

Online Communication: The Implementation of the Collaborative mLearning Science Module in a Malaysian Secondary School

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Abstract: Communication skills are required for collaborative discussions among scientists in constructing science knowledge. A collaborative mLearning (CmL) module with online communication tools (discussion forum, wiki, and text messaging) can enable authentic discussions for learning of science outside the classroom. This study seeks to determine whether online communication and collaboration is effective for learning. A developmental research approach with three phases of needs analysis, design, and implementation was employed. An urban school with a multiracial composition was selected for this study. In the Needs Analysis phase, a survey of 158 learners' background in the use of technology was conducted to determine the types of tools which can be used in the CmL module. The module was implemented with twenty (20) selected Form 2 students to determine the types of interactions in their online discussions. Transcripts of their online communications were analyzed according to the types of interactions and processes; the learners were interviewed to verify if learning was effective in the CmL module. The findings showed that learners interacted with the content, instructor, and other learners in the discussion forum. However, only learner-content interaction was detected in the wiki, and learner-instructor in the text messaging SMS Quiz. Findings from interviews verified that learning was effective in the CmL module. In addition, the discussion forum allowed for argumentation to challenge the dualism of science knowledge. This study is significant as it shows that online communication tools force collaboration and are effective for teaching science. [DeWitt D, Norlidah A, Saedah S. **Online Communication: The Implementation of the Collaborative mLearning Science Module in a Malaysian Secondary School.** *Life Sci J* 2013;10(1):1352-1363] (ISSN:1097-8135). <http://www.lifesciencesite.com>. 204

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1. Introduction

Scientists need to have good communication skills. Communication is important for making meaning out of scientific discussions arising from experimental findings. Communication skills are required in order to debate and defend scientific arguments (Nielsen 2012). Communication and collaboration are skills required in the real world of science. This is because scientific discovery does not occur in isolation with one scientist making conclusions, but with interactions among other scientists, within a community of peers (Sharma & Anderson 2009). In reality, scientific processes occur when there is collaborative communication among scientists (Hogan & Fisherkeller 2005). As scientists defend the case from their research perspective and try to convince their peers, they require specialized communication skills (Sharma and Anderson 2009).

In order to write convincing reports to argue their viewpoint, scientists need to have good writing skills. Written communications forms an important resource for reference among other scientists (Kubli 2005). However, it is noted that written scientific documents in the original form are not popular for reading even among scientists (Goodney and Long 2003). Hence, science learners should have both reading and writing skills for effective communication

in order to contribute to building knowledge in the scientific community (Dodick, Argamon and Chase 2009).

Communication in science should be emphasized in order to teach the nature of science. Teachers seem to have a dualistic perception of the nature of science knowledge (Emdin 2010). In Malaysia, teachers seem to encourage students to memorize the facts of science as they perceive there is insufficient time for science instruction in the classroom (Lee 1991; Sophia 2002; Tan 2002). There is also little time for communication and collaboration in the classroom, and social interactions are conducted at a lower cognitive level. This situation seems to be similar some urban schools in America (Emdin 2010).

Very few studies have been done on communications in science instruction, and even less on using online communications. However, online communications can be employed to address this problem of limited time for collaboration and communication, and to enable science learners to experience the nature of science in their communications as they contribute to the body of knowledge. Science learning is optimized and thinking skills are enhanced while motivation increases with online communication tools (Driscoll 2007; Guzdiyal and Turns 2000; Kaye 1992; Jonassen,

2000; Jonassen, Lee, Yang, and Laffey 2005; Osbourne and Hennessy, 2003; Slotta and Linn 2000).

This study seeks to determine if collaboration using online communication tools such as text messaging, discussion forums and a collaborative online workspace, wiki, is effective for learning science. A collaborative mobile learning (CmL) module would be developed based on the survey of technology tools accessed by the learners in the context. This module would be implemented with a group of learners to determine the type of interactions and processes occurring. It is believed that online communication tools enable interactions for collaboration which allows the nature of science to be observed during the construction of knowledge, in an authentic manner similar to the processes encountered by actual scientists. This study is different from other studies as firstly it focuses on online communications for teaching the topic of nutrition in science which attempts to depict the nature of science through an argumentative approach using written communications. Secondly, it uses online collaborative communication in an environment natural to the younger learners who are already engaged with these tools. Thirdly, the online communication interactions are investigated to determine if they encouraged higher level cognitive processes which contribute to knowledge-building during the given tasks.

