CHAPTER 2

REVIEW OF LITERATURE

Technology in science instruction can be utilized to enhance the development of the science process skills among learners. One of the science process skills neglected in school science is communication, which occurs both in the form of words and symbols of science. Technology, especially information and communications technology (ICT), has enabled communications, but the full potential of ICT has yet to be fully utilized in science instruction. In this chapter, computer-mediated communication (CMC) tools for collaborative mLearning, as well as the benefits, limitations and delivery of collaborative mLearning, are discussed. The purpose of this discussion is to design instruction to take advantage of the affordances of CMC tools for a blended approach of collaborative and mobile learning.

Instructional design (ID) theories should emphasize the learner, the learning process, and the learning environment. In this study, an eclectic theory of ID, the first principles of instruction (Merrill, 2002), is utilized with underpinnings of the social constructivist theory, to design the learning module. The collaborative mLearning environment is described using the Framework for the Rational Analysis of Mobile Education (FRAME) model (Koole, 2009).

Nature of Science and Science Education

Scientific knowledge is built upon using scientific reasoning processes (Abruscato, 2000) conducted individually or in collaboration with other scientists. The processes of science should not be neglected as science consists of both the science content, and the scientific and reasoning processes (Howe & Jones, 1993).

This is because science is actually “a way of reasoning about phenomena, alone and within a community of peers” (Hogan & Fisherkeller, 2005, p. 96). In the construction of scientific knowledge, the scientific community communicates and collaborates using scientific processes (Etkina, Mestre, & O’Donnell, 2005; Scanlon, 1997).

The teaching of science should reflect this nature of science. Teaching science should not only be based on the transmission of scientific knowledge, but should stress on the processes of inquiry and communication to build knowledge (Ford & Forman, 2006). Science learners should be provided the opportunity to communicate and collaborate in the process of inquiry and discovery to construct knowledge and develop scientific process skills (Etkina, Mestre, & O’Donnell, 2005; Hogan & Fisherkeller, 2005; Kozma, 2003; Osbourne & Henessy, 2003).

In Malaysia, the importance of science and technology as a rapidly growing field of knowledge, is recognized. The National Science Education Philosophy in Malaysia is in line with the National Education Policy and aims to “nurture a culture of Science and Technology by focusing on the development of individuals who are competitive, dynamic, robust and resilient, and able to master scientific knowledge and technological competencies” (MOE, 2002, p. ix). This philosophy emphasizes not only on science content, but also the processes, skills and a culture of science. The goals of science education incorporates these aspects: scientific content knowledge; scientific methods which consist of the processes and skills; and the culture of science encompassing societal issues, personal needs and career awareness (Trowbridge, Bybee, & Powell, 2000).

In the discussion that follows, only the first two goals in the Malaysian science Integrated Curriculum for Secondary Schools (ICSS) are addressed:

scientific content knowledge, and scientific methods consisting of the science processes and skills.

Scientific Knowledge

Scientific knowledge or science content is derived from discoveries about the natural world through scientific processes (Abruscato, 2000). In the classroom, science knowledge consists of facts, concepts and principles or laws of science (Abruscato, 2000; Trowbridge, Bybee, & Powell, 2000). Some of these scientific facts and concepts arise from direct observations of the world around us, while other aspects of knowledge may arise from a complex reasoning process of confirming hypotheses and concluding on other scientific phenomena (Howe & Jones, 1993).

In the Malaysian ICSS science syllabus, science content is organized according to themes comprising of learning areas and within that several learning objectives and learning outcomes (MOE, 2002). In the syllabus, the science content covers the cognitive and affective domains on nine themes: Introducing Science; Man and the Variety of Living Things; Matter in Nature; Maintenance and Continuity of Life; Force and Motion; Energy in Life; Balance and Management of the Environment; Technological and Industrial Development in Society; and Astronomy and the Exploration of Outer Space. The content in the learning areas is covered in 5 years from Form 1 to Form 5 in the core science subject.

In this study, the science content is limited to Form 2 science. In Form 2 science there are four themes in the Curriculum Specifications: Management and Continuity of Life; Man and the Variety of Living Things; Matter in Nature; and Technological and Industrial Development in Society. Within these four themes are ten learning areas: The World through our Senses; Nutrition; Biodiversity; Interdependence among Living Organisms and the Environment; Water and Solution; Air Pressure; Dynamics; Support and Movement; Stability; and Simple Machines (MOE, 2002).

The ICSS science syllabus emphasizes using a variety of teaching strategies to encourage thinking skills development, integrated with the acquisition of scientific knowledge, the mastery of science skills, as well as the development scientific attitudes and noble values (MOE, 2002). Although there may be a large amount of science content in Form 2, this content must be taught through the development of scientific and thinking skills.

Scientific Method

The scientific method employs the processes of scientific inquiry to discover science knowledge (Abruscato, 2000; Trowbridge, Bybee, & Powell, 2000). The science process skills for scientific inquiry are observing, classifying, using space and time relationships, using numbers, measuring, communicating, hypothesizing, experimenting, controlling variables, interpreting data, predicting, inferring and defining operationally (Abruscato, 2000; MOE, 2002). In addition to the science process skills, creative and critical thinking skills for scientific reasoning are also required in the scientific process. The scientific method involves both the processes of science, and the process of reasoning and thinking.

In the ICSS science syllabus, scientific skills are divided into science process skills and manipulative skills (MOE, 2002). These science process skills should promote thinking in a “creative, critical, analytical and systematic manner” (MOE, 2002, p. 4) while the manipulative skills are psychomotor skills. In addition to the scientific skills, the syllabus emphasizes the use of thinking skills: critical thinking skills, and creative thinking skills for conceptualizing, making decisions and problem solving (MOE, 2002). These thinking skills are incorporated into the science process skills (MOE, 2002).

The scientific method to acquire scientific knowledge consists of both the science process skills and the thinking and reasoning processes and skills.

The Reality of Science Education in Malaysia

Science education is not only conveying scientific knowledge but also acquiring scientific method. Hence, acquiring scientific knowledge should involve the scientific methods and scientific reasoning.

In teaching for the scientific method, the teacher has to guide and challenge learners at all stages of the scientific inquiry process, as well as focus on scientific inquiry (National Research Council, 1996). This would mean that in acquiring scientific knowledge and practicing scientific methods, learners would be knowledgeable enough and be able to reason and debate issues related to science.

The growth of knowledge in the field of science and technology is so rapid that new discoveries are constantly made (Halpern, 1992). Technologies like the internet, makes knowledge accessible immediately (Rose & Nicholl, 1997). Hence, the way we learn may need to change to keep up with the increase in knowledge in this fast-paced world. For the teacher or the learner to know all aspects of science is impossible. So, in order to cater for the rapid growth of knowledge, the emphasis of science teaching should shift from memorization and drilling practice, to the process of scientific reasoning and communication (Ford & Forman, 2006).

The role of the science teacher may need to change. The teacher may no longer be the sole 'keeper' and 'transmitter' of knowledge. Knowledge is transient and constantly changing as new discoveries are constantly being made (Jarvis, 2002a). Hence, science teachers should not just teach the facts, but also place emphasis on the process of building scientific knowledge and values (Abruscato, 2000) in a collaborative environment, similar to what the community of scientists does (Hogan & Fisherkeller, 2005). As the teacher's role changes, he would need to acquire new skills to take into account the impact of social, culture and individual differences on learning (Jarvis, 2002b).

In Malaysia, science learners at secondary school level still do not understand the nature of science and seem to memorize facts in science. A survey showed that at Form 6 level, many learners have yet to understand the nature of science as they study for scientific facts (Chong, 2005). In addition, the language of science was confusing to many students, and this led to many misconceptions in science (Pathmini, 1999).

The science teachers' methods of instruction did not reflect the nature of science. Science teachers seemed to prefer presenting the facts of science, and stressed on memory work (Lee, 1991; Ling 2002; Tan, 2002). There seemed to be a lack of emphasis on the development of scientific processes of inquiry as teachers preferred to explain science concepts first, rather than allow learners to form hypotheses and conclusions through experiments conducted (Sopia Mohd. Yasin, 2002). Moreover, teachers preferred to demonstrate experiments to learners, rather than allow learners to attempt to design experiments (Lee, 1991; Sopia Mohd. Yasin, 2002).

The ideals of the National Science Education Philosophy to nurture a culture of science and technology and the development of competitive individuals (MOE, 2002) may not be achieved if the emphasis of acquiring scientific knowledge is not changed. One method to encourage scientific inquiry is to employ collaborative learning and problem solving in the teaching of science. This is because when learners collaborate to solve problems in science, the scientific processes of inquiry and reasoning are developed (Belland, Glazewski, & Richardson, 2008; Halpern, 1992; Hogan & Fisherkeller, 2005; Nadelson, 2009; Osbourne & Hennesy, 2003).

Importance of Communication in Science

Communication, one of the science process skills, uses the more complex words and symbols of science. Communication in science is crucial at the basic level in acquiring scientific knowledge. In order to reason and undergo the scientific processes, a person must be able to understand what is being communicated, to communicate his feelings and give feedback. In this section, the importance of communication as one of the scientific processes in learning science is discussed from a social constructivist viewpoint.

The scientific process of communication is the passing of information in the form of words or symbols among individuals or groups of individuals (Wolfinger, 2000). Some authors stress on the importance of communication in the construction of knowledge and thought processes. This is because the social and cultural processes of communication, such as language and non-verbal cues, support learning (Champagne & Kouba, 2005; Hoyle & Stone, 2000).

Firstly, in order to understand scientific discussions, learners need to have scientific verbal knowledge. Scientific verbal knowledge is the knowledge of communicating in the science vocabulary (Hoyle & Stone, 2000; Karpov & Haywood, 1998; Wolfinger, 2000). With scientific verbal knowledge, the learner is able to use scientific terms, as well as construct meaningful phrases and sentences to communicate his thoughts.

At a higher language skill level, the learner would be able to understand and participate in scientific discussions. The progress of the learners' communication skills would depend on the patterning, modeling and scaffolding by his peers and teachers to develop science concepts and principles (Hoyle & Stone, 2000; Karpov & Haywood, 1998; Wolfinger, 2000). Hence, as emphasized by Vygotsky, both scientific verbal knowledge and mastery of basic procedures are required to enable learners to benefit from scientific discussions to build their understandings of concepts and principles (Karpov & Haywood, 1998).

Furthermore, Vygotsky's view is that scientific knowledge and procedures should not be taught directly, but should be constructed by learners in the course of a discussion (Greeno, 1992; Karpov & Haywood, 1998). These discussions should not be teacher-centered where the learner merely questions the teacher, but should allow learners to contribute ideas based on their current understandings of concepts and principles (Greeno, 1992). The advantage of conducting student-centered discussions is that critical thinking skills are developed during the discussion. This is because learners would propose their understandings based on their personal experiences, discuss these understandings with the views and opinions of other learners, and resolve their differences among themselves to reach a mutual understanding (Greeno, 1992; Hoyle & Stone, 2000; Karpov & Haywood, 1998).

Discussions allow for practice in the language of science. Language which is considered simple to an expert may actually be extremely difficult for a novice science learner unsure of the language. When Ellerton (2003) reviewed a website from National Parks, Malaysia, she showed that the seeming simple language used was actually laden with complex scientific concepts and conventions. In such cases, the adult-child or expert-novice interaction is important. In the social interactions during the discussions, learners usually acquire the tools and symbols of language, or scientific verbal knowledge, from the teacher (Karpov & Haywood, 1998). The teacher provides the opportunities for patterning and modeling, and scaffolds the learner.

The social constructivist framework for teaching science has been used in Australia and New Zealand for several science programs (Northover & Leslie, 2003). The New Zealand Ministry of Education implemented the School Science Pilot Project (S^2P^2) Program in 2001 in three Waikato communities to raise the motivation and achievement in science for primary and secondary schools (Northover & Leslie, 2003). Among the principles employed are to identify learners' prior knowledge for building learners' understandings in order to use conversation in teaching to identify and challenge preconceptions learners may have. In this manner, learning is through investigation in an active collaborative process (Northover & Leslie, 2003).

The importance of communications for discussion and building of scientific knowledge cannot be denied. In fact, acquiring scientific verbal knowledge should be the first aspect of science instruction as scientific verbal knowledge enables the learner to communicate and develop scientific reasoning.

Principles for Science Instruction

The social constructivist view places importance on communications for building scientific knowledge. Science instruction should be designed based on principles which emphasize communication.

Firstly, additional problem tasks as well as additional time for more group discussions should be given. Learners must be given sufficient activities for discussion to assist in building science vocabulary, and understanding of scientific concepts and principles (Greeno, 1992).

Secondly, teachers must be more aware of the difficulties learners experience when trying to comprehend the vocabulary and language structures of science (Ellerton, 2003). More opportunities for patterning and modeling should be given to the novice learner. This can be done through videos, simulation software, tutorials, as well as drill and practice software. The teacher's role is to provide both individualized scaffolding, specifically targeted to the learner; and more opportunities to show patterns of the words, symbols and models of scientific language (Hoyle & Stone, 2000). Hence, developing the language skills for use in scientific discussions, example listening and speaking skills, is important for planning, sharing, developing ideas and understandings in science, as well as developing critical thinking skills (Ellerton, 2003; Hoyle & Stone, 2000).

Thirdly, problem tasks should start from simple to difficult to allow for opportunities to link with present knowledge. This enables the learner to build his own personal experience (Ellerton, 2003). Even learners at elementary school level between Grade 8 and 10 can participate in scientific discussions (Brown, 2006; Greeno, 1992; Olitsky, 2007). However, the success of the discussions would depend on the learners' understandings of the language, their motivation, beliefs, and whether they have assimilated into the culture (Brown, 2006).

Finally, meaningful tasks which interest and motivate learners should be designed. Social interactions have motivated learners to be engaged in carrying out activities successfully to build their knowledge meaningfully in science (Brown, 2006; Cosgrove & Schaverien, 1996; Greeno, 1992; Olitsky, 2007).

The application of these principles of social learning for science instruction can enhance instruction in the science classroom, as well as in the online environment. Communications, through the use of ICT, can be used for science instruction and problem solving.

The Use of Technology in Teaching Science

Technology can be used both to deliver science content, as well as teach the scientific method which consists of science process skills and thinking skills (Jonassen, 2000; Osbourne & Hennesy, 2003).

