Evaluation of a Collaborative mLearning Science Module: 
The Users’ Retrospective

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ABSTRACT

In this study a collaborative mLearning (CmL) Science module for teaching secondary school science, designed based on social constructivist learning theories would be evaluated. This study is part of a developmental research in which computer-mediated communication (CMC) tools were employed: discussion forums, collaborative work spaces (wiki), and text messaging. The module was implemented with study sixteen (16) Form 2 students. Data collected from surveys; interviews with the students; online communications on forums, wikis, and text messages; pre and post tests; as well as journal records of students and researchers, were analysed. The findings showed that the CmL module could be used for learning. Learning occurred anywhere and at anytime through both formal and informal learning of science. The findings provide insights on how to promote a CmL environment which integrates both the formal and informal learning for teaching science. In addition, the findings show that the CmL module could effectively be used by teachers for transforming learning in science.

Keywords

Collaborative learning, Computer-mediated communication tools, Mobile learning, Informal learning, Evaluation.

Introduction

Science is the body of knowledge built when a scientific process is used to make discoveries about the natural world (Abruscato, 2000). An interdisciplinary approach to teaching science is often used as science combines various subject matter such as mathematics, art and physical education (Wolfinger, 2000). In the real world, scientific discoveries are made through scientific processes, and in collaboration with other scientists (Abruscato, 2000; Hogan & Fisherkeller, 2005). These collaborations can be done because discussions are conducted in a scientific language.

A similar discovery approach should be used when teaching science formally in the classroom. The focus of instruction should be on scientific methods and processes, and not on content or scientific knowledge. In order to do this, science learners need to be able to interact socially: to communicate and debate issues regarding science and society, as well as use science for their personal needs in life. Through social interactions, the learners can
attempt to link the newly acquired knowledge with their existing knowledge, and be provided individualized scaffolding (DeWitt & Siraj, 2008).

The language of science is important as science learners require a language in order to build science concepts. The skills in communicating in science are important for all learners as scientific verbal knowledge is used to plan, share ideas, develop their understandings and promote critical thinking (Ellerton, 2003; Hoyle & Stone, 2000). Scientific terms can be defined and taught formally in the classroom, but the vocabulary and language structures in science are acquired informally.

Learners’ interactions with the materials, teachers and peers enable the patterning and modeling of the language of science (Karpov & Haywood, 1998). Learning science is not limited to the classroom but involves awareness of individual and societal needs. This means that learning science cannot be limited to formal learning alone. Modeling of science language is done in the formal as well as informal situations. Hence, science learning has to be integrated between the formal and informal environment.

In the Malaysian scenario, there is little time for social interaction in the science classroom. Teachers perceive that there is insufficient time to complete the science syllabus. The emphasis in most schools is on passing the standardized examinations. This has lead teachers to emphasize on memorization of facts, rather than on the scientific processes (Chong, 2005).

Computer-mediated communication (CMC) tools can facilitate the communication and extend it outside the classroom (Anastopolou et al., 2011; Arrigo, Gentile, Taibi, Chiappone, & Tegolo, 2004; Capuano, Gaeta, Miranda, & Pappacena, 2004; Guzdial & Turns, 2000; Chang, 2010; Jeng, Wu, Huang, Tan, & Yang 2010; Slotta & Linn, 2000; Saeed, Yang, & Sinnappan, 2009). CMC tools such as wikis, forums and text messaging enable informal discussions in science outside the formal classroom, and can be monitored by a facilitator or tutor. Research has shown that formal classroom learning can be supplemented with informal learning through technology use (Anastopolou et al., 2011).

Collaborative learning occurs as the acquisition of knowledge, skills and attitude as a result of interactions in a group (Johnson & Johnson, 2004). When CMC tools are used, collaborative mlearning, which occurs as a result of interactions in a group, can happen at anytime and anywhere, even outside the formal classroom environment (Ally, 2004; Siraj & Alias, 2005; Siraj, 2005).

Although studies have been conducted on the use of collaborative mlearning using CMC tools (Arrigo et al., 2004; Capuano et al., 2004; Guzdial & Turns, 2000; Saeed, Yang, & Sinnappan, 2009; Slotta & Linn, 2000), not many studies have been done on the effect of a combination of three CMC tools. The forms of communication and learning in the collaborative mlearning (CmL) Science module would be determined. In this study, the three CMC tools of the wiki, discussion forum and text messaging would be combined to develop the CmL Science module.
Purpose of the Research

The purpose of this research is to determine whether a CmL Science module developed based on Merrill’s principles of instruction can be used for learning. This study seeks to answer the following research questions:

- How do learners learn with the CmL,Science module?
- How effective is the CmL module in learning science?

