple-choice questions and fill-in-the blank- type of questions.

The *TOPIK* section could be accessed by clicking the mouse on the Main Menu Button. The Main Menu screen would appear after which a click on the word *TOPIK* would bring the user to the *MENU TOPIK* (see Appendix 12). The *TOPIK* section dealt with all the concepts found in Electrochemistry. These concepts were summarized in Table 3.

Table 3:
Concepts found in Electrochemistry.

CONCEPT	CONTENT
1. Electrolysis	(i) Definition of electrolysis, electrolyte, non-electrolyte and electrode. (ii) Ionic theory (iii) Factors affecting the product of electrolysis (iv) The uses/applications of electrolysis
2. Chemical/ Galvanic Cells	(i) Simple cell and Daniel cell (ii) Other chemical cells – primary and secondary cells (iii) Electrochemical Series and its uses

Within this section, the user could decide whether to go through the sub-sections of *ELEKTROLISIS* (ELECTROLYSIS) or the sub-sections of *SEL KIMIA* (CHEMICAL CELLS) (see Concept Map and Appendix 12). The two sub-sections had their own sub-menu. The sub-section of *ELEKTROLISIS* had a menu of *Elektrolisis* (Electrolysis), *Teori Ion* (Ionic Theory), *Faktor-Faktor* (Factors Affecting Electrolysis), *Kegunaan Elektrolisis* (Applications of Electrolysis)and finally the *Penilaian* (Assessment) (see Appendix 13).

The user could click on any of the phrases in the menu to access information on each of the sub-topics. Within the *Kegunaan Elektrolisis* (Uses of Electrolysis), the user could click on any of the underlined statements for further explanation of the different applications of Electrolysis (see Appendix 15). For instance, if the user wanted to find out how electrolytic principles were used to extract metals, then a click on the phrase

'Pengekstrakan logam' (Extraction of Metals) would bring the user to the text, still image and animations about the extraction of aluminium from bauxite. Assessment questions on the topic Electrolysis could be accessed by clicking on the *Menu Elektrolisis* (Electrolysis Menu) button at the bottom of the screen and then clicking on the word *Penilaian* (Assessment) (see Appendix 13).

Similarly, the sub-section of Chemical Cells had another menu of *Sel Ringkas* (Simple Cells), *Sel Daniell* (Daniell Cell), *Sel Kimia Lain* (Other Chemical Cells), *Pembinaan Siri Elektrokimia* (the Electrochemical Series), *Kegunaan Siri Elektrokimia* (Uses of Electrochemical Series) and finally the *Penilaian* (Assessment) (see Appendix 14). Within the *Sel Kimia* Lain (Other Chemical Cells), the user could click on any of the words in this sub-section for further information (see Appendix 16). For example, if the user clicked on the word *Sel Kering* (Dry Cell), a picture of a dry cell, followed by a cross-section image of the cell would be screened. This would be followed by an explanation in text and animations of how the dry cell functioned. Or, if the user clicked on the word nickel-cadmium batteries, a picture of the battery would be exhibited followed by a text explanation of the workings of this particular cell. Assessment questions on the topic Chemical cells could be accessed by clicking on the *Menu Sel Kimia* (Chemical Cells Menu) button at the bottom of the screen and then clicking on the word *Penilaian* (Assessment) (see Appendix 14).

The presentation of the concepts in Electrochemistry within the *TOPIK* (TOPIC) section was done in a series of narrated questioning accompanied by the text of the questions itself. The answers to these questions appeared on the screen in

text form only. The presentation of information, in both visual and verbal form, according to the Paivio's Dual Coding Theory, was believed to enhance recall or recognition (Paivio, 1986).

Hypertext, still images and animations were found only in the *PENGENALAN* (INTRODUCTION) and the *TOPIK* (TOPIC) section. Words which were underlined contained hypertext. Hypertext embedded within the text in the program was an option for the user to delve further into the meaning and elaboration of a particular concept. For example, the narrated question in the first screen within the *PENGENALAN* section asks the student *"Apakah yang dimaksudkan dengan elektrolisis?"* (What is meant by electrolysis?). The answer to this question appeared in text form. Several underlined words in the text explanation could be clicked for further explanation. For example, if the words *bahan kimia* (chemical compund) is clicked, another smaller screen appeared to elaborate the meaning of a chemical compound (see Appendix 20). Similarly, if the words *larutan akueus* (aqueous solution) is clicked, an animation sequence to show how an aqueous solution can be prepared was shown (see Appendix 21).

Certain underlined words contained more than one layer of hypertext. As an example, the underlined word *elektrolit* would present the meaning of the term electrolyte when clicked. Using a scroll bar, the text ended with another underlined word *bukan elektrolit* (see Appendix 23). The user could click on this word for further explanation on the meaning of *bukan elektrolit* (non-electrolytes). At the end of this text, yet another underlined word could be found (see Appendix 25). A click on the word *molekul* would explain the meaning of the term molecule.

Animations, text and still images found in the hypertext had a different background and font. Reading through some of the hypertext required the user to use the scroll bar provided. Animations could be viewed by clicking at any part of the screen or as instructed. For example, if the instruction was to click on the electrodes in the diagram, the user should click at either of the electrodes to see the subsequent animations (see Appendix 22). A click on the negative electrode would result in the positive ion (X^+) moving towards the negative electrode. An electron moves form the electrode into the positive ion which then becomes a neutral atom X. Alternatively, a click on the positive electrode would result in the negative ion (Y^-) moving towards the positive electrode. An electron moves from the negative ion into the electrode which then becomes a neutral atom Y.

