CHAPTER 3

METHODOLOGY

In this study, the developmental research approach for instructional technology was used, in which the research was combined in the development process (Ritchey, 1997). Throughout the study, the principles of developmental research were followed (Wang & Hanafin, 2005). The study was divided into several phases which may be iterative: analysis, design, development, implementation and evaluation (Wang & Hanafin, 2005). The research methodologies for the phases are outlined in this chapter.

In this study, Phase 1 was the analysis phase where the frequency of use of technology and perceptions of technology of a sample of learners from a selected school was determined. Phase 2 was the design and development phase where the instructional materials and the learning environment for the collaborative mLearning module was be developed and formative evaluation conducted by experts. The information the Subject Matter and Technology experts gave was used to assist the development of the collaborative mLearning module. Finally, Phase 3, the evaluation phase, looked at the impact of the implementation of the collaborative mLearning module on the learners.

In the following sections, the purpose, sample selection, methodology and procedure for data collection for each phase is explained. As the research design is of a developmental approach, different methodologies are used in the different phases.

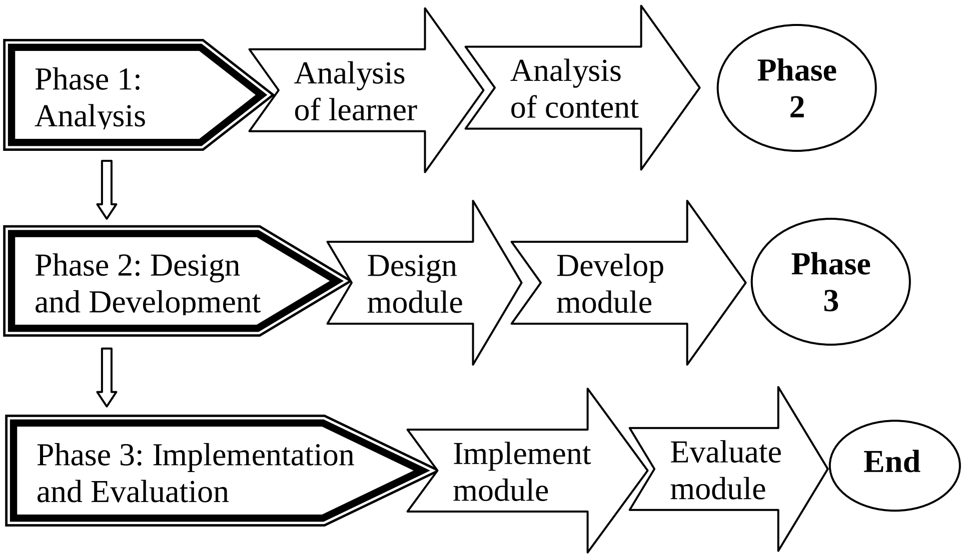

Figure 3.1. Summary of phases in the developmental research

Phase 1 of Developmental Research: Analysis

In the first phase, an analysis of the situation among the students in the context of the study to assess their needs (Rossett, 1995) was conducted. The analysis phase is the initial starting phase for developmental research where information on the context and environment is gathered. Based on the analysis, recommendations on solutions to problems and the introduction of new technology can be made (Rossett, 1995).

In this study, the research questions in the analysis phase was to describe the situation among the group of students in the context of this study regarding the use of technology with regards to level of technology skills, forms of CMC tools accessed, and the frequency of use of the forms of CMC tools, as well as the students' perceptions in the use of computers and mobile phones for teaching and learning. In addition, the content of the module was analyzed to determine the resources required in designing the lessons.

Sample of the Study

In this study, an urban school in the Klang Valley, which had a multi-racial student population from a range of social economic status, was selected. The school was selected based on the recommendation and data at the District Education Office.

The racial breakdown for the Form 2 classes was 62 (36.0%) Malays, 54 (31.4%) Chinese, 25 (14.5%) Indians and 31 (18.0%) of other races (East Malaysians, Eurasians, and domiciled Indonesians with red Malaysian identity cards). In this phase, all the Form 2 students in the school were surveyed as the collaborative mLearning module was targeted at Form 2 students.

The students' actual performance in science and English language was obtained from records of the students' performance from class assessments and reports. The results of the participants' previous science and English language test scores were recorded. The scores for both science and English were normally distributed as evidenced from stem and leaf plots, box-plots, and normal Q-Q plots.

Procedure

The instrument was administered to the respondents who were divided into two groups, at separate sessions. At each session, the instrument was distributed to all the respondents and general instructions were given first. Standardization of the items in the instrument was done as each item was read, and ambiguous terms explained or translated to the national language when required. The purpose of the standardization was to ensure the interpretative validity (Cohen, Manion & Morrision, 2003) of the instrument to reduce errors due to misinterpretations of the items in the instrument.

The respondents were given as much time as they required to complete the instrument. The return rate for the instrument was 100%.

The Instrument

The instrument used in this study is the Technology Skills and Usage Questionnaire (Appendix A) which determined respondents' background on technology; the technology skills and usage; as well as the perceptions on the use of the computer and the mobile phone for learning. This questionnaire was adapted from the Computer Skills and Usage Questionnaire, which was originally designed to determine teachers' and students' skills as well as their use of computers (Norizan Ahmad, 2005), The original instrument was developed based on the Smart School Teachers' Training Curriculum, Information Technology and Skills Curriculum and National Educational Technology Standards (Norizan Ahmad, 2005). For this study, the Computer Skills and Usage Questionnaire was updated to take into account the latest trends and progress of technology as in the National Educational Technology Standards for Students / NETSS (International Society for Technology in Education / ISTE, 2005).

The instrument used in this study was validated by three experts in the field of education technology. The instrument showed a high Cronbach Alpha coefficient of .882 when tested for reliability on the items for technology skills usage, and perceptions of use of technology in learning.

The Technology Skills and Usage Questionnaire consist of three parts: (a) background information; (b) technology skills and usage; and (c) perceptions of use of technology in learning.

In the Questionnaire, the background information required general information on the types of technology the respondents accessed, the perception of the respondents' skill, and their latest test results for Science and English.

