eleed
e-learning
& education

Issue 5
2009

Effectiveness of an Online Social Constructivist Mathematical Problem Solving Course for Malaysian Pre-Service Teachers

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urn:nbn:de:0009-5-19999

Abstract

This study assessed the effectiveness of an online mathematical problem solving course designed using a social constructivist approach for pre-service teachers. Thirty-seven pre-service teachers at the Batu Lintang Teacher Institute, Sarawak, Malaysia were randomly selected to participate in the study. The participants were required to complete the course online without the typical face-to-face classes and they were also required to solve authentic mathematical problems in small groups of 4-5 participants based on the Polya's Problem Solving Model via asynchronous online discussions. Quantitative and qualitative methods such as questionnaires and interviews were used to evaluate the effects of the online learning course. Findings showed that a majority of the participants were satisfied with their learning experiences in the course. There were no significant changes in the participants' attitudes toward mathematics, while the participants' skills in problem solving for "understand the problem" and "devise a plan" steps based on the Polya Model were significantly enhanced, though no improvement was apparent for "carry out the plan" and "review". The results also showed that there were significant improvements in the participants' critical thinking skills. Furthermore, participants with higher initial computer skills were also found to show higher performance in mathematical problem solving as compared to those with lower computer skills. However, there were no significant differences in the participants' achievements in the course based on gender. Generally, the online social constructivist mathematical problem solving course is beneficial to the participants and ought to be given the attention it deserves as an alternative to traditional classes. Nonetheless, careful considerations need to be made in the designing and implementing of online courses to minimize problems that participants might encounter while participating in such courses.

Keywords: e-learning; online course; social constructivist; mathematical problem solving; critical thinking, satisfactions

1. Introduction

The Web represents the second wave of digital revolution that begins with the introduction of the personal computers in the 1980s (Wilson & Lowry, 2000). Its far-reaching impact is felt in many areas including the field of education. In fact, online learning utilizing the features of the Web is increasingly becoming an important tool for education (Bullock & Schomberg, 2000; Gallagher, 2001; McKimm, Jolie, & Gantillon, 2003; Yang & Cornelius, 2004). In particular, online discussions that encourage students to be involved and interact in the learning environment (Dillenbourg, 1999; Lavooy & Newlin, 2003; Tsoi, Goh, & Chia, 2000; Woo & Reeves, 2007) is steadily becoming a method of choice for teaching and learning.

Meanwhile, there has been an increase in the number of online courses being developed using the social constructivist approach (Downing, 2001; Gold, 2001; Young & Norgard, 2006). The social constructivist paradigm of learning emphasizes on the importance of social context in learning. Instructional models developed based on the social constructivist paradigm underline collaborative and interactive initiatives amongst the involved parties in the learning process (Woo & Reeves, 2007). The Web provides a good platform in which the ideals of social constructivism in learning could be realized. In fact, this is only the beginning, the Web holds great potentials in which many of the goals of social constructivism could be made to come through.

While there is a growing enthusiasm on the founding of teaching and learning within a social constructivist framework, educators, however, ought to be wary that students may not necessarily acquiesce and show interests in learning within such a setting (Becker, 2002). Furthermore, students' satisfactions and perceptions of online learning environments are important factors that could affect their success in the course (Arbaugh & Duray, 2002; Young & Norgard, 2006).

However, studies of social constructivism for online learning of math education in Malaysia are limited, especially those related to the training of pre-service teachers (Hong & Lee, 2005).

1.1 Aims of the study

This study investigated Malaysian pre-service teachers' assessment of an online mathematical problem-solving course. An online course on mathematical problem solving was specifically developed using a social constructivist approach. In addition to determining the participants' satisfactions and basic perceptions of the online course, this study examined the impact of the constructivist-based course on mathematical problem solving skills, critical thinking, as well as students' attitudes toward mathematics. Furthermore, it examined the effects of demographic characteristics such as gender, and computer competency on course achievements. The study also identified aspects of the course that facilitated and obstructed learning processes amongst the course participants.

2. Literature review

2.1 Constructivism and Web based Learning

The Web is an ideal forum to support constructivist learning though it has limitations. There are increasing numbers of Web courses being designed based on the principles of constructivism (Bragg, 1999; Jiang & Ting, 1998, 2000; Kanuka & Anderson, 1998). The Web technology enables the formation of a reflective and collaborative environment (Duffy & Cunningham, 1996; Eastmond, 2000) that erases geographical and social distances which helps foster better relationships and thus enhances the acquisition of knowledge through reflections via involvements in open and critical discussions (Maor, 1998). Meanwhile, Driscoll (1994) asserted that computers could provide interactive environments to carry out constructivist strategies, e.g., problem solving and the employment of knowledge in a reflective way which was hard to achieve in different media settings. According to Downes (2005), web-based learning placed the control of learning in the hands of the learner. In other words, it was learner-centred. Through web-based courses, learning is enhanced by allowing the students greater autonomy as well as increasing interactions between students and teachers. Findings from Lim (2003) and Balcytiene (1999) suggested that students generally performed better with Web learning based on constructivist principles as compared to conventional classroom learning environments.