To view the demonstration of the experiments found in this topic, a click on the word *EKSPERIMEN* in the Main Menu would bring the user to the objective statements of this section. This would be followed by a sub-menu of this section where the user could decide to view either the video clip of the experiments in electrolysis or the video clips on the experiments in chemical cells or to do the assessment questions first (see Appendix 17). Within the sub-menus of electrolysis or chemical cell, the user could yet again deliberate on the particular experiment he or she wished to see. A click on the word *ELEKTROLISIS* would bring the user to the experiments found in electrolysis (see Appendix 18). A click on the word *Sel Kimia* on the other hand, would bring the user to the experiments on chemical cells (see Appendix 19). A click on any of these experiments would present the user with the video clip of the demonstrated experiments concerned. However, if the user decided to skip the whole video clip of

the demonstrated experiments, a click on the word *Penilaian* would bring the user to the assessment questions on the experiments in Electrochemistry .

During the actual video clip of the experiments, demonstrated by the researcher, several questions on the various aspects of the experiments were asked. For example, during the experiment on the electrolysis of lead bromide, the students were asked questions like why carbon electrodes were used in the experiment, why the electric bulb light up only after the lead bromide had melted but not when it was in powdered form. These questions were meant to provoke interest and utilized the inquiry approach to this section.

At the end of each video clip of the demonstrated experiments, five to seven questions, in text form, were presented to the students pertaining to the particular experiments. The students were given 10 seconds to attempt to answer each of these questions after which the answers would automatically appear on the screen.

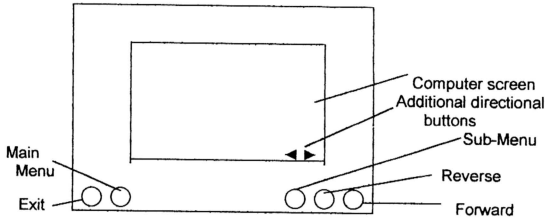
The forty multiple-choice questions provided in the EXERCISE and in the TEST sections were similar to the format of the Paper One (Objective Paper) in the actual public examination, *Sijil Peperiksaan Malaysia* or the Malaysian Certificate of Education. The student was allowed one attempt to answer each of the questions. At the end of the assessment questions, the student's score would be displayed. If the student scored full marks, an encore awaited him or her. If the students scored less than 40, a text appeared which encouraged them to repeat the whole assessment questions again.

The time taken to go through ELEKTROKIMIA depended on the user who was granted control over the programme . The user was given the opportunity to determine the point of entry, go forward, backward, repeat any section, go to other sections of the menu or exit at anytime of the programme. However the average time to go through the entire length of the programme was about three hours. The option to go to another section of the of the sub-menu, or the Main Menu or to exit from the program was provided by buttons located at the bottom of the computer screen.

These directional buttons were provided at the bottom right-hand corner of the screen to allow the user to go back or forth within the sub-menu of the program. The buttons automatically became inactivated at the end of a particular text within the sub-section. Additional forward and reverse buttons in different colour mode were also provided for text within a sub-menu in the sub-section. All the buttons provided were designed for flexibility where students were given choices to navigate the programme in a self-paced and self-directed manner.

The Main Menu button and the Exit button were provided at the bottom left-hand corner of the screen. These two buttons remained active throughout the program to allow the user to either go to other sections of the program or to exit from the program at any time. The following diagram in Figure 9 illustrated the positions of all the navigational buttons.

Figure.9:
A model of the computer screen



Assessment questions in all the sections were the multiple-choice and fill-in-the blank- type of questions. Students either had to click on the correct response for the multiple-choice questions or click and drag the correct response for the fill-in-the-blank-type of questions. All the assessment questions were immediately rewarded with a music hit. The immediacy of reinforcement following the elicited response was in accordance to Skinner's learning model (Skinner, 1971). The music hit was used as a reinforcer which could help to strengthen the desired response. From the researcher's observation, most teenage students enjoy music, thus the reward for getting the correct response might motivate them to find the correct response to the assessment exercises.

A text to further explain and elaborate briefly the correct answers were also given after each of the correct responses. Providing reasons for the "correctness" of a correct response is essential to the effectiveness of feedback as it aids better learning and retention (Gilman ,1969).

Students' Evaluation of the ELEKTROKIMIA programme

The results from the pilot test indicated that the students found the ELEKTROKIMIA programme relatively easy to use. The language used in certain sections of the text content and in some of the assessment questions however, was felt to be not clear. Some of the sentences used were thought to be too long. There were also certain parts in the programme where the students were uncertain of what to do next in order to proceed. In general, the students indicated that they were happy with the presentation of the whole programme. Based on these feedback, the programme was revised and amended. The language used was made simpler and the sentences in some of the assessment questions were shortened. More text instructions were added to prompt the user what to do next during the course of the programme.

The revised prototype was then evaluated by thirty-five students during field-testing. The programme was evaluated by the students actually going through the entire ELEKTROKIMIA programme and then responding to the questions found in the Evaluation Form Of A Multimedia Programme for Students (Appendix 1).

The Evaluation Form Of A Multimedia Programme For Students (Appendix 1) was given to each student together with the ELEKTROKIMIA programme. The students were then instructed to go through the entire program before responding to the questionnaires in the Evaluation Form. The Evaluation Form consisted of two sections, Part A and Part B. Part A was used to solicit information with regard to the socio-economic background of each student and the achievement scores they obtained from their school's semester test in Chemistry. Part B consisted of fifteen statements

pertaining to the various features of the program . Each statement was followed by three responses. Students were asked to mark the response that they agreed most with.