The language of science

Language enables the thinking processes for the construction of knowledge (Hoyle & Stone, 2000). In order to be able to reason scientifically, a person needs to understand what is communicated, and to give feedback. Scientific verbal knowledge, or the knowledge for communicating in the science vocabulary, is required for understanding science (Hoyle & Stone, 2000; Karpov & Haywood, 1998; Wolfinger, 2000). Learners can then construct meaningful phrases and sentences with scientific terms to communicate their thoughts and develop science concepts (Hoyle & Stone, 2000; Karpov & Haywood, 1998; Wolfinger, 2000). The advantage of student-centered discussions is that critical thinking skills are developed during the discussions with other learners, as differences of opinions are resolved to reach a mutual understanding (Hoyle & Stone, 2000; Karpov & Haywood, 1998).

The vocabulary and structures of the language of science is not taught formally but is informally modeled by the learner through social interactions. 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 (Karpov & Haywood, 1998). In this way the learner builds scientific verbal knowledge and the understanding of science concepts. Interaction with other learners, the tutor and learning materials on a suitable platform can enhance the learners’ current understandings of concepts and principles.

Design of instruction for learning science

The CmL Science module designed for teaching science is based on social constructivist learning theories. Sufficient activities for learners to build their personal understanding through discussions (Hoyle & Stone, 2000), opportunities for patterning, and modeling with individualized support, and scaffolding to address the difficulties learners experience in trying to comprehend the language of science (Ellerton, 2003; Hoyle & Stone, 2000) are provided. Learners are provided opportunities to link the science knowledge with their own personal experience (Ellerton, 2003) while social interactions to motivate and engage learners in carrying out activities to build meaningful science knowledge (Brown, 2006).

CMC tools, such as wikis and discussion forums, have been used for teaching science. The Knowledge Integration Environment (KIE), a platform for storage of web resources and scaffolding through tips and guidance for the activities used an online asynchronous discussion forum for collaborative mLearning in science (Slotta & Linn, 2000). Another platform for collaborative mLearning, CaMILE, has discussion forums and encourages communication and collaboration on science projects (Guzdial & Turns, 2000). Both these platforms were effective in learning science.
Text messaging has been used for language instruction where messages can be pushed as textual learning objects (Capuano et al., 2004) and has been used combined with a wiki (Arrigo et al., 2004). A combination of text messaging with discussion forums has shown that the use of text-messaging motivated learners, while the use of online discussion groups improved examination performance (Rau, Gao, & Wu, 2008). A combination of CMC tools can be used for learning science.

Technology has been used to extend the formal learning of science in the classroom by providing a platform for informal learning (Anastopoulou et al., 2012; Arrigo et al., 2004; Guzdial & Turns, 2000). Similarly, it is believed that the CmL Science module in this study can support informal learning to provide experiences for building scientific verbal knowledge and concepts in science. In the Malaysian context, there is a lack of research in the use of a combination of CMC tools on a CmL platform for teaching science. It is hoped that this study will provide insights in the use of a CmL environment for science instruction.

The Social Constructivist Theory of Learning

Social dialogue and interaction internalizes learning. The interactions in a social environment encourage learning (Gredler, 1997; Schunk, 2000). In the external environment, cultural tools such as computers and mobile phones; and abstract social tools, such as language, the school, and CMC tools assist in developing the learners’ thinking. These tools encourage the process of cognitive change in the learner (Gredler, 1997).

Through social interactions, learning is situated (Chang, 2010; Jeng, Wu, Huang, Tan, & Yang 2010). In using CmL, knowledge creation through inquiry learning and construction of arguments is enabled (Laru, Jarvela, & Clariana, 2012; Rogers, Connelly, Hazlewood, & Tedesco 2010). New ideas can be generated (So, Tan, & Tay 2012) as learning is scaffolded by their peers (Boticki, Looi, & Wong, 2011; Timmis, 2012).

In this study, learners interact socially in a group through peer collaboration (Schunk, 2000) to complete tasks and develop their understandings from cognitions which result from interpersonal interaction within that culture and community (Vygotsky, 1981).