2.2 Satisfactions with online courses

Participants' satisfaction toward the learning environment is a critical factor in online learning (Andreatta, 2003). Previous studies (Blackwell, Roack, & Baker, 2002; Hong, Lai, & Holton, 2003; Klinger, 2003; Young & Norgard, 2006) reported that most participants were satisfied with the online courses, while other studies reported participants having higher satisfactions with face-to-face courses (Lauren, Jennifer, & Marguerite, 2004). Furthermore, while Gallo (2007) and Strachota (2003) reported that participants' characteristics such as gender, age and computer skills could influence students' satisfaction with online courses, other studies (Hong, 2002; Hong et al., 2003) reported otherwise; high satisfaction towards web courses were dependent upon more positive attitudes and good performance in mathematics as well as good existing computer skills. Meanwhile, a number of the literature (Graham, Cagiltay, Lim, Craner, & Duffy, 2001; Hiltz, Coppola, Rotter, Turoff, & Benbunan-Fich, 2000; Motiwalla & Tello, 2000; Sher, 2004; Young & Norgard, 2006) showed that interpersonal interactions and positive feedbacks by instructors impacted positively on participants' satisfactions with online courses. Andreatta (2003) argued that feedbacks with affective components supported students' motivations, which in turn resulted in higher satisfactions.

2.3 Perceptions toward online courses

Participants of online learning environment generally appreciated the flexibility and the structures in online classes where learning can be carried out individually and independently (Pedone, 2003). Hong (2002) and Hong, Liau, and Lee (2006) in their studies reported that participants perceived flexibility in course structure as the strength of online courses, and that the participants found their learning experiences in these courses to be motivating. According to Krebs (2004), participants of online courses viewed online learning environment as enabling them to study at their own pace, to be actively involved in the learning activities, to improve their intrinsic motivation to learn and to practice self-study as compared to those students attending traditional face-to-face classes

Generally, the literature concurs that participants of online courses had positive perceptions of the collaborative nature of online learning experiences. The participants believed that collaborative group activities were interesting and stimulating (Young & Norgard, 2006). Studies (Lavooy & Newlin, 2003; Woo & Reeves, 2007) have also found that the use of unsynchronised collaborative communication would yield a more conducive learning environment in the understanding and learning of course materials by the participants. However, the study by Curtis and Lawson (2001), which explored collaborative learning in online learning environment, reported differences in collaborative behaviours in face-to-face contexts and online environments among the participants and attributed the differences to the lack of the “explain and challenge cycle” which was one of the defining characteristics of face-to-face interactions. Furthermore, Williams and Purry (2002) reported that some participants felt uneasy during online asynchronous discussions regardless of whether the discussions were optional or compulsory.

2.4 Studies on online mathematics/ mathematical problem solving course

Gallo (2007) in her study on mathematics online courses argued that students participating in online courses generally performed on par with those enrolled in on-campus courses. Age and students’ academic ability were found to impact positively on students’ achievement in online statistics courses. Furthermore, Allen, Stecher, and Yasskin (1998) posited that students who were strongly motivated, self-starters and intellectually mature were more likely to succeed in online courses.

Problem solving is an important component of mathematics learning (NCTM, 2000). Based on Polya’s Problem Solving Model (1981), Lau, Hwa, Lau and Limok (2003) reported that students’ achievements deteriorated significantly with increase in the difficulty level of the mathematics problems assigned to them. Furthermore, Brown (2003) found that teachers generally possessed positive attitudes toward problem solving but were rather weak in their abilities to solve problems. Utsumi and Mendes (2000), on the other hand reported significant differences in attitudes toward mathematics based on variables such as types of schools, stage of schooling, age, students’ understanding of mathematical problems solved in class, and students’ achievement in mathematics.

In general, online learning environment has shown potentials in promoting thinking skills (Saba, 2000). Furthermore, Dockrill (2003) found that students perceived interactive teaching and learning approaches as facilitating the acquisition of critical thinking skills. Kosiack (2004), in his research on the quality of online mathematical communications, reported that collaborative mathematical problem solving has a positive impact on mathematics achievements. Kinney, Stottlemyer, Hatfield, and Roberston (2004) reported improvements in achievement for online mathematics learning environment. Carter (2004), however, found that the use of online learning did not result in significant improvement in achievements and attitudes toward mathematics. Hong (2002) obtained similar results in terms of attitudes toward statistics course.

3. Research methodology

3.1 Research design

This study employed the pre-experimental approach without the utilization of control groups (Creswell, 1994). Quantitative data were collected using questionnaires, while qualitative data were collected through interviews. Questionnaires were used to measure the major parameters examined in the study. Additional information was collected during the interview sessions with the course participants. According to Windschitl (1998), qualitative data can capture unique phenomena on online learning.

3.2 Research participants

The participants of the study comprised of 37 pre-service teachers in the second semester of a one and half year Graduate Diploma in Teaching Program specializing in secondary mathematics education at the Batu Lintang Teacher Institute, Sarawak, Malaysia. They were selected using random sampling from the population of pre-service teachers comprising of the July 2004 and January 2005 intakes. From the 37 participants, 11 were female, and 26 were male, all between 20-30 years of age. They rated themselves as being novice and moderate computer users and have only used computers for e-mailing and searching and downloading of information. The participants were on-campus students and they could access the online course using their own laptops or the computers in the laboratories. The specifically designed mathematical problem solving course is a requisite for the Bachelor Degree in Primary Education (PISMP) Program for participants with the equivalent of GCE “A” entry-qualification and the Diploma in Education Program (KPLI) for participants with bachelors degree entry-qualification offered by the Department of Teacher Education, Ministry of Education, Malaysia.

