Promoting Mathematical Thinking and Communication in a Bilingual Classroom

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Abstract:

This paper aims to discuss our experiences of promoting mathematical thinking and communication among some primary school mathematics teachers through lesson study. A series of six workshops were conducted to provide these teachers the concept of lesson study and to experience themselves activities that promote mathematical thinking and communication. Six schools were involved in the project but this paper focuses on one Chinese primary school. Feedback from the participating teachers reflected positive responses such as (i) teachers gained better understanding of the concepts and process of mathematical thinking and communication; (ii) enhanced their self confidence and interest in promoting mathematical thinking and communication through lesson study process. This case study also highlighted the important role of language proficiency in thinking and communicating mathematically for both teachers and pupils.

Introduction

The significant role of mathematical communication is highly valued in Malaysian primary and secondary school mathematics curriculum. Mathematical communication was stated explicitly as one of the five emphases in teaching and learning of mathematics as follows:

> *Communication is one way to share ideas and clarify the understanding of mathematics. Through talking and questioning, mathematical ideas can be reflected upon, discussed and modified. The process of reasoning analytically and systematically can help reinforce and strengthen pupils' knowledge and understanding of mathematics to a deeper level. Through effective communications pupils will become efficient in problem solving and be able to explain concepts and mathematical skills to their peers and teachers.*
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> (Ministry of Education Malaysia, 2003, p. xvi)

However, several local studies (e.g. Jamaliah Kamal, 2001; Chiew and Lim, 2003; Ruzlan Md Ali, 2007). which examined classroom discourse have characterised Malaysian mathematics teaching as teacher-centred with procedural approach being the main teaching strategy. Jamaliah (2001) observed and described a typical Malaysian mathematics lesson as: *"The teacher will present the day's lesson in the form of questions-answers, or present a brief explanation of the topic through examples, either taken from textbooks or workbooks, followed by drill exercises"* (p.164). As reviewed by Lim and Chew (2007), there is still considerably lack of mathematical thinking and communication practices among Malaysian teachers and students.

Therefore, there is an urgent need to develop mathematical thinking and communication skills among mathematics teachers before they can foster these skills among their students.

Based on the APEC Lesson Study project framework, we have proposed a local study to promote mathematical thinking and communication among mathematics teachers and students in six Malaysian primary schools. We argue that mathematical thinking and mathematical communication are inter-related and therefore, they should be promoted hand-in-hand. The detailed procedures and methods used will be described in later section. Now we turn to discuss briefly the theoretical framework that guided this study.

Theoretical Framework

From the cognition perspective, Putnam and Borko (1997) emphasised that teacher's knowledge and beliefs (about teaching, learning and subject matter) are the key components that determine how a teacher teaches. According to Schon (1987), teachers gain new knowledge of their students, curriculum and pedagogical practices by engaging in actual teaching practices. Ball (2001) provided three perspectives of teachers' learning: (i) learning by acquiring new knowledge (ii) learning through collegial interaction, and (iii) learning in and from practice (in a classroom context). Hence, to promote mathematical thinking and communication in the classroom discourse, teachers ought to be given opportunity to learn and to experience themselves so as to change their approach of teaching.

To develop mathematical thinking, teachers must provide students with opportunities to acquire mathematical knowledge and skills through mathematical activities such as problem solving, reasoning and proof, communication, connection and representation (National Council of Teachers of Mathematics [NCTM], 2000). To implement such activity-based learning in mathematics classroom, teachers must plan lessons and teaching approaches that develop and promote mathematical thinking and communication in mathematics.

However, as pointed out by Takahashi (2007), "one of the reasons for teachers' hesitation to provide activities that cause students to develop mathematical thinking might be that the teachers themselves have rarely experienced such lessons when they learned mathematics themselves" (p.56). Hence, by allowing teachers to experience themselves activities that foster mathematical thinking and communication through workshops is deemed an effective way of enhancing teachers' confidence and competence in mathematical thinking and communication.

The Study

Participants

There are three types of primary schools in Malaysia, differentiated by the medium of instruction: (a) The National primary school (SK) with Malay language as the medium of instruction; (b) National Type Chinese primary school (SJKC) with Mandarin as the medium of instruction; and (c) National Type Tamil primary school (SJKT) has Tamil as its medium of instruction. However, since the year 2003, the medium of instruction for

mathematics has been changed to English in all types of primary schools, except the Chinese primary schools where mathematics is taught in both Mandarin and English.
We initiated this study in six schools; two for each type of school. For each school, we approached a potential school mathematics teacher to be recruited as a participant. The teacher concerned then soliciting two to three other teachers in his/her own school as participants. Upon their consent for voluntary participation, we approached their respective headmaster to seek formal permission to conduct this research. As compared to the normal top-down directive from the school administrator, this manner