First principles of Instruction

The design of this module was based on the First Principles of Instruction (Merrill, 2002). These design-orientated principles could be used to solve real-world problems for learning environments in any delivery system (Figure 1). 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. Application of the First Principles of Instruction in the CmL module is summarized in Table 1.
Table 1. Application of First Principles of Instruction

<table>
<thead>
<tr>
<th>First Principles of Instruction (Merrill, 2002)</th>
<th>Application in the collaborative mLearning module</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Learning is promoted when learners are engaged in solving real-world problems</td>
<td>An online problem task is a real-world problem that would be solved through group-work on the wiki.</td>
</tr>
<tr>
<td>2. Learning is promoted when existing knowledge is activated as a foundation for new knowledge</td>
<td>Smaller problems as discussion questions on the online forum.</td>
</tr>
<tr>
<td>3. Learning is promoted when new knowledge is demonstrated to the learner</td>
<td>An instructional module on webpage with links to other web pages, videos, and interactive software.</td>
</tr>
<tr>
<td>4. Learning is promoted when new knowledge is applied by the learner</td>
<td>Smaller problems for discussion questions on the online forum.</td>
</tr>
<tr>
<td>5. Learning is promoted when new knowledge is integrated into the learner’s world</td>
<td>Quiz pushed through text messages to the learners and group-work on the wiki.</td>
</tr>
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</table>

Methodology

Design of the Study
The study is part of a developmental research in which the CmL module was designed (Muhamad Sabri, Nor Aziah, Zawawi & Nurulhuda 2012; Richey 1997; Wang & Hanafin 2005). This paper focuses on the final user-evaluation in which the user reactions on
completion of the module was analysed. The evaluation is based on the usability evaluation method framework (Chai & Chen, 2004; Norlidah Alias, Saedah Siraj & Vanitha Thanabal, 2011).

An urban secondary school in the state of Selangor was selected for implementation of the CmL Science module. The users were the sixteen Form 2 students who had completed the problem tasks. Their reaction towards the tasks and the module was captured in a survey of the usability of the module for learning, and through interviews determined through a survey and interviews. The responses given were triangulated with data from online communications in the module. A comparison of means for the pre-test and post-test of the module was done to determine the effectiveness of the module.

Data Collection and Analysis

A pre-test on the knowledge items in the module was conducted before implementation of the module. During implementation, data from the online communications on forums, wikis, and text messages, participants’ and researchers’ journal records, were recorded. At the end of the module, a post-test was conducted followed by a survey and an interview.

The interviews and online communications were transcribed and then coded according to the emergent themes. The data was analyzed to find out how the students in the context of the study were learning in the CmL environment, and how effective the learning was. Triangulation of data was done through the analysis of the online communications to verify that the users were learning.

Development of the CmL Science Module

The CmL Science module on the topic of Nutrition was designed based on the social constructivist learning theory (Gredler, 1997; Schunk, 2000) and the First Principles of Instruction (Merrill, 2002). The topic of Nutrition was selected as learners had many misconceptions in this topic. Secondary school children were confused about the concept of food: water and vitamins are not food but were considered as food by learners (Lee & Diong, 1999). In addition, students rated Nutrition as the most difficult topic with a lot of factual knowledge in science (DeWitt & Siraj, 2007).

The CmL module was hosted on a website, with links to content, videos, animations, and CMC tools. The activities were designed to incorporate a main problem task, to be solved collaboratively with other smaller problem tasks to activate, demonstrate, apply and integrate knowledge on a forum with individual quiz through text messaging. Demonstration of knowledge is found on the web page where links to content and interactive tools were provided. Application of knowledge was through practice questions on the discussion forum, and integration of knowledge where the opportunity to reflect and use the knowledge learnt through questions on the discussion forum and SMS Quiz.
Module Implementation

The CmL Science module was implemented with a group of sixteen Form 2 students from the selected school. The participants were from a pool of volunteers and equal numbers of high, medium and low-achievers in science were selected. Most of the students in the selected school (81.6%) owned a mobile phone, and had access to computers (63.9%). However, laptops with a mobile broadband modem for internet access, and mobile phones for text messaging after school hours in school were provided to enable students who required access.

Results and discussion

The research questions on how learners learn with the CmL Science module, and on how effective the CmL module is in learning science is discussed.

Learning Science

The findings of this study may provide insights into the effects of CmL and whether it could be used for teaching science. Most learners (84.3%) believed their understanding in science improved after completing the module, while the rest were undecided. The CmL encouraged learning as it improved understanding and encouraged learning (Table 2).