The section on technology usage investigated frequency of use of the following: (a) basic computer operations, concepts and productivity tools; (b) technology research and problem solving tools; and (c) technology communication tools (NETSS, 2005). Responses rated were on a scale of 1 to 4 ranging from 'never doing a particular item'; to 'frequently used, which is equivalent to using more than once a week'.

The final part of the Questionnaire explored students' perceptions of use of computers and mobile phones in learning. Responses was rated on another scale of 1 to 4 ranging from 'no knowledge of a particular item'; to 'feels that the response is very true'.

Data collected was analyzed using descriptive statistics, and scored using frequency and percentages. The analysis of the results enabled a description of the students in the context of the study.

The Initial Study

An initial study on Form 2 students was carried out in an urban school in Selangor. The report of the findings showed that the students had access to mobile phones but were not using it for learning, and the internet was commonly used by most students (DeWitt & Saedah Siraj, 2007). In addition, students preferred learning facts in science, and learning in groups.

However, based on the initial study, the instrument which was used for data collection was reassessed and the items were refined in order to be specific. The instrument was improvised by incorporating the use of an existing instrument, the Computer Skills and Usage Questionnaire, and updating the instrument according to the latest updates in technology.

Document Analysis

Documents such as the syllabus, curriculum specifications and the approaches in the implementation of the teaching and learning of secondary school science, were analyzed. The Curriculum Specifications of the Ministry of Education was used to set the standards for the optimal or desired performance for science process skills. In addition, documentation of the suggested approaches, such as constructivism, project based learning and future studies were reviewed.

In the analysis phase, the sources of knowledge to be taught were identified (Moore & Kearsley, 2005). The mapping of the contents of the topic in the Curriculum Specifications was mapped to eight lessons (See Appendix B). Then the lesson plans and problem tasks were developed in the next phase.

Choice of Content Topic

The rationale for choosing the topic was made based on literature review and the researcher's experience is described in this section.

In the choice of content, only topics from the Form 2 Science Malaysian Integrated Curriculum Specifications (MOE, 2002) were considered. The topic of

Nutrition in Form 2 was chosen as it was one of the topics in which there were frequently questions asked in the *Penilaian Menengah Rendah* (Lower Secondary Assessment). Even though Nutrition was an important science topic which contributed to promoting a healthy lifestyle, learners had many misconceptions in this topic.

The misconceptions on nutrition started from an early age and were carried on until adulthood. Children of preschool and primary school had problems understanding the structure of the digestive system (Berthelsen, 1999; Teixeira, 2007) and the concept of food and digestion (Berthelsen, 1999). Even among secondary school children there was confusion on the concept of food: water and vitamins were considered food when water is not a food, and vitamins are nutrients (Lee & Diong, 1999). Undergraduate students continue to practice bad dietary and eating habits. In a study of more than two thousand students, almost 70% do not eat any fruit in a day, while more than 40% do not eat vegetables and 65% eat food high in fats (Melby, Femea & Siacca, 1986).

Misconceptions on nutrition were also found among trainee teachers. In a study of the food the trainee teachers ate, half of them believed that the role of protein was as a source of energy, and did not know the relationship between proteins, amino acids and nitrogen (Lakin, 2004).

A survey of the *Penilaian Menengah Rendah* (Lower Secondary Assessment) of the years 2004, 2005 and 2007 showed that there were questions on the topic of nutrition in each of the year's paper. In 2004, a complete structured question was on the Digestive system (MOE, 2004), in 2005 a complete structured question was on food tests and food classes (MOE, 2006), and in 2007, a section of a structured question was on an organ in the digestive system and another on the digestive system (MOE, 2008).

Several recommendations were made by the Ministry of Education after the analysis of the candidates answers in the *Penilaian Menengah Rendah* (Lower Secondary Assessment) Science papers. Among the recommendations were: teachers are asked to use English for the teaching of Science (MOE, 2005); teachers should stress on concept attainment and application of science concepts to daily life (MOE, 2005; MOE, 2006; MOE, 2008); teachers should vary the teaching and learning strategies and consider using ICT (MOE, 2004; MOE, 2005); and teachers should stress on problem solving (MOE, 2008).

These recommendations were taken into account in the planning of the collaborative mLearning module. Firstly, this module provides the opportunity of using English in learning science concepts and applying the concepts of science to situations in life. In addition, emphasizing on meaningful learning meant that there were opportunities for the learners to relate the use of science in their lives and to build upon their existing knowledge of science. Next, the use of the collaborative mLearning module meant that a different teaching and learning strategy employing the use of ICT was used, and finally, the module is organized with the emphasis on problem solving.

Hence, it is believed that the needs of the Ministry of Education could be met in both the choice of the topic and the design of the collaborative mLearning module. The summary of the procedure for the analysis phase is shown in Figure 3.2.

