

Developing a Mathematics Module in Support of Secondary School Reflective Learning

Asmahwati Binti Rosli¹, Wun Thiam Yew², Ahmad Zamri Khairani³

¹Kuala Kangsar Education District Office, Perak, Malaysia, ^{2,3}School of Educational Studies, Universiti Sains Malaysia, Penang, Malaysia

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Abstract

Reflective learning is a teaching method where active student learning is a core component of instructional design. In mathematical instructions, reflection and knowledge-construction take place in the language of mathematics. The development of mathematics module in the current study employs three computer-mediated communication (CMC) tools: Google Classroom, discussion forum and text messaging. This study seeks to determine the communication and learning forms which support reflective learning in the usage of CMC tools within the mathematics module. 30 Form 2 students with different mathematical abilities were selected as participants. Data collection include students' online communication on Google Classroom (GC), forum discussion, and text messaging. A survey of students' perception of communication using CMC tools and learning were also distributed. Google Classroom and text messaging were reported to have the highest frequency of communication among learners. The combined usage of the three CMC tools was found to be effective as it caters to learners' preferred learning styles, encouraging collaboration and experiential learning. This study offers insights into group interaction in a reflective learning environment and its influence on the scaffolding of mathematics knowledge.

Keywords: Reflective Mobile Learning, Computer-Mediated Communication Tools, Mobile Learning, Google Classroom

Introduction

Reflective learning approaches emphasize active student engagement in teaching and learning (Dewey 1933; MDPI, 2020; Schön, 1983) where the acquisition of knowledge, skills and attitudes are results of group interactions (Minot, 2015; Potkonjak, 2016; Smith et al., 2016). When CMC tools are employed in these interactions, reflective mobile learning is said to occur. This phenomenon allows group interactions outside the formal classroom environment, encouraging learning in the situated environment (Müller & Faltin, 2011; Pitts, 2015).

The advancement of information technology (IT) initiated the development of various computer-mediated communication (CMC) and social networking tools (May, 2008; Ou et al., 2013), allowing content-sharing to take place efficiently, and in real-time. However, the effect of computer-mediated communication (CMC) tools for reflective learning remains

underexplored. Reflective learning is especially useful in scaffolding support and generating ideas through the use of different CMC tools such as discussion forums (DeWitt et al., 2013; Haines, 2015; Sun et al., 2018), Google Classroom (Becker et al., 2018; Kondos, 2018) and text messaging (Li & Lewis, 2018; Sun et al., 2018).

CMC tools have been implemented in teaching mathematics (Hadjinicolaou, 2018) where the lessons combined two tools: text messaging and Google Classroom (Milman, 2018), as well as, text messaging and a discussion forum (Winoto, 2018). These lessons were proven to be effective in the teaching and learning of mathematics. The current study will investigate the combination of two tools in developing a Mathematics module.

Literature Review

Teaching materials are subject matter content compiled completely and systematically based on the pedagogical principles employed by teachers and students alike. These materials can be categorized into print and non-print (Depdiknas, 2008). Print teaching materials consist of textbooks, modules, worksheet, practical guide, and the likes, while non-printable materials can be online games, e- modules, interactive videos, and virtual labs. The selection of the teaching materials must be determined appropriately according to robustness and student's learning style (Wenno, 2010).

Figure 1.1 presents the three main questions in conducting reflective learning according to the reflective model introduced by Borton (1970). These questions prompt an explanation of a given situation, leading one to analyse the situation and construct knowledge based on what one has learned through experience. Practitioners then improve it based on the consequences of their reactions to the experience.

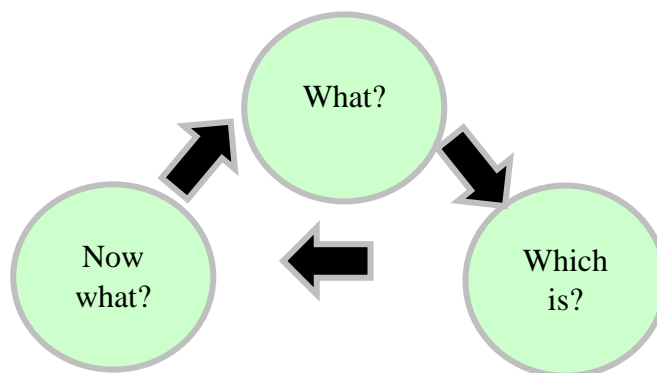


Figure 1.1. Reflective model (Borton, 1970).