3.3 Research instruments

Data were collected from the participants using questionnaires and interviews. The questionnaires gathered information pertaining to the participants' gender, age, existing computer and Web skills. The questionnaires also measured the participants' satisfactions toward the course as well as their perceptions on the delivery method, course structure, interactions amongst participants, interactions between the participants and the materials, interactions between the participants and facilitators during computer conferencing and participants' autonomy. Collection of data was also done through a mathematical problem solving performance test (to measure mathematics achievement, problem solving and critical thinking skills); a questionnaire on participants' mathematical problem solving skills; and a questionnaire (*Aiken Revised Mathematics Attitude Scale*) that measures participants' attitudes toward mathematics.

The research instrument consisted of four main sections; namely, Problem Solving, Problem Solving Skills, Perceptions of the Web-based course, and Attitudes Toward Mathematics. The first section, Problem Solving, was a test consisting of 15 multiple-choice questions and eight open-ended questions. The contents of the problem solving test complied with the Test Specification Table included in the course syllabus, and was validated by two senior mathematics lecturers at the teachers' college. The duration of the test was 2 ½ hours. It was pilot tested with an earlier group of 24 students from the same program. The Cronbach Alpha value was 0.87 for the multiple-choice questions and the inter-rater reliability coefficient was 0.86 for the open-ended questions.

In the second section, Problem Solving Skills, there was a questionnaire of 20 items with Likert-scale responses. The 20 items outlined the various skills that the participants might use to solve mathematical problems. The participants selected responses ranging from 1 (never) to 10 (very often) to indicate the level of use of the various skills. This Problem Skills Scale was developed by Lau et. al (2003). The Cronbach Alpha coefficient of this instrument was 0.80.

The third section, Perceptions of the Web course, was adopted from Hong (2002). In this section, the participants indicated to what extent they agreed with statements made about the web course. Participants' perceptions about the web course's delivery system and course structure, as well as the presence of interactivity and learner autonomy were measured. The reliability of this section was reported as 0.83 (Hong, 2002).

The final section of the instrument was Attitudes toward Mathematics. It consisted of 20 Likert-scale items developed by Aiken (1963) and translated into the Malay language (the national language of Malaysia) by Panting (1985). The participants were required to indicate to what extent they agreed with each statement that was made about carrying out a specific mathematical task. Their responses ranged from 1 (Strongly Agree) to 5 (Strongly Disagree). The Cronbach alpha value was reported as 0.88 by Panting (1985).

3.4 The online mathematical problem solving course

The course aimed to provide pre-service teachers with the skills to solve mathematical problems based on the Polya's Problem Solving Model (Polya, 1981). Generally, effective problem solving initially entailed the following: the identification and understanding of the problem which included labeling and identifying unknowns, the conditions of the problem, the required data and the solvability of the problem. This was followed by the formulation of plans to solve the problem (device a plan). In order to devise a plan it was necessary to draw on prior knowledge to frame an appropriate technique, restating the problem if necessary. Subsequently, the chosen plans/ techniques (carrying out the plan) were then employed to solve the problem which was then re-examined (review) to see if it achieved the desired results. The final phase consisted of checking the correctness of each solution with the intention of adding each problem to one's store of knowledge for use in solving future problems.

The course was a one-credit course carried out in eight weeks between July to September of 2005. At the same time, they were also enrolled in two other courses of one credit each. They were expected to spend around three hours per week in the course, including two hours per week reading the online resources, participating in the online asynchronous discussions and discussing the group assignments, with the remaining hours used for offline activities such as completing assignment individually, self-reading and information gathering.

Participants registered in the course could access the main page using the provided username and password. The main page offered information concerning the synopsis, objectives, content, schedule, student name list and the lecturer profile of the course. Through the main page participants were able to carry out computer conferencing via group and general forums. Participants also made use of the file sharing portal to upload related files. Each participant was required to write a reflection at the end of every week to be published online. And all course materials were made available online. The course content domain in the web main page comprised the learning units, reference materials, assignments and timeline for course implementation.

The participants were required to follow the course online without face-to-face interactions between the course facilitator (third author) and the participants. All communications were done through online asynchronous discussion. The facilitator/ teacher during the discussion forum, if required, began with a general question or suggestion and if necessary, narrowed gradually to more specific and concrete questions and suggestions until reaching one which elicited a response from the students. The teacher in this study prompted the students with the use of key suggestions and questions. The key suggestions and questions had two common characteristics; they were common sense and general in nature. As the questions and suggestions were common sense, answers from the participants often came naturally. Because they were general, they helped the students unobtrusively, indicating a general direction and leaving plenty of opportunity for the participants to form their own ideas.

The course consisted of three units - Unit 1: Introduction to problem solving; Unit 2: Mathematical problem solving process; and Unit 3: Problem solving strategies. Unit 3 was further divided into four subunits encompassing strategies such as using tables, drawing diagrams, elimination and working backward. The social constructivist learning environment in this online course was developed based on the Jonassen, Peck, and Wilson's Model (1999) shown in Figure 1.