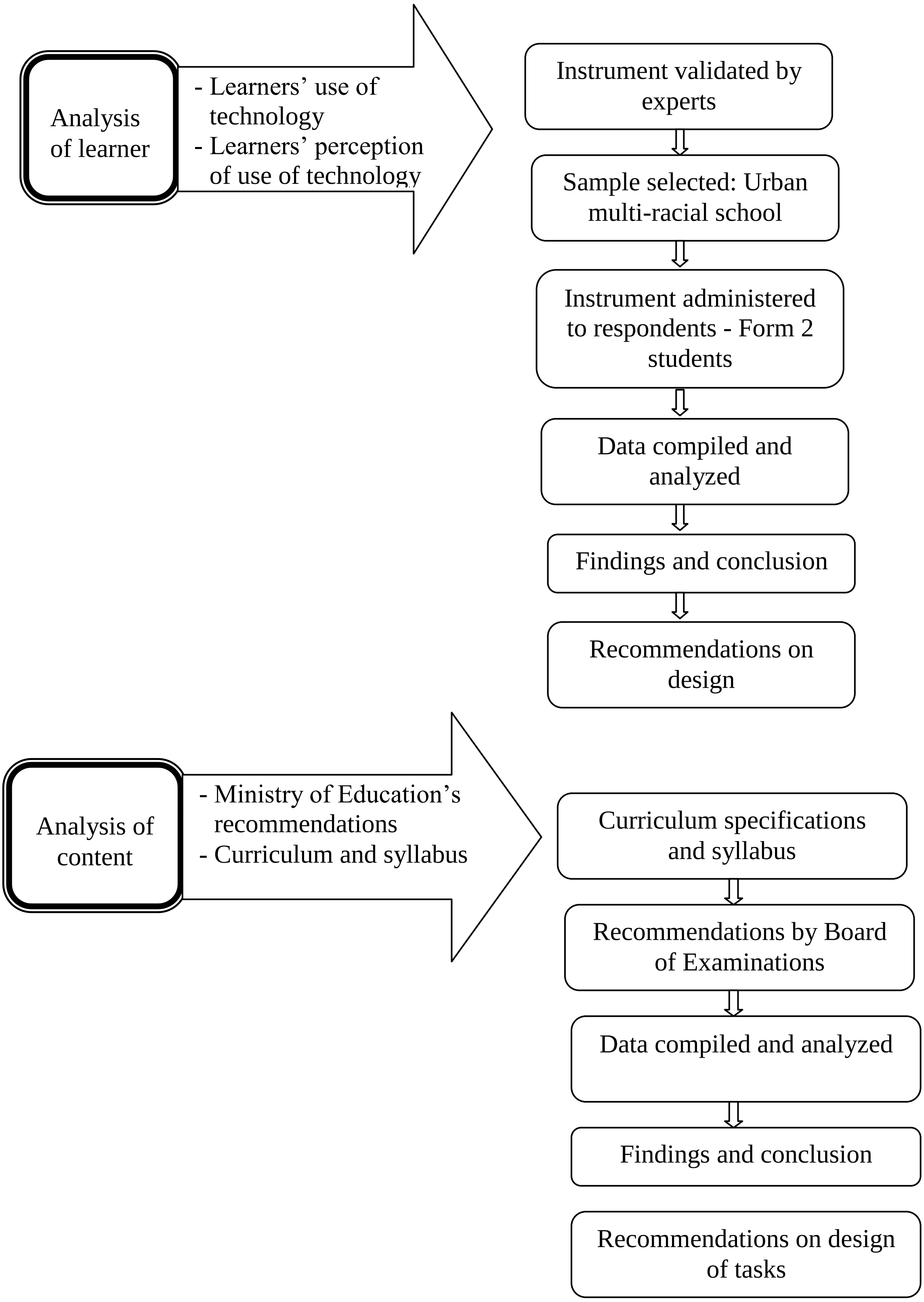

Figure 3.2. Research procedure in phase 1: Analysis

Phase 2 of Developmental Research:

Design and Development

In the second phase of the study, the findings of the analysis phase were used to guide the design. The analysis showed that communication in secondary school science with the use of easy-to-access technology like the internet and text messaging on mobile phones can be used for learning. The content that was mapped during the first phase was analyzed to identify the skills and knowledge. The collaborative mLearning module was then developed based on Merrill's First Principles of instructional design.

The objective of the second phase is to design a module for collaborative mLearning for a Form 2 science topic based on the information gathered in the analysis phase and to describe the information given by subject matter and technology experts during formative evaluation of the module to assist in the development.

The research question was to describe the information the subject matter and technology experts can give to assist the development of the collaborative mLearning module on the topic of nutrition in Form 2 science. The data was collected from the written comments of the experts on the design documents, and from the interviews. The written documents and transcripts were analyzed, and the themes that emerged related to the design of the module was reported and discussed.

Design Documents for the Collaborative mLearning module

In this phase, the design documents for the collaborative mLearning module were prepared in the following areas: the problem tasks, the syllabus and lessons, the logistics and policies, the learning environment, and the interactions.

Designing the Problem Task

Based on the mapping in Appendix B, eight lessons were planned for the topic of Nutrition in Form 2 based on Merrill's (2002) First Principles of Instruction. The central part of the instruction process is a problem which is meaningful to the learner. In order to solve the main problem, smaller problems were attempted to activate prior knowledge through recall and restructuring of knowledge, and integrate new knowledge and skills with opportunities to practice and apply the new knowledge.

In order to plan the lesson, the knowledge, skills and pre-requisite knowledge for each learning activity was determined. The knowledge required for a problem or activity could be factual knowledge, concepts or generalizations, while the skills were the science process skills, and skills related to the use of technology. The pre-requisite skills were also identified (see Appendix C).

In each lesson, the expected learning outcomes were listed with the main problem task. The problem task designed using the Merrill's First Principle (2002), was translated into a lesson plan. The lesson revolves around this problem task. The activation, integration and demonstration processes are designed in the lesson with learning activities to support the main problem. An example of the design of a lesson with the learning activities is in Table 3.1. The syllabus and lessons and are in Appendix D.

Table 3.1

Designing Lesson 4: Counting Calories

Section	Description
Objective	To estimate the amount of calories in a given meal using information given on amount of calories.
[a]Outcomes	A student is able to estimate the calories of food taken in a meal.
[b]L4 Outcomes	A student is able to estimate the amount of calories contained in a given meal from a given energy table.
Problem 4	Using the meal that your group was given in Task 1, estimate the total amount of calories in the meal from the energy table provided in the link in the class web page. Show your calculations.
[c]Phases	Tasks
Activation	Discussion 1a: Compare food labels on several drinks and determine the number of calories for a 250 ml glass of the following: 1. A cup of chocolate beverage, example, milo 2. A can of aerated water, example, Coke, Pepsi, etc. 3. A can of isotonic drink, example 100 Plus.
Demonstration	1. Web page demonstrating examples with table showing calorie content of different food. 2. Links to tools: Nutrition and energy analyzer tool Energy food comparison tool Nutrients and calories search tool at *Nutrient Data Lab* Interactive software to compare nutrition in food Calories required on *Daily Needs Calculator.* 3. Links to websites: Calorie requirement of people with different activities. 4. Examples from peers answer in discussion forums.

Table 3.1 (*continued*).