ICT has been always used for science instruction. The main forms of technology which have been used for school science are as follows: tools for data capture, processing and interpretation (Grabe & Grabe, 2004; Jonassen, 2000; Osbourne & Hennesy, 2003; Roblyer, 2006; Wolfinger, 2000), multimedia software for tutorials (Roblyer, 2006), simulation (Grabe & Grabe, 2004; Metcalf, Krajcik, & Soloway, 2000; Roblyer, 2006; Trowbridge, et al., 2000), drill and practice (Grabe & Grabe, 2004; Wolfinger, 2000), instructional games (Dede, Salzman, Loftin, & Ash, 2000; Grabe & Grabe, 2004; Roblyer, 2006), information systems tools which include storage devices and the internet (Jonassen, Howland, Moore, & Marra, 2003; Osbourne & Hennesy, 2003; Roblyer, 2006; Wolfinger, 2000), and tools for publishing and presentations (Grabe & Grabe, 2004; Jonassen et al., 2003; Osbourne & Hennesy, 2003).

In Malaysia, the MOE had launched several initiatives for integrating ICT in the teaching of science. Firstly, during the Smart School Pilot Project (Smart School Project Team, 1997), teachers were trained to integrate technology in teaching and learning. The resources from the internet were used for teaching (Pembangunan Pendidikan Bestari /PPB, 2004) and courseware meant for self-paced learning was developed to incorporate tutorials, simulation, as well as drill and practice for the smart schools. Further, when the Teaching of Mathematics and Science in English was implemented in 2002, teaching courseware to assist teachers in teaching science in the second language was developed (MOE, 2006) and distributed to all schools in Malaysia. ICT has been used in teaching science in Malaysia in the last decade.

However, even with all the training and courseware distributed during the Smart School pilot project, studies show that there seemed to be a lack of use of technology in teaching and learning science in the smart schools (MOE, 2001; Pasukan Penyelidik Penilaian Bersepadu Sekolah Bestari /PPPBSB, 2003). Online learning was not implemented widely. The reason that was given was that there was not enough computers for all students, and the amount of time a student could spend on a computer in school was limited. However, the study also showed that among the technologies used for teaching and learning, the internet seemed to be the most utilized by both students and teachers (PPPBSB, 2003).

The use of ICT for communication in learning science is still below the expectation (Osbourne & Hennesy, 2003). Technology can encourage collaborative learning as students work together and communicate on projects in science, while sharing knowledge and expertise. Online discussion forums and wikis allow students to improve work in progress. In addition, e-mails to experts in the field of science and technology, enable feedback and authentic discussions (Osbourne & Hennesy, 2003). As language is important for communicating during science lessons, communications technology can enhance discussions. Hence, CMC can be used to develop scientific knowledge and processes (Osbourne & Hennesy, 2003).

A study conducted by a team of experts in science education which compared the outcomes and characteristics of students from smart schools and non-smart schools, showed that students from smart schools had significantly higher science process skills compared to students from non-smart schools (MDeC, 2009). The researchers contributed the difference to technological tools employed for learning science. However, the researchers also cautioned that a 'one-fit-for-all approach' for learning was not suitable. Learning had to be personalized to the learner. In addition, this study also showed that teachers preferred to impart knowledge through 'chalk and talk' methods and avoided the use of technological tools due to their perception that there would be a lack of time in finishing the syllabus in the exam-orientation education system (MDeC, 2009).

ICT has been integrated in science instruction in Malaysia, mainly through the use of courseware for teaching science in English. Communications technologies for science instruction have only been used to a limited extent: mainly the internet for acquiring information. As such, there is still a potential for the use of CMC for science.

Computer-Mediated Communication Tools

In this section, technology tools that enable communications using CMC are discussed. CMC is any form of two-way interaction using the computer (Inglis, Ling, & Joosten, 2002) and has been used for the delivery of information and for social interaction (Romiszowski & Mason, 2004). An individual can perceive, exchange and transform information through networked telecommunication systems (December, 2007).

There are two main forms of CMC: synchronous, enabling real-time communication; and asynchronous, or at a delayed time (Jonassen, 2000).

There are various forms of synchronous communications. Chats, messaging systems, multi-user domains and desktop video conferencing are some of the forms of synchronous communications (Jonassen, 2000). The first form of synchronous communications was the text-based conferencing, Internet Relay Chat (IRC), which allowed interactions between groups of users (Jonassen, 2000). Present messaging systems allow users more control as users can choose whom they chat with, as in AOL Instant Messenger and MSN Messenger (Jonassen, et al., 2003). Other shared online environments that allow multiple users such as multi-user domains (MUDs), MUDs object-orientated (MOOs), and multi-user, web-based, object-orientated (WOOs), allow characters to communicate and use virtual objects in a virtual environment (Jonassen, 2000). Finally the third form, desktop videoconferencing, allows live data to be received and transmitted from specific points with web cameras and audio devices (Grabe & Grabe 2004; Jonassen, 2000).

Asynchronous communications are delayed communications such as e-mails, mailing lists, bulletin boards, and conferences (Grabe & Grabe, 2004; Jonassen, 2000). E-mails are especially useful as data can be sent and shared directly between the user and the teacher (Grabe & Grabe, 2004; Jonassen, 2000; Jonassen, et al., 2003). Another communication tool, the bulletin board, enables users to post and read messages posted by others (Jonassen, 2000). Some bulletin boards may have other functions such as conferencing, file and data bases access, distribution of news, lectures and online publications or journals (Jonassen, 2000). Computer conferences and online forums have features of both e-mails and bulletin boards, and enable interactions through messages for collaboration on tasks, projects and discussions (Grabe & Grabe, 2004). Other resources for communication and collaboration are the wiki and Seedwiki, an open online collaborative web site to write, edit and publish documents collaboratively (Jonassen, et al., 2003).

As technology advances to wireless systems, learning becomes mobile. CMC need not be done on a desktop computer. Laptops and mobile devices such as Personal Digital Assistants (PDAs) enable communications to be conducted anywhere: at home, out of school, or on the move; and at anytime, even after school hours. CMC can be mobile.

CMC has enabled communications to extend beyond physical boundaries. Discussions and exchange of information can take place virtually and at the convenience of the user, at either real-time or in delayed-time. One of the affordances of this feature of CMC is collaboration.

Nature of Collaborative Learning

Collaborative learning is the acquisition of new knowledge, skills and attitudes by individual learners occurring as a result of interactions in a group (Kaye, 1992). The process of social interaction does not depend on learning materials (Kaye, 1992; Jonassen, et al., 2005) but on the fact that the group of learners work together to achieve a shared goal (Palloff & Pratt, 1999). As the learners cooperate and are interdependent on one another, they provide support to the members of the group (Jonassen, et al., 2005).

Collaborative learning differs from cooperative learning. In cooperative learning, learners cooperate and are interdependent on one another (Johnson & Johnson, 2004). However, collaborative learning is influenced by Vygotsky's social constructivist theory (Vygotsky, 1962; Vygotsky, 1981) and is a natural learning that occurs from the learners' unplanned responses and interactions from within the community of learners (Johnson & Johnson, 2004). It is an individual process as it is influenced by a variety of factors, including group and inter personal interactions (Kaye, 1992). Learning is derived from dialogues and interactions with other learners, and with the teacher or tutor (Johnson & Johnson, 2004). The social interactions involve the use of language to reorganize and modify personal knowledge structures for active and social learning (Kaye, 1992).

Learners in the collaborative group report and share information from articles, books and websites accessed to achieve the learning goals and then to assimilate the knowledge into their own personal knowledge structures (Kaye, 1992; Pallof & Pratt, 1999). The social process of learning is involved when meaningful tasks are given, and when feedback, ideas and other interests are shared in the group (Kaye, 1992; Pallof & Pratt, 1999).

Collaborative learning is not structured or determined by the teacher, but is dependent on the learners' culture, community and procedures of learning (Johnson & Johnson, 2004). While cooperative learning is teacher-directed, collaborative learning is learner-directed: the teacher does not need to detail the steps for the acquisition of knowledge (Johnson & Johnson, 2004). The teachers' role is to provide the learning tasks, which may be ill-structured problem solving tasks for authentic and complex problems (Jonassen, et al., 2005).

To summarize, collaborative learning is a natural form of learning that occurs among learners, through discussions and interactions with other individuals in a learning environment. Collaborative learning can be useful for promoting communications in learning science.

Collaborative Learning Using CMC

The use of CMC tools has greatly increased the different types of communications for learning. CMC tools have been used for presenting ideas and information to groups of learners; for class interactions such as sharing ideas, giving feedback, and for collaboration (Driscoll, 2007). Communication for collaborative learning engages learners, as they are able to give and receive feedback, while working towards a goal (Driscoll, 2007). In this section the use of the CMC to support collaborative learning is discussed.

While collaboration is a result of communication, communication alone does not ensure a collaborative environment can be maintained for the group (Kaye, 1992). Text-based asynchronous and synchronous CMC can be used to create both formal and informal environments for collaborative activity (Kaye, 1992). In addition, some tools like conferencing systems support many-to-many messaging, and have features that assist collaboration.

Computer-supported collaborative learning (CSCL) is a system which supports learning in collaborative groups by mediating and scaffolding group processes in a community of learners (Jonassen, et al., 2005). Learners in virtual groups are connected by the internet even though they may be separated in space (Søby, 1992). Through this connection, learners are able to access information, communicate and interact, and engage in collaborative problem-solving activities (Jonassen, et al., 2005).

In real-life, many jobs require workers to cooperate and collaborate on assignments and tasks. Collaboration and communication is often used to exchange experiences and views, offer suggestions in on the job training, administration, and in socializing in the work market (Kaye, 1992). Hence, formal education should prepare learners to work collaboratively in groups (Kaye, 1992).

CMC tools afford collaborative learning by combining the use of technology and the communication skill for learners to work collaboratively effectively. Some of these CMC tools are free or low in cost, easy to use, and do not require expensive infrastructure (Driscoll, 2007). Many are web-based and available online, for example blogs and wikis.

Learning at a Distance: mLearning

As computers become smaller and portable, CMC will have to include mobile communications. Mobile communications has enabled a different form of distance education (Keegan, 2005) or e-learning to be developed. In this section, the mobile learning, or mLearning, is discussed with examples on how it developed as a form of distance education.

Education can be divided into two types: conventional education, and distance education (Keegan, 2005). Conventional education includes face-to-face interaction between the learner and other learners, and with a teacher; while distance education includes individualized learning through interaction with the media (Keegan, 2005). Definitions of distance education have changed since the 19th century when the print media was used to teach typing and shorthand (Moore & Kearsley, 2005). Early definitions emphasized on the separation of the instructor and the learners (Caladine, 1999) and the structure of learning materials to assist learning in an educational organization (Moore, 1996). Later definitions stressed a systemic approach integrating elements such as the technical media, a communication system and an industrialized form education (Keegan, 1996; Stenerson, 1998). Distance education definitions had evolved to include an organizational approach which integrated various elements of learning in a system.

The process of learning was emphasized in later years where distance learning was defined as learning at a distance. The instructor, assisted by media and technology, guides the acquisition of skills and knowledge as learning is intentional and the learner plans for learning to occur (Moore & Kearsley, 2005). This differed from Keegan's (2005) definitions which stated that learning need not occur individually, but through interactions with the media, either print or electronic, the instructor and other learners, to acquire skill and knowledge (Roblyer, 2006).

As technology changed, different forms of distance education evolved and mLearning was considered a form of distance education. Keegan (2005) identified mobile learning through PDAs, mobile phones and smart phones for education and training as one of five subdivisions of distance education. mLearning was considered as one form of distance education.

The concept of e-learning came about as computers and the internet began to be used to distribute learning materials in the electronic form. E-learning was considered as a form of distance education. Allan (2002) differentiated the forms of e-learning as online learning, web-based training, and networked collaborative learning, emphasizing the use of electronic technology as e-learning.

mLearning began to be developed as a form of e-learning as it involved electronic materials and a networked environment. The difference mLearning had over other forms of e-learning was the tools which were portable and could be accessed from anywhere (Brown, 2005; Quinn, 2000), and the terminologies used for learning (Laouris & Eteokleous, 2005). Similar to other forms of e-learning, mLearning employed learning and content management systems (Brown, 2005; Saedah Siraj, 2004) as well as tools such as PDAs and mobile computers with wireless capabilities to access the internet (Brown, 2005; Quinn, 2000).

However, some researchers insist that mLearning cannot be considered a form of e-learning. The concept of mobile learning should emphasize the ownership of the mobile device, the informal form of learning, the mobility of the learner, and the context of learning (Traxler, 2009). In addition, the organization of content materials for mLearning would differ from that for e-learning. Knowledge would have to be seen in a different aspect in mobile learning, and the access to information would differ from that in e-learning (Traxler, 2009). Hence, skills related to accessing information and collaboration would have to be developed for effective mLearning.

The mLearning definitions have changed from the emphasis on technology and devices, towards the learning process. Originally, mLearning definitions were on the devices used for mobility. Researchers have defined mLearning as learning through the use of mobile devices: equipment and tools which were portable and used wireless technologies, such as laptops, tablet computers, PDAs and Palmtops (Mohamad Ally, 2005; Saedah Siraj, 2004).

The later definitions of mLearning focused on the learning process. mLearning was seen as the acquisition of knowledge and skills anywhere and anytime (Saedah Siraj, 2005; Geddes, 2004). Laouris, and Eteokleous (2005) emphasized on the mobile learner and the learning process stating mLearning as a function of time, space, the learning environment, the learner's mental abilities and the method used. According to them, learning in a mLearning environment means that the learner has access to a multitude of devices and other technical equipment, using different devices according to the learner's needs.

The ideal form of mLearning should include a variety of teaching methods to support learning that is personalized, authentic and situated (Traxler, 2009). The teaching methods should include collaboration and discussion through the various forms of technologies for communication to cater for different learning styles. In recognizing the differences and variety of learning styles, the need exists for personalized learning, in meaningful contexts (Henning, 2004) which includes real-world problems.

Forms of mLearning

mLearning developed due to the availability of the different types of mobile technologies. The portability of mobile devices was used for definitions of mLearning (BECTA, 2004; Saedah Siraj, 2004; Wagner, 2005) and this was achieved by using technologies such as GPS, WiFi and Bluetooth. This means that one form of mLearning was based on the portability of the devices used for learning.