Furthermore, this study is significant as it would determine whether online communications can be used for teaching science infused with the elements of the nature of science. Science teachers can use the findings of this study to design instruction which enable teaching for the nature of science while allowing for communication among peers. As scientists may already be using online communications in the written form in communities of practice, researchers in science education need to be aware of the types of online communications taking place among scientists.

In this study, a collaborative mLearning (CmL) module was designed to teach science to address the need for collaborative communication in the science classroom. The problem of insufficient time for collaboration, communication and other interactions in the science classroom can be resolved using online communication tools as science tasks can be completed out of the formal classroom. In addition, the CmL module employed tools such as discussion forums, wikis, and text messaging, to allow for written communication and collaboration. This also addresses the need for improving science learners' skills in written communication in science.

This study is aimed at determining if the CmL module developed using collaborative and

mobile learning is effective for learning science among students. A developmental approach was employed (Ritchey 1997; Wang and Hanafin 2005) in which the module was developed based on learners' background in using technology. During the module implementation, the types of interactions and processes in the online communications among the students in the context of the study were recorded and analyzed to determine the cognitive processes occurring.

As the CmL module employed three types of tools, the types of written interaction in each tool were identified. This is important as it would determine if written communications enabled learning in science to occur. The research questions are:

Need Analysis Phase

What are the communications equipment which the learners in the context of the study have access to?

What is the frequency of use of the technology communication tools among the learners in the context of the study?

Implementation

What are the types of interaction in the technology communication tools in the CmL module? What are the processes (cognitive, social, teaching, attitude and noise) during the interactions in the online communications in the CmL module?

Is the CmL module effective for learning?

2. Communication for Learning Science

Communication is important in the process of acquiring scientific knowledge. Communications in science requires a language structure with vocabulary and rules to make meaning (Nielsen 2012). The vocabulary of science is the scientific verbal knowledge which may be specific to the discipline of science. The scientific verbal knowledge is the first aspect required for making meaning out of the experiences in science (Goodney and Long 2003; Hoyle & Stone 2000; Karpov and Haywood 1998; Nielsen 2012). The scientific verbal knowledge in combination with language structures enable learners to construct meaningful phrases and sentences to communicate their thoughts, develop science concepts and give feedback (Hogan and Fishkeller 2005; Hoyle and Stone 2000; Karpov and Haywood 1998).

Discussions based on higher level interactions enable learners to better recall and transfer these concepts (Emdin 2010). Hence, discussion on science concepts, activities and experiences will enhance learning. However, Emdin (2010) noted that different levels of discussions can occur in classrooms. Higher level interactions involve explanation and meaning-making of the science processes while low level interactions involve little

discussion about science, but include lots of gestures and noise. His study of the interactions in a science classroom in an urban school showed that higher level interactions improve learning but low level interactions among learners do not enhance learning and recall (Emdin 2010). This study verifies the findings from other research that discussions and communications in science improves the quality of learning compared to the memorization of science facts (Kubli 2005; Sharma and Anderson 2009).

On the other hand, discussions with higher level interactions, which attempt to interpret and analyze findings of experiments, contribute to new scientific facts. There is no specific rule for deriving these scientific facts but the discussions during the attempt of making meaning of the information in the natural world contributes to the construction of scientific knowledge (Sharma and Anderson 2009). Hence, interactions during discussions such as questioning, arguments and debates encourage the construction of science knowledge. These forms of interactions develop critical thinking skills as differences of opinions are resolved in reaching mutual understanding (Hoyle and Stone 2000; Kampourakis 2010; Karpov and Haywood 1998; Kim & Song 2005).

The nature of science indicates that scientific knowledge is theory-laden, yet tentative. Science is part of human culture and is influenced by elements in the culture it resides in (Lederman 2007). Hence, the nature of science knowledge should be exposed to learners through the processes of discovery of new knowledge. However, the new knowledge may be in conflict with the existing knowledge, which will then require reinterpretation of the knowledge (Emdin 2010). This interpretation of knowledge is dependent on the learners' perception of the nature of science knowledge.

The four stages of the nature of science knowledge are: dualism, multiplicity, relativism, and contextual relativism (Oliveira, Akerson, Colak, Pongsanon, and Genel 2011). In dualism, knowledge is absolute and is viewed as a collection of facts; while the multiplicity approach treats knowledge as being diverse yet uncertain with accuracy determined by an authority. The relativism approach sees knowledge as being tentative and truth as relative as everyone is entitled to an opinion whether right or wrong while the contextual relativism approach treats knowledge as complex, contextual, and open to reevaluation where the accuracy, right or wrong, depends on specified contexts, and adequacy judgments.