Designing Lesson 4: Counting Calories

[c]Phases	Tasks
Application	1. Discussion question 1b: Find out which drinks have the most energy by comparing the calorific value for a 250 ml glass of the following: a. A cup of chocolate beverage, example, milo b. A can of aerated water, example, Coke, Pepsi, etc. c. A can of isotonic drink, example 100 Plus. Problem 4: Estimate the total amount of calories in the meal given to your group from the energy table given.
Integration	Discussion question 2: How many calories does an average teenager require? Do you think you are consuming enough calories? SMS Feedback Quiz 1: Which class of food has the highest energy per gram? REPLY by choosing ONE answer: Carbohydrates, Protein , Fats

Note. [a]Outcomes refer to learning objectives and learning outcomes from the Form 2 Science Malaysian Integrated Curriculum Specifications. [b]L4 Outcomes are expected learning outcomes from Lesson 4. [c]Phases refer to the phases in Merrill's First Principle (2002).

The delivery of the instructional resources identified was through computers with internet access, and text messaging. The website for collaborative mLearning for Form 2 Nutrition was designed on *Freewebs.* Instructional content was delivered from this site. There were links to an online discussion forum, *Yahoo groups*, and a collaborative work space on the *Freewebs* wiki for group problem solving tasks.

In addition, a text messaging system was used to deliver SMS quizzes, alerts and other information.

In designing the main problem task, the activities and resources for a collaborative mLearning environment were planned according to Merrill's First Principles.

Designing the Syllabus and Lessons

The syllabus was planned to include a face-to-face orientation meeting, eight online lessons, and a final concluding lesson to summarize the problems solved (see Appendix D). The module was to be conducted over a period of 5 weeks.

In each lesson, learning activities comprised of an online group problem solving task, online discussion questions, and quiz questions using text messaging. However, not every lesson had all three learning activities.

For each learning activity, a task analysis of the knowledge, skills, and pre-requisite skills required was done (see Appendix C and D).

Designing the Logistics and Policies

The logistics and policies of the module included the syllabus, schedule of activities, and guidelines for participation. The scheduled activities, which included both face-to-face and online meetings, were negotiable and were subject to change. Policies, such as attendance at meetings, participation in the discussions, activities and problem tasks, was outlined to ensure that participants knew exactly what was expected of them (see Appendix D). The delivery of the instructional activities, as well as the problem tasks and assignments to be completed were described. In addition, other resources were identified. A description of the learning environment, including online discussion groups, wikis, and text messaging, was given.

The logistics and policies of the implementation of the module were compiled into a Students' Guide which documented a description and the purpose of the module.

Designing the Learning Environment

The learning environment was both online and face-to-face at school. The online environment consists of the collaborative mLearning for Form 2 Nutrition on the *Freewebs* website; the online discussion forums, *Yahoo groups*; the collaborative work space on the *Freewebs* wiki; as well as text messaging and telephone calls on the mobile phone. The face-to-face meetings at school were for the orientation meeting, and the final meeting.

Learning in the collaborative and mobile environment meant that the learner was able to work and discuss with his peers online, have discussions, and access the learning materials and activities anywhere. Hence, learning can occur at home, a friend’s house, cybercafés, or even when travelling.

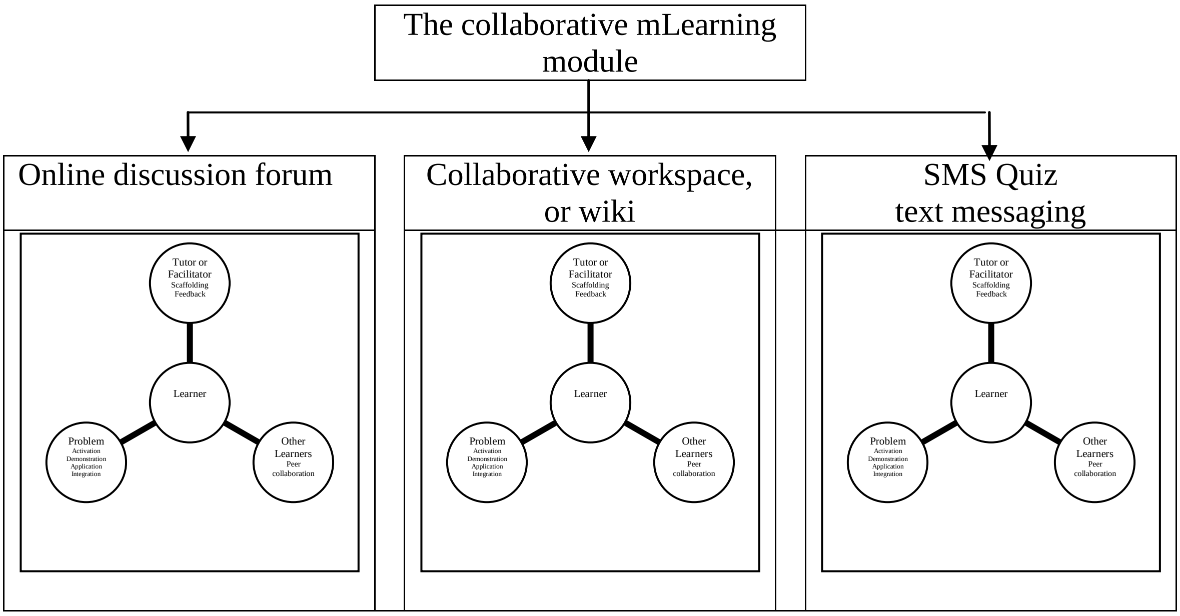

Figure 3.3. A conceptual model for a collaborative mLearning tools and the interactions

Designing the Interactions

Interactions include interactions between learner and problem tasks, learner and tutor, as well as learner and learner as in Figure 2.4. The social constructivist theory of learning employed in the design of the collaborative mLearning module meant that learning was dependent on the interactions. Hence interactions were designed in each activity. Interactions with the problem task, among peers, and with the facilitator, were important in acquiring knowledge and skills in this environment. These interactions were designed in each activity as in Figure 3.3.

Interactions provided scaffolding, which is given through examples, hints and other forms of assistance. Through the messages posted on the online discussion forums, the comments on the collaborative work space on the *Freewebs* wiki, and the text messages, the facilitator provided scaffolding. Scaffolding was diminished as the learner progressed to be an expert. Opportunities for patterning and modeling are provided as demonstration examples, and answers given by their peers will enable the learner to transfer knowledge.

The scaffolding for the problem tasks was incorporated in the activation of prior knowledge, integration in the transfer of new knowledge, the demonstration and application to other problem tasks. This incorporated through the problem task, discussion forum, and SMS Quiz as interactions with the tasks, with other learners and with the facilitator occurred.