Another reflective model introduced by Kolb (1984) highlighted the concept of learning based on experience and knowledge transformation (see Figure 1.2) that occurs after the event, and involves the practitioner reflecting on these experiences. After gaining a general understanding of the concepts encountered, the general understanding was then tested in a new way. In this way, knowledge is formed from the conditions that are constantly being applied and reapplied, building on the experience of the practitioners and knowledge. These CMC tools enable cognitive change in learners as ideas are challenged and debated upon to create new knowledge (Chan, 2012).

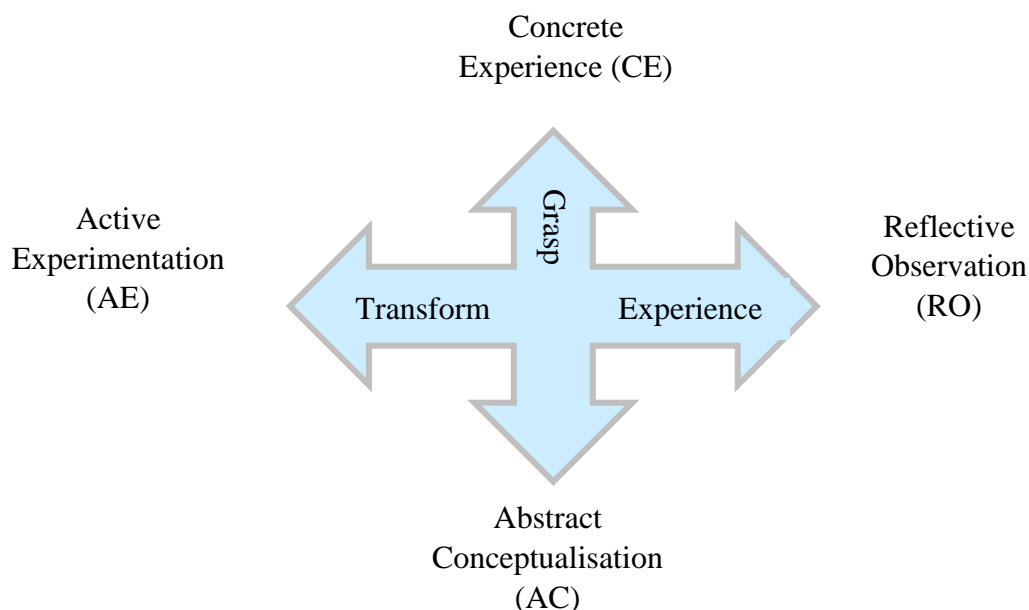


Figure 1.2. Kolb model (Kolb, 1984).

The teaching training module is a systematic and reflective process in developing teaching and learning principles for lesson plans, teaching materials, information resources and assessments (Smith & Ragan, 2005). Reiser and Dempsey (2007) agreed on a similar notion in the advancement of education and training based on creativity while Kemp, Morrison, and Ross (1998) argued that teaching training modules are teaching processes based on practice.

Studies by Ros Eliana Ahmad Zuki (2014), Mas Norbany Abu Samad (2016) and Tee (2013) demonstrated the positive impact of these modules where there is a significant difference in terms of student achievement. In ensuring that module effectiveness can be achieved, certain aspects such as target groups, module contents, facilitator capabilities, relevant time and objectives are emphasised upon. Modules and appropriate learning processes generate motivation and learning stimulation that provides good learner psychological effects (Novitasari et al., 2016).

Learning activities are a major component of good modules that accommodate active processes. Learning activities should be contextualised within a student environment (Widodo et al., 2017) as an additional supplement to the active process of discovery. Thus, the knowledge gained in learning is more accurate and memorable as they are directly practised (Ali et al., 2010).