The reality in Malaysian classrooms indicates the teachers' perception of the nature of science knowledge is in the dualism stage. Teachers prefer to teach the facts of science, stressing on memory work

among the learners rather than allowing them to communicate and collaborate to develop hypotheses and conclusions through experimentation (Lee 1991; Sopia 2002; Tan 2002). Science knowledge is not dualistic but relativistic in nature as science knowledge is not absolute and there is no correct and wrong answer (Oliveira et al. 2011; Sharma and Anderson 2009). Hence, instruction should be designed to take into consideration and correct the science teachers' misconceptions of the nature of science (Oliveira et al. 2011)

In conclusion, scientific knowledge constructed through discussions among peers in order to draw conclusions from scientific discoveries needs higher level communicative skills for argumentation and persuasion of a scientific proposition to defend ones' claims (Emdin 2010; Kampourakis 2010; Sharma and Anderson 2009). Learners of science should be aware of the relativism in the nature of science and be able to practice presenting and defending their findings as a process of communicating in a culture of science. This is required because scientists in the real world work in a social context and interact with communities of other scientists, communicating within a culture of science (Emdin 2010; Sharma & Anderson 2009). Hence, Science learners should also be understanding and practicing in a similar culture of scientific discovery, communicating and collaborating with their peers as part of the building of scientific knowledge (Emdin 2010; Nielsen 2012). The component of scientific communication as a nature of science should be included in science instruction to avoid the misconception that science is only knowledge and processes (Nielsen 2012).

3. Communicating Science in the Classroom

In science, communication is not taught formally in the classroom. Learners acquire scientific verbal knowledge (vocabulary) and language structures of science by observing patterns and models during social interactions (Karpov and Haywood 1998; Sharma and Anderson 2009). The collaborative communications during these social interactions assist learners in identifying patterns of science language to model and build their personal scientific verbal knowledge (Hogan and Fishkeller 2005; Hoyle and Stone 2000). At the same time, their peers scaffold as they assist each other in understanding the task during their interactions (DeWitt and Siraj 2008; Karpov and Haywood 1998).

Science instruction in the classroom should consider the importance of developing communication skills in teaching for the nature of science. A structured form of science instruction should be designed to incorporate collaborative communication

in the science classroom. Vygotsky believed that learners should be taught scientific concepts in the same way as in foreign language instruction (Kubli 2005). This is because words are “tools of thought” (Kubli 2005) which are manipulated to make meaning. Instruction should enable interactions with other learners, the tutor and learning materials (Kim & Song 2005; Sharma & Anderson 2009).

Collaborative communication approaches such as Socratic dialogue and problem solving make learning meaningful (Kubli 2005; Sharma and Anderson 2009). Problem-solving tasks have been shown to be effective for student-centered learning where learners take responsibility for their own learning (Johnson and Johnson, 2004). Meaningful and authentic tasks ensure that enriching and creative ideas can be shared in the group during problem-solving activities (Jonassen et al. 2005; Kaye, 1992; Palloff and Pratt, 1999; Puntambekar 2006; Siraj and Norman 2012; Vaughan, 2010; Woo and Reeves, 2007). Interactions can enhance the learners’ current understandings of science concepts and principles as learning becomes meaningful.

In this study, Socratic dialogue and problem solving will be conducted online, respectively, on a discussion forum and a wiki, which is accessed through the class web page. These online interactions will be permanent in a written form for all learners to view and model their interactions. Written communication is also important in developing learners’ writing skills. Resources such as textbooks have been used to provide information to scaffold and motivate the learner (Kubli 2005). In this study, web resources through information and links on the web page will be used as a resource to scaffold the learner.

Science instruction in a context and culture which the learner is familiar and engaged with enhances learning. A study which integrated the hip-hop culture, focused on communication, increased participation in the science classroom (Emdin 2010).

Online communication tools have been employed in science for collaborative learning. Studies have shown that online tools such as wikis and discussion forums can scaffold science learning (Guzdial and Turns 2000; Slotta and Linn 2000). Learners are able to improve upon their task, give feedback and have authentic discussions (Osbourne and Hennessy, 2003). This enables a higher level of reflective and constructive thinking for critical thinking (Jonassen, 2000; Jonassen et al. 2005), and increases motivation in learning (Driscoll 2007; Kaye 1992).