The learning environment consists of the learning environment, the interactions, logistics and policies, syllabus and lesson plan, and the problem task as in Figure 3.4.

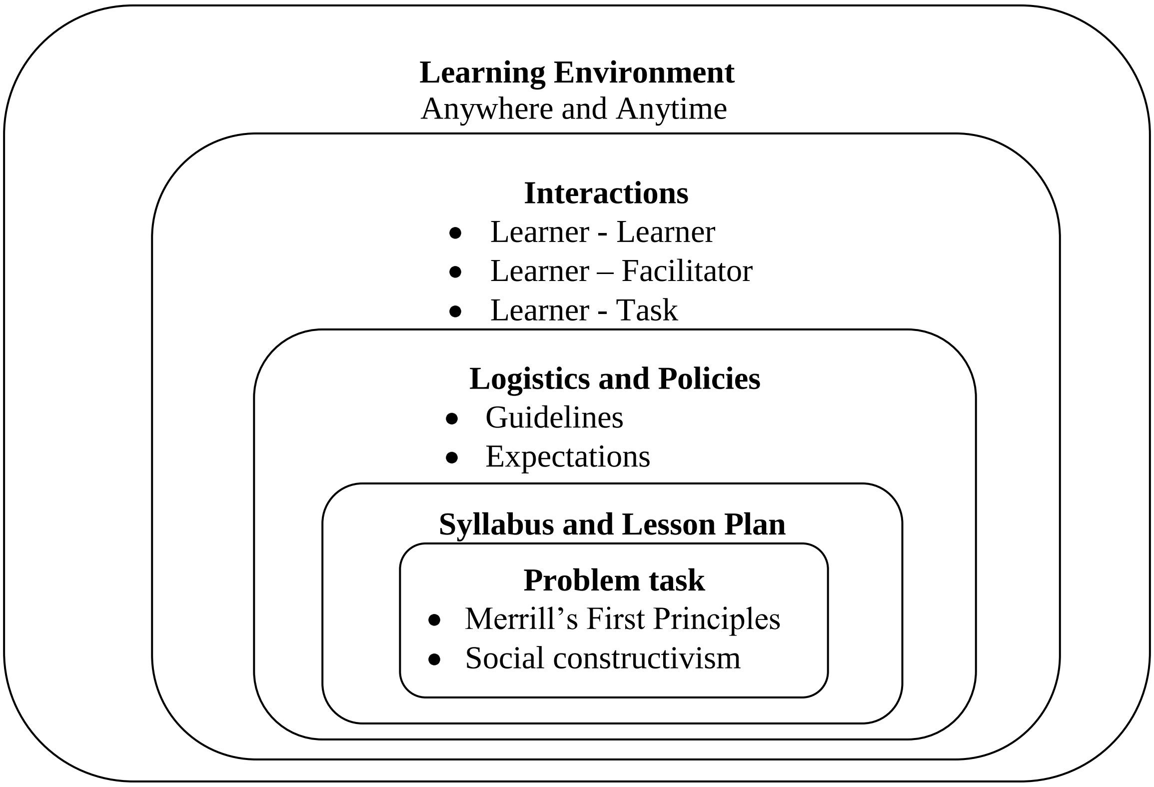

Figure 3.4. Design of the collaborative mLearning module

Formative Evaluation 1

After the documents were completed, formative evaluation was carried out by the researcher using The Checklist for Evaluation of Instructional Materials (Appendix E) to identify if the items required in the design using the First Principles and collaborative learning was taken into account. This checklist covers the six aspects of Merrill's synthesis of the First Principles (2007): problem-centered; activation; demonstration; integration; application; and implementation.

There was a second formative evaluation on the design of the collaborative mLearning module by a team of selected experts.

Evaluation of the Design of the Collaborative mLearning Module

In this section, the research question of this phase of the study was addressed, which is to describe the information the Subject Matter and Technology experts can give to assist the development of the collaborative mLearning module for Form 2 Nutrition.

Data collection will be from the written comments of the experts on the design documents, and from the interviews. The written documents and transcripts of interviews were analyzed, and the themes that emerged related to the design of the module was reported and discussed.

Participants of the Study

The evaluation of the design of the collaborative mLearning module was done with a team of five experts, two technical experts and three subject matter experts. The experts were determined using the following criteria: (a) has practical knowledge and training in the use of technology in education; (b) has at least 5 years experience in education as a teacher; and (c) is willing to take part in the research.

Additional criteria for the technical experts were: (a) has knowledge and experience in instructional design; and (b) has experience in using latest technology for teaching and learning.

For subject-matter experts, the additional criterion was to have at least 5 years of experience teaching the topic of nutrition in secondary Science.

Selection of experts

Based on the above criteria, two technical experts and three subject-matter experts were identified and formally invited to participate in determining the design of the collaborative mLearning module. Their response to the invitation was used as confirmation of their willingness to take part in the study. The experts experience and qualifications are tabulated in Table 3.2.

A brief outline of the expertise of the technical and subject-matter experts in the design and development environment follows.

Technical Expert 1 (TE1) is an officer in the Ministry of Education. Prior to this, she was a Mathematics teacher in a Chinese-medium primary school and had been using ICT for teaching for 13 years. In the last eight years in the Ministry of Education, she has been involved in training teachers in the use of ICT in teaching. She is qualified as a technical expert as she has been involved with evaluating the latest technology trends for use in education and is a graduate with a Masters degree in Instructional Technology.

Technical Expert 2 (TE2) is an experienced History teacher and has been using ICT for teaching History for more than ten years. She has been involved in evaluating new technology and in instructional design for the last five years. She is qualified as a technical expert because of her experience as a teacher and in the use of new technology, and her Masters degree in Instructional Technology.

Subject-matter expert 1 (SME1) is attached to the Ministry of Education and has experience training teachers in the use of ICT in teaching science. Her area of expertise in the Ministry is in evaluation of electronic instructional materials in Science. She has had 19 years experience in teaching secondary school science. She is qualified as a subject matter expert because of her experience in evaluating teaching and science materials evaluation.