On the other hand, other researchers insist that only the learner needs to be mobile (Laouris & Eteokleous, 2005; Naismith, Lonsdale, Vavoula, & Sharples, 2004). This would mean that technologies in which the equipment may be static, such as desktop computers at home, in cybercafés and in access centers, can be used in the framework of mLearning.

Naismith, et al. (2004) analyzed technologies based on its use and suggested four quadrants to classify these technologies. The y axis identified a personal - shared dimension while the x-axis identified portable - static dimension (see, Figure 2.1).

In the first quadrant, devices are both personal and portable: mobile phones, PDAs, tablet PCs and laptops. In the second quadrant, devices are static in one location and yet, limited to one user to allow personal interaction with the class, for example, classroom response systems. The third quadrant is for portable and shared learning, such as the use of kiosks, which are not physically mobile and yet provide learning experiences to users. Learners are mobile in this quadrant. In the final quadrant, technologies are shared and static, for example videoconferencing and the use of interactive whiteboards.

However, only the devices in the first three quadrants are considered when defining mobile technologies (Naismith, et al., 2004). Hence, mLearning can take place with portable devices, or with the learner on the move, using devices which are personalized or shared but not static and shared, as in Figure 2.1.

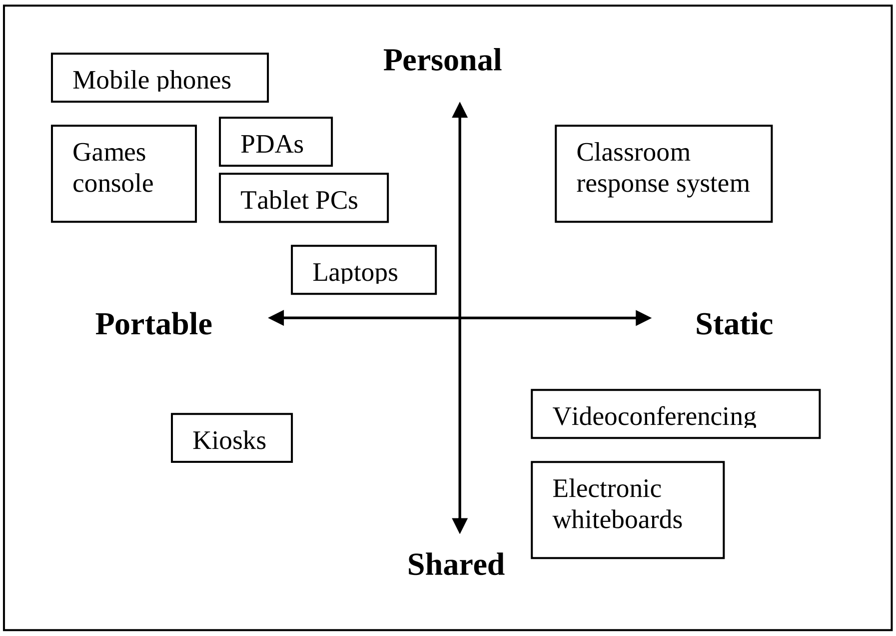


Figure 2.1. Classification of mobile technologies (Naismith, et al., 2004)

In considering the use of mobile technologies for learning, learning can take on two aspects: (a) conventional or safe learning; and (b) disruptive learning (Stead, 2006). Safe learning occurs when learners construct their own knowledge through interaction with the media and the process of socialization. On the other hand, in disruptive learning, learners are in control and create their own learning.

In safe learning, content materials are in the form of learning objects or web pages adapted for the size of the device and delivered through wireless technologies. This form of learning has included content materials (Bull & Reid, 2004; Mavorga-Toledano & Fernandez-Morales, 2004; Proctor & Burton, 2004), quizzes (Colley & Stead, 2004; Dawabi, Wessner, & Neuhold, 2004), educational games (Attewell & Saville-Smith, 2004; Mitchell, 2004), and platforms for collaboration and exchange of ideas (Frohberg, 2004; Dawabi, et al., 2004). Learning can take place anywhere and anytime as mobile devices provide access to Learning Management Systems in the local area network or internet. Other studies have explored the use of Global Positioning System (GPS) to detect users' position and deliver content as learning objects or text messages (Naismith, et al., 2004; Rogers, Price, Harris, Phelps, Underwood, Wilde, et al., 2002) in the real-world context.

In disruptive learning, learners produce materials in the process of learning. Photos, text and audio clips compiled in authentic environments are used to produce materials that can be shared with other learners (Brandt, Hillgren, & Björgvinsson, 2004; Colley & Stead, 2004; Weiss, 2004). Learning occurs during the production of these materials, as well as when the materials are shared with others.

However, some studies have used a blended approach for the use of mobile technology, combining lectures, seminars and face-to-face sessions, and using learning experiences for multiple devices (Luckin, Brewster, Pearce, Siddons-Corby, & du Boulay, 2004; Naismith, et al., 2004; Noessel, 2004). In fact, Stead (2006) describes that mLearning worked best as a blend with other group activities, and incorporated with other media, either paper-based materials or other ICT materials to be used for teaching, creating, collaborating and communicating.

Mobile technologies provide a range of possibilities for learning. Mobile tools and devices are already commonly used by youths to communicate, build communities, create media, publish and perform activities such as blogging, text messaging (SMS) to television channels, instant messaging, and podcasting (Stead, 2006). Hence, Stead (2006) states that these tools can used for learning as follows: (a) text messaging for skills check and collecting feedback; (b) audio-based learning through iPods and MP3 players; (c) Java quizzes to download to colour-screen phones; (d) specific learning modules on PDAs; (e) media collection using camera phones; (f) online publishing or blogging using SMS, MMS (picture and audio messages), cameras, email and the web; (g) field trip using GPS and positional tools. The challenge is to design activities using these mobile tools for the purpose of learning.

The research done on mLearning has shown several categories of mLearning: (a) technology-driven mLearning; (b) miniature but portable e-learning; (c) connected classroom learning; (d) informal, personalized and situated mLearning; (e) mobile training and performance support; (f) remote and rural and development mLearning (Traxler, 2009).

In this research, the mobile learning environment would stress on the learning process, where the connected classroom is used for learning. Technologies such as computers and laptops would be used to support the learning process, as well as personal and portable mobile phones. Using CMC, a collaborative learning in a collaborative mLearning environment would be designed for the teaching of Form 2 science.

Collaborative mLearning

Collaborative mLearning is the acquisition of new knowledge and skills by the individual learner anywhere and anytime as a result of interactions in a group through CMC. These will include text messages online or through the mobile phone, online group forums and an online collaborative workspace. Collaborative mLearning can be conducted with mobile devices or through computers networked to the internet to enable collaboration. Collaborative mLearning is not only limited to mobile laptops and PDAs, but also lower-end mobile phones which have text messaging functions. Collaborative learning which uses CMC is a form of CSCL.

However, collaborative learning which enables the mobility of the learner, which may be achieved with mobile devices, or a mobile learner, is collaborative mLearning. The relationship between CMC, collaborative learning and mLearning is shown in Figure 2.2.

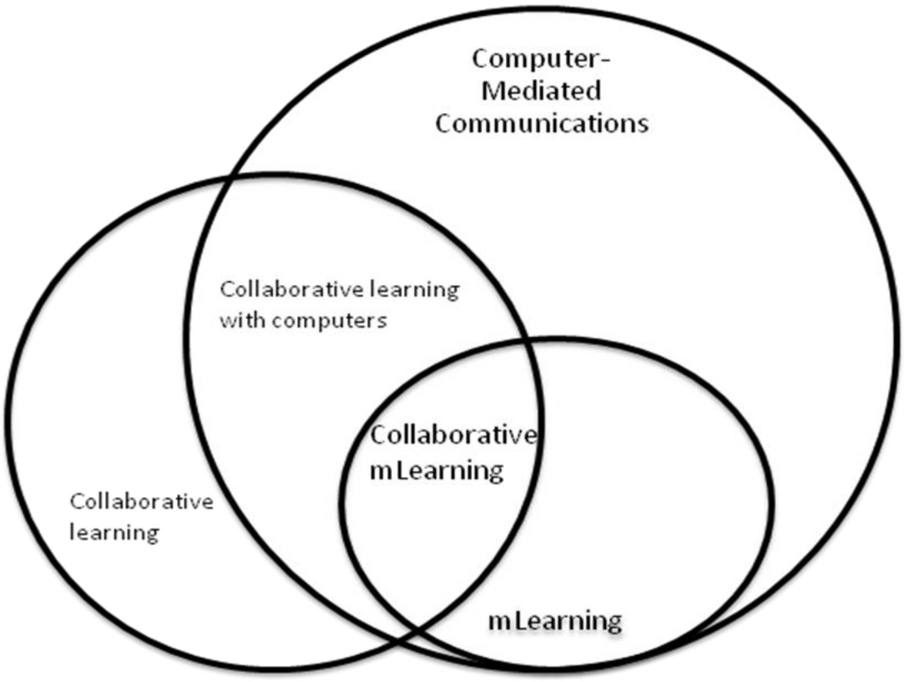


Figure 2.2. The relationship between CMC, collaborative learning and mLearning

Collaborative learning can be done with or without CMC tools. However, mLearning requires the use of a mobile device for communication. Hence, all types of mLearning require CMC, but not all CMC tools can be used for mLearning. This is because some CMC tools are static. However, collaborative learning can be conducted with or without the use of CMC tools. When collaborative learning is conducted in a mobile environment, it is referred to as collaborative mLearning. In Figure 2.2, collaborative mLearning is the intersection of collaborative learning, mLearning, and CMC.

In this study, the module developed creates a collaborative mLearning environment which combines the use of computers and mobile devices.

Benefits of Collaborative mLearning

Collaborative mLearning combines both the benefits of collaborative learning and mobile learning. In addition, CMC which includes mobile technology is used for collaborative mLearning in this research.

Many researchers have listed the benefits of mobile technology. The devices are portable and compact, cost less than computers, and are easy to use (Colley & Stead, 2004, Saedah Siraj, 2004; Vaino & Ahonen, 2004). When mobile technology is used in learning, there are many benefits. Mobile technology has been used to support the learning process in the classroom through different activities (Attewell, 2005; Harrison, 2004; Saville-Smith, Attewell, & Stead, 2006). At the same time, learners' knowledge can be consolidated and assessed (Attewell, 2005; O'Nuallain & Brennan, 2005). As a result, both learners, and their mentors, have perceived that learners' literacy and numeracy skills improve from the use of this technology (Attewell, 2005; Naish, 2005).

CMC has been used for supplementing distance education courses (Simon, 1992; Søby, 1992), and in international research programmes (McCreary & Brochet, 1992). There are many benefits of the use of CMC for collaborative mLearning.

Firstly, collaborative mLearning can be conducted anywhere. It is place-independent as learners do not have to be at the same location for learning to occur (Grabe & Grabe, 2004). Learners collaborate at a distance as long as there is a networked computer with internet access available (Inglis, Ling & Joosten, 2002).

Secondly, collaborative mLearning can be conducted at anytime as asynchronous tools, like email and conferencing, are time-independent. Learners do not have to interact immediately, but can view the messages later at their leisure (Grabe & Grabe, 2004). This asynchronous nature makes collaborative mLearning more convenient to the user (Inglis, Ling & Joosten, 2002), providing a learning environment that is available anytime: 24 hours a day, 7 days a week (Jonassen, 2000).

Thirdly, collaborative mLearning enables learners to share their experience and expertise with others. The interaction with learners of different cultures and contexts enables different opinions and viewpoints to be shared (Driscoll, 2007; Grabe & Grabe, 2004; Kaye, 1992). The social process of collaborative learning can be enabled locally at the school level, or extended to a national and international level using collaborative mLearning (Jonassen, 2000). Hence, the social construction of knowledge occurs as different perspectives are shared and learners verbalize their own knowledge and understanding (Kaye, 1992). As the learner contributes to the discussions and attempts to solve problems with peers, he develops general problem-solving skills and strategies through the internalization of cognitive processes in interaction and communication (Kaye, 1992). In fact, collaborative mLearning is believed to be highly beneficial during the initial exploration of group work or in a problem task as brainstorming and generation of ideas, can be done (Kaye, 1992).

Fourthly, collaborative mLearning can enhance critical thinking skills. Synchronous debates and quizzes using desktop video conferencing, chats and text-messaging in collaborative mLearning focus on the individuals' opinions as he contributes to the learning environment (Jonassen, 2000). Fast-paced live interactions means that the learner has no time to reflect on the answers he gives in a debate, which is exciting and motivating to the learner (Jonassen, 2000). The learner would need to use critical thinking skills when engaged in synchronous conferencing: the learner finds themes, evaluates messages received, rates their importance and responds accordingly (Jonassen, 2000). The messages are personalized as the learner elaborates, expands, modifies and concretizes ideas in the discussions (Jonassen, 2000). The importance of the social environment and interpersonal interactions to provide feedback in the thinking and writing process is emphasized (Jonassen, 2000).

On the other hand, collaborative mLearning is also useful in enhancing reflection. Asynchronous discussions for collaborative mLearning are beneficial for reflective learners who need time to reflect before responding. Grabe, and Grabe (2004) noted that research has shown that in a face-to-face environment in a classroom, teachers speak between 40 to 80 percent of the time, and only learners who respond quickly are attended to. Asynchronous discussions would enable reflective learners to participate in the discussion and activities. In addition, there seems to be more effective collaborative efforts in collaborative mLearning (Jonassen, 2000, Jonassen et al., 2005).

Computer conferencing and wikis can be used to create a virtual classroom with communications and learning spaces. It enables knowledge sharing for a wider audience and supports long-distance collaboration (Jonassen, 2000). Such asynchronous conferences enable a higher level of reflective and constructive thinking in the social learning process (Jonassen, 2000; Romiszowski & Mason, 2004). This is because learners have to think critically (Romiszowski & Mason, 2004; Jonassen, et al., 2005) as they consider the responses they wish to make; analyze the relevance and suitability of the response; and verbalize their thoughts in a text-based environment (Jonassen, 2000).

Metacognitive skills of self-reflection are involved as revision in learning takes place (Jonassen, 2000). As learning occurs in the social negotiation of ideas about the content being studied during the collaborative construction of new knowledge, creative thinking and other complex thinking skills are scaffold (Jonassen, 2000; Jonassen, et al., 2003). In addition, a deeper level of understanding occurs when learners discuss and debate among themselves, as well as with peers, experts and teachers (Kaye, 1992).