Collaborative learning is the acquisition of new knowledge, skills and attitudes occurring as a result of interactions in a group (Jonassen, Lee, Yang, and Laffey 2005; Kaye 1992) while mobile learning,

or mLearning, is the acquisition of new knowledge and skills anywhere and anytime (Geddes 2004; Saedah 2005). mLearning can take place using either mobile phones, or networked computers to access the internet from not only school, but from the home, library, access centers, or cybercafé at any time of the day. When collaborative and mobile learning are combined, Collaborative mLearning (CmL) is the acquisition of new knowledge and skills anywhere and anytime as a result of interactions through communications in a community and culture of learners. These interactions include postings on wikis, discussion forums and text messages online or through the mobile phone.

The culture of participatory learning in a collaborative environment for social interactions is afforded by online tools (Bonk et al., 2009; Pifarré and Li 2012). Learners gradually become experts as they participate in the active learning process while they build knowledge (Bonk et al. 2009; Pifarré and Li 2012; Zhang et al. 2007). As they gather and evaluate the information and knowledge, learners assimilate and apply the knowledge in solving problems (Biasutti and El-Deghaidy 2012). At the same time their peers and instructors scaffold the learners to help them achieve expert status (Whipp and Lorentz 2009; Pifarré and Li, 2012; Zhang et al., 2007).

Using online communications in learning has many advantages. Reading and writing skills as well as conceptual understanding improve (Imperatore, 2009; Lee, 1999; Shihab, 2009); learners also develop reasoning abilities and critical thinking (Bonk et al. 2009; Biasutti and El-Deghaidy 2012; Higdon and Topaz 2009; Zhang et al. 2007); gain confidence in using online tools effectively (Ertmer et al. 2011) and become more creative as they interpret and reorganize the information gathered to be presented in a different way, and collaborate with others (Biasutti and El-Deghaidy, 2012; Pifarré and Li, 2012).

The full potential of online communications for teaching science needs to be investigated further to study the impact of online communication on social and cognitive processes in learning (Ertmer et al. 2011). The type and quality of interaction in different web-based tools may also differ and will need to be investigated (Huang, 2010). For example, wikis have been used in secondary schools science for collaboration work and communication to document the process of scientific inquiry (DeWitt 2010; Hannafin et al. 2009). A wiki is a public web page that can be accessed and edited by anyone. Learners can post information, and their peers can add on to the document and edit it. The wiki enables collaboration to be designed in the instruction for construction of knowledge, and this information can be shared with an audience in an online portal (Bonk et al. 2009). This

asynchronous communication tool allows not only the sharing of knowledge and information on a webpage, but also transforms knowledge as the learners involved in creating the web page generate, share and reshape knowledge on the wiki (Bonk et al. 2009). These interactions resemble the processes of generating knowledge which scientists go through.

However, lack of interaction between learners involved in online communication activities has been shown to be attributed to lack of motivation to contribute in the wiki, mainly due to learners' lack of knowledge in the subject matter (Ertmer et al. 2011; Huang, 2010). Learners perceived that they would be judged negatively for giving the wrong answer (Ertmer et al. 2011).

Discussion forums are similar to bulletin boards which are platforms for sharing information. Forum comments can be viewed by everyone and the questions posted can be answered by anyone. Some forums restrict access to registered members only. The Knowledge Integration Environment (KIE) is a platform with an online asynchronous discussion forum for social and collaborative learning in science (Slotta and Linn 2000); it allows the storage of web resources, and provides scaffolding in the form of tips and guidance for the activities. The participating learners found the system useful for learning science as they were able to evaluate web pages effectively and ask relevant science questions (Slotta and Linn 2000). Another discussion forum, CaMILE, was effective for learning science as it encouraged learners to communicate and collaborate on science inquiry projects (Guzdial and Turns, 2000). However, both platforms did not use have any text messaging feature.

Text messages sent through the mobile phone Short Messaging System (SMS) can also be used for teaching science. Text messaging has been used for language instruction (Capuano, Gaeta, Miranda, and Pappacena 2004); when combined with other tools, text messaging is effective for learning (Arrigo, Gentile, Taibi, Chiappone and Tegolo 2004; Rau, Gao and Wu 2008). Hence it is possible to use text messaging with other online tools such as wiki and discussion forum.

Collaborative mLearning has been successfully implemented for inquiry-based teaching approach in science with the use of social media tools such as wikis and discussion forums (Guzdial and Turns, 2000; Slotta and Linn, 2000; Spa, 2004; Turcotte, 2012; Zhang et al. 2007). Socratic dialogue, authentic problem-solving and project-based learning approaches are best used with collaborative workspaces for interaction in a social context as they encourage reflection and critical thinking in learning (Jonassen et al. 2005; Osbourne and Hennessy 2003; Siraj and Norman 2012) and increase learners'

motivation (Driscoll, 2007; Kaye, 1992; Mayer, 2011).