Subject-matter expert 2 (SME2) has been teaching for more than 19 years at a premier school in Kuala Lumpur, where she is also the Science Department Head. As Department Head, she monitors and evaluates the standard of science examination papers to maintain the quality. She has been teaching Form 2 Science for the last eight years and has been using ICT in teaching science for the last six years. She is qualified as a subject matter expert because of her teaching experience especially in Form 2 Science. The collaborative mLearning module to be developed is on a topic in Form 2 Science.

Subject-matter expert 3 (SME3) was also a science teacher but was at the time of data collection, a senior officer in the Ministry of Education. He has been involved in the evaluation of electronic content materials for teaching Science for the last nine years but has had more than 20 years experience in teaching secondary school science. His experience in teaching, the evaluation of science materials, as well as application of new technology for education makes him suitable as an expert.

All three subject-matter experts are well-versed in the subject matter and have experience in evaluating Form 2 science content.

Table 3.2

A Comparison of Experts' Experience and Qualification

Expert	TE1	TE2	SME1	SME2	SME3
1. Technology in education					
[a]Training	Yes	Yes	Yes	Yes	Yes
[b]ICT use (years)	13	10	10	6	9
2. Education					
Experience (years)	13	22	19	19	20
[c]Previous occupation	Teacher		Teacher		Teacher
Current occupation	Officer in Ministry of Education	History Head teacher	Officer in Ministry of Education	Science Head teacher	Officer in Ministry of Education
3. Instructional design					
[d]Trainer (years)	8	5	4		4
Qualification	[e]M.I.T.	M.I.T.	M.I.T.		[f]ID Cert.
Experience (years)	10	10	10		9
Other related experience:	Evaluation of new technology		Evaluation Science content materials		Evaluation Science content materials
4. Uptake of latest technology trends					
[g]Technology evaluation	10	5			5
[h]Pioneering technology	10	5			5
5. Experience in Science Education					
[i]Science (years)			19	19	20
Qualification	[k]B. Sc. (Hons) Cert. Ed.	[j]B. A. (Hons) Dip. Ed.	[k]B. Sc. Ed. (Hons)	[k]B. Sc. Ed. (Hons)	[k]B. Sc. Ed. (Hons)

Note. A comparison of the expertise of two technical experts and three subject matter experts. [a]Training refers to any course of training related to technology. [b]ICT use is the length of time in years ICT was used in education. [c]Previous occupation is only noted if different from current occupation. [d]Trainer refers to number of years training others in use of ICT in education. [e]MIT is Masters in Instructional Technology. [f]ID Cert. is Instructional Design Certificate. [g]Technology evaluation refers to the number of years of experience in evaluating technology in education. [h]Pioneering technology refers to number of years of experience evaluating new technology. [i]Science refers to number of years teaching secondary school science. [j]B. A. (Hons) is Bachelors Degree in Social Sciences with Honors. [k]B. Sc. Ed. (Hons) is Bachelors Degree in Science with Education with Honors

The team of experts had mixed abilities and experience. However, all the experts were trained and experienced teachers who used technology in teaching. In addition, the technical experts, and one of the subject matter experts, had experience in evaluating new technology for teaching. All the subject matter experts were knowledgeable in the science content and had experience evaluating science content materials.

Data Collection and Analysis

First, the design documents, which included the syllabus, lesson plans, learning activities, and guidelines for the collaborative mLearning module which had been evaluated by the researcher, was given to the team of experts for review. The experts were asked to evaluate the design based on The Checklist for Evaluation of Instructional Materials (Appendix E), and to include their comments in the evaluation.

After the documents were evaluated and returned, the researcher went through the written comments and identified the areas which required further investigations. A date was set with each expert for an interview, and the experts were probed further on their comments.

The written documents and transcripts of the interview were analyzed, and the themes that emerged related to the design of the module, were reported and discussed. The recommendations of the experts were considered in the development of the collaborative mLearning module. A summary of the procedure for data collection in Phase 2 is shown in Figure 3.5.