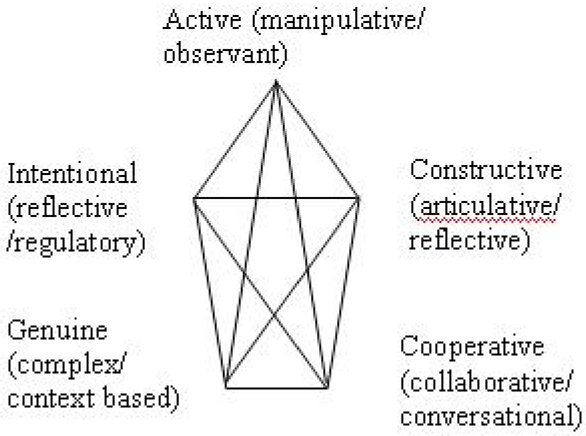

Figure 1: Model of the social constructivist learning environment

This model enabled course participants to be actively involved in meaningful learning and had five characteristics i.e., it was active, constructive, intentional, authentic and cooperative. Course materials were uploaded to the Web to allow access at any time. The participants were required to have interactive online group discussions for the given assignments and had their works uploaded into a public forum to be commented on by participants from other groups. The participants participated actively and intentionally in the tasks assigned to find the solutions. Assessments were done at the end of the course through a mathematical problem solving test. Figure 2 is an example of authentic group assignments which were formulated based on meaningful practical tasks and online asynchronous discussions. These authentic assignments were presented in a manner relevant to the participants' future use and real life applications (Dolmans, Snellen-Balendong, Wolfhagen, & van der Vleuten, 1997; Jonassen, 1997) and addressed the instructional objectives of the course (Dolmans et al., 1997).

A travel agency has a special offer for tourists going to Taman Negara using coaches with the following terms:

- Cost for each ticket is RM100 if all the 40 seats in the coach is filled
- Otherwise, the surcharge per seat is RM5 for each empty seat

How many tickets should the agency sell to maximize its profit for each trip?

Figure 2: An example of authentic problem

For each unit in the course, the participants had to read the reading materials uploaded in the course web site and collaboratively discussed the authentic assignments in groups of four or five using the private online forums. The groupings were decided by the course instructor based on mixed-ability groupings. Completed assignments were posted online to be commented and discussed by other participants. The course instructor facilitated these discussions. These discussions were constructive, reflective, active and cooperative in nature, and were meaningful, enabling participants to fully understand the domain of the online course. According to Woo and Reeves (2007), while engaging in authentic learning tasks with peers and facilitators, learners could generate and share ideas, negotiate, and synthesize their thoughts with those of others, thus completing the tasks and refining them on the basis of sharing of insights and critiques.

The online course was developed using Coldfusion and a screenshot of the online asynchronous discussions is shown in Figure 3. It gives the illustration of the discussion of an authentic problem using the National Language (Malay Language). The students can use equation editor in the Word Processor to include more complex equations or paste scanned images of written solutions to the discussion board. In Figure 3, it is shown that some of the participants wrote comments in English, while others wrote in the Malay Language (the National Language of Malaysia). Participants were allowed to discuss in a mixture of the two languages as at the time of this study, the Malaysian Education System was in a transition from teaching mathematics in the Malay Language to teaching it in English. In addition, the students were able to enter more complex formulas by using the Microsoft Equation 3.0 or by scanning images.

Figure 3: Screenshot of the online asynchronous discussion.

3.5 Data analysis

Data on the participants' perceptions and satisfactions toward the online course were obtained from questionnaires and interviews. Semi-structured interviews with four focus questions on the participants' views/values, experiences/behaviours and feelings (Patton, 1990) after completing the online course were conducted with all the 37 participants. Follow-up probing questions were presented to obtain more data from the focus questions. Besides being analysed and presented using descriptive statistics (frequencies, means and standard deviations), the scores and responses to the test and questionnaires were computed and compared using independent and dependent t-tests.

4. Results

4.1 Satisfactions with the online course

Table 1 shows the responses from the participants for two items associated with their satisfactions with the online course. The results showed that 97.3% of the participants agreed that the course had helped them to learn problem solving in mathematics (Mean, M=4.2; Standard deviation, SD=0.5). Furthermore, 91.9% of the participants believed that the online course was a conducive learning environment (M = 4.2, SD = 0.6).

	Responses						
Items	SA	A	US	DA	SDA	M	SD
I believe that the online course helps me to learn problem solving in mathematics.	8	28	1	0	0	4.2	0.5
I believe that the online course provides a conducive learning environment.	9	25	3	0	0	4.2	0.6
Note: SA = Strongly Agree (5), A = Agree (4), US = Unsure (3), DA = Disagree (2), and SDA= Strongly Disagree (1), M = Mean, SD = Standard Deviation							

Table 1: Satisfactions with the online course

4.2 Perceptions of the course delivery system and course structure

Table 2 shows the participants' perceptions of the various features in the online course. The participants were generally satisfied with the course delivery system (M = 4.0, SD = 0.7) and the course structure (M = 3.9, SD = 0.7). In terms of course delivery system, 97.3% of them felt that the online course was effective for interactive learning, 81.1% felt that the course content was well-delivered and 91.9% experienced enhanced interests in learning. However, only 64.9% reported gaining easy access to technical support during their online learning experiences.

For course structure, 83.8% of the participants felt that the course content was well structured, 86.5% perceived the course assignments to be appropriate, 94.6% agreed that they could actively involve themselves in the learning activities, and 81.1% felt that the course materials satisfied their learning needs. A total of 56.8% of the participants felt that they could access the course without the constraints of time and place. The remainder 43.2% of the participants had some problems using the course website. Of the 43.2%, 10.8% did not own personal laptops or computers and depended on the computers at the college's computer laboratories. The other 32.4% of those participants who had problems using the course website did own computers; however, they reported problems accessing the course websites at times due to intermittent internet access at their homes or college dormitories.