Another advantage is that there is more interaction among learners in a collaborative mLearning compared to in a face-to-face environment as learners tend to spend more time online (Jonassen, et al., 2005). The forms of communication in the discussions are more complex and diverse: researchers note that e-mail messages are longer, more complex and productive compared to classroom discussions (Grabe & Grabe, 2004). As all comments are accepted in conferences, this encourages participation as there is no threat as compared to a classroom environment which may cause a learner to perceive unfavorable cues (Grabe & Grabe, 2004; Inglis, Ling, & Joosten, 2002).

Collaborative mLearning engages learners. Learners in the new environment are engaged to experiment, communicate and collaborate using new techniques and tools such as SMS, blogs, wikis, and live messenger service (Ragus, 2006). Learners are engaged and motivated to contribute to the group discussion and are generally more active and vocal compared to a face-to-face environment (Driscoll, 2007; Kaye, 1992). The learner is motivated as he is empowered to be creative, share his ideas and publish his work (Driscoll, 2007). Working in a collaborative environment in an informal setting, individual learning occurs through informal group interactions, with help and support from peers and colleagues (Kaye, 1992). The learning experience is also less formal as knowledge in areas other than the school curriculum is addressed (Attewell, 2005; Saedah Siraj, 2005). This type of learning engages learners who are normally not interested in learning (Attewell & Webster, 2004; Saville-Smith, Attewell, & Stead, 2006). Using mobile devices enables such learners to be focused for a longer period of time (Attewell & Webster, 2004; Proctor & Burton, 2004), and show interest in learning and sharing information (Colley & Stead, 2004; Geddes, 2004).

Learning with mobile technology encourages independent learning (BECTA, 2004; Saedah Siraj, 2004). It allows learners to use the materials according to their different learning styles (Stead, 2006; Traxler, 2009), enabling them the privacy of working at their own time and place (BECTA, 2004; Colley & Stead, 2004; Kadyte, 2003; Saedah Siraj, 2005), as well as in a collaborative virtual environment (Colley & Stead, 2004; Attewell, 2005). Feedback can be given to the learner immediately (Attewell, 2005; Dawabi, et al., 2004; O'Nuallain & Brennan, 2005), and areas where the learner needs assistance in can be identified (Attewell, 2005; Attewell & Webster, 2004). Hence, learning can be personalized to the learner in terms of knowledge, depending on the background and goals of the learner (Mohamad Ally, 2004).

mLearning has been shown to improve learners' self-confidence, especially for learners who are not interested in learning (Attewell & Webster, 2004; Attewell, 2005; BECTA, 2004). In addition, it has also been used to cater for learners with special needs (Attewell, 2005; Rainger, 2004; Saedah Siraj, 2005).

The use of mobile technology can also be used to encourage the use of ICT and bridge the digital gap (Attewell, 2005; Brown, 2005). In fact, learners have reported increased confidence in the use of personal computers and other ICT skills when they have used mobile devices, and are able to support users who are new to this form of learning (Colley & Stead, 2004).

Collaborative mLearning can occur anywhere and anytime, and is used to improve learners' skills by promoting the social process, critical thinking and reflection. Collaborative mLearning encourages independent learning while catering to learners' different learning styles, allowing learners to work at their own time and place, and giving immediate feedback for learner's to identify areas they are weak in while engaging learners. Learners gain more self-confidence and improve their ICT skills. In conclusion, collaborative mLearning provides just-in-time learning where learning is provided anytime, anyplace and with learner-centered content.

The affordances of collaborative mLearning are that it supports learning at anywhere and anytime; encourages the social process of learning; develops critical thinking skills, and other metacognitive skills, such as reflection; engages learners;

promotes independent learning; and builds learners confidence in using ICT. In this study, a collaborative mLearning environment was designed using tools like text messaging, a group forum and a collaborative workspace, or wiki.

Limitations of Collaborative mLearning

There are several issues in using CMC for collaborative mLearning which need to be addressed in order for this form of learning to be beneficial. These are the lack of social cues during communication, information overload, and lack of skills to manage the use of the module.

In collaborative mLearning, there is a lack of non-verbal cues such as facial expression and voice intonations, which may be present in face-to-face communications for a learner to abstract meaning from the communication (Jonassen, 2000). In fast-paced synchronous communications, the learner does not have time to decide on the implication of the text viewed. This may sometimes lead to miscommunications, both in synchronous and asynchronous communication. One way to address this issue is to use emoticons to indicate feelings such as happiness or sadness, to ensure the feelings of the learner are expressed.

Generally because there is little face-to-face communication, there may be no commitment to continue participation. The may be little interaction among students, and teachers. This may lead to feelings of isolation in the learner, who chooses to disregard learning. The learner may also not feel the need to participate in learning and loses interest. The leaner needs to be strongly motivated to study and to continue participation. However motivating the learner to participate, access the learning tools and attempt the tasks, may be difficult. This is especially so if the course is totally online. More face-to-face sessions, and continuous instructional support through scaffolding may encourage and motivate learners.

In collaborative mLearning, the large number of messages can overwhelm the learner. The learner can be burdened by the quantity of discourse, and get lost in the discussion. This is more obvious in synchronous communications, where the fast-paced interactions could confuse learners who have missed a portion of the discussion. Having the choice to view the discussion thread in the conferencing system would help focus the learner on the purpose of the discussion (Jonassen, 2000). The learner must be reminded to align discussions to the purpose of the activity (Jonassen, 2000).

In general, there is less direction in collaborative mLearning as compared to face-to-face learning. The large amount of resources and data made available can confuse the learner who does not know where to start or what to concentrate on. This may lead to dropouts of the learning as the learner either cannot cope, or becomes bored with the tremendous amount of data. By providing just-in-time resources, which means providing the resources when required, not all given at the same time, the confusion can be reduced. In addition, instructional scaffolding is required to direct the learning.

The emphasis on the large amount of knowledge that had to be transferred to the learner also contributed to the large amount of online data. The emphasis on critical content leads to the large data, and may lead to less engagement with the learning as learning is boring. Active learning with meaningful activities is required to sustain learners' interest.

The teacher may not have the skills to manage the collaborative mLearning environment. The skills required by the teacher as a facilitator is important in collaborative mLearning. The teacher's role is to monitor discussions, to mediate when the discussions and interactions are heading into dangerous areas, to realign and focus information to help learners stay on task, and to minimize empty socializing (Jonassen, et al., 2003).

The participants may not have the skills for both the technical and communicative aspects while using the collaborative mLearning tools. A support system should be in place to ensure that technical difficulties encountered can be handled with a minimum number of interruptions to the process of acquiring knowledge and skills (Jonassen, 2000). To ensure that minimal technical difficulties are encountered, tools that are stable and easy to use should be chosen. In addition, a user-friendly interface, which is easy to use, would ensure that there is little resistance in adapting to the system (Jonassen, 2000). The learners in collaborative mLearning should possess sufficient skills in language and typing (Jonassen, 2000). Proficiency in the language enables a higher quality of communication, while basic typing skills would ensure the fluency and flow of ideas.

Collaborative mLearning has other limitations. There might be difficulties in getting prompt response for group discussions, more so if discussions involve countries in different time zones (Jonassen, 2000). Delays in communication may occur.

In any conference group, there might be individuals who do not contribute to the discussion. This could be because of communication anxieties, personal social insecurities, or technophobia (Jonassen, 2000). The lack of social cues in this form of communication may also make it difficult to interpret information leading to these feelings.

Technology is constantly being upgraded and changing for the better. Collaborative mLearning may also make use of newer and more powerful tools. As portable devices used have more functionality, they cost more as well. New technologies may also mean that new devices and new software tools are required. However, this may increase the costs of usage.

Collaborative mLearning has several limitations which will have to be addressed in order for this form of learning to be beneficial.

Delivery of Collaborative mLearning

There have been several types of research using different CMC tools for collaborative mLearning. Most of these are developmental research which stress on the evaluation of the use of the environment for learning. Text and multimedia messaging systems, global positioning systems, and multimedia content on Learning Management Systems could be used to manage, and deliver collaborative mLearning.

Text and Multimedia Messaging

The use of text messaging for delivery of content through mobile phones has been widely used. However, most research involving text messaging was done in Asia and Europe (Stone, 2004). The slow uptake in the United States has been because of the lack of a standard service for text messaging (Noessel, 2004). The description below is mainly on research projects which used portable mobile devices.

Text messaging has been used for language instruction. There have been several studies where text messages were pushed to mobile phones when teaching language (Naismith, et al., 2004; Pincas 2004; Sim, 2004). In one research, a prototype was developed to push lessons incorporating both sound and text for learning the Finnish language to mobile phones (Kadyte, 2004). According to Kadyte (2004), learners personalize the information required according to their preference of language for the delivery of content, vocabulary, topics, or milestones for tracking personal progress. Kadyte describes how push technology was used to deliver content in the form of SMS and MMS alerts, as well as voice technology, without the learner requesting for it. In the future, his research would employ 3G technologies for assessing networks and increasing interactivity among learners and tutors.

The Calvary system, a prototype developed to enable learners to request through SMS the following items: an automated dictionary, thesaurus, and Italian-English or English-Italian translation lookups (Noessel, 2004). However, Noessel (2004) described that the mobile phone had to be hooked up to a computer via a cradle cable to access the Java server to send and receive the requests, which were processed within 10 seconds. In addition, Noessel described that the learners could send open-ended questions to the system but that would require a longer time to answer. Among his findings on the survey of a group of ten learners using the service was that the learners were interested in such a service and would not mind paying for the service on a request basis. He also reported that most learners were not concerned with the time delays involved with the service but were more concerned with capturing the question they had when they thought of it, and renewed their interest when learners received the reply to their message.

Using the InLET system, SMS was used to teach the Greek language to tourists during the Olympic games (Pincas, 2004). By regularly pushing free SMS on phrases and words in the language to registered tourists, Pincas (2004) believed it would serve to remind and motivate the users to learn a little Greek to interact with the local people. According to her, this effect could not be achieved with a normal print media, such as a phrase book, as the constant reminders and the ease of saving and retrieving these messages in their mobile phones when needed during conversations, would encourage the learners to use the language. However, her survey of 200 mature adults, in an Online Education and Training Course in the University of London on whether they would like to receive such a service showed that more than half did not want to receive SMS help. Pincas felt that this finding should not be taken too seriously as it was done out of context and might have different results when done in the appropriate context in Greece.

Messages sent with push technologies have been highly effective in promoting regular study and manage learning. In the BBC BitSize program, content was provided in the form of videos and interactive games using Java programming (Naismith et al., 2004). In the European Union mLearning project, prototype products and technologies such as MMS, SMS, XHTML, WAP Java and Flash were found to engage learners (Popat & Stead, 2004).

In another research on the use of SMS, Colley and Stead (2004) used mobile phones to provide SMS and mobile content on the following themes: driving, sport and health education. Messages, dialogues, quizzes with VoiceXML, and other matching activities were sent to learners with mobile phones. In addition, mobile content in the form of Flash movies, animated activities and quizzes were sent to learners who were supplied with PDAs. Colley and Stead noted that creativity and ingenuity were required for developing effective SMS activities for the mobile phone.

SMS has been particularly effective in managing the learning for underprivileged learners who did not have access to computers. Brown (2005) reported on a pilot project in the Faculty of Education in University of Pretoria for 1,725 majority-black teachers aged between 31 and 51 years, who had English as their second language. Almost all these teachers had mobile phones but almost none of them had computers, nor could access emails. In this project, bulk SMS were sent to these learners for basic administration, which included reminders and distribution of study materials. Brown reported that the use of SMS was cost-efficient compared using the postal service, and that learners' response to the SMS was immediate as attendance for activities they were sent reminders about improved tremendously compared to previous semesters.

Messages have been used to deliver content and interactivity. The use of text messages can encourage individualized learning as the learner can interact with the message and the tutor or facilitator. In addition, messages can be used among the peers within the learning community. This form of collaborative mLearning engages learners.

Global Positioning System

Another form of collaborative mLearning uses the location of the learner to deliver content. Mobile technology with Global Positioning System (GPS) is used to detect location. When the activities are done in groups, collaborative mLearning is encouraged.

Some subjects can be taught effectively using GPS. Pintus, Carboni, Paddeu, Piras, & Sanna (2004) claimed that subjects like geophysics and mineralogy in geography, history and ecosystems in biology, mechanics in physics, geometry and linguistics could use the real environment for learners to improve their knowledge. As learners look for information and observe the real environment, they are involved in learning and are able to behave independently. Pintus, et al. used teachers to develop lessons to be delivered through mobile devices. They prepared coordinates for hotspots on a particular historical site in Sardinia. The learners used devices such as notebooks, tablet PCs, and smart phones, and roamed through the site. Like in a treasure hunt, messages in the form of information, descriptions, quizzes and other teaching materials were delivered when learners approached a hotspot. The learners' position and progress could be monitored on-site. The researchers found that both teachers and learners were excited by the on-site experience. The learners were engaged by the innovative approach, direct contact with the environment and the competitiveness.

Collaborative mLearning using GPS can be used to deliver content and encourage collaboration for learning science.

Content for Collaborative mLearning

A variety of content form can be delivered using mobile phones, depending on the technology of the device. The content can be highly interactive animations and games, to simple text messages.