Total agreement with the statements in the Evaluation Form was assigned the value of 3, partial agreement with the statements was given the value of 2 while not agreeing with the statements was given the value of 1 (see Appendix 1). The mean score of the features of the programmes were tabulated in Table 4. The mean values of the student's response were given together with the standard deviation. The percentages as well as the actual number of those who totally agreed, partially agreed and who disagreed with the statement posed about the features of the program were also given.

Each feature of the programme was ranked based on the mean score values. Those features which had the same value for the mean score were given equal rating by averaging between the two rating values. For instance, if two features of the programme had the same ranking of two for example, due to the same mean and standard deviation values. The ranking value of both the features was added and then divied by two (that is, two is added to three and the sum will then be divided by two). This would mean that each feature will be assigned the values of 2.5.

Table 4:
Students' Evaluation of the ELEKTROKIMIA programme

Ranking	Features of the programme	Mean	Standard Deviation	% of students who		
				totally agreed	quite agreed	disagreed
1.5	Language used was satisfactory	2.97	0.17	97.1 (34)	2.9 (1)	0
1.5	Multimedia used was helpful in understanding concepts	2.97	0.17	97.1 (34)	2.9 (1)	0
3.0	Would recommend programme to a friend	2.89	0.32	88.6 (31)	11.4 (4)	0
5.5	Programme was easy to use	2.82	0.38	82.9 (29)	17.1 (6)	0
5.5	Presentation of concepts is logical	2.82	0.38	82.9 (29)	17.1 (6)	0
5.5	Programme is motivating	2.82	0.45	85.7 (30)	11.4 (4)	2.9 (1)
5.5	Need to think in the programme	2.82	0.38	85.7 (30)	14.3 (5)	0
8.5	Enough instructions in the programme	2.80	0.41	80 (28)	20 (7)	0
8.5	Concepts presented are clear	2.80	0.47	82.9 (30)	14.3 (4)	2.9 (1)

Note: Number in brackets denotes frequency of students

Table 4: (continued)

Ranking	Features of the programme	Mean	Standard Deviation	% of students who		
				totally agreed	quite agreed	disagreed
10.5	Know what to do in the programme	2.71	0.46 (25)	71.4 (10)	28.6	0
10.5	Can control the rate of the programme	2.71	0.46	71.4 (25)	28.6 (10)	0
12.5	Would do the programme again	2.63	0.55	65.7 (23)	31.4 (11)	2.9 (1)
12.5	Assessment questions are suitable and adequate	2.63	0.55	65.7 (23)	31.4 (11)	2.9 (1)
14.0	Learned all the concepts that should be known	2.54	0.51	54.3 (19)	45.7 (16)	0
15.0	Prefer to do the programme in one go	2.28	0.44	25.7 (9)	74.3 (26)	0

Note: Number in brackets denotes frequency of students

In general, the ELEKTROKIMIA programme has been perceived by students to be above average with an overall mean score of 2.75 (range of values is one to three). The highest mean score was 2.97 while the lowest mean score was 2.28. This would indicate that the programme has been well-received by the students.

It is encouraging to note that the students totally agreed the programme was easy to use, the multimedia elements were helpful, the level of language used was satisfactory and the concepts presented were clear and logical. It would appear the students agreed that the programme could increase their motivation and there were sufficient instructions in the programme to help them go through the programme. There were some however, who were uncertain what to do in the programme. Others felt that there were insufficient assessment questions in the programme and not all agreed that all the concepts of Electrochemistry have been presented.

From the results tabulated above, it would appear that the strength of ELEKTROKIMIA programme was the use of the multimedia elements in the understanding of the electrochemical concepts as well as the level of language used. This was totally agreed upon by more than 97% (34) of the students. The results revealed that the use of graphics, still images, video clips and animations seemed to have helped students to understand the concepts of Electrochemistry. The results also indicate that the students agreed that the presentation of concepts were clear, logical and orderly.

It is encouraging to note that more than 85% (30) of the students felt that the programme was motivating and required them to think about Electrochemistry. Another strength of the program appeared to be the relative ease of use of the programme which was agreed upon by more than 82% (29) of the students.

There is indication that the students liked the programme where more than 88% (31) of the students considered the ELEKTROKIMIA programme to be good enough to be recommended to another friend. With regards to the user-friendliness of

the programme, it appears the students were of the opinion that there were enough instructions for the user in the ELEKTROKIMIA programme as indicated by 80 % (28) of the students.

However, only 71% (25) of the students indicated that they could control the rate of the programme and knew what to do in the programme. This apparent weakness was an important point to consider for the revision of ELEKTROKIMIA programme. It would suggest that more instructions have to be included at strategic locations within the program to ensure navigation problems would be minimized.

With regards to the assessment questions provided, more than 65% (23) of the students perceived them to be suitable and adequate. It was noted that although all the concepts in Electrochemistry had been presented in the programme, only 54% (19) of the students believed they have learned all the concepts that they should know in this topic.

Finally, the least likeable feature of ELEKTROKIMIA programme appeared to be the length of the programme. More than 74% (26) students preferred to do the programme in stages rather than in one go. However, despite this apparent weakness, more than 65% (23) of the students would like to repeat the programme. This would suggest that the ELEKTROKIMIA programme can be considered as viable choice to supplementary self-paced, learner-centred programme.