<table>
<thead>
<tr>
<th>No.</th>
<th>Categories</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Understanding science</td>
<td>i. Because when I do this module, it improves my knowledge. In addition, the module helped in my revision of the topic (Mat)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ii. I think there’s nothing that I disliked. Cause if I do this module, it’s good for my knowledge.” In</td>
</tr>
</tbody>
</table>
addition, the module helped in the revision of the topic (Shah)

iii. Because we like to talk to our friends, chit chat, and then ‘masuk kepala juga’

<table>
<thead>
<tr>
<th>2. Encouraging search for information</th>
<th>i. It makes me open my book. I won’t open it if I don’t have exams. (Nabil)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ii. I read my friends answers (Siti)</td>
</tr>
<tr>
<td></td>
<td>iii. And I can do a lot of research online (Nadirah)</td>
</tr>
<tr>
<td></td>
<td>iv. I like it because it makes me open my science book more often (Shah)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. Learning through online discussions</th>
<th>i. Well, one thing for sure, with the questions, you can always ask people, or you can refer to your Science text book. At least it helps us to brainstorm a bit. (Shah)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ii. I remember better after doing the discussions. There’s this one question on the walls of the organ in the objective section. I picked C as the answer. And in the subjective questions, they asked about the name of the movement for food in the organs, so I recalled it—peristalsis (David)</td>
</tr>
<tr>
<td></td>
<td>iii. Sometimes I’m online at MSN, then I ask my group members what I should do. Then they tell me (Nadirah).</td>
</tr>
</tbody>
</table>

| 4. Learning through face to face discussions | i. 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) |

<table>
<thead>
<tr>
<th>5. Learning through interaction with content</th>
<th>i. Honestly, I think the SMS Quiz makes me remember (Shah)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>ii. I did not post any answer. I don’t know the answer. But I did see the others’ answers. It helped a bit. (David)</td>
</tr>
<tr>
<td></td>
<td>iii. Like it because can give our opinions and comments (Nadirah)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>6. Interest in learning</th>
<th>i. It’s interesting. I have something to keep me occupied. (Nabil)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ii. Well once in a while when I don’t have anything else better to do, or if I have questions asking about the online question, then I can at least have the (SMS) questions to keep me company (Shah).</td>
</tr>
<tr>
<td></td>
<td>iii. You get to learn differently, and not just from the book. So, you get to use the internet, and then ya, something different. (Alia).</td>
</tr>
<tr>
<td></td>
<td>iv. I expected fun, I enjoyed internet (Jeanne)</td>
</tr>
</tbody>
</table>

| 7. Immediate feedback  | i. Our phone is just inside our (pockets) so we can just reply immediately… |
Table 3: The weakness of learning with the CmL Science Module

<table>
<thead>
<tr>
<th>No.</th>
<th>Categories</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Technical difficulties</td>
<td>i. I don’t know how to use. (Alvin)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ii. I dislike doing it because I don’t have a Yahoo account (Chan)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>iii. I am a little confused with Yahoo Tech groups. (Nadirah)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Freewebs - Participation in this forum was easier and can post discussions)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>iv. The online stuff kinda hard as I can only access the internet sometimes. Depends on the connection. (Nabil)</td>
</tr>
<tr>
<td>2.</td>
<td>Language - English</td>
<td>i. Yes, some language problems. Grammar - I don’t understand (David)</td>
</tr>
<tr>
<td>3.</td>
<td>Perception of learning</td>
<td>i. I don’t read others’ answers. Because if I read their answers, maybe they’ll think I’m copying them (Nadirah).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ii. I don’t think if I see the others answers I will learn (David)</td>
</tr>
<tr>
<td>4.</td>
<td>Other Priorities</td>
<td>i. I was preoccupied with homework (Ann)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ii. Because sometimes I’m not in the mood to (Gwen)</td>
</tr>
<tr>
<td>5.</td>
<td>Parental control</td>
<td>i. My mother don’t let me use so much internet (Shahirah)</td>
</tr>
<tr>
<td>6.</td>
<td>Group work</td>
<td>i. Dislike it because I need group members (Shah)</td>
</tr>
</tbody>
</table>

The CmL Science module improves understanding and enables both formal and informal learning. 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. The learners are able to recall the knowledge constructed better and could model their answers in quizzes and tests.

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 observed 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.
Several weaknesses were identified in the module. There were some technical difficulties in using the discussion forum, and some learners had difficulty with the language used as the medium of instruction: English. There were also learners who did not post any answers to the forum. However, it was verified that some learners did read their peers' postings, but it was not verified that they used the forum to learn from it. On the other hand, there were some who perceived that reading the posts of others answers were considered copying. Their belief was that learning was individualized and a not a process to be shared with others.