Research Questions

This research aims to determine the forms of communication and learning among learners in the development of a reflective learning mathematics module. This study seeks to answer the following research questions:

1. How do learners communicate in the development of a reflective learning mathematics module?
2. How do learners learn with the Mathematics module as reflective learning support?

Methodology

Participants

The reflective learning mathematics module was developed based on a survey of communication tools accessed by learners. An urban secondary school was selected to implement the mathematics module on the topic of speed and acceleration. The module was implemented among thirty 14-year-old students where participants' perceptions on learning and communication while using the module were captured through observations, online communications and a survey of the module. The participants consisted of an equal number of high, medium and low achievers in mathematics where most of them owned a mobile phone (89.6%) and have access to computers (84.5%). Laptops and mobile phones were also made available during the implementation since mobile phones were required for text messaging after school hours. Participants who needed a mobile phone could borrow one.

Data Collection

A pre-test on the knowledge items in the module was conducted before the module implementation. During the implementation, data was collected from online communication on Google Classroom (GC) and text messages. At the end of the module, a post-test was conducted using a survey to determine learners' perception of their understanding and required learning support. Triangulation of data was done through the analysis of online communications.

Development of the Module

The development of the reflective learning mathematics module considered the CMC tools which learners have accessed. This module was developed on Google Classroom where resource links to content, videos, animations, and tasks were offered using CMC tools. The topic of Speed and Acceleration was selected as there are many misconceptions in this topic (Tabachnick et al., 2018). Secondary school students are often confused when it comes to comprehending physico-mathematical relations and their deep interpretation (Mwangala & Shumba, 2016).

CMC Tools in the Mathematics Module for Reflective Learning

The reflective learning mathematics module consisted of online lessons and face-to-face meetings (see Table 1). The activities in the module include problem task, group work assigned on Wiki, related questions on discussion forums and quizzes on text messages. The teacher provided feedback and support for all the tasks. Table 2 provides a summary of all the CMC tools used in the mathematics module for reflective learning.

Table 1

Lessons in the mathematics module for reflective learning

| Lessons | Title |
|----------|---|
| Initial* | Orientation to module |
| 1 | Speed as a rate |
| 2 | Uniform and non-uniform speed |
| 3 | Average speed |
| 4 | Solving problems involving speed |
| 5 | Acceleration and deceleration |
| 6 | Unit conversion |
| 7 | Solving problems involving acceleration |
| Final* | Summary |

**Face-to-face meetings*

Table 2

Tools and activities in the Mathematics module

| The Mathematics module | |
|------------------------|--|
| CMC tool | Activity |
| Google Classroom (GC) | Group Activity: Groups of 3-4 students The task is to analyse the speed and acceleration topic in a given example and post their findings on GC. Each group has a specified GC and can add additional comments. |
| Text Messaging | Individual Activity: Telegram Quiz |

Data Analysis

The data collected were analysed to identify how students communicate and learn in a reflective learning environment. The results of the pre-test were compared to the post-test at the end of the module to determine if there were differences in the scores, indicating learning efficacy. As for the survey conducted after the implementation of the module, descriptive analysis was used to analyse the responses.

Results

The discussion is focused on two areas of the reflective learning mathematics module, communications and learning. The findings provided insights into the communications of the mathematics module to support reflective learning and the contribution to learning mathematics.

Communication in the Reflective Learning Module

In order to investigate learners' communication in the mathematics module, two domains were analysed: the frequency of CMC tools usage and different types of group activities.

CMC Tools

The frequency of using the CMC tools to complete the assigned tasks varied among participants (see Figure 2). Participants were most active on the Telegram Quiz (85 log-ins)

due to the accessibility offered by mobile devices. In addition, personalized feedback was also provided during the Telegram Quiz.