Results from the open-ended questions

In the same Evaluation Form, the students were also asked to write the

reasons why they liked or disliked the ELEKTROKIMIA programme. From their responses, it can be summarized that the students liked the ELEKTROKIMIA programme because it;

- was easy to use
- had adequate instructions
- had notes that were simple, short and complete
- had illustrations that were accurate and interesting
- had diagrams that were clear and easy to understand
- had clear explanation of the concepts
- had sufficient information on the topic
- was an effective program to increase understanding of the topic
- could increase their interest in the topic
- had an interesting presentation
- had assessment questions to help them evaluate their understanding of the topic
- helped them to "see" what was happening during electrolysis
- helped them to understand the experiments through the use of video clips
- was different
- had the music hits to their correct responses in the assessment questions
- helped to increase their achievement score in Electrochemistry.

It is noted that several of the responses were similar to the ones already asked in the questionnaires. On the other hand, some of the features that some of the students were not happy with the programme were;

- it was too long
- it had insufficient notes on the content
- it had insufficient assessment questions
- the video clips were not clear and had no sound
- it had no information or feedback to the incorrect responses that were given to the assessment questions.

Results from the observation and interview of students

Observation of students going through the programme and interviewing them at the end of the programme would allow the researcher to obtain more information about the problems that students might encounter as well as obtain information on how they felt about the programme. Ten students out of the thirty-five were selected for the observation and interview. None of the students had a computer at home and they had no experience with any educational CDs before. They considered their computer skills to be very poor. These students, although went to schools in the district of Petaling Jaya were from the rural areas in the country. They were all staying at a hostel. All ten students selected were considered the low-ability students based on their Chemistry score of less than 50% in their schools' semester examinations.

The selected students were notified and briefed about the evaluation prior to the actual observation. They were observed individually at the hostel library. Although there were other students (about ten of them) using the library, distractions were minimal as the computer was placed at a secluded corner of the library. Before starting the programme, the researcher had casual conversation with each of the students about themselves, their families and their problems in Chemistry in general and specifically in Electrochemistry. This would help them to relax and feel less apprehensive about using the computer and the ELEKTROKIMIA programme. The researcher also assured the students that their evaluation was important to help identify the weaknesses of the programme where their feedback would be important to help improve the programme for other users in the future.

The students were informed of the purpose of the task which was to evaluate the ELEKTROKIMIA programme and to find out whether the programme could help them understand the topic Electrochemistry better. The students were also told to note down any problems that they might encounter when using the programme. The researcher informed the students that they should attempt using the programme without asking for any assistance from the researcher. The ELEKTROKIMIA programme was already in the CD-ROM drive and was ready to be used by the students. The researcher sat beside each of the students throughout the programme during observation.

It is encouraging to note that the majority of the students (8 of them) were able to go through the programme without any guidance from the researcher. However, the remaining two students did not know what to do in order to proceed with the programme. From the observation, these two students seemed to be nervous

before the start of the programme and were even more apprehensive when they finally approached the researcher for assistance. The students were then shown how to use the mouse click and where to click in the programme by the researcher. They were then able to continue with the programme on their own without further assistance.

All the students seemed to be totally engrossed while doing the ELEKTROKIMIA programme. It was noted that only one student was rather restless throughout the session. When asked later about his restlessness, the student replied that he would have preferred to do the programme in stages without the presence of the researcher. This student felt that the programme was too long to do in one go. The others however, did not seem to mind that the programme took more than three hours to complete. They felt that it was worth the time spent. At the end of the programme, each of the students were interviewed individually by the researcher through a series of questions (see Appendix 3). Observation and interview of each student took about four hours.

The comments made by the students would confirm that they liked the ELEKTROKIMIA programme. The students indicated that they found learning using the computer much more enjoyable and motivating. The comments also confirmed that the illustrations and the animations seemed to have helped them understand better the processes and migration of ions during electrolysis and the movements of electrons in chemical cells.

There were similarities in the comments given by all the students about the video clips of the demonstrated experiments. It appears that these video clips were a favourite based on their comments that the clips have helped them to note and

observe what they were supposed to observe in the experiments. The image, sound and pictures in the video clips were clear. The students were also of the opinion that they found these clips to be motivating. The students indicated that they were happy with the questions during and at the end of the experiments. Although they could not answer all of them, they felt that they now knew what were the important things to look out for in all the electrochemical experiments.

Based on their comments, it would appear that all the students were happy with the assessment questions. They enjoyed the music response that came with the correct responses to the assessment questions. However, only one student turned down the volume of the music responses midway through the programme. This was because she was concerned that the music had attracted the other students who had come over to observe the programme as well.

It is encouraging to note that all the students liked the music and the images at the beginning of the programme. They felt that the video clip of the application of Electrochemistry, like the different types of batteries and the various silverware and gold-plated ornaments shown, has helped to motivate their interest in the topic.

It is also noted that the students felt they could control the rate of the programme, although some felt that the animations were too fast. Despite the programme being lengthy, they indicated that they would not mind going through it again to ensure that they thoroughly understood the concepts in the topic.

With regards to the text, colour and design of the programme, the students were of the opinion that these features were satisfactory. The students indicated that they did not have any problems with the language used. They also indicated that they liked the audio presentation of the concepts because they felt as if a teacher was actually asking them the questions on what they should know about Electrochemistry. The students also agreed that this approach has helped them to focus on the important concepts they should know about the topic. Based on their comments, it was noted that the students were happy to have this programme as a revision course.