	Feedbacks						
Items	SA	A	US	DA	SDA	M	SD
Delivery system							
I believe that the online course is an effective means for interactive learning	11	25	0	1	0	4.2	0.6
I believe that the online course contents are well delivered	4	26	5	2	0	3.9	0.7
The online course enhances my interests toward learning	11	23	2	1	0	4.2	0.7
It is easy to gain access to technical supports	3	21	10	3	0	3.7	0.8
(For these four items, M = 4.0, SD = 0.7)							
Course Structure							
I believe that the online course contents are well structured	3	28	5	1	0	3.9	0.6
I believe that the tasks assigned are reasonable	7	25	4	1	0	4.0	0.6
I am able to access the course content without the constraints of time and place	3	18	9	7	0	3.5	0.9
I can actively involve myself in the learning process	8	27	2	0	0	4.2	0.5
I believe that the course materials satisfy my learning needs	2	28	6	1	0	3.8	0.6
(For these five items, M = 3.9, SD = 0.7)							

Table 2: Perceptions of the course delivery system and course structure

4.3 Learning Autonomy

As shown in Table 3, the participants generally had positive attitudes toward individual learning in the online course (M = 4.1, SD = 0.6). Majority of them (91.9%) agreed that they were able to determine their direction of learning in the course, 83.8% could obtain the learning resources from the library and the Internet, 75.7% could complete the learning tasks on time, 97.3% preferred to study at their own pace, 86.5% liked to be actively involved in group discussions, 91.9% valued the facilitator's contributions in the learning process and all of them believed that discussions with other course participants formed an integral part of their learning in the course.

	Responses						
Items	SA	A	US	DA	SDA	M	SD
I can determine the direction of my study	7	27	3	0	0	4.1	0.5
I can obtain the materials from the library and Internet for learning	7	24	5	1	0	4.0	0.7
I can complete the task assigned within the time given	4	24	6	3	0	3.8	0.8
I like to study at my own pace	9	27	0	1	0	4.2	0.6
I like to involve myself actively in group discussions	7	25	5	0	0	4.1	0.6
I appreciate the contributions from the facilitator toward learning in the course	11	23	3	0	0	4.2	0.6
I believe that discussions with other course participants are part of the learning experience	15	22	0	0	0	4.4	0.5
(For seven items, M = 4.1, SD = 0.6)							

Table 3: Perceptions of learning autonomy

The following results were obtained through feedbacks from participants during interviews on their perceptions toward the online course.

Design of Web pages and course activities

Generally, the participants felt that the Web pages were well-designed, complete and easy to access. The participants also observed that the learning materials, such as the course notes and assignment questions were complete and easy to access. The findings from the interviews suggested that the participants believed that the course activities fitted well with the course objectives and helped them to master the required problem solving skills. Specifically, a participant reported that “the activities carried out were suited to the competency levels of the participants, and the objectives of the course were attainable.” Furthermore, 32.4% of the participants felt that the course activities were interesting and managed to inculcate creative thinking and could stimulate their interests in mathematics.

Course delivery, course structure, flexibility of courses and new learning experiences

A participant pointed out: “It was an interesting, interactive and friendly learning environment. It allowed participants easy access to information.” The participants also believed that the course helped them to think systematically, logically and critically. They viewed the flexible nature of the course as an advantage for them. They were able to follow the course without the constraints of time and place. “I was able to access the course regardless of where we were insofar as there are Internet networks,” commented a participant. They felt that the online course was an interesting and new learning experience, enjoyable and motivating.

Positive attitudes, self-discipline and students’ autonomy

The participants believed that they required positive attitudes to succeed in online learning and in fact, the course did inculcate some of them with positive self-attitudes. For instance, one of the participants believed that the “course instilled positive attitudes and we were able to overcome many problems encountered. The course also emphasized on knowledge sharing and encouraged us to share information.” Apart from that, the participants believed that they need to have self-discipline to succeed in the course, as a participant emphasized: “The course tested our self-discipline because participants’ concentrations could be easily diverted when we did not meet the facilitator face-to-face. Furthermore, participants could stray from the course Web site and surf unrelated Web pages in the Internet.” The self-paced and self-access mode of learning made them more independent in learning, as one of the participant aptly observed, “The course helped the participants to become independent and this was important because there were participants who could be at remote areas, far from the facilitator.”

Role of facilitators and authentic problems

The interviews suggested that the participants in general believed that the facilitator was effective in facilitating the course activities. Amongst others, a participant stated that “the facilitator would assist us when we faced problems in solving mathematical problems.” They also viewed that the use of authentic mathematical problems related to their daily lives assisted them in understanding the course content and enhanced their critical thinking skills as shown in the following comment, “I felt that I have become more critical in solving mathematical problems and also I could understand the different aspects of problem solving through interacting with other participants.”

4.4 Interactions in the online asynchronous discussion

As Table 4 shows, on the whole, participants were satisfied with the effectiveness of group discussions in the online asynchronous discussion (M=4.1, SD=0.7 for the five items on “small group dynamics”). Specifically, 72.9% agreed that group discussions during the online asynchronous discussion function effectively, 83.8% believed that the group discussions enhanced their understanding of mathematical problem solving process, while 91.9% felt that they could contribute to the group discussions. Furthermore, 97.3% of the participants stated that they were able to learn from the other participants, while 91.9% agreed that group size of 5-6 participants was appropriate for group discussions (Scripture, 2008).