In the Malaysian context, research is lacking on the use of a combination of online tools on a CmL platform for teaching science. It is hoped that this study will provide insights in this new area of science education. The relativism in the nature of science can be promoted in the discussion forum to encourage different opinions and views among the learners to show the many possibilities and answers to a problem, and not the dualistic nature of having only one correct answer.

Designed based on social constructivist learning theories the CmL module encourages communication and collaboration (Schunk 2000). Firstly, there must be sufficient activities for discussion to assist learners in building their personal understanding of scientific concepts and principles (Hoyle and Stone 2000). Secondly, opportunities for patterning and modeling should be provided with individualized support. The scaffolding will assist learners who have difficulties with the language of science (Ellerton 2003; Hoyle and Stone 2000; Merrill 2002). Opportunities should also be given for learners to link the science knowledge with their own personal experience (Ellerton 2003, Merrill 2002). Finally, there should be social interactions to motivate and engage learners in carrying out activities successfully and build meaningful science knowledge (Brown 2006).

The CmL module has problem tasks and allows for online group discussion. Modeling can occur from the artifacts such as the instructional material, tasks on wiki and comments on the forum and text messages while scaffolding is provided through interactions with peers and the tutor.

In distance learning, the theory of transactional distance explains the reason for the need for interactions. A shorter transactional distance (TD) means better communication between learner and instructor. In online communication, the gap can be reduced through dialogs between the learner and instructor in the form of interaction (D), structure of the course content and delivery (S), and the instructor enabling and learner exercising autonomy (A) (Moore 1993). The interactions in the online environment will be observed to determine whether learning occurs. Three types of interactions can occur: between the learner and content, between the learner and other learners, as well as between the learner and the instructor (Moore and Kearsley 2005). In this research the framework of these three types of interaction was used to determine the interactions in the CmL module. These interactions were further analyzed to determine the cognitive, social, teaching and attitudes processes.

4. Material and Methods

This research takes on a developmental research approach in which a CmL module was developed based on the data from the first phase, the needs analysis (Ritchey, 1997; Wang and Hanafin, 2005). Based on the input on the communication tools the learners were familiar with, the module was developed and then implemented with a smaller group of learners for data collection.

a. Needs Analysis

In this first phase, a survey was conducted on the ownership and access to communication tools among students in a selected urban secondary school in the Klang Valley in Malaysia. The school was selected based on the enrolment which reflected the proportion of the multiracial student community in Malaysia. A total of 158 fourteen-year-old Form 2 students were surveyed to determine the types of technology tools they could access.

The CmL module on the topic of Nutrition in science was designed based on The First Principles of Instruction (Merrill 2002) and the social constructivist learning theory (Schunk 2000). The module consists of five online lessons, an initial face-to-face orientation meeting to the module, and a final face-to-face meeting (Table 1).

The findings of the first phase were taken into account to develop the CmL module. The three communication tools were chosen based on the findings of the needs analysis phase: wiki, discussion forum and text messaging. The CmL module would have a main problem task as group work on the wiki. Discussion questions which were smaller problems related to the main problem task would be posted on the discussion forum and answered individually on the forum. In addition, SMS Quiz, through text messaging, was pushed to learners' mobile phones. Feedback could be given during the learning process in all the tools by both peers and the instructor.

Table 1. List of lessons in the CmL Module

Lessons	Title
Initial ^a	Orientation to module
1	The classes of food
2	Special diets (balanced meals)
3	Tests for food classes
4	Counting calories
5	Food in customs and cultures
Final ^a	Summary

a. Implementation

The CmL science module was implemented with a group of 20 student volunteers, comprising

equal numbers of high, medium and low achievers in science. Laptops with internet access were made available to participants to access the CmL module during school hours while text messaging would only be sent to mobile phones after school hours as mobile phones were not allowed in schools. During the implementation, data were collected from the records of communication on the tools used and personal journals, as well as interviews with the learners. The written communications were coded for the types of online interactions (Moore & Kearsley, 2005) which were further analyzed to determine cognitive, social, teaching processes, and attitude. The coding and analysis was verified and validated by a second reviewer.

The Community of Inquiry (COI) Framework uses social, cognitive and teaching presence to investigate online discourse and collaboration (Garrison et al., 2010). Shedletsky (2010) included an additional category, discourse, to the original three presences of cognitive, social, and teaching processes. Attitudes enabled the affective aspect to be captured, while noise, was any communications which could not be identified. The complete list of interactions is in Table 2.