Two of the students however, felt that it would be better if there were feedback and information to the incorrect responses given to all the assessment questions. They felt that they would know why the answers that they had chosen were wrong. Three students felt that the questions were too difficult for them to answer. While only one of them preferred to do the programme with another friend, the rest preferred to do it alone.

Results From the Achievement Test of Low-ability Students

The achievement test of students referred to the test performed by ten low-ability students who scored less than 50% in their school's semester Chemistry test. The students selected to do this achievement test were those students who came from the rural areas but staying in a hostel and went to different schools in the district of

Petaling Jaya. None of the students were computer- literate. These were the same students who were observed and interviewed earlier.

Each of these students was given the ELEKTROKIMIA programme to evaluate at the hostel library. The researcher remained with each of them throughout the evaluation of the programme. The ten students were required to do the achievement test which is in the *UJIAN* (TEST) section in the programme (see Appendix 9). The researcher directed the students to answer the 40 multiple-choice questions in the *UJIAN* (TEST) section of the ELEKTROKIMIA programme first before going through the rest of the programme. The students were told to click on the correct response to the 40 multiple-choice questions (see Appendix 4). The score of this achievement test was shown on the computer screen at the end of all the questions and recorded by the student and the researcher. This score constituted their pre-test scores. They were then allowed to go through the rest of the ELEKTROKIMIA programme.

At the end of the entire programme, the students were asked to repeat the same questions in the *UJIAN* (TEST) section in the ELEKTROKIMIA programme. The score which was presented on the screen at the end of all the questions were recorded as their post-test scores.

Each correct response was given a score of 1. The maximum attainable score was 40 while the minimum score would be 0. The results of these two scores and the means of the two tests were calculated, together with the standard deviation as shown in Table 5:

Table 5 :
Pre-test and post-test scores of students
in the achievement test

Student	Pre-test score	Post-test score
A	12	22
B	15	24
C	17	25
D	18	27
E	20	25
F	18	24
G	16	25
H	15	25
I	21	30
J	14	28
Mean Score	16.6	25.5
Standard Deviation	2.76	2.27

The results from the table showed that the mean score of the pre-test by the ten students was 16.6 as opposed to the mean score of the post-test which was 25.5. The results of the pre-test and post-test scores of these students were also subjected to the statistical analysis Mann- Whitney Test to see whether the increase in the scores of the post-test over the pre-test was significant at the 0.5 level of confidence. The scores for the pre-test constituted the Test 1 while the scores for the post-test constituted the Test 2. The results of the statistical test was tabulated in Table 6.

Table 6:
Results of the Mann- Whitney
Test Statistics

	Test 1	Test 2
Mean Rank	1.0	2.0
Sum of Ranks	1.0	2.0
Mann-Whitney U	= 0.01	
Asymp. Sig. (2-tailed) =	0.37	

The results of the Mann- Whitney analysis indicates that the mean rank of the post-test was significantly different from the mean rank of the pre-test at $p<0.05$. This would indicate that the increase in the achievement test is significant at the 0.5% level of significance. Thus it appears that ELEKTROKIMIA programme has helped the low ability students to increase their performance in Electrochemistry.

Teachers' Evaluation of the ELEKTROKIMIA programme

A total of six senior Chemistry teachers responded to the questionnaire in the Evaluation Form Of A Multimedia Programme For Teachers (Appendix 2). Each teacher had at least twelve years' experience of teaching Chemistry at the Form Four, Form Five and Form Six level. Three of them have been actively involved in the development of educational softwares for Smart Schools. Each teacher was allowed to bring home the ELEKTROKIMIA programme for one week to evaluate the programme.

They were then asked to respond to the questionnaire in the Evaluation Form for Teachers. The teachers were also requested to note down any problems or technical difficulties that were encountered during the evaluation of the programme.

Total agreement with the given statements in the Evaluation Form was assigned the value of 4, agreement with the given statements was given the value of 3, quite agreeing and disagreeing with the given statements were given the values of 2 and 1 respectively (see Appendix 2). The results of the teachers' response to the questionnaire about the various features of the programme were displayed in Table 7 in descending rank order and mean score. The mean, standard deviation, percentage and the actual number of teachers totally agreeing and agreeing to the statements given in the Evaluation Form were also included in this table. Each feature of the programme was also assigned a rank order.

The rank order was determined by the values of mean scores of each of the features of the programme. The higher the mean value , the higher the rank order. Those features of the progarmme with the same mean scores were assigned the same rank order by averaging the rank order between those features. For instance, if three features of the programme had the same mean scores with a ranking of five, then each would be given the value of six. Thus was done by adding the values of five, six and seven to the three features and then dividing the sum by three.