Smyth (2004) described the 'skoool' project, an e-learning initiative at Intel IT Innovation Centre in the United Kingdom (U.K.) and Sweden which was for a two-year duration. He describes the 'myskoool' courseware, developed to cater for low bandwidth, which could be downloaded from the 'skoool' portal, or from a hosting peer and viewed offline. This courseware could be downloaded to a desktop computer and then transferred via infrared or Bluetooth wireless technology to a smartphone or PDA. Smyth described the content as being of three forms: (a) LearnSteps, which consisted of instructional learning objects for learning and revision; (b) LearnSims, or interactive simulations for the application of learning; and (c) Study Notes, which enabled text-based content to be sent as reminders and revision. According to Smyth, a total of 45,000 text messages were delivered to students in Ireland using this portal in the month of May 2004. An evaluation of the U. K. portal for this project described by Smyth showed that the users found the content beneficial as it was well-structured and based on sound pedagogy, while simulations provided interactivity and mobility. However, he observed that content delivered would have to be concise and less wordy. In addition, he noted that there was not enough opportunity for learners to give ideas and create knowledge, and that the experience of mLearning was similar to online learning. The learners wanted the opportunity to communicate and create knowledge,

In a project to improve literacy and mathematics, a collaboration game which enabled messages to be sent to an internet based platform was developed. Naish (2005) reported on the Learning Skills Development Agency's (LSDA) project in Sweden, Italy and U. K. for young people who needed support in literacy and numeracy. In this project, PDAs and smart phones which could access the internet were used. He found that the learners liked the learning activities, were more focused during learning sessions, and could remain focused for up to 2 hours, when they would normally be restless after 15 minutes. The activities that most engaged learners were the mediaBoard, which was a form of Treasure Hunt, and the driving theory test game. In the mediaBoard game, photos and videos could be attached to a map on a website using Multimedia Messaging System (MMS). Players could work collaboratively and also send messages to each other as they did the activity. The driving theory test game tested knowledge on road signs through multiple choice questions, giving feedback on the answers chosen. This game also involved number skills as there was a game where learners had to calculate stopping distance of a car based on the speed it was traveling. Not only was there a rise in both literacy and number skills of the learners, but learners' self-esteem increased as they were confident in providing support and assistance to each other.

Content when designed using sound ID systems can be effective in engaging learners and encouraging learning. Mobile technology has been used to teach physics at secondary school (Naismith et al. 2004), and basic literacy and number skills (Attewell & Savill-Smith, 2004; Colley & Stead 2004; Mitchell & Doherty 2003; Traxler, 2004). In addition, conceptual understanding of materials could be improved as learners were allowed to articulate, elaborate, reflect and evaluate the content (Naismith et al. 2004).

mLearning Management Systems

Learning management systems (LMS) have been used to organize and deliver content materials as well as provide a platform for learning. The cases described show the use of LMS in collaborative mLearning.

Arrigo et al. (2004) used a collaborative platform for mLearning using e-mails and SMS to send messages to the Peer to Peer Communication module in the system. In this platform, learners stored and shared photos and videos from their mobile phones in a repository and were able to collaborate and build their understandings.

In another research that combined the use of SMS with a LMS to support learning, 20 undergraduate students were surveyed on their experience of using communications technology for group collaboration. The results showed that students' experience with both SMS and Instant Messaging was favorable (Stone, 2004) but not e-mails and face-to-face communications. However, Stone found that all the students asked were interested in using SMS to support their learning. Based on this feedback, an SMS support service to complement a Learning Management System (LMS) for collaboration was offered in one of the core modules in a degree programme for first year undergraduate students. Although registration for this service was voluntary, a large number of learners registered. Stone reported that messages offered timely and relevant information to students as well as tips on where to find information. However, he reported that the number of responses to the messages sent was low, but that the survey at the end of semester indicated that students found the messages most useful when messages were reminders and notification of updates on the LMS. He also reports that students were just as likely to inform their peers of information shared with an SMS as compared to a voice call or face-to-face communication. According to him, this indicated peer communication can occur in a variety of ways.

Another team of researchers incorporated SMS in an LMS for e-learning. Capuano, Gaeta, Miranda & Pappacena (2004) offered "SMS pills", short textual learning objects, in a course which incorporated an e-learning platform to track learners' progress and respond to answers to the quizzes. The team developed the following resources: SMS Test, SMS Textual and SMS Course and enabled Voice based interaction. They report that the trials have shown users were more motivated to learn using SMS, as compared to browser-based interactions.

A collaborative mLearning project in Chile used hand held mobile computers where teachers downloaded materials in their pocket personal computers and transmitted the materials to learners' handheld PCs, and then retrieved the final product uploaded in the school's computer (Naismth, et al., 2004).

Arrigo, et al. (2004) used a mobile platform for computer-supported collaborative mLearning to improve collaboration via 3G mobile phones. In this platform, data in the form of photos and videos, shared to enable knowledge building.

The LMS for mLearning, or mLMS, would have to be different from an LMS for pure e-learning. The content for an mLMS has to be designed differently. This is because collaboration and interaction on a mobile platform differs from that in an e-learning platform.

To summarize, there is a variety of content material and a variety of delivery methods for collaborative mLearning. Some methods of delivery are simple while others require Learning Management Systems specifically for mLearning to manage, deliver and enable collaborative mLearning to be conducted.

Collaborative mLearning in Malaysia

There has been little research done on collaborative mLearning in Malaysia. Most of the studies done are on undergraduates and on the use of online discussion forums, wikis, and text messaging.

Online discussion forums have been used to determine trainee teachers' critical thinking skills. It was found that trainee teachers are more engaged in collaborative learning, and increased their depth of thinking with the use of online discussion forums (Irfan Naufal Umar, Noor Hazita Ahmad, Nur Hidayah Ah. Kamal & Nurulizam Jamiat, 2009). In another study among undergraduates, online discussion forums encouraged the construction of knowledge and fostered critical thinking skills (Siti Nazuar Sailin & Abdul Malek Abdul Karim, 2007). A collaborative and problem-solving approach in an e-commerce course using online discussion forums engaged students because it was relevant and employed real-life problems (Norhashimi Saad & Sathiyvani, 2007).

There has been some research on online discussion forums for learning in secondary schools. In teaching General Studies among Form 6 students, it was found that although the students did use the forum for collaboration and sharing information, there seemed to be a lack of interaction and academic reflection among the students (Firuz Husin, Hanim M. Salleh & Lim, 2007). In another study, a web-based collaborative mLearning environment for teaching the literature component in English for Form 5 used the Jigsaw Technique and synchronous discussion on a message board. Online discussions reduced anxiety and increased the attention, confidence and satisfaction among English second language learners (Norhashimi Saad & Aniqah Husda Abdul Latif, 2007). Although online group forums have been used for collaborative mLearning among university students, it has only been used to a limited extent in some secondary schools (Fong, Raja Maznah Raja Hussin, Rozhan Idrus, Shekaran, & Chong, 2008; MOE & Intel Malaysia, 2008; MOE & Oracle Education Foundation, 2008).

Collaborative mLearning using mobile applications have recently been used in some universities in Malaysia. A mobile learning system for undergraduates consisting of a knowledge base, collaborative learning modules, and a mobile pedagogy agent, was implemented in an institute of higher learning in Malaysia. On this collaborative mLearning platform, SMS, MMS and a collaborative environment were delivered through mobile devices, laptops and personal computers (Sazilah Salam & Saharah Sahmi Hameed, 2009).

Collaborative mLearning has been used in schools. Wikis have been used successfully at the elementary school level in the field of English language writing (Lee, 1999). In teaching English grammar, text messaging has been used to deliver quiz questions and encourage interaction (Sim, 2004). In another study, content was also developed for disadvantaged learners. Mobile learning applications developed for dyslexic children using a mobile web browser on PDAs was evaluated by 40 test users, who had no problems in using the application (Ronaldi & Fadilahwati, 2009).

In short, collaborative mLearning has been conducted in Malaysia using discussion forums, text messaging, and interactive multimedia content. There is a potential for more research to be carried out in this area, especially in the development of relevant and effective mobile content.

Collaborative mLearning in Secondary School Science

There has been some research on the use of collaborative mLearning in English in Malaysia (Lee, 1999; Sim, 2004) which showed that it could be successfully implemented at the elementary school level. However, there does not seem to be much research done on collaborative mLearning in science.

During the Smart School Pilot project, a Smart School Management System (SSMS) was developed for managing teaching and learning in the pilot schools (Educational Technology Division, 1999). For the teaching and learning aspect, a module was developed for communications among teachers and students: *Kolaborasi.* According to the condensed manual, BestariFlip, the function of this module is to prepare and display research projects, and to maintain and prepare these sites where the projects resided (Custommedia, 2003). This module was supposed to be a collaborative module for students to work on projects as well as share files and websites online. Even though teachers found it relatively easy to use, this module was hardly used in the first three months after implementation of the enhanced version of the system (PPPBSB, 2003).

On the other hand, there has been successful implementation of collaborative mLearning in teaching science in other countries. The Knowledge Integration Environment and CaMILE are two examples of collaborative mLearning environments.

The Knowledge Integration Environment (KIE) is an instructional shell that provided the social context and opportunity for collaborative work in science for learners from elementary to high school (Slotta & Linn, 2000). Besides tracking students' progress, there are tools that allow for the following: storing web resources (KIE Evidence Database); scaffolding in the form of tips (Mildred the Cow Guide); links to tools and activities (KIE Tool Palette); guidance for a sequence of activities (Activities Checklist); specific frames for argument which allow thinking to be made visible (SenseMaker); and an online asynchronous discussion tool (SpeakEasy). In their research, 8th grade students who participated in the project were able to evaluate web pages effectively, and ask relevant science questions with the cognitive guidance and modeling that was given. The students also found the system useful for learning science (Slotta & Linn, 2000).

CaMILE, a web-based collaborative mLearning tool to support student discussions was also found to be effective in encouraging learners to communicate and work together in science inquiry projects (Guzdial & Turns, 2000). From the discussions that were conducted on CaMILE, there was evidence that science learning was made personally relevant as learning took place at the individual level;

and that the discussions were more sustained showing that the learners were engaged with the topics (Guzdial & Turns, 2000). However, Guzdial and Turns (2000) assumed that the success of the use of this forum was due to the teachers who were interested in using this form of collaborative tool, and this may have influenced their students' interest.

There has been little research done on the use of collaborative mLearning in science in Malaysia, and there is a need to investigate whether this form of learning can benefit our Malaysian secondary school students.

Designing Content for Collaborative mLearning

In this section, several design issues related to the use of collaborative mLearning is discussed such as text on a smaller mobile device, profiling the user, personalizing the content, presentation of content and web-standards. These issues should be taken into consideration when the learning environment is designed.

The analysis of the learners should be conducted prior to implementing collaborative mLearning. This is because the profile of the users would influence the designs and choices, as in the European Union mLearning project (Popat & Stead, 2004). The younger generation was attracted to strong colours, animations and sound effects, so the learning objects, which in their project consisted of test items and practice materials, had colourful and attractive features (Popat & Stead, 2004).

Information had to be personalized to the learner to be effective. Naismith, et al. (2004) also noted that the context of the content had to be designed so that information sent to the learner is personalized to him and his environment. This would mean that the instructional designer had to have background information on the learner (Naismith, et al., 2004). Learning had to be contextual and meaningful to the learner (Wan Mohd Fauzy, 2007).

The learning goals for the lessons delivered on a mobile device had to be short, precise and skill-focused (Popat & Stead, 2004) as content had to be chunked and delivered in small pieces to avoid information overload (Mohamad Ally, 2004). The small screen size meant that content was compensated. Graphical interface had only 5 to 9 chunks, so as not to overload short-term memory (Mohamad Ally, 2004; Wan Mohd. Fauzy, 2007). The use of intelligent agents to anticipate learners' needs and responses, as well as navigational strategies for the content can be considered (Mohamad Ally, 2004).

Effective presentation strategies (Mohamad Ally, 2004) and the use of advanced organizers to expose the framework of the lesson, as well as comparative advance organizers, to make sense out of existing knowledge (Ausubel, 1968), should be used. Concept maps, summarizers and other learning tools would be effective in preparing the materials. Pre-instructional activities would allow learners to form a framework of the lesson (Mohamad Ally, 2004) and enable meaningful learning.

There is still a lack of standardization of mobile content. Designers had to cater for different solutions for different platforms. In most cases for web-accessed content, a XHTML standard was used but, there were bugs in different mobile devices due to different browsers and small screen size (Popat & Stead, 2004). So, alternative content for multimedia Flash and XHTML mini web pages should be provided, such as having the content written in SMS as well (Popat & Stead, 2004).

Naismith, et al. (2004) summarized some of the problems and challenges in the implementation of collaborative mLearning: lack of localized content relevant to studies; lack of detailed feedback in mobile devices with small screen; small memory capacity which limits the type of media that can be used; incompatibility between devices in cross-platform environment as service providers have different standards for browsers; costs to the learner; personalized context so that messages received address the learner directly and takes into account his prior knowledge and experiences.

Even though the advantage of mobility in the 'anywhere, anytime' concept of collaborative mLearning encourages learning experiences outside of the teacher-managed classroom, the instructional designer has to consider that the learner may also explore other environments not related to the learning goals (Naismith, et al., 2004). As learning takes place over time, there is a need to have tools to record, organise and reflect on their collaborative mLearning experiences (Naismith, et al., 2004). An mLMS specifically catered for collaborative mLearning may need to be developed.

In a developmental research study on a collaborative mLearning environment called an 'Always-Online Environment', content materials and resources were used with discussion forums and emails (Rekkedal & Dye, 2009). Both computers with internet access and mobile devices were employed. A mobile LMS was used to support both the mobile and traditional learning process. Online content resources as well as online synchronous communication tools, including text-messaging, were used. The findings showed that the readability of text in messages was important to the users, while graphics were considered as less effective for learning. In addition, most participants were active in using the mobile device, but were less active in logging on to the internet.

As a result of these studies, the set of guidelines developed by Naismith, et al. (2004) was improved upon. The guidelines would be used in the design of instructional materials for a collaborative mLearning environment with CMC tools. The guidelines are:

1. Profile learners before implementing collaborative mLearning. Record learners experiences with collaborative mLearning for the profile.
2. Personalize content to learner and his environment so that content is meaningful.
3. Learning goals are short, precise, and skill-focused.
4. Use effective presentation strategies
5. Use an open-source format for content and development.

The above guidelines are taken into consideration in the development of content in this study. A blended approach, where collaborative and group learning is supported in an online group environment is proposed. The learning goals selected are for topics that are more effective when mobile technology is used.

Comparison of CMC Tools for Learning

There has not been much research on which CMC tool is most efficient for learning. In a study in Taiwan, a comparison of the use of SMS, emails and online discussion groups was done on motivation and performance for four groups of students. The use of SMS motivated learners while the use of online discussion groups improved performance in examinations.

Rau, Gau, & Wu (2005) described an empirical research in Taiwan to study the effects of SMS and collaboration on motivation, pressure and students' exam performance in traditional classrooms in a vocational senior high school. In their first experimental study, students were randomly assigned into four groups and were sent messages and learning materials, including notes and exercises, through the experimental media. The groups were: SMS group, e-mail group, online discussion forum group, and control group. The control group was given the same information, but through face-to-face interaction in the classroom. At the end of the three weeks of their experiment, results showed that although there was no difference in motivation and pressure among the groups, the learning performance of the SMS group compared to the control group did increase. The SMS group also felt more pressure compared to the control group, but were more motivated as they perceived that the lecture notes and reminders helped them improve. There was no difference in motivation and pressure in the email and discussion forum group compared to the control group. However, there was a significant increase in one of the quiz results in the discussion forum group when compared to the control group.