Participants were generally satisfied with the role of the facilitators in computer conferencing (M=4.0, SD=0.8, for the five items in the “role of course facilitators/ participants”). Specifically, 83.8% of the participants agreed that the facilitators had succeeded in encouraging group learning through questioning, challenging and providing appropriate criticisms. Another 94.6% felt that they could obtain assistance in understanding the content of the course, 64.9% believed that they were able to obtain the necessary information from the facilitator as frequently as they required it, 67.6% were satisfied with the interactions between participants and facilitators, while 91.9% felt that the content of the discussions amongst participants enhanced their learning.

As a whole, most of the participants were satisfied with the learning materials used in the online asynchronous discussion sessions (M=4.1, SD=0.6 for the three items on “learning materials”). Besides enabling participants to understand the course content (97.3%), the participants’ comprehension of the mathematical problem solving process was enhanced by studying the problems (89.2%) and course materials online (89.2%).

	Responses						
Items	SA	A	US	DA	SDA	M	SD
Small group dynamics							
On the whole, my discussion group functions effectively	9	18	6	4	0	3.9	0.9
The group discussion enhances my understanding of the mathematical problem solving process	7	24	5	1	0	4.0	0.7
I can contribute to the group discussion	5	29	2	1	0	4.0	0.6
I can learn from other students in group discussions	11	25	0	1	0	4.2	0.6
The group size is appropriate for discussions	15	19	1	2	0	4.3	0.8
(For these five items, M = 4.1, and SD= 0.7)							
Role of Facilitators/ Course Participants							
The facilitators encourage group learning through questions, challenges and criticisms	8	23	6	0	0	4.1	0.6
I obtain feedbacks from facilitator as frequent as I need them	6	18	10	3	0	3.7	0.8
I could interact with the facilitator as frequent as I need them	6	19	9	3	0	3.8	0.8
I could obtain assistance to understand the content of the course	6	29	1	1	0	4.1	0.6
The content of discussions amongst the participants could enhance my learning	12	22	1	1	1	4.2	0.8
(For these five items, M = 4.0, SD = 0.8)							

Learning materials							
I can understand the course content	6	30	1	0	0	4.1	0.4
Paying attention to the mathematical problem enhances my understanding of the problem solving process in mathematics	9	24	4	0	0	4.1	0.6
The use of materials in the course enhances my understanding of the mathematical problem solving process	9	24	3	1	0	4.1	0.7
(For these three items, M = 4.1, SD = 0.6)							

Table 4: Perceptions of the dynamics of small groups, role of facilitators, and learning materials used in online asynchronous discussion

The following results were obtained from participants' feedbacks during the interview sessions.

Sharing of knowledge, collaborative activities and active involvement in computer conferencing
The online asynchronous discussion provided the participants with the opportunities to exchange opinions and share ideas and in the process improved their learning experiences. For instance, one of the participants felt that "the most important aspect of the online course was the online asynchronous discussion where they were able to exchange and give opinions." They also had the opportunities to carry out collaborative activities with other participants, as one of them stated that "the course provided opportunities to discuss, to share information as well as learning through collaborations."

Enhancement of computer skills and motivation to learn
About 11% of the participants perceived that online asynchronous discussion could enhance their computer skills. A participant noted that "My computer skills were enhanced after completing the course." This was largely due to the fact that the participants were forced to use the computer and certain software to complete the assignments. The participants believed that online asynchronous discussion was able to increase their motivations and interests in learning. For instance, one of the participants stated that "it was as though we were competing amongst ourselves to solve the given tasks, each wanting to become the earliest to present the answers. The course was interesting and I was motivated to learn."

Factors influencing the effectiveness of online asynchronous discussion
The participants outlined seven factors they believed could contribute to the effectiveness of online asynchronous discussion. In fact, 56.8% of the participants believed that active involvement and cooperation amongst participants played an important role in determining

the effectiveness of online asynchronous discussion. And 45.9% of them felt that the participants need to have positive attitudes toward online asynchronous discussion to achieve the objectives set for the online asynchronous discussion sessions. However, 43.2% of the participants felt that individual differences in terms of the ability levels could influence progress in the course and that the rate of feedbacks from fellow participants influenced their learning and interests in studies. Good computer skills could assist them in the course.

Aspects of the course that hinder learning
From the interview, seven weaknesses hindering learning were identified. A small number of the participants (8.1%) felt segregated while following the online course. Some of the communication problems faced by the participants were difficulties in explaining and understanding of the mathematical solutions via online asynchronous discussion, availability of sufficient computer facilities, and technical problems related to the computer server such as unavailability and problematic speed of network connections, as well as difficulties in up- and down-loading of files. Majority (81.1%) of them would like to equip themselves with the basic computer skills, such as “Microsoft Word,” “Excel,” “Equation Editor,” and graphic software in order to follow the course effectively.

4.5 Attitudes toward mathematics

Table 5 shows that there was no significant improvement in attitudes toward mathematics before (pre-test) and after (post-test) completing the online course ($t(36)=1.75$, $p=0.089$). However, the means for the pre-test (M = 82.65) and post-test (M = 84.84) indicated that the participants had positive attitudes toward mathematics.