Table 7:
Teachers' Evaluation of the ELEKTROKIMIA programme

Ranking	Features of programme	Mean	Standard Deviation	% teachers who totally agree	% teachers who agree
1.	Topic is important	4.0	0.0	100 (6)	0
3.	Language used was satisfactory	3.67	0.52	66.7 (4)	33.3 (2)
3.	Text was easy to read	3.67	0.52	66.7 (4)	33.3 (2)
3.	Curriculum requirements were fulfilled	3.67	0.52	66.7 (4)	33.3 (2)
5.5	Objective of programme achieved	3.5	0.55	50.0 (3)	50.0 (3)
5.5	Information in the program accurate and suitable	3.5	0.55	50.0 (3)	50.0 (3)
7.5	Questions on experiments are suitable	3.5	0.84	66.7 (5)	16.7 (1)
7.5	Concepts are correct	3.5	0.84	66.7 (5)	16.7 (1)
12.5	Presentation was orderly	3.33	0.52	33.3 (2)	66.7 (4)
12.5	Assessment questions were suitable	3.33	0.52	33.3 (2)	66.7 (4)

Note: Number in bracket denotes frequency of teachers

Table 7: (continued)

Ranking	Features of programme	Mean	Standard Deviation	% teachers who totally agree	% teachers who agree
12.5	Information in the programme were sufficient	3.33	0.52	33.3 (2)	66.7 (4)
12.5	No language problem	3.33	0.52	33.3 (2)	66.7 (4)
12.5	Sufficient time for activities in the programme	3.33	0.52	33.3 (2)	66.7 (4)
12.5	Programme is better than other teaching aids	3.33	0.52	33.3 (2)	66.7 (4)
12.5	Programme fulfills the learning objective	3.33	0.52	33.3 (2)	66.7 (4)
12.5	Can improve learning	3.33	0.52	33.3 (2)	66.7 (4)
18.5	Programme encourages thinking	3.33	0.82	50 (3)	33.3 (2)
18.5	Sufficient assessment questions	3.33	0.82	50 (3)	33.3 (2)
18.5	Programme can increase motivation	3.33	0.82	50 (3)	33.3 (2)
18.5	Can understand information in the programme	3.33	0.82	50 (3)	33.3 (2)

Note: Number in bracket denotes frequency of teachers

Table 7: (continued)

Ranking	Features of programme	Mean	Standard Deviation	% teachers who totally agree	% teachers who agree
22.5	Can exit programme anytime	3.17	0.41	16.7 (1)	83.3 (5)
22.5	Can follow instructions in the programme	3.17	0.41	16.7 (1)	83.3 (5)
22.5	Information on use sufficient	3.17	0.41	16.7 (1)	83.3 (5)
22.5	Feedback provided sufficient	3.17	0.41	16.7 (1)	83.3 (5)
26.	Level of difficulty satisfactory	3.17	0.75	33.3 (2)	50.0 (3)
26.	Multiple learning strategy used	3.17	0.75	33.3 (2)	50.0 (3)
26.	Presentation of concepts satisfactory	3.17	0.75	33.3 (2)	50.0 (3)
29.	Colour used was satisfactory	3.0	0	0	100 (6)
29.	Programme was easy to use	3.0	0	0	100 (6)
29.	Can control rate of sequence in programme	3.0	0	0	100 (6)
32.	Suitable learning strategy	3.0	0.63	16.7 (1)	66.7 (4)

Note: Number in brackets denote frequency of teachers

Table 7: (continued)

Ranking	Features of program	Mean	Standard Deviation	% teachers who totally agree	% teachers who agree
32.	Sufficient interaction in programme	3. 0	0.63	16.7 (1)	66.7 (4)
32.	Can follow information in documentation	3.0	0.63	16.7 (1)	66.7 (4)
37.5	Graphics and animation used as suitable and satisfactory	3.0	0.89	33.3 (2)	50.0 (3)
37.5	Introduction interesting	2.83	0.41	0	83.3 (5)
37.5	Screen design satisfactory	2.83	0.41	0	83.3 (5)
37.5	Video clip satisfactory	2.83	0.41	0	83.3 (5)
37.5	No technical problem	2.83	0.41	0	83.3 (5)
37.5	Sufficient instructions in the programme	2.83	0.41	0	83.3 (5)
37.5	Can do the programme unaided	2.83	0.41	0	83.3 (5)
41	Can control programme	2.83	0.75	16.7 (1)	50.0 (3)
41	Introduction satisfactory	2.67	0.82	0	83.3 (5)
43.	Sound effect satisfactory	2.50	0.55	0	50.0 (3)

Note : Number in brackets denote frequency of teachers

It is encouraging to note that the teachers found the ELEKTROKIMIA programme to be satisfactory in terms of the educational value, presentation, content, usability, documentation and overall perception. All the teachers were of the opinion that the programme had fulfilled the requirements of the curriculum, the text was easy to read while the language used was satisfactory. This was totally agreed to by most (4) of the the teachers.

It would appear that the objectives of the programme have been achieved, the information in the programme were accurate and suitable, the concepts in the programme were correct and that questions on the experiments were found to be suitable . These features of the programme were agreed upon by half (3) the teachers.

It was noted that some (2) of the teachers totally agreed the presentation of information was orderly, the assessment questions were suitable and the information in the programme were sufficient. The same number of teachers agreed that there were no problems with the language used, that there were sufficient time for activities in the programme, the learning objectives of the programme were fulfilled and could improve learning and finally, the programme was better than other teaching aids.

The ELEKTROKIMIA programme was found to have encouraged students to think. This feature of the programme was totally agreed upon by half (3) of the teachers. Similarly, the same number of teachers agreed that there were sufficient assessment questions, the programme could increase student's motivation and the information provided in the programme was easily understood.

Almost all (5) the teachers agreed that students could exit the programme at any time . The same number agreed that instructions in the programme could be easily followed and that there were sufficient information on the use of the programme. The feedback provided were also thought to be sufficient.

With regards to the level of difficulty of the content in the ELEKTROKIMIA programme, some (2) of the teachers totally agreed that they were satisfactory. Multiple learning strategies have been used in the ELEKTROKIMIA programme and that the presentation of concepts was satisfactory. These features were agreed by half (3) of the teachers.