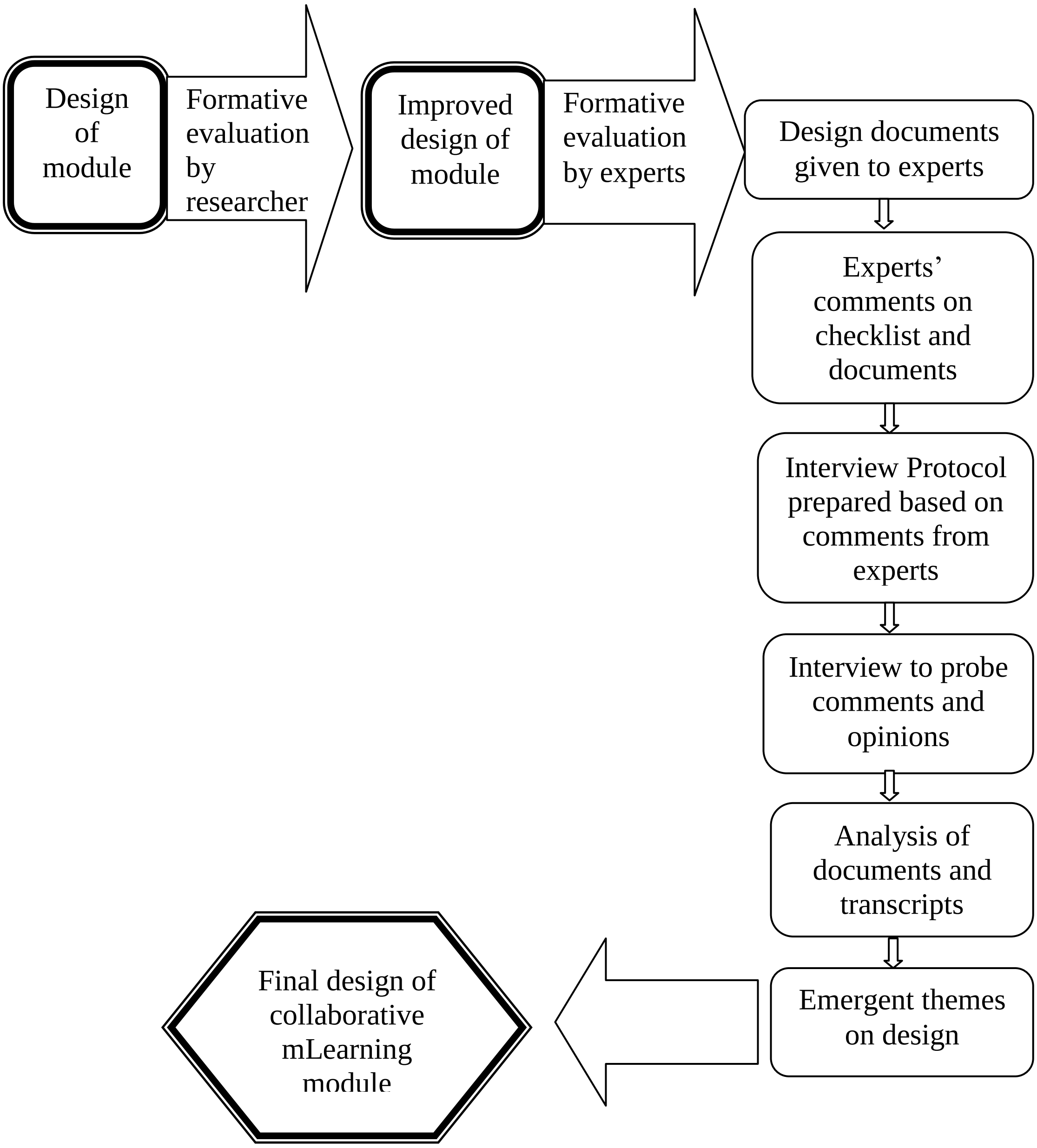

Figure 3.5. Procedure for data collection and development in the design phase

Phase 3 of Developmental Research:

Implementation and Evaluation

In this phase, the module which was evaluated by the experts was implemented over a four-week period with a group of selected student participants. The students had to attend meetings, access the online activities and receive assignments and messages through the internet and mobile phone. Some of the activities given required collaboration and group presentation while other activities required individual response. Laptops and computers were provided at scheduled times both during and after school hours to access the online tools, while mobile phones were after school hours.

In this phase the participants' perceptions of the activities and tools in the collaborative mLearning module is studied, and the difficulties faced during the implementation of the module was determined. In addition, the meaning of collaborative mLearning was explored. Data was collected from participants' responses during the implementation of the module, as well as from a survey and interview after the completion of the module.

Sample of the Study

The participants in this phase were selected from the group of Form 2 students in the selected urban school in the Klang Valley from the first phase of the study. All students were invited to take part in the study but were required to give their particulars. Selection of volunteers was based on whether the students' had access to computers with internet and a mobile device such as a simple mobile phone. Twenty participants with varied ability in science were selected.

At the beginning of the implementation, participants were given a briefing on the use of the module and what was expected from them. Parent and participant consent forms had to be filled and returned for the participant to be eligible to participate in the study (see Appendix F). Requirements and guidelines on the participation in the module were given, including costs which were covered by the researcher.

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Implementation Procedures

An initial orientation session to meet the participants face-to-face to explain the design of the module and the use of the tools was scheduled. The implementation of the module did not require the involvement of the class teachers. Participation was online, and one computer with internet connection was made available in the school for the participants. Additional laptops were available and scheduled for use during school hours for participants who could not access the internet at home. Participants who were free on the scheduled day could use the equipment to complete their online tasks.

The participants were introduced to the CMC tools used: the module's home page, the online discussion group (*Yahoo groups*), and a collaborative workspace, wiki. The participants had to be registered in *Yahoo groups*, so a session on online registration was conducted for participants. There was some confusion in using the *Yahoo groups*. In order to be a member of the *Yahoo group*, students had to sign-up as members of *Yahoo* mail. Observation showed that the students were confused on the procedure. After a week of using the *Yahoo groups*, a separate forum was created on *Freewebs*.

Contact with the participants was mainly through mobile phones, text messaging, and sometimes voice calls. The participants were informed that they would be reimbursed for the text messages sent in relation to learning using the module. This was to eliminate the lack of interaction among the participants due to the cost of the technology.

The participants were assigned into groups for the online problem tasks. A Students' Guide for the module was provided for each participant. Each lesson in the module was outlined with the learning outcomes, expected behaviors and other requirements when doing the module stated. The participants are encouraged to participate in online discussions and be active online. They were also asked to respond to the messages and keep a journal to record their feelings, concerns and other issues they may have concerning the activities and other aspects of the module.

In this research, the researcher is a participatory observer, playing the role of tutor and facilitator in the collaborative mobile learning environment.

Evaluation Procedure

In this phase the evaluation of the course was conducted. The objective of the evaluation is to determine the participants' perceptions of the activities and tools in the collaborative mLearning module, the difficulties during implementation, and the collaborative mLearning among the participants in the context of this study.

Data collection was divided into two sections: during the implementation, and after the implementation of the module.

Data Collection During Implementation

During the implementation of the module, data was collected from several sources: a pretest, all communications, including text messaging and emails; online responses to the activities; records in researcher's journals; and interviews with participants.

A pretest on the content of the module was conducted before implementation of the module (see Appendix G), and the mean marks of this test was recorded. This was to determine the group's baseline.

Communications in the emails, text messages, forums and other online sources were captured and transcribed. The online responses as the participants attempted the online problem tasks, discussion questions and SMS Quiz were also transcribed.

In the online collaborative workspace, or wiki, each group's activity was monitored. The responses on the wiki were transcribed and analysed. The frequency of uploading information on the wiki was recorded for each group.

In the online discussion forum, the activity of participants as they participated in answering discussion questions posted was monitored. Initially the *Yahoo* group was used but due to technical difficulties faced by the participants, a new forum was set up on *Freewebs*. Both groups were maintained throughout the implementation. The responses on both forums were transcribed and analysed.

The text messages sent and received by the participants were also captured, and transcribed.

In addition to data from the activities, the participants were observed during the implementation, and their activities and responses transcribed and recorded in a journal. The journal was maintained throughout the implementation and records were made after each session. The data in the journal was later analysed.

The participants were also interviewed during the implementation to find their opinions on the activities. These interviews were recorded and then transcribed for analysis.