A combination of SMS and online groups could improve learning performance and motivation. Rau, et al.'s (2005) second experimental study combined SMS with internet communication tools in the instruction process to measure the effect on pressure, performance and three aspects of motivation: intrinsic, extrinsic and overall motivation. The three groups used the following: First group used SMS and email; the second group used SMS and online forum; and the third group had no digital media. In this study, e-mails and online forums were used to deliver notes and activities while SMS was used for reminders and to check the receipt of materials distributed. The experiment showed electronic mediation improved performance as learning performance for the two groups was much better compared to the control group. This suggested that extrinsic motivation for both media groups compared to the control group was also significantly increased. However, the SMS and online group also recorded increase in overall motivation and pressure. Rau's team showed that learners' motivation increased with the use of electronic media as the instructor and learners could communicate. Hence, when a combination of mobile and internet tools were used, concise information was relayed in a personal manner. This seemed to indicate that a combination of mobile and internet tools increased learners' motivation to study and contributed to improved performance.

Hence, text messaging is useful in supporting learning. When text messaging is combined with another collaborative tool, learning may be improved. However, in the Malaysian context there is still lack of research in this area.

Theoretical Foundations of This Research

In this study two major theories were used: instructional design and learning. The instructional design theories were used to design the learning environment and an eclectic instructional design model was used for the development of the module. The theory of learning determined the overall approach for learning and instruction and a collaborative mLearning framework was used to analyze the findings of this study.

Instructional Design

Instruction is the process of conveying knowledge and skills to a learner. Defined as the organization of events to achieve a learning goal using internal learning processes (Romiszowski, 1999; Schunk, 2000), instruction occurs through a variety of processes and interaction: among the learners; between the learners and a teacher; or with media, such as video, audio, computers or books (Schott & Driscoll, 1997). However, instruction should be based on a set of guidelines and rules of instructional design derived from theories of learning, instruction, educational psychology, educational philosophy and educational sociology (Bednar, Cunningham, Duffy, & Perry, 1995; Schott & Driscoll, 1997). In short, instruction in itself is a technology for ‘a means to an end’ as it is a planned effort to provide the opportunity for learning, or, acquiring knowledge, skills or values in a unique setting (Schott & Driscoll, 1997).

Instructional design is concerned with both the process and the product of instruction to improve student learning (Tennyson & Schott, 1997). Shambaugh and Magliaro (2001) used a process definition to define instructional design as a complex, instructional process for solving instructional problems. In the process of solving the instructional problem, the product would be the design of instruction.

Instructional design models are usually based on a define-develop-evaluate paradigm. Models that are used are the ADDIE model in which the five steps are Analyze the Problem, Design the instruction, Develop the program or product, Implement, and Evaluate. Another model is the ASSURE model (Heinich, Molenda, & Russell, 1993) which consists of the following steps: Analyze the learners, State objectives, Select methods, media and materials, Utilize media and materials, Require learner participation, Evaluate and revise.

In instructional design, the process and the product of instruction assist in improving students' learning. Another dimension, the educational context or setting of instruction, enables interactions to be conducted in the course of learning.

The Importance of the Educational Context

The dimension of the educational context should be included in the definition of instructional design (ID). Flechsig (1997) defined ID as the process of producing or developing instruction, as a product that defines a specific educational context. The educational context has a varied learning culture and setting, and can include the integration of different types of products for different styles of learning. This would mean that when instruction is designed, the product must cater to different contexts and take into account the learners' different learning styles and preferences.

The context of the study is important in ID as it influences the learning experience. Learning does not occur in a vacuum (Tessemer & Richey, 1997) because many factors in the environment can influence learning: the classroom setting, the time of the instruction, and interactions of other learners in the environment. ID is context-specific, and should deliberately accommodate the differences in the learner and his environment (Tessemer & Richey, 1997).

In this research, the context takes into account three levels: the orienting context, instructional context, and transfer context (Tessemer & Richey, 1997).

In the orienting context, firstly, the learner's background in the use and perception of technologies employed in this research was surveyed. The environment for learning, which consists of face-to-face meetings in the school and other places for accessing the technology used, was also considered when designing instruction. Finally, the organization's learning culture in the school was observed to determine the amount of scaffolding that might be required for learning.

In the instructional context, the learners had an active role in solving problem tasks which were authentic and meaningful. The solutions to the tasks had to be shared online with the learning group. The online learning would be influenced by the environment when learning occurred. During meetings in school, the round table seating arrangement enabled group discussions but the setting in other environments was less structured and more individualized. Learners who had computers networked to the internet would access it at home while those who did not would have to access at other places: cybercafés, the school access centre, the resource room. However, the online tools used in the study would provide the setting for sharing in a collaborative environment. Learning schedules were also given and included times for live and synchronous meetings as well as online group lessons. The ease of use of equipment would also influence learning, and in this study, equipment which was considered easy to use by the learners in the context of the study was utilized.

In the transfer context, meaningful tasks were assigned so that learners could apply the learning for their own personal use. In addition, the use of social tools for communication would provide the learners the expertise in the use of these technologies. Moreover, quiz questions in the examination questions format would provide additional practice. In the online setting, sufficient social support would be given from peers and the tutor. Opportunities for modeling in the online environment and feedback would be provided both online and face-to-face, thus personalizing to the learner.

Purpose of Instructional Design

ID was considered a prescriptive science (Seel, 1997) with the objective of prescribing suitable processes and products for use in different educational settings. In fact, ID is a cross-disciplinary practice with a practical impact on education and takes into account both instructional practice as well as instructional theory (Snelbecker, Miller, & Zheng, 2006).

Traditional ID focused on analyzing the content knowledge as the design of lessons was to ensure that learning outcomes were achieved. Most traditional ID was based on Gagne's Conditions of Learning (Gagne, 1970). However, new approaches in ID shift away from the outcomes-based model and focus on the learning processes rather than learning outcomes, and on developing tools and systems to support the learning process (Driscoll & Burner, 2005). Instructional designers are now required to develop both the instruction and the learning environment. The learning environment where the interaction occurs includes the learning resources, and social support groups, which include the learners, their peers, and tutors.

Methodologies in Instructional Design Research

Research approaches used in ID have changed because of the change of focus. Initially, studies were quantitative studies with experimental designs but later, qualitative approaches were used to support these studies (Driscoll & Burner, 2005). As the processes of learning were emphasized in ID, more qualitative approaches were employed.

In recent years however, developmental research approaches, which are context-specific, have been used for studies in ID (Driscoll & Burner, 2005; Wang & Hanafin, 2005; Richey, Klein, & Nelson, 2004). Developmental research originated from formative evaluation or usability testing and was meant for improving instructional materials, tools and curricula while testing ID theories in a specific context (Reigeluth & Frick, 1999). Even though developmental research using ID theory is context-specific, this form of research in the form of case studies has been employed to improve as well as develop new theories and models while in a particular context (Reigeluth & Frick, 1999).

In this study, a developmental approach is used to study the implementation of a collaborative mLearning module in a specific context. A specific school, with a particular environment and community of learners was studied.

Instructional Design Theory Development

ID is influenced by theories of educational psychology and instruction. A theory is useful as theories can be used to predict outcomes involving variables that have been rigorously tested against the theory (Tennyson, 1997). As Schott & Driscoll (1997) point out, theories of educational psychology investigate the teaching and learning processes while ID theory investigates problems of ID. Specifically, ID theory includes the methods to be used in the design of instructions and the situations, or settings, in which these methods are used (Reigeluth, 1987).

There are two types of theories: descriptive theories provide the understandings and reasons the theory work; and prescriptive theories, to guide on the methods to be used to attain a goal (Reigeluth, 1987). ID theory has been more often a prescriptive theory, rather than a descriptive theory, as it is often used to predict the conditions for given learning outcomes (Reigeluth, 1987; Reigeluth, 1999; Seel, 1997; Tennyson & Schott, 1997). However, Reigeluth (1999) noted that even though ID theory is focused on the attainment of goals of each learning event, the methods of instruction were probabilistic, and there was no certainty that the goals of learning would be attained.

The ID theories were classified in terms several types of theories. Snelbecker (1987) classified ID based on the following theories: (a) behavioral, (b) cognitive, which is based on context, (c) humanistic psychology, is the learners' perspective and includes maintaining learners' interest in the activities, and (d) eclectic instructional theories, which address wide range of issues as well as use diverse resources and ideas based on many theories. This classification of ID theories is used in research. The choice of ID theory applied would then influence the design of instruction. The impact of the ID theory would be realized in the phases of analysis, development, implementation and evaluation (Reiser, 2001a).

In the design process, methods that best support the attainment of learning goals in specific situations are identified and detailed based on instructional theories (Reigeluth, 1999). When an instructional theory is used for a certain context and setting, it becomes an ID model.

Instructional Design Models

Models in ID are different from models based on the theories of science as models in ID are organizational models of instruction for a sample of a certain concept of teaching in a particular instructional situation (Seel, 1997). On the other hand, models in the philosophy of science are representative of a more comprehensive theory (Seel, 1997). So, models in ID are based only on a specific aspect of instruction in certain conditions and settings. However, ID models represent theories which have been substantiated by research findings (Tennyson, 1997) and developed based on a research framework. The research framework of the models would have included a set of descriptors, content analysis of documents and information for instruction, and the media to be used (Flechsig, 1997).

In most cases, an ID model is prescriptive with well-structured set of rules used to address certain needs or goals (Andrews & Goodson, 1995; Schott & Driscoll, 1997). Andrews, and Goodson (1995) state that ID models have been developed for the following purposes: (a) improving learning and instruction; (b) improving the monitoring and control of functions of the approach; (c) improving the evaluation of the design processes; and (d) testing and building learning and instructional theory.

ID models are based on ID theory. There are two types of models: descriptive and prescriptive. Descriptive models describe the components or activities of ID based on descriptive theories of instruction while prescriptive models prescribe necessary activities and predict effective instruction for intended learning outcomes (Andrews & Goodson, 1995; Reigeluth, 1987; Reigeluth, 1999).

Theories assist in understanding and controlling the learning environment (Andrews & Goodson, 1995).

The Social Aspect in Instructional Design Model Development

The types of theories and models being used for designing instruction has changed through the last century. Resier (2001b) observed that early models of ID were based on the processes of task analysis, specification of behavioral objectives, and criterion–referenced testing to develop behaviorist models. This was followed by a systems approach to instruction. Instructional models like Dick and Carey's (1985) adapted a more systematic approach to learning and instruction to show a systematic flow of the processes, and specify the products developed for each process (Resier, 2001b).

When the personal computer was made available in schools during the 1980s, new models emphasizing cognitive psychology were developed for computer-aided instruction (Resier, 2001b). In the 1990s, several trends emerged: the interest in constructivist learning principles; the expansion of the use of the internet for distance learning; and the rapid development and management of information. These trends and the explosion of knowledge led to a need for more comprehensive design principles (Resier, 2001b). As a result, a large number of design theories were developed in the late 1990s, which were more general to certain contexts in education and less dependent on theories of psychology (Snelbecker, 1999).

Learning theories have influenced ID theories. The behaviorist theories used in programmed instruction in the 1970s are still being used in some forms of computer assisted instruction (Wiley, Sanchez & Moher, 2005). The cognitive revolution in the 1980s arose because behaviorist theories were inadequate for explaining certain learning situations (Royer, 2005). Cognitive theories emphasized on the knowledge to be transmitted to learners based on associations made with learners' prior knowledge but as learning became more active and emphasized understanding through exploration and problem-solving, constructivist learning theories were applied (Wiley, Sanchez & Moher, 2005).

In recent years, humanistic theories of learning have became more important. Learning takes place through social interactions which shapes our experiences and beliefs. Humans are social creatures who will assimilate information from the environment. However, it would be impossible to analyze where the information comes from (Royer, 2005). As the environment and the learning process become important for learning, the theories of learning have became more social in nature (Freebody, 2005). Royer (2005) is of the opinion that learning has now become more social in nature. However, there is still insufficient research involving social learning in the field of educational technology and the impact of these theories are being investigated (Royer, 2005).

Social learning theories have influenced ID theories with the use of communication technologies. As the internet began to be used more and more for learning, ideas on student-centered learning and learner-centered design were developed (Hanafin, Land, & Oliver, 1999). This meant that the teachers' role would have to shift towards being a facilitator in an open learning environment (Reigeluth & Frick, 1999). Constructivist learning environments (Jonassen, 1999) supported the student-centered and open learning environment for learners to solve problems, both individually and in groups, as learners are scaffold to construct their personal understandings. The social context was emphasized by Nelson (1999) as cooperative learning was done in a problem-based learning environment in the Collaborative Problem-Solving Theory. However, her theory was limited as it did not allow for personalized learning as the focus was on group processes for learning (Reigeluth & Frick, 1999).

Merrill (1999) attempted to be adaptable and flexible in learning by identifying transactions and providing learner guidance to aid learners in achieving learning outcomes in his Instructional Transaction Theory ID theory. He claimed that this theory was a second generation ID theory which was relevant when designing instruction with computer-based tools (Merrill, Li, & Jones, 1991). However, some theorists claimed this theory was too structured. Hence, a theory which could balance both the aspects of social learning and instructional content, allowing flexibility in instruction, is needed.

In the choice of an ID theory, two aspects should be considered: how the selected theory fits in the collection of instructional theories available; and the added value that the selected theory would provide (Reigeluth & Frick, 1999). In this study, an eclectic theory of instruction is used to prescribe the ID process. Eclectic theories are general and use different approaches to instruction but do not focus only on instructional objectives or techniques (Snelbecker, 1987). An eclectic instructional theory can cater to general conditions, be adapted to different approaches to learning and instruction, as well as adapted easily to cater to changes. Theories such as the Gagne and Briggs Instructional Theory (Perry, Mouton, & Reigeluth, 1983), Component Display Theory (Merrill, 1983), Elaboration Theory

(Reigeluth & Merrill, 1983), and First Principles of Instruction (Merrill, 2002) are examples of eclectic theories (Snelbecker, 1999).