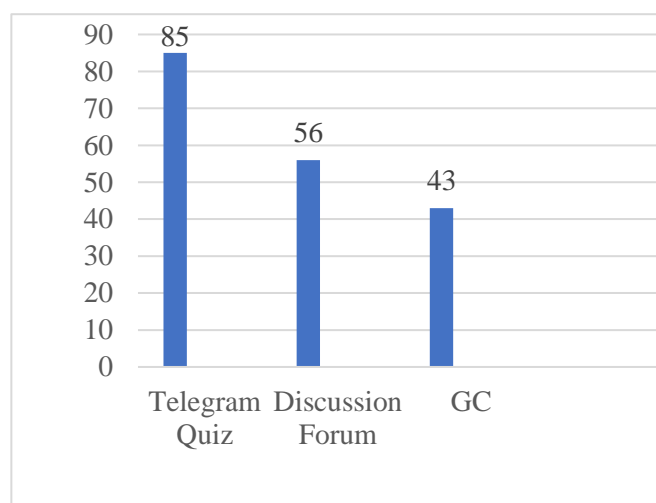


Figure 2. Frequency of log-ins for CMC tools (n=20).

There were a large number of postings on the discussion forum (56 responses) but the analysis showed that only an average of 24 participants had responded. Most responses were posted by two or more learners, indicating the participants' preference for group work since the participants are required to collaborate with their peers before posting in the discussion forum.

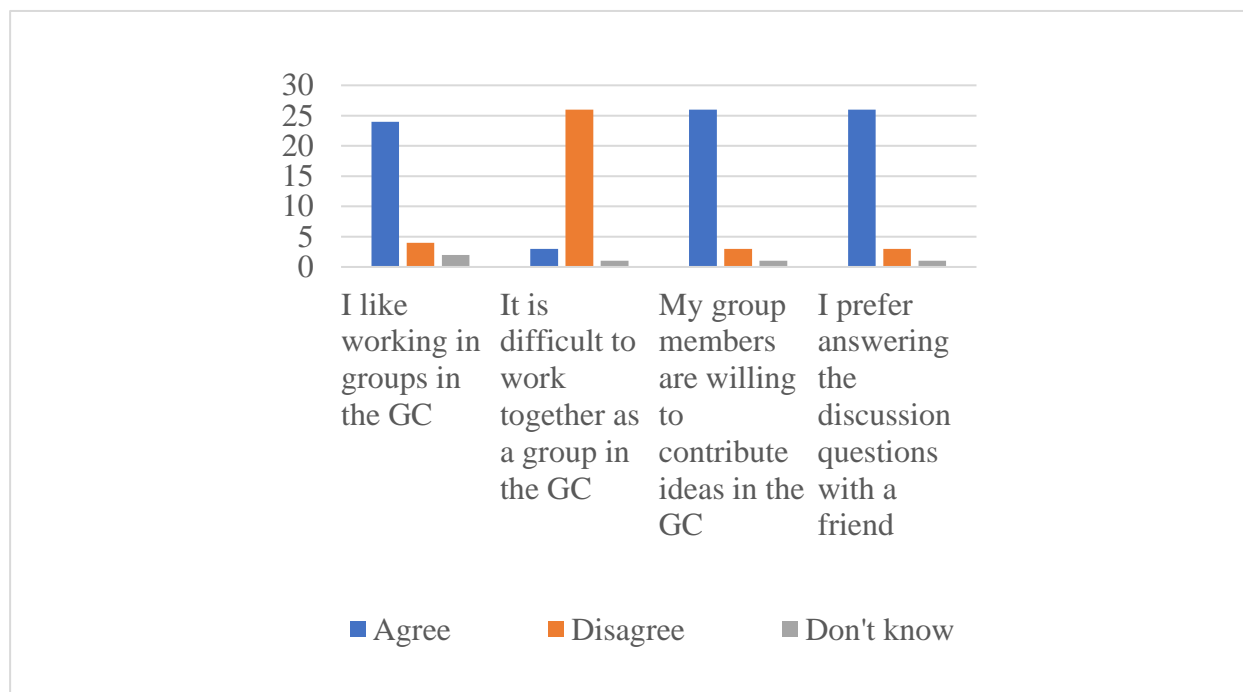
GC was the least accessed (43 log-ins) by only 21 participants as compared to the other tools. However, participants were engaged with the task on GC from the first week where they edited their group GC, as well as, created, distributed and animated video meeting and grading assignments. There was only one group in which members failed to cooperate and no activity was detected.

In sum, the mobile phone is a personal device which offers easy accessibility and, hence, is the most frequently used. There were fewer posts in the discussion forums and Wiki where the learners were working in groups despite, but both tools are useful for group responses. On the other hand, the GC enabled artefacts such as graphics and text to be used in communication.

Working in Groups

Participants preferred working in groups as can be seen in Figure 3, where group task on GC was attempted by most participants. In addition, contributions to the discussion forum were posted by participants belonging to groups of two or three.

Figure 3. Participants' perception of group work (n=30).



Results from the survey revealed that participants preferred to work in a group for both the online tasks (80%) and discussion forum (87%) and did not perceive group work as difficult (67%) (see Figure 3). Most perceived that their group members are willing to contribute ideas (87%). Group discussions were conducted face-to-face discussions and extended to text messages on Telegram and GC chat.

Learning in the Reflective Learning Module

Learning with the reflective learning mathematics module was investigated by understanding mathematics and learning support.

A pre-test and post-test on the similar concepts reported an increase in the mean scores of the participants. The paired sample t-test for statistical analysis was computed for 30 participants who completed both pre-test and post-test. The difference in the mean scores showed an increase indicating that the module was effective for learning mathematical concepts (see Table 3).

Table 3.

Mean of pre-test and post-test scores of participants, n = 30

| Mean scores | | Increase in mean scores |
|-------------|-----------|-------------------------|
| Pre-test | Post-test | |
| 58.97 | 84.07 | 25.09 |

Discussion

The mathematics module enhanced understanding of mathematical concepts related to speed and acceleration. Learners made references to materials, both online and print, enabling learners to formally model their answers during informal discussions. The findings of this study support the implementation of reflective learning in secondary school for mathematics. Communication processes on Wiki and discussion forums are public and present a permanent answer to the problem. At the same time, informal communications in constructing the solution contribute to the thought process. These interactions and discussions are beneficial for learning and constructing mathematics knowledge as proven by the results of the pre-test and post-test. These findings are also relevant as participants are from different level of mathematical abilities. Future studies can determine the effectiveness of reflective learning in mathematics module with a larger sample since the current study only involved 30 participants.

Previous studies have reported a combined use of several tools for learning where the combination of two tools was more effective than one. Not all learners will utilise CMC tools during implementation. By providing several tools as options, learners can respond by using the most suitable tool for learning. GC lends itself to collaborative problem solving; discussion forums are best for debates and arguments while text messaging are effective for factual and conceptual knowledge. This study also confirms that text-messaging can be used for informal discussions in knowledge-building besides being a stimulus for formal learning, especially in quizzes.

The preference for different CMC tools is related to learners' learning styles and convenience. Both components are potential areas for further research. In addition, future studies can also investigate if there are any significant differences between the usages of one, two or three CMC tools.

Conclusion

Findings confirmed that the development of mathematical module in support of reflective learning can be used to address learning needs in the field: (1) appropriate tool as teaching material in the development of a reflective learning mathematics module, (2) Mathematics teachers are expected to use this module during the process. The module can be used for mathematical learning outside school hours and address the issue of time constraint for classroom discussion.

The findings of the study reinforce the fact that important for learners to plan, share ideas, develop their understanding and promote critical thinking in a collaborative environment (Chikiwa & Schäfer, 2018; Ellerton, 2003). Communication contributes greatly to the learning of mathematics.

In conclusion, social learning in the use of mathematics module for reflective learning can also be extended to science subject. The social interaction aspect for knowledge-building through formal and informal learning can also be extended to other subjects as well. Contextual components, including participants' answers, are artefacts to "mediate" learning. Hence, in the mathematics module, if non-participation did not mean the learner was inactive. Learning could take place formally and informally when other learners' answers and interactions mediated learning.

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Author:

Asmahwati Rosli ¹, Wun Thiam Yew ², Ahmad Zamri Khairani ³

Affiliation:

^{1,2,3} School of Education Studies, University Sains Malaysia, 11800, Penang, Malaysia

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