	M	SD	t-value	df	p-value
Pre-test	82.65	12.33	1.75	36	0.089
Post-test	84.84	10.26			
Note: Scores of 60 to 100 on the Aiken Revised Mathematics Attitude Scale indicate positive attitudes toward mathematics					

Table 5: Dependent t-test results: Attitudes toward mathematics

Though there was no difference in attitudes, high scores in attitudes toward mathematics appeared to have direct implications on motivations. Mathematics attitudes refer to the students’ feelings about the importance and relevance of mathematics, as well as their enjoyment of mathematics. What is more, motivation to learn refers to the students’ tendency to find academic activities meaningful and worthwhile (Brophy, 2004). It also reflects the students’ inclination to derive intended learning benefits from academic activities. Thus, although there was no significant difference in attitudes, generally they had high affective views on mathematics, i.e., they viewed mathematics as important and relevant. Furthermore, the enjoyment of mathematics in turn motivated them to get the most out of their web based mathematics learning experiences. In fact, the participants perceived the course as being able to enhance their confidence and motivation to learn mathematical problem solving. One of the participants commented: “After the course, I am more motivated to solve mathematical problems using the various methods. I am interested in problem solving in mathematics. Indeed, I would be using mathematical problem solving in my daily live.”

4.6 Critical thinking skills

On critical thinking scores, the pre-test mean score was 48.16 from a total score of 79. This showed that the participants’ critical thinking skills were generally low. The mean score for the post-test was 55.14 indicating moderate level of critical thinking. Table 6 shows the result of the dependent t-test for the pre- and post-test on critical thinking skills. There was a significant improvement in the critical thinking skills among the course participants ($t(36) = 5.52$, $p < 0.05$).

	M	SD	t-value	df	p-value
Pre-test	48.16	15.06	5.52	36	< 0.0005
Post-test	55.14	13.33			

Table 6: Dependent t-test results: Critical thinking skills

The interview data also showed that the participants believed that the Web-based mathematics problem solving course created opportunities for them to think logically, systematically and critically. A participant stated that “The online discussion was collaborative in nature. We can discuss and assist each other to understand and solve mathematical problems.”

4.7 Mathematical problem solving skills

Analysis in this section employs Polya’s four-steps model in problem solving. As shown in Table 7, the mean scores for “understand the problem” before (M = 8.09) and after (M = 8.47) attending the Web-based course were satisfactory. For “devise a plan”, the mean score of the participants before attending the course was 7.68 and this score indicated moderate level of competency. The mean score after attending the course was 8.02, showing that the level of competency improved to satisfactory. Scores for the participants before and after attending the course for “carry out the plan” and “review” were between 7.38-7.86. These scores indicated that the participants’ skills in “carry out the plan” and “review” were just at the moderate level.

There were significant improvements in the problem solving skills of “understand the problem” (t(36)=2.25 and p=0.031) and “devise a plan” (t(36)=2.30 and p=0.028). However, there were no significant increases in the mathematical problem solving skills for “carry out the plan” and “review”.

		M	SD	t	df	p-value
Understand the problem	Pre-test Post-test	8.09 8.47	1.06 0.89	2.25	36	0.031
Devise a plan	Pre-test Post-test	7.68 8.02	1.06 1.02	2.30	36	0.028
Carry out the plan	Pre-test Post-test	7.38 7.68	0.84 0.99	1.61	36	0.116
Review	Pre-test Post-test	7.66 7.86	0.98 1.10	1.18	36	0.244

Table 7: Dependent t-test results: Problem solving skills.

4.8 Demographic characteristics and course achievements

Table 8 shows the independent t-tests results. There were no significant differences in course achievements based on gender (t(35)=0.41, p=0.686). However, the achievements of the groups, which had low and moderate initial computer skills, differed (t(35)=3.548, p=0.001).

		M	SD	t	df	p-value
Gender	Male (n=11) Female (n=26)	7.18 8.35	7.12 8.25	0.41	35	0.686
Initial computer skills	Low (n=16) Moderate (n=21)	3.44 11.48	3.18 8.60	3.548	35	0.001 *
*Note : * Significant at p < 0.05*						

Table 8: Demographic characteristics and achievements

5. Discussions

5.1 Course satisfactions and aspects of the course that aid learning process

The study reported high level of satisfactions toward the online course. This is consistent with the findings of most studies on online courses in the literature (Hong, 2002; Klinger, 2003; Young & Norgard, 2006).

Similar to the findings reported by Hong (2002), Hong et al. (2003) and Klinger (2003), course flexibility was one of the reasons participants were satisfied with the online course. Likewise, as stated by Hong (2002), the participants in this study believed that they must have positive attitudes, self-discipline, ability to work independently and self-confidence to succeed in the course. Furthermore, they need to have intrinsic motivations to take part in the activities designed in the online course including completing the assignments, reading the course materials and participating in the online asynchronous discussion and this was consistent with the results reported in Gallo (2007) and Roberts (2003).

Participants of the course also pointed out that the online course provided them with the opportunities to discuss, share information and carry out collaborative learning through online asynchronous discussions. Via online asynchronous discussion, they were able to interact with fellow participants and the facilitator at any time and place. In general, the participants were satisfied with the interactions amongst participants and with the facilitator. In fact, the participants would like to be actively involved in the online asynchronous discussions and believed that discussions with other participants were important for their success in the course. Nonetheless, as reported in Matuga (2001), some groups may have better group dynamics resulting in more frequent and more quality discussions compared to other groups.

The literature also reported other factors that could impact on learning in online courses such as accessibility to course materials and frequencies, immediacy and length of feedbacks from the instructors (Hong et al., 2006; Lauren et al., 2004). Likewise, in this study, the participants reported that they were able to interact and obtained feedbacks from the facilitator as frequently as they required. For them, the moral support and assistance provided by the facilitator were some of the factors that contributed to their satisfactions with the course and these findings were also reported by Andreatta (2003). However, some participants became disappointed when they were not given feedbacks within reasonable time frame from other group members and when their fellow participants were not actively involved in the discussions.