Later studies included attitudes and noise as interaction (Pinzon-Salcedo, Barros, Zarama, de Meza, Carulla, and Bejarano 2008). While some researchers indicate there is little evidence of cognitive processes like critical thinking in students' online communications (Garrison, Anderson and Archer, 2010), others have found more evidence of critical thinking in the online communications as compared to face-to-face communications using this framework (Heckman and Annabi, 2005; Shedletsky, 2010).

Interviews were conducted after the module implementation to evaluate the effectiveness of using the usability evaluation method framework (Chai and Chen, 2004; Norlidah, Saedah and Vanitha, 2011). The final-user evaluation in retrospective was conducted through interviews and analyzed to determine user reactions to the effectiveness of the CmL module for learning.

Table 2. Categories for analysis of online communications (Shedletsky 2010)

Category	Explanation
Cognitive Process	Components of critical thinking as follows:
• Triggering	Messages encourage thinking about issues, posing a problem
• Exploration	Messages relate and connect but are not supported, a search for information
• Integration	Messages are supported and

	build on previous messages; construction of a possible solution
• Resolution	Messages develop a hypothesis and suggest ways to test and defend the hypothesis – an assessment to the solution
Social Process	Characteristics of social interaction such as cohesiveness.
Teaching Process	Design of the learning experience, delivery and facilitation of students
Discourse Process	Responses between learners, and learners and instructors

In this study the types of interactions and the level of cognitive processes occurring in the online communications were investigated. Verification of the effectiveness of the CmL module using online communications for learning science was done through usability evaluation.

5. Results

The findings are described according to developmental research, according to phases. The findings of the needs analysis would contribute to the design of the CmL module. During the implementation phase, the transcript of the online communications, journals and interviews were coded and analysed according to the categories.

a. Needs Analysis

In the needs analysis phase the survey of the tools and frequency of tool usage was done to answer the following research questions: What are the communication equipment which the learners in the context of the study have access to? What is the frequency of use of the technology communication tools among the learners in the context of the study?

The findings indicate the majority of the students in the context of the study had access to simple mobile phones (81.6%) while more than half the respondents owned or had access to computers (63.9%). However, fewer (44.3%) could access the internet with computers. The equipment most of the respondents had access to was the mobile phone, followed by computers and video players.

The CmL module is effective for learning as there were cognitive processes in all the communication tools. The highest level of cognitive process, resolution, was recorded in the discussion forum (38.4%) while integration for the construction of solutions was recorded in the wiki (37.9%) and SMS Quiz (51.3%).

Most learners (84.3%) believed their understanding in science improved after completing

the module, while the rest were undecided. The CmL module encouraged learning as it improved understanding and encouraged learning (Table 5). When learners searched for information and made references either online or to print materials, they were formally modeling their answers. In addition, the informal discussions in the search for knowledge contributed to learning. There was interaction with peers and with the content in using the language of science and learners are able to recall the knowledge constructed better and could model their answers in quizzes and tests.

The communication tool used most frequently was the telephone (Table 3). The telephone was used for discussion (mean = 2.97), text messaging (mean = 2.95) and file transfers (mean = 2.51). Online discussion tools (mean = 1.86) and e-mails (mean = 1.64) were less frequently used.

Table 3. Analysis of Frequency of Use of Technology Communication Tools

Tool	Mean
E-mail	1.64
Online Discussion Tool	1.86
Presentations (newsletter, web pages)	1.50
Telephone discussions	2.97
Telephone text messaging	2.95
File transfer on mobile phones	2.51
Access internet on mobile phones	1.64

N = 158 respondents

Note. * 1 – Never doing a particular item,
2 – Once a month
3 – Once a week
4 – Frequently used, that is more than once a week.

The findings verified that text messaging could be used for developing the CmL module. An online discussion forum for sharing information and files could also be used in the CmL module as online discussion tools were preferred to the use of e-mails which had a lower frequency of use.

b. Implementation Phase

The implementation of the CmL module was done with 20 volunteers in this phase to answer the following research questions: What are the types of interaction in the technology communication tools in the CmL module? What are the processes (cognitive, social, teaching, attitude and noise) during the interactions in the online communications in the CmL module? Is the CmL module effective for learning?

Different technological tools lend themselves best to certain forms of interactions. The number of interactions seemed to be the highest in text messaging (339 responses), followed by discussion

forums (30 responses) and wiki (29 responses). While the most number of interactions occurred with text messaging, the discussion forum enabled all the types of interactions: interaction among the learners, with the instructor, and with the content was observed (Table 4).