The eclectic nature of Merrill's Component Display Theory and the Elaboration Theory were some of the electric theories which led to the development of the theory which would be used in this study, the First Principles of Instruction.

Merrill's Component Display Theory (Merrill, 1983) has behavioral, cognitive and humanistic perspectives. Firstly, by identifying and distinguishing the type of content, a behavioral perspective is exhibited. Teaching strategies such as mnemonics, feedback and attention-focusing assistance to learner show a cognitive and humanistic perspective (Merrill, 1987). Next, strategies for teaching concepts and principles are stressed to identify performance levels and content types, and this shows the focus on the cognitive domain. The humanistic perspective occurs when there is interaction among learners as they discuss and obtain feedback, while building knowledge. Merrill's Component Display Theory employed different perspectives in the design of instruction.

The Elaboration Theory (Reigeluth & Merrill, 1983) is an eclectic theory and was developed as an extension to the Component Display Theory. Concepts, procedures and theories were elaborated and sequenced to make it relevant to instruction (Reigeluth, 1987). Sequencing strategies, to sequence information from simple to complex reflected a behaviorist perspective while integrated elaborative strategies to arrange content material into sets of sequences reflected a cognitive perspective in organizing and processing information. The use of summarizers, synthesizers and analogies are examples of cognitive strategies used (Reigeluth & Merrill, 1983). In addition, learner control is important and reflected a humanistic perspective (Reigeluth & Merrill, 1983). The Elaboration Theory also employed various perspectives and theories in the design of instruction.

Merrill developed a theory which incorporated more of the environment and interactions within the environment for the learning process in the 1990s. In Merrill's Instructional Transaction Theory, emphasis was on the learning transactions and learner guidance to achieve the intended learning outcomes (Merrill, 1999). The instructional delivery environment was one of the subsystems in which interactions with learners occurred through instructional transactions (Merrill, Li, & Jones, 1991). Within the learning environment, interactions, learning resources and tools would be provided.

The development of the principles of several theories showed a trend towards eclectic theories that combined the environment and the social aspect for learning. This development led to the development of the First Principles of Instruction.

First Principles of Instruction: A Synthesis of Instructional Design Theory

The ID theory in this research is the First Principles of Instruction, an eclectic theory which arose from Merrill's (2002) attempt to study empirically the different ID models and theories such as the Component Display Theory, and the Elaboration Theory. The main principles in the theories were consolidated and the basic methods (Reigeluth, 1983) common to these models and theories were distinguished and identified as the first principles of instruction.

Merrill's (2002) first principles of instruction were design-orientated principles that influenced learning. Merrill claimed that these principles could be used to solve real-world problems and design effective learning environments in any delivery system. Instruction should then take into account the four phases of learning: (a) activation of prior experience; (b) demonstration of skills; (c) application of skills; and (d) integration of these skills into real world activities (Merrill, 2002, p. 2).

In this study, the learning environment will be designed based on the First Principles of Instruction to develop a collaborative mLearning module.

Problem

Merrill's (2002) first principles are based on the fact that learning is facilitated when learners are engaged in solving real-world problems. This problem-centered approach is described by Merrill (2002) as a "Let me do the whole task" where the learner would be able to solve real-world problems after being shown and being actively involved in solving problems. However, the first problems that were given as tasks should be simple problems, and then progress towards more complex problem-solving tasks (Merrill, 2002; Reigeluth, 1999) to ensure that learners gain expertise in problem solving.

Merrill (2002) stresses that problem tasks should be authentic, real world and personal to make the tasks meaningful. This increases the relevance of the tasks to the learner (Ausubel, 1968) and builds the learners' confidence (Keller & Kopp, 1987).

In the four phases of the first principles of instruction, Merrill (2002) claims that the learners' existing knowledge must be activated in order to build new knowledge and skills, and before the new knowledge is demonstrated to the learner to be applied and integrated into the learners' world.

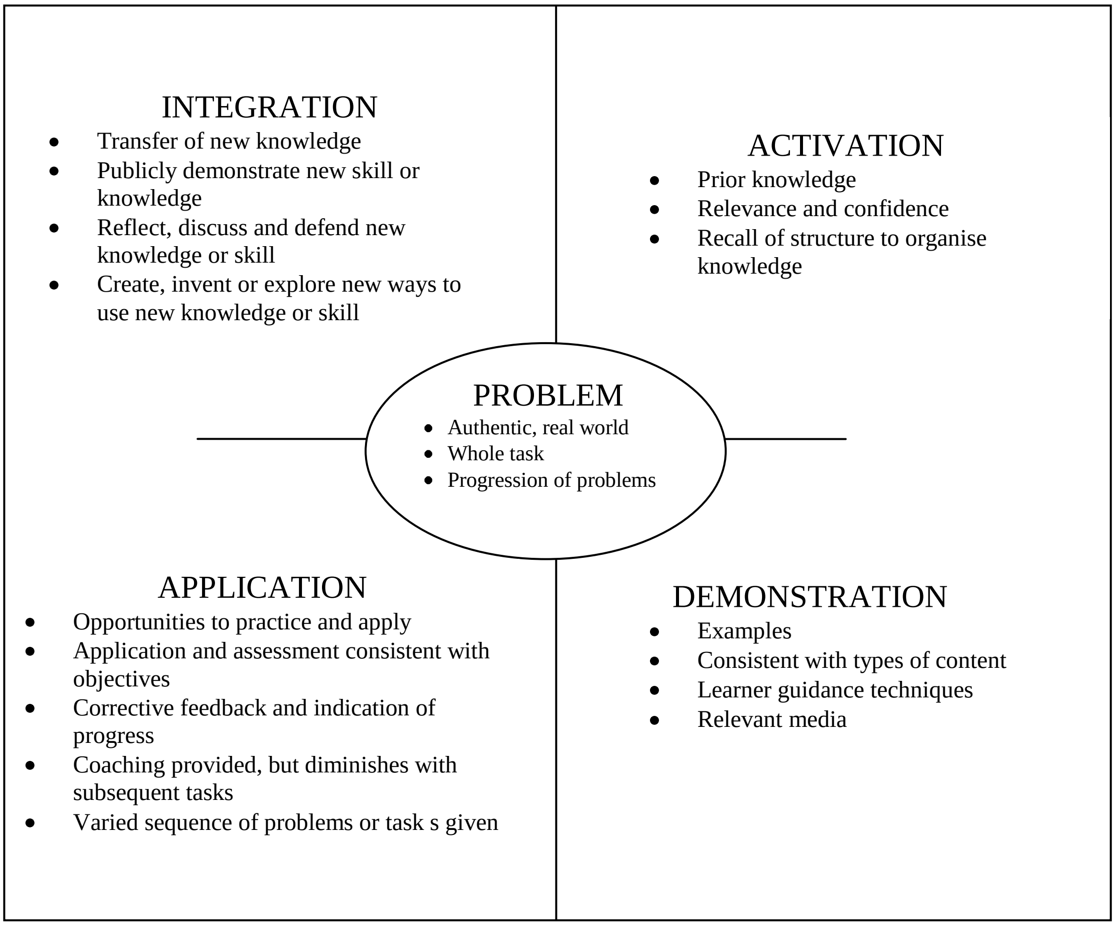


Figure 2.3. First Principles of Instruction, synthesized (Merrill, 2007)

Activation

The initial activation phase activates prior knowledge either by directly requesting the learner to relate or recall, or by allowing the learner to demonstrate and apply his prior knowledge to new situations and experiences which show the relevance of the new knowledge (Merrill, 2002; Merrill, 2007).

The activation of prior knowledge is used in Gagne's events of instruction to gain attention and recall prerequisite knowledge (Gagne, 1970) so as to ensure learner-readiness (Brunner, 1960; Nelson, 1999) for the learning activities that follow. Identifying the learners' entry behavior (Dick & Carey, 1985) is important for planning the next phase of instruction. By ensuring that the new knowledge to be learnt is relevant to the learner (Keller & Kopp, 1987), the learner would have to relate the new knowledge to what he already knows (Ausubel, 1968) in his existing schemas.

Demonstration

The demonstration or "show me" phase should include the demonstration of the learning which would be consistent with the learning goals and content taught (Merrill, 2002). Different strategies of instruction are used for concepts, procedures and processes while appropriate learner guidance techniques should be employed to direct learners' attention, use multiple representations, and to relate the new information to the previous structure in the activation phase. The use of relevant media will facilitate learning (Merrill, 2002; Merrill, 2007).

In Gagne's (1970) fourth event of instruction, presenting the stimulus material provides the learner opportunities to model the behavioral, cognitive or attitudinal change (Schunk, 2000). Different strategies such as summarizers, synthesizers, and analogies may be used to sequence the structure of learning depending on the need for conceptual, procedural or theoretical elaboration (Reigeluth, 1987). Positive and negative exemplars, the use of counter examples, and the use of various cases (Collins, 1987) are methods that can be used to demonstrate learning.

Application

In the application or "let me do it" phase, learners practice by using the new knowledge or skill for solving problems (Merrill, 2002). Practice on "information about" (factual information), "parts-of" (location, naming and description of parts), "kinds-of" (concepts), "how-to" (procedures) and "what-happens" (process to predict the consequences of a process) is required to achieve the learning objectives (Merrill, 2007). Learner guidance for problem solving is given through scaffolding to provide corrective feedback and coaching as the learner solves a sequence of varied problems. This scaffolding is gradually diminished with each task and is slowly withdrawn until the learner can perform without assistance (Merrill, 2007).

This stage is related to several events of instruction: eliciting performance, providing learner guidance, providing feedback and assessing performance (Gagne, 1970). By engaging the learner in the problem solving process and proving sufficient scaffolding, the learner is able to plan and develop solutions to the problem tasks (Nelson, 1999). The learner could form and test hypotheses and consider alternative solutions when solving problems (Collins, 1987). This in turn would enable the learner to see the relevance to the task which he becomes familiar with, and builds his confidence as he is challenged to perform and expects success (Keller & Kopp, 1987).

Integration

In the integration or "watch me" phase, learners integrate the new knowledge and skill into their everyday life (Merrill, 2002). Learners are given an opportunity to demonstrate publicly their new knowledge or skill as they reflect, discuss and defend their new knowledge or skills and create, invent and explore new ways of using their new knowledge or skills (Merrill, 2002).

Integration of the knowledge into the learners' personal experiences ensures that transfer of learning (Gagne, 1970) has occurred. Reflecting, synthesizing and assessing the processes that took place during problem solving enable the learner to formalize the learning experience (Nelson, 1999).

Merrill (2009) later introduced a separate section on implementation under the integration phase to include other aspects that were not in his original theory. According to him, instruction should facilitate learner navigation by using items such as course maps and navigation options on all screens to ensure that the learner does not get lost. This would also ensure a degree of learner control. He also added that collaboration should be structured so that it could be used effectively and that instruction must be personalized to the learner.

Learning Theories

The development of instructional design theories for designing instruction has been influenced by educational psychology. The early theories of design were based mainly on behavioral theories which emphasized designing objectives to define the tasks. When the cognitive skills to process information gained more importance, information processing models of learning influenced instructional design and the systems approach was developed (Snelbecker, 1987). The advent of constructivism has seen the need for the development of newer theories to incorporate building of knowledge and thinking skills.

Most ID theories are not based on one learning theory and many researchers feel that ID should not be concerned with the theories of learning but should use the strengths and weakness of the theories to select the best to be used for learning (Mergel, 1998). This meant that an eclectic approach, which deals with multiple perspectives of learning, is more practical (Mergel, 1998; Merrill, 1983; Perry, et al., 1983; Reigeluth, 1987; Snelbecker, 1987; Snelbecker, Miller, & Zheng, 2006).

Learning theories are descriptive theories as they describe the process of learning. Using a description of learning and developmental theories enables the researcher to develop effective instructional theories.

The act of learning is the process of acquiring new information, which is then transformed and evaluated to determine if it is suitable for a related task (Bruner, 1960). Schunk (2000) has noted three criteria when defining learning: (a) behavioral change or the capacity for change; (b) endures over time, and (c) occurs through practice or other forms of experience to develop new action or modify existing actions. Hence, learning is a change in behavior or the capacity to behave in a certain manner which endures over time, and is a new or modified action.

Social Constructivist Theory

In this study, the main theory that is used to describe the learning processes is the social constructivist theory. This is because there are elements of social and culture in the learning process when learners take part in collaborative mLearning. As in distance learning, in the social learning environment learners have dialogues with tutors and their peers, as well as interact with the materials.

Vygotsky emphasized the importance of the social environment for learning (Brunings, Schraw, & Ronning, 1995; Schunk, 2000; Vygotsky, 1981). Learning and thinking develop through the individual's interaction with the world through social experiences and social interaction (Gredler, 1997). External social factors and internal personal factors integrated with the environment promote learning (Brunings, et al., 1995; Schunk, 2000).

In the external environment, cultural tools which include physical objects in a shared culture, to more abstract social tools, such as language and social institutions like schools assist in the development of the learners' thinking (Brunings, et al., 1995; Schunk, 2000). Signs, symbols and tools such as language, written letters, scientific language and scientific symbols assist in building scientific knowledge. Without these signs and symbols, the process of thinking may be hampered. Vygotsky viewed cognitive function as resulting from the learner's social interactions in a cultural context (Brunings, et al., 1995).

The meaning of the signs and symbols are learnt through social interactions of members in the culture, in this case the community of learners. Cultural tools used in social interactions are internalized and processed for cognitive change to occur (Brunings, et al., 1995). Tools like the instructional module, video and web pages assist in enabling the learner to interact and actively adapt to the environment. The community of learners forms their own culture as they use the discussion forum, wiki, and text messaging for dialogue and interaction. Hence, the setting for learning, the major concepts and ideas in learning, the means of communication, and ways of viewing the world are part of the culture of the community of learners (Gredler, 1997).

The instructional tasks designed in science will have to take into account the social and cultural factors in the learning environment. Instruction should allow for modeling, peer collaboration, and instructional scaffolding.

Modeling Instruction

The learner may need to be taught first the basic concepts in science in order to maximize development (Gredler, 1997). When a learner has to complete a problem task initially, he may need to collaborate with others to solve it. However, his experience will later enable the learner to solve the task independently when he reaches a higher developmental level. Hence, in the social constructivist learning environment, the learner may initially need to consciously learn and master basic concepts.