It is noted that all the teachers also agreed the color used in the programme was satisfactory and that the programme was easy to use. The teachers also felt that the students could control the rate of sequence of the programme. The results indicate that most of the teachers agreed that the learning strategy utilized was suitable. The same number also felt that there were sufficient interaction in the programme. The results reveal that the graphics and animation used to illustrate the concepts were agreed to be suitable and satisfactory by all the teachers except one. The teachers also agreed that the introduction to the program was interesting. The screen design and video clip were satisfactory, there were no technical problems when using the programme, there were sufficient instructions in the programme and finally the students could do the programme unaided. These features were agreed upon almost all (5) the teachers.

All but one of the teachers agreed that the introduction was satisfactory. The sound effect found in the programme was given the last ranking of 43. Only half (3) of the teachers found it to be appropriate. The teachers were also requested to give a numerical summative grade to the programme with the value of 1 being very poor to 10 being excellent. Table 8 showed the result of the teachers' summative grade.

Table 8:
Teachers' rating of the programme

	Very Poor						Excellent
Rating of ELEKTROKIMIA	1	←		7	8	9	10
% of teachers (No. of teachers)	-	-	-	16.7 (1)	66.6 (4)	16.7 (1)	-

Mean = 8, Standard deviation = 0.633

It is encouraging to note that most (4) of the teachers gave a rating of 8 for the ELEKTROKIMIA programme. One teacher each gave a rating of 7 and 9 respectively. The mean value for the rating was the same as the values for median and mode which was 8. Thus it can be perceived that the ELEKTROKIMIA programme was found to be fairly excellent by the six teachers.

At the end of the questionnaire, each teacher was requested to comment on the strength and weaknesses of the program. Some found the animations in the programme, especially the movement and migration of ions to the electrodes during electrolysis and the subsequent discharge of the ions, to be interesting and could motivate students' interest in the topic.

The video clips on the experiments were well-received by most of the teachers. The comments confirm that the video clips could help students focus on the important aspects of the experiments and on the results that they should obtain from the experiments. The questions posed at the end of each experiment were also thought to be useful in reinforcing and focussing on the important aspects of the particular experiment. These questions were also thought to have helped the students to be familiar with some of the questions that were frequently asked in the public examinations.

The results reveal that the teachers were happy with the hypertext incorporated in the programme which provided instant information about relevant concepts related to Electrochemistry. Assessment questions provided in the programme appeared to have helped students in self-evaluating their understanding of Electrochemistry.

There are similarities in the comments given by all the teachers regarding the orderly presentation of the electrochemical concepts. The content of the programme was thought to be easy to follow while the music used as a reward for each correct response was found to be stimulating and motivating for the students.One of the teachers however, felt that the content of the programme was too lengthy and resembled the text book. The experiments too were similar to those found in the text book. This teacher, who currently works in a Science Centre with the national petroleum company, likened the programme to an electronic textbook.

The assessment questions too were felt to be too simple for the students by one of the teachers. Another felt that the animations were too fast and that one has to repeat the animations to have a better view of what was happening. Others wanted more coloured pictures in the programme. Yet another teacher commented that the correct answer should be given to every incorrect response given by the user to the assessment questions. Based on other verbal comments, the teachers indicated that the programme could be recommended to other teachers and students. Some wanted to know where these CDs could be purchased as they wanted a copy for their school's resource material. All the teachers felt that students could benefit from the programme especially for revision and enrichment purposes.

All the teachers agreed that the programme could be used either individually or in a group. One of the perceived advantages of the ELEKTROKIMIA programme was that the teachers felt that they could access to any section of the programme with any student to help identify any concept that a student need clarification and further explanation. From their comments, the teachers felt that the programme could also help them identify which part of the topic students did not understand.

This could probably be done in a tutorial group or a revision group after the topic has been taught or prior to an examination. In addition, the video clips of the experiments could be shown repeatedly to help students make sense of the the happenings of the electrochemical cells at the macroscopic level with that at the symbolic level. Furthermore, the animations can be utilised to help students visualize the happenings of the electrochemical cells at the micsroscopic level. The teachers felt

that they can use the ELEKTROKIMIA programme to help students relate at the three level of representations of a chemical change like in a electrochemical cell.

Teachers' and Students' Evaluation of the ELEKTROKIMIA programme

The teachers' and students' evaluation of the ELEKTROKIMIA programme were then compared. The features selected for this comparison were the similar ones which appeared in both the Evaluation Forms Of A Multimedia Programme For Teachers (Appendix 2) as well as for Students (Appendix 1). The percentage of the teachers' and students' responses were tabulated in Table 9.

The percentage of total agreement and agreement of teachers have been combined together and compared to the percentage of total agreement by students. The students' responses to the questionnaire in their Evaluation Form were 'totally agree', 'quite agree' and 'disagree' while the teachers' responses in their Evaluation Form were 'totally agree', 'agree', 'quite agree' and 'disagree'. There was no 'agree' response in the students' Evaluation Form. In this comparison, the teachers' responses for 'totally agree' and 'agree' has been combined together against the students' response of 'totally agree'.