Table 4. Types of interactions on different technology communication tools in the CmL module (L-L, Learner – Learner; L-I, Learner – Instructor; L-C, Learner – Content)

Types of interaction	Discussion Forum			Wiki	SMS Quiz
	L-L %	L-I %	L-C %	L-C %	L-I %
Social	7.7	0.0	0.0	0.0	2.9
Cognitive					
• T*	0.0	20.0	16.7	0.0	0.0
• E*	0.0	0.0	8.3	10.3	0.9
• I*	7.7	20.0	75.0	37.9	51.3
• R*	38.4	0.0	0.0	0.0	0.0
Teaching	15.4	0.0	0.0	0.0	43.9
Attitudes	23.1	40.0	0.0	34.5	0.3
Noise	7.7	20.0	0.0	17.2	0.6
Total	100	100	100	100	100

Note. * T : Triggering
E: Exploration
I: Integration
R: Resolution

In the wiki, the only form of interaction was learner-content interaction: The learners did not seem to be interacting with other learners. However, as they posted the solution to the task online, there was interaction with the content. One reason for this lack of interaction was that the group members had already discussed on their solution for the wiki task using text messaging or face-to-face, before posting the solution on the wiki: *“We do in a group, we don’t use computer. We talk and sit face-to-face, and one person will write what we discussed about it (Sl.S6.146).”*

The SMS Quiz recorded the highest number of interactions, mainly learner-instructor. The number of interactions was the highest among all the tools. The highest percentage of cognitive processes in the text messaging was on integration by the student (51.3%); this was followed by teaching process with the instructor (43.9%). Text messaging seemed to be preferred among the students as it was personalized to the learner. This study indicates that text messaging could be used for the cognitive process of constructing a solution by students.

Cognitive processes were recorded during all the interactions in all the technological tools at high levels (Table 4). The highest level of cognitive

process occurred in the discussion forum for resolution of the solution. Of note is that social processes were detected when using the discussion forum and text messaging, but none in the wiki. However, this may not indicate that there were no social processes during the interaction, as interactions were conducted offline. The teaching process was highest (43.9%) in the SMS Quiz as the interactions were mainly learner-instructor.

In general, the interactions were observed to be of a collaborative nature on the wiki as the tasks was completed with group discussions. Group responses were also detected in the discussion forum as a total of four responses (13.8%) were given by groups of two and more students, indicating a preference for working in groups. However, in the text messaging SMS Quiz, all the responses (100%) were from individuals.

Table 5. Strengths of learning with the CmL Science module

Categories	Comments
Understanding science	Because when I do this module, it improves my knowledge. . . the module helped in my revision of the topic (Mat)
Encouraging search for information	It makes me open my book. I won’t open it if I don’t have exams. (Nabil) And I can do a lot of research online (Nadirah)
Learning through online discussions	I remember better after doing the discussions. There’s this one question in the exam I recalled it immediately (David)
Learning through face to face discussions	We do discussions in a group, we don’t use the computer first. We talk and sit face-to-face, and one person will write what we discussed about it (Nailah)
Learning through interaction with content	Honestly, I think the SMS Quiz makes me remember (Shah) I did not post any answer. But I did see the others’ answers. It helped. (David)
Interest in learning	It’s interesting. I have something to keep me occupied. (Nabil) You get to learn differently, and not just from the book. So, you get to use the internet, and something different (Alia).
Immediate feedback	Our phone is just inside our (pockets) so we can just reply immediately...

Several weaknesses were identified in the module (Table 6). There were some technical difficulties in using the discussion forum, and some learners had difficulty with the language used as the medium of instruction was English. Some learners did not post any answers to the forum at all. However, it was verified that some learners did read their peers' postings, and benefited from it. On the other hand, some perceived that reading the posts of others' answers was considered copying. Their belief was that learning was individualized and a not process to be shared with others, revealing the belief in the dualism of science knowledge.

Table 6. Weaknesses of learning with the CmL Science module

Categories	Comments
Technical difficulties	I dislike doing it because I don't have a Yahoo account (Chan) I am a little confused with Yahoo Tech groups. (Nadirah) The online stuff kinda hard as I can only access the internet sometimes. Depends on the connection. (Nabil)
Language - English	Yes, some language problems. Grammar - I don't understand (David)
Perception of learning	I don't read others' answers. Because if I read their answers, maybe they'll think I'm copying them (Nadirah). I don't think if I see the others answers I will learn (David)
Other Priorities	I was preoccupied with homework (Ann) Because sometimes I'm not in the mood (Gwen)
Parental control	My mother don't let me use so much internet (Shahirah)
Group work	Dislike it because I need group members (Shah)

The learning materials and the environment in the CmL Science module gave learners the opportunity to observe and pattern the scientific verbal and content knowledge. These patterns are formed during the discussions while learners collaborate on their tasks, and while they quietly observe the discussions among their peers. Both the online and offline discussions and scaffolding were for informal learning. However, these informal sessions contributed to the formal learning in the module. The difference between formal and informal learning becomes less obvious in the module but is seamlessly

integrated for effective learning. Learning was a social activity where elements in the environment, including answers of the participants could be artifacts to "mediate" learning.