Learners need to be taught the cultural tools by teachers (Karpov & Hayword, 1998). For science, teachers should teach the scientific method for it to be internalized as a cognitive tool before learners are asked to identify and model important characteristics of objects and events (Karpov & Hayword, 1998). Although scientific concepts need the acquisition of verbal knowledge and the mastery of certain procedures, Vygostsky believed that learners who have gained experienced and developed cognitive skills will have better scientific process skills (Karpov & Hayword, 1998).

Vygotsky (1981) also believed that teachers who give learners scientific definitions without internalizing the definitions, were just giving meaningless verbal definitions to the learner. He felt that scientific knowledge was best taught in a course of discussion with the teacher, and through the sharing of personal experiences in a research activity.

Learners can only achieve a certain level of mastery and expertise through modeling instruction. There is a difference between what the student can do and learn on his own through his interactions, and what he can achieve with expert help. The gap between the students' understandings and skills compared to that of an expert is called the zone of proximal development (ZPD). With sufficient help, either from his peers or from the teacher, the learner has the potential to achieve a higher level (Brunings, et al., 1995).

Peer Collaboration

Vygotsky's theory emphasizes social context and collaboration. Each individual is different and hence, needs to be provided different activity for participation in discussions and problem solving. When the learner is given guidance and acquires cultural knowledge through interactions, cognitive change can occur. As learners participate in a wide range of challenging activities with peers, integrating the new experiences with their own experiences, they construct better understandings (Berk, 2006; Schunk, 2000). This form of learning is collaborative in nature and assumes that human intelligence originates in society or culture, while individual cognition results from interpersonal interaction within that culture and community (Vygostky, 1978; Jonassen, et al., 2005).

Learning can only take place within a community of learners when learners have sufficient science knowledge and science methods to solve concrete problems in a course of a collaborative activity. Learners of varying abilities can work together in teaching and helping each other through peer collaboration (Berk 2006). This aspect of collaborative learning which assumes that learners are interdependent on one another and must cooperate knowingly towards a goal fits into the social constructivist framework.

Important elements in collaborative learning are the participants, the tools they use, and the social institutions that these tools are in. Cognition is distributed among the tools and the individual. Learning is situated and dependent on social cognition (Jonassen, et al., 2005). Peer collaboration enables the learners to internalize the learning, thus ensuring the ZPD is narrowed.

Instructional Scaffolding

In instructional scaffolding, the learner is provided selective assistance by the teacher through the use of cognitive mediators (Schunk, 2000). These cognitive mediators are signs, symbols and language and include guided questions, drawing attention to certain important aspects, and providing guidance and hints on strategies to be used to reduce the ZPD (Schunk, 2000). The support is gradually withdrawn as the learner approaches the expert's level (Schunk, 2000; Brunings, et al., 1995). The learners integrate the dialogues they had with the experts and use it to organize and internalize their thoughts (Berk, 2006).

Teachers can guide learning through assisted discovery, tailoring their interventions to each child's ZPD. Assisted discovery mean the learners are given opportunities to talk about science, while teachers inform, correct and ask them to explain, ensuring that learners reflect on their thought processes to shift to higher levels of cognitive activity (Berk, 2006).

In a constructivist framework, learners are active agents who construct their own knowledge by reflecting on their thoughts while the teacher provides modeling and scaffolding. In this study, the social constructivist theory is used to develop instruction, explain and interpret the environmental observations in the research process. A collaborative learning environment would be designed. In this learning environment, learners interact firstly with the problem or the task assigned. There is also opportunity for interaction with other learners in a collaborative work space or the discussion forum, where questions can be forwarded and debated on and collaborative work done. To support learning, scaffolding in the form appropriate feedback will be provided when necessary. The scaffolding is not only through CMC but also through text-messaging, making the environment a collaborative mLearning environment. The conceptual model of the interactions in the collaborative mLearning environment is as in Figure 2.4.

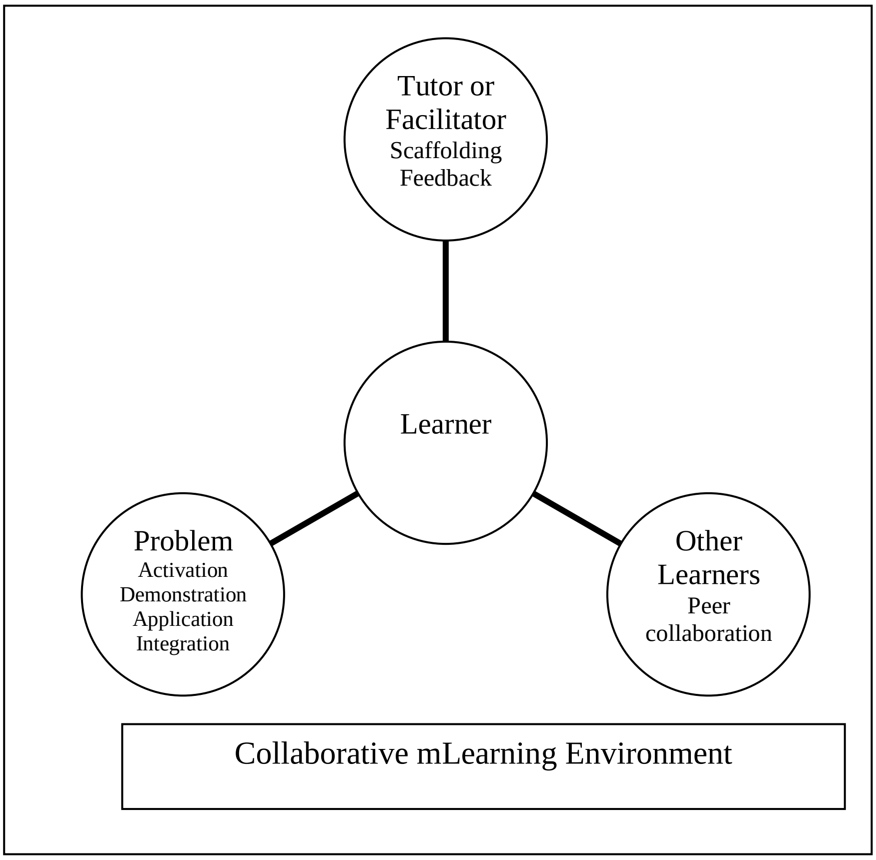


Figure 2.4. A conceptual model for a collaborative mLearning environment

The Attribution Theory

The attribution theory provides an explanation on the aspect of motivation in the use of the collaborative mLearning module and environment. This may provide an explanation on the learners' perception of the difficulty of the module.

The basis of the attribution theory is that there is a tendency for one to try to attribute the reasons for the causes of outcomes in one's life. This tendency was the basis of studies on achievement behavior which led to the development of the attribution theory (Schunk, 2000). The achievement and lack of achievement in tests has been attributed to several causal factors: ability, effort, task difficulty, luck, mood or illness, and help from others (Gredler, 1997). This theory makes the assumption that people are inclined to seek information, form attributions, and to assign causes.

The model of causal attribution (Weiner, 1996) represented the causal dimensions as being: (a) internal or external to the individual; (b) relatively stable or unstable over time; and (c) controllable or uncontrollable by the individual (Schunk, 2000). However, there are other influences. Attributions are also formed by the meanings that have been learnt through prior experiences, or "situational cues." Success that was earned easily, physical exertion on motor skills required, mental effort or persistence over cognitive tasks, and social norms are situational cues that may contribute to success in achievement.

Attribution will influence beliefs, emotions, and behavior and contribute to motivation. Firstly, the "stability dimension" is related to the "expectancy of success" (Weiner, 1996). Assuming that the task conditions remains the same, the expectancy of success can be attributed to stable causes, such as high ability and lower task difficulty. High ability and easier tasks result in higher expectations of future success. The expectation of success and emotional reaction are related (Schunk, 2000).

Secondly, the “locus dimension” relates to “affective reactions” (Schunk, 2000). When one succeeds, one experiences greater pride; but when one fails, there is greater shame. Both these examples are attributed to internal causes. Further, students have greater pride when they achieved the activity on their own ability and effort rather than when they perceived external factors such as teacher assistance or the ease of task assigned, to be responsible.

The “controllability dimension” has mixed effects. Feelings of control contributed to the promotion of choosing to engage in academic tasks, effort, persistence at difficult tasks, and achievement (Weiner, 1996; Schunk, 2000). Students who do not have much control over their academic outcomes have low expectations for success and low motivation to succeed.

As a summary, it can be assumed that there are multiple causes on information about outcomes. However, people’s belief systems and cognitive analyses form the positive and negative outcomes expected. In addition, expectancies, self esteem and the tendency to engage in achievement related behaviors are perceived causes of outcomes. The components of motivation are related to the attribution: ability, effort, task difficulty, mood or illness, luck and others; and the dimensions of locus of causality, stability and controllability**.**

The attribution theory is applied to the design of the collaborative mLearning module. In considering the role of the tutor in providing instructional scaffolding, the scaffolding should be positive attributional feedback regarding the competency of the learner. This will increase the learners’ self-efficacy and motivation.

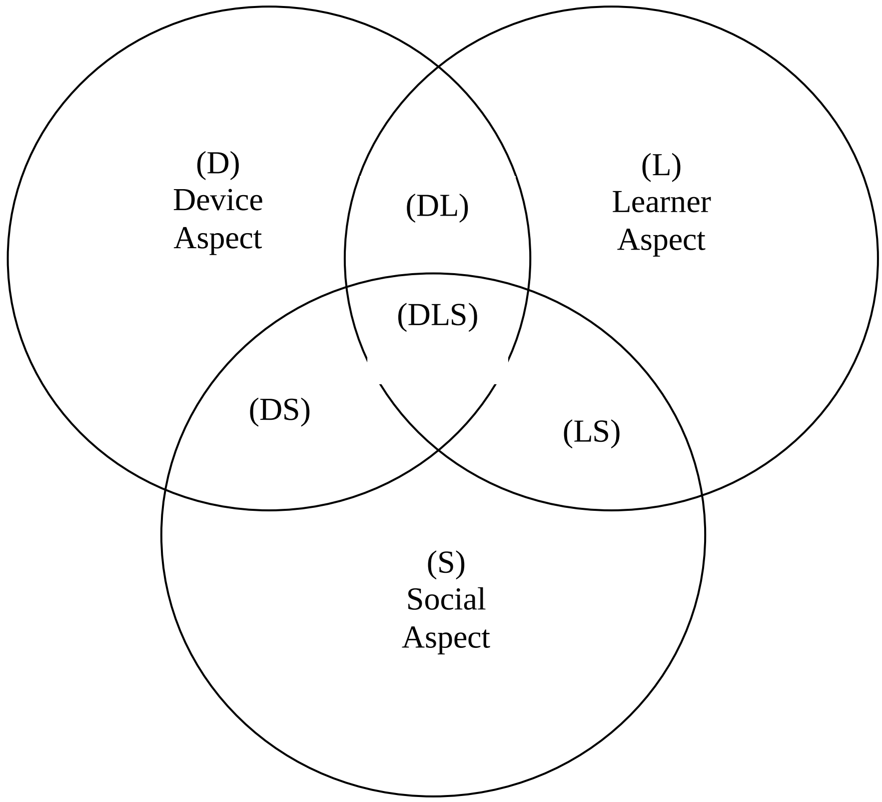
The structure of the classroom provides attributional effects. The competitive conditions in the classroom will appeal to some students, but not to others. For such a situation, consideration for group work to be rewarded for collective performance, not individual performance, should be given to reduce the difference.

The attribution theory was used to explain the learners' use of the collaborative mLearning module and environment.

A Framework for Collaborative mLearning

mLearning is a relatively new area of learning and there have not been many models developed which can describe the mLearning environment. The Framework for the Rational Analysis of Mobile Education (FRAME) is one model which is used in this study in an attempt to describe the collaborative mLearning environment.

In the Framework for the Rational Analysis of Mobile Education (FRAME) model (Koole, 2009), three main aspects are considered: device (D); learner (L); and social (S). The device aspect (D) emphasized the physical and technological aspect of the device, such as the size, weight and portability of the device; and the input and output capabilities of the device, whether a stylus or keyboard is required for input, and what monitors or speakers are required for output. This framework is based on the social constructivist theory of learning as the learner aspect (L) takes into account the learners' cognitive abilities, memory, prior knowledge (Ausbel, 1968), emotions and motivations (Schunk, 2000). The social aspect (S) will describe the processes of social interaction through discussions, and cooperation.



DL: Device Usability
DS: Social Technology
LS: Interaction Learning
DLS: mLearning

Figure 2.5. The FRAME Model

In the FRAME model, the intersections refer to the interactions of the two aspects in consideration. The intersection of D and L refers to the device usability (DL), where characteristics of the device are related to the users' satisfaction and comfort in using the device for learning. The intersection of D and S refers to a community (DS) using the device for communication and collaboration. These would include the CMC tools for communication and collaboration. The intersection of L and S represents the theories of learning and instructional theories used in the design (LS). In this research, Merrill's (2002) first principles of instruction is used with the theories of social constructivism. Interaction stimulates learning in a real environment while communities of learners are interacting (Koole, 2009).

Finally, in the FRAME model the section ‘DLS’ is the intersection of all three aspects of D, S, and L. In the DLS section there is collaboration among learners, access to information and contextualization of learning. The tasks designed for mLearning should allow for collaborative problem-solving where online artifacts are used to support and mediate learning. The learner learns through authentic learning experiences, identifying relevant information and forming patterns and relationships (Koole, 2009). This section, DLS, relates to the process of collaborative mLearning.

Summary of Theories

The underlying theories in this study are theories of ID and learning. An eclectic theory of ID, the First Principles of Instruction, was used to design instruction. Specifically, the problem and tasks in the learning environment, and the principles of social constructivism were incorporated in the instruction as the tutor provides scaffolding, motivation and feedback within the environment. In the learning process, the social constructivist theory and the attribution theory provides an explanation for the observations of the processes internalized by the learner. The collaborative mLearning environment is further explained using the FRAME model.

Chapter Summary

In this chapter, the nature of science was discussed in relation to the importance of acquiring the scientific methods to develop scientific knowledge. Communicating in science is integral to developing scientific thought in the scientific method. CMC affords communications in science and offers many benefits in a collaborative mLearning environment. Hence, using an eclectic ID theory which emphasizes meaningful learning and social interaction, in a social constructivist framework, a collaborative mLearning module was designed. This module is described in the framework of the FRAME model for the collaborative mLearning environment.