Data Collection After Implementation

On completion of the collaborative mLearning module, data was collected from a post test, survey and interviews. The post test tested similar aspects of knowledge as in the pretest (see Appendix H). The mean marks of the students were computed as a comparison with the pretest. However, no t-test analysis was done as the number of participants was small, and the difference of means could not be considered a valid comparison.

The students were given a survey form, the Evaluation of Collaborative mLearning Module (see Appendix I), which enquired their perceptions of the activities and the tools used in the module. Focus group interviews were next conducted with the groups to find out their perceptions of the module. The interview questions are in Appendix J. It was believed that participants would be more willing to be interviewed with their friends and in a non-threatening group environment. The interviews were then transcribed.

The summary of data collection procedure for Phase 3 is shown in Figure 3.6.

Analysis of Data

The transcribed data from the communications, online activities, and interviews were coded and analyzed in order to answer the research questions. The data from the survey was also used to determine the participants' perceptions on the activities and tools, difficulties faced and the collaborative mlearning environment. Triangulation of the data was done to ensure that the results were reliable. The data was analyzed and used to answer the research questions.

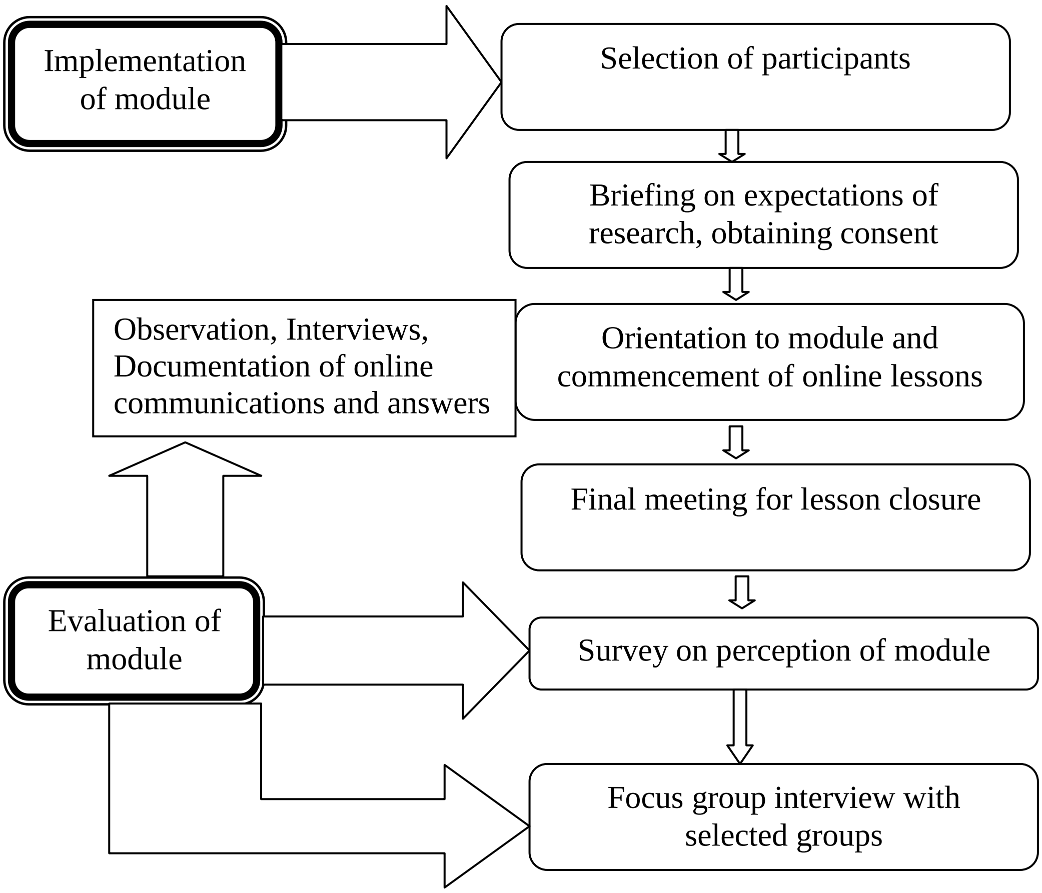

Figure 3.6. Procedure for data collection in Phase 3: Implementation and evaluation

Validity and Reliability

In a developmental research, the researcher is often a participant and has to ensure the internal validity of the research by being objective (Richey, Klein, & Nelson, 2004). In this research, the researcher was a participant observer as the facilitator for the module. Objectivity was ensured through systematic data collection during the three phases of the research, and triangulation of data collected from observations was done with data from other sources, such as participants' interviews and documentation.

In the first phase, a survey was conducted using an instrument which was content-validated by three experts. The instrument was adapted from an instrument which had been previously validated. In addition, during the administration of the instrument, errors due to misinterpretations of items in the instrument were reduced by standardizing and explaining ambiguous terms for interpretative validity (Cohen, Manion & Morrision, 2003).

In the second and third phases of design and evaluation, the research design was qualitative in nature. In order to capture the richness of data and to ensure this data was valid, several strategies were undertaken. The module was implemented for a period of 5 weeks, through an orientation session and 8 lessons, which was a sufficiently long period to collect data. The researcher had prolonged engagement (Cohen, Manion & Morrision, 2003) with the students both online and face-to-face, and tried to obtain their trust to ensure responses were credible.

Interviews in the design and evaluation phases were recorded on an audio recorder. The data collected was member-checked for respondent validation (Cohen, Manion & Morrision, 2003) and triangulated with data from other sources.

Reliability was ensured through the triangulation of data. As the study used qualitative approaches, the researcher was the instrument for data collection, and had to be familiar with the use of the new technologies and the online school setting (Miles & Huberman, 1994). The researcher, with her teaching background, brings into the study the experience in using technology in a school setting. Further, her experience in the Ministry of Education, using existing and new technologies, and her experience in a similar research in using mobile and collaborative learning tools (Saedah Siraj & DeWitt, 2007) enhanced the reliability of the researcher.

Summary of the methodology

This study used a developmental research approach with the focus on the development of a collaborative mLearning module. There were three main phases: the analysis; design and development; and finally, implementation and evaluation. Different methodologies were used in each phase, and the findings are reported in the next three chapters.

There were multiple participants in the study: students in a selected urban school, and experts in the field of science content and educational technology. Data collection was done through surveys, interviews, documentation online and offline, and observation.