In general, the CmL module motivated the learners as they were interested to use it. Learning takes place formally and informally when the social interactions through other learners’ answers and mediated learning.

**Effectiveness of the CmL module**

The module was effective for learning. A pre test and post test on the similar concepts showed an increase in the mean scores of participants. The *t*-test for independent samples for statistical analysis was not computed as only 16 participants took the test. However, the difference of the mean scores showed an increase which indicates the module was effective for learning science concepts (Table 4). Further studies would have to be conducted to be conclusive.

<table>
<thead>
<tr>
<th>Mean scores</th>
<th>Increase in mean scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre test</td>
<td>Post test</td>
</tr>
<tr>
<td>61.97</td>
<td>83.07</td>
</tr>
</tbody>
</table>

*Note. Number of participants, n = 16*

**Implications and Conclusions**

The findings of this study indicate that the CmL Science module enables learning in secondary school science, both formally and informally. Learners participated in the discussions in science using CMC tools. This indicates that CMC tools can be effectively used to support learning (Anastopolou et al., 2011; Arrigo et al., 2004; Guzdial & Turns, 2000). Although there were only sixteen participants in this study, the findings are relevant as the participants were of different science abilities. However, future studies would be done to determine the effectiveness with a larger sample.

The communications which were part of the process of achieving a shared goal in the task (Johnson & Johnson, 2004) enabled the thinking processes is actually beneficial for learning for constructing science knowledge (Hoyle & Stone, 2000). Communication and learning can be conducted virtually outside the science classroom.

The use of a combination of CMC tools have been shown to be effective for learning (Arrigo
et al., 2004; Rau et al., 2008). In the CmL module, a combination of three CMC tools was used for teaching science. Providing a combination of tools allowed learners to respond and use the tool most convenient or most preferred for learning. The learners’ preference for different tools might be related to different learning styles of the learner and could be a possible area for further research.

When the CMC tools are used, collaborative mlearning is encouraged (Guzdial & Turns, 2000; Slotta & Linn, 2000) as learners to work in groups to solve tasks. The findings of this study reinforce the fact that collaborating in science is important for learners to plan, share ideas, develop their understandings and promote critical thinking through the language of science (Ellerton, 2003; Hoyle & Stone, 2000). The communication that occurred both formally and informally contributed to the learning of science. The patterns and modeling of the language of science used during the discussions could be developed (Karpov & Haywood, 1998).

The ‘silent observers’, who did not seem to participate, but chose to observe the social interactions, were also involved in the informal learning process when they viewed other participants’ answers and observed the patterns for modeling and use of scientific verbal language (Karpov & Haywood, 98). The lack of participation could be because of the learners’ perception that there was only one correct answer in science. These learners have to be given more scaffolding and encouragement to participate in the communication and learning process (Schunk, 2000). In addition, considerations may have to be made in the social and cultural tools to include more exemplars and guidance for discussion questions (Gredler, 1997).

A discovery approach in teaching science which emphasizes scientific methods and processes should allow social interactions. In this study, the social interactions and collaboration, both formally and informally, have contributed to building scientific verbal knowledge (Abruscato, 2000; Hogan & Fishkeller, 2005). The skill of communication and collaboration in science would enable learners to collaborate with experts in the multiple disciplinary sciences. Learning occurred during the process of this communication, and this shows that there is a seamless integration between formal and informal learning.

The findings are important as in the transformation of the education system there is a need to improve human capital, namely teacher training. There is a need for innovative and creative teaching methods for the delivery of information and construction of knowledge. The CmL module is an effective method of building knowledge in science.

In this module a discovery approach to allow the processes of learning science through communication and discussion is encourage. Social interaction in which the learner debates issues and integrates with their existing knowledge is useful in building meaningful knowledge. The use of suitable instructional design principles, which allow for problem-solving in learning can be employed (Merrill, 2002).

Collaborative mlearning has shown to be effective for learning. CMC tools allow for the learner to have meaningful discussions and can be a platform for collaboration. The affordance of CMC tools is that learning can take place outside the formal classroom.
In summary, social learning in the use of the collaborative mLearning Science module is effective for teaching science to address the learning needs in the field of science. This aspect of social interaction thorough formal and informal learning can be extended to other subjects as well.

ACKNOWLEDGMENT

The authors wish to thank the Faculty of Education, University of Malaya, and the Ministry of Education Malaysia. This work was supported in part by a grant from the Postgraduate Research Fund, University of Malaya, Kuala Lumpur.

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