Table 9:
Comparison of teachers' and students' evaluation of the ELEKTROKIMIA programme

Features of programme	% teachers who totally agreed and agreed	% of students who totally agreed
1. Language used was satisfactory	100	97.1
2. Programme was easy to use	100	82.9
3. Presentation of of concepts clear and logical	100	82.9
4. Multimedia elements were helpful	83.3	97.1
5. Need to think in the programme	83.3	85.7
6. Sufficient instructions in the programme	83.3	80
7. Programme can motivate students	83.3	85.7
8. Sufficient and suitable assessment questions	83.3	65.7
9. Can control programme	100	71.4
10. All concepts presented	100	54.3

It must be noted that the number of students who evaluated the programme was much larger than the number of teachers. Nevertheless the general agreement of both groups on some of the features of the ELEKTROKIMIA programme will be discussed below.

The results indicate that the strength of the programme was the language used and the relative ease of use. Both features of the programme were agreed upon both teachers and students. In general, the presentation of concepts was acceptable by these two groups.

There are similarities in the results by both groups with regards to the use of multimedia elements in this programme. It appears that these multimedia elements were appreciated by more 97% of the students and by more than 83% of the teachers. More than 80% from both groups agreed that the ELEKTROKIMIA programme has motivated students to think and the same number felt that there were sufficient instructions in the programme.

More than 80% of the teachers agreed that there were adequate assessment questions found in the programme while more than 65% of the students agreed on the same feature. Although all the teachers felt that the programme could be controlled, only 71.4% of the students shared this view. Finally, the results reveal that although all the teachers agreed that all the concepts have been presented, only about half of the students agreed with this statement. Such discrepancies may be attributed to the fact that teachers were expected to know the topic in greater detail than the students.

The results from both the students and teachers would suggest that the ELEKTROKIMIA programme has been successfully developed which contained some of the features normally seen in the commercial product in the market. That the language used was satisfactory was important to ensure concepts and explanation of Electrochemistry were understood by the students themselves. It would appear that the multimedia elements incorporated in the programme have helped students "see" and appreciate the processes of electrochemical cells. Thus, perhaps would increase their understanding of the concepts in Electrochemistry.

Revision of the ELEKTROKIMIA programme

There were minimal amendments made to the programme. Some of the features in the programme that were revised were the instructions for the user and the feedback to incorrect responses for the assessment questions. More help needed to be given to ensure the ELEKTROKIMIA programme to be more user-friendly and effective.

One of the ways to make the programme easier to use was to make the navigation simpler for the user. For instance, the image of the first screen was to welcome the user to the "World of Electrochemistry" (see Appendix 8). This image was reprogrammed to dissolve after two seconds before automatically proceeding to the next screen. Prior to this, the user had to click on the screen in order to proceed with the programme. Next, the user was requested to type in their names and class before

getting access to the rest of the programme . This would instill a sense of belonging towards the programme.

Another addition to the programme was an inclusion of a new screen page prior to the Main Menu. This page consisted of several pre-test questions reminding students about some of the concepts that they should know from the first three topics in the Form Four Chemistry syllabus before going through the program (see Appendix 11). The students were advised to revise the three topics again should they not know the answers to some of the questions presented. This additional page was included to reinforce the third of the external events as proposed by Gagne, Briggs and Wager (1992) to support learning processes, which was "Reminding learners of previously learned concepts for retrieval from Long-term Memory".

Some of the animation movements in the electrolytic cells were found to be too fast by some of the teachers and some of the students. Using the software Macromedia *Director*, the rate of the movements of ions were readjusted to allow the students to have a better viewing of the movement and migration of ions in the electrolytic cells. The video clips of the demonstrated experiments were also re-edited to ensure a clearer and sharper image of the whole experiments. This involved recapturing the whole video clip from the VHS tape using the software *MPEGator.*

Lastly, the correct answers to each of the assessment questions were programmed into the ELEKTROKIMIA programme following an incorrect response given by the students. This was done to address some of the dissatisfied features mentioned by some of the teachers and students regarding the lack of correct feedback to the assessment questions.

Research has shown that corrective feedback has the greatest positive effect in an instructional program when it follows a wrong response (Cohen, 1985; Weller, 1988). The aim of corrective feedback is to correct the student when he or she is wrong. The information content can help facilitate understanding and comprehension of the material (Anderson et al.,1972; Bardwell, 1981; Barringer and Gholson, 1979; Kulhavy, 1977). Alessi and Trollip (1985) and Steinberg (1984), have shown that the incorporation of the correct feedback given to the incorrect responses could provide correction and even remediation with the purpose of improving future performance.

Summary

This chapter has presented three results, first was the description of the development of the ELEKTROKIMIA programme, secondly, the evaluation results of the programme by the teachers and the students and third, the results of the achievement test by the low-ability students.

The ELEKTROKIMIA programme was developed based on selected principles of instructional design that was a combination of several ID models. The presentation of the programme's content was based on the Information Processing Theories model and Gagne's nine instructions of events. Multimedia elements like text, graphics, still images, video clips and animations were incorporated within the programme to help students utilize the multi-modal senses in understanding the concepts of Electrochemistry. The programme was developed using the authoring tools of

Authorware 4.0 and *Director* 6.0. Other softwares used to develop the programme included *MPEGator*, *Soundforge*, *Freehand* and *Adobe Photshop* 4.0.

The evaluation was conducted by administering two instruments, one for the teachers (Appendix 2) and the other for the students (Appendix 1). The results show that both teachers and students were in agreement regarding the overall features of the ELEKTROKIMIA programme. These results have not only established the strengths of the programme but also uncovered other areas of weaknesses which required due attention during revision.

The programme was considered to be effective based on the significant increase in the achievement test on the low-ability students at the 0.5% level of confidence. It must be noted however, that the sample size in this study was small and non-parametric statistics have been used to calculate the mean rank.