In conclusion, the CmL module was effective for learning as cognitive processes and opportunities for learning were provided.

6. Implications

Technology can be used for teaching science as majority of science learners in secondary school in Malaysia already have access to computers and mobile phones. This is verified from the findings of the needs analysis. In addition, they already had the skills to use these communication tools.

Social interactions are important for learning science. Communications in the CmL module, on the wiki, the discussion forum, and text messaging, SMS Quiz allowed learners to use cognitive processes (Hogan and Fishkeller 2005; Hoyle and Stone 2000; Karpov and Haywood 1998). Only through communication with scientific verbal knowledge in the language of science could reflection and critical thinking occur among the learners.

In the process of collaboration and problem solving, the social interactions contributed to developing cognitive processes for learners to acquire new knowledge and skills. Interactions which enable collaborative learning involve the cognitive processes of forming concepts, resolving differences and developing critical thinking (Hoyle and Stone 2000; Karpov and Haywood 1998; Kim and Song 2005). This is done at different levels. Firstly thorough triggering, which are communications that encourage thinking about issues. This is followed by exploration to connect and search for information; integration to build a possible solution on previous messages; and resolution to test and defend hypotheses (Shedletsky 2010).

The findings of this study expand on the findings of other studies to show that online communications can be used to develop critical thinking skills (Heckman and Annabi 2005; Jonassen 2000; Jonassen et al. 2005; Shedletsky 2010). In the use of the CmL module, Learner-Learner, Learner-Instructor, and Learner-Content interactions were observed (Moore and Kearsely 2005).

However, in this study an important finding is that different tools afford different types of interactions and processes. The use of discussion forums involves all the three types of interaction: Learner-Learner, Learner- Instructor, and Learner-Content interactions. In addition, there were a large proportion of higher level cognitive processes in the interactions: (38.4%) in the learner-learner interactions, and some in the learner-content-

interactions (75.0%). This indicates that it is effective for learning.

There were also higher level cognitive processes in the text messaging SMS Quiz (51.3%). In addition, the frequency of use was the highest among all the tools (339 responses). The text messaging SMS Quiz has a lot of potential for future use because of its popularity and the level of cognitive processes. Text messaging appears to be the most effective tool to reduce transactional distance (Moore 1993) as learners would not feel the online distance of the instructor as they are able to interact fully in personal dialogue with the instructor, and have autonomy over their learning.

The wiki was also frequently used and allowed for some high level interaction (37.9%). Its collaborative nature enabled learners to collaborate on solving meaningful problems as they knew their work was being published. However, not all the group members would contribute to the writing on the wiki. This was because group work was conducted face-to-face prior to posting on the wiki. There might be more cognitive and social processes which were captured in the data.

The discussion forum allowed for interaction to determine opinions related to the nature of science. Most of the learners stated that a question which had been answered need not be responded to. This reflected their perception of the dualism in the nature of science knowledge (Oliveira, Akerson, Colak, Pongsanon and Genel 2011). The instructor had to facilitate the forum to encourage members to give other opinions and to elicit responses from others.

The CmL module and the tools for communication can be used for developing cognitive processes through social interactions and communications among Form 2 science learners. There were also social and teaching processes and some noise during the communications. Of note is that the attitude was high in the wiki as the learners were able to show their creativity and personalize the page they were working on. The module allowed for written communications for exploring the nature of science knowledge by giving the learners authentic and meaningful tasks. The learners noted that they understood science better and had to search for information. They also admitted that the online discussions and face-to-face discussions enabled learning in the CmL module. Of note is the learners' belief in the dualism of science knowledge; they expected that there was only one accurate answer in science, and were challenged in the discussion questions as they were continuously requested for more diverse answers.

However, the limitation of the study is that it was carried out in an urban school. Further research would be required to determine if the findings will be

similar in rural schools. A measure of the communication skills in science should be developed to determine if the CmL module could improve written scientific communications as well as cognitive processes. In addition to communication and cognitive processes, future studies may be conducted to determine the effectiveness of teaching the nature of science through individual technology tools or a combination of the tools.

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