Nearly two thirds of the participants agreed that the interface design of the Web page was user friendly, simple and attractive. In addition, they found that the course content to be well organized, notes easy to refer to, and files could be easily uploaded and downloaded. They also felt that the course activities suited the course objectives and the competency levels of the participants. Furthermore, these course activities were able to enhance their interests toward mathematics and encouraged them to think critically. The study also showed that most of them preferred to study with self-access at their own paces. As reported in Hong (2002) and Hong et al. (2003), the participants believed that the course not only helped them to enhance their mathematical problem solving skills, it also enhanced their computer skills and knowledge.

5.2 Aspects of the course that hinder learning process

However, a small number of participants (8.1%) felt isolated while completing the online course. This could be attributed to the lack of face-to-face interactions. As reported in the literature, participants lacking learning experiences with online courses required more assistance from facilitator compared to experienced participants (Chang, 2003). About 41% of the participants experienced technical problems while using the Web pages and computers including server and computer breakdowns, Internet disconnections, and problems related to uploading and downloading of files from the Web pages as similarly reported in Hong (2002). And 68% of the participants found it cumbersome to explain mathematical problem solving through online asynchronous discussion, especially if their computer skills were lacking as sometimes diagrams and mathematical equations were required to facilitate the discussions.

5.3 Attitudes toward mathematics and critical thinking skills

Meanwhile, the study found no significant improvement in attitudes toward mathematics. However, the interviews showed that most participants (82%) believed that the course was challenging, stimulating and fun for them. The participants also showed positive attitudes toward mathematics. The results of the study indicated that online courses might not necessarily change participants' attitudes toward mathematics; as reported likewise in Carter (2004) and Hong (2002).

On the other hand, the course succeeded in enhancing critical thinking skills amongst the participants. The participants felt that the course gave them the chance to think deeply, logically and systematically, and helped to generate critical thoughts. This finding was supported by those reported in Lim (2003). The use of authentic problems, online discussions and various tools in the online course such as external links to relevant sources enabled the participants to gain new knowledge and they were able to restructure their knowledge scheme. As Chrenka (2001) pointed out, the constructivist framework for learning enabled students to restructure their thinking by assisting them to think in increasingly complex ways on the multiple perspectives of a problem and the problem solving process.

5.4 Mathematics problem solving skills

The study showed that there was a significant enhancement in the mathematical problem solving skills of “understand the problem” and “devise a plan” based on the Polya's Model. The participants' skills in “understand the problem” was good before attending the course and it improved further upon completing the course. On “devising a plan”, the skills of the participants were at moderate level prior to the course, and they were good at it upon completing the course. There were no significant changes in “carry out the plan” and “review”. However, data from the interviews indicated that most participants showed higher interests and motivations toward problem solving in mathematics. Although the participants felt that the problems given were difficult and challenging, they were able to use appropriate strategies to solve them. The participants were able to solve the problems at their own pace and collaborations among participants helped in the problem solving process.

5.5 Respondents’ characteristics and course achievements

There were no significant differences in achievements in the online course based on gender, consistent with the findings of Hong (2002) and Wang and Newlin (2002). There were, however, significant differences in course achievements based on initial computer skills. Generally, participants reporting their computer skills at the novice levels tended to perform lower in the course. This finding concurred with those reported by Wang and Newlin and Wen and Truell (2001) but contradicted those reported by Frederickson et al. (2000), Hong (2002), and Swan et al. (2000). The participants with higher computer skills could have experienced fewer obstacles in handling the computer and web tools required to effectively learn the course content as compared to those with less computer skills (Hong, 2002). It is possible that the participants with higher computer skills may have been more satisfied with the Web-based course. They then, in turn, could have been more motivated to learn, and hence were able to learn more effectively in this learning environment. However, some researchers such as Swan et al. (2000) further argued that computer skills might not be an important factor in determining success in Web-based courses as it was expected that the technology would eventually evolve to a user-friendly stage where even participants of Web-based courses with novice computer skills would not face problems interacting in the learning environment.

6. Conclusions

The study examined the various important dimensions of an online mathematical problem solving course designed using a social constructivist approach. Participants generally provided positive feedbacks on the online learning environment though they were faced with challenges, problems and constraints in attending the course. Most participants were satisfied with the designs, materials and course activities, interactions and communications amongst participants as well as the role played by the facilitator. In fact, they believed that these factors helped in their studies.

Generally, online courses could successfully enhance participants’ course achievements, critical thinking skills and two of the four mathematical problem solving skills (Polya’s Model). Participants’ existing computer skills could impact on their success in an online course. However, gender is not a factor that could influence success in such courses. The outcomes also suggest that the participants need to be exposed to the use of software such as “equation editor”, scanner and mathematical graphing software. These computer skills are able to lessen participants’ uneasiness in learning through online courses and serve to enhance their confidences as well as motivate them to learn in this new environment. Furthermore, online discussions facilitator should ensure that there are interactions among the course participants during the active period of e-conference by giving guidance and moral support to the participants. Additionally, software to monitor participants' involvement in online courses and online discussions (such as frequency and length of involvement as well as the web pages accessed by the participants) could be made available to assist facilitators ensure that all participants actively collaborate in the learning activities.

In sum, the online mathematical problem solving course using the social constructivist approach were appropriate and ought to be given serious attention and could be seen as an alternative to traditional classes. However, educationists should take extra care in designing and implementing online courses to minimize problems that participants might encounter while participating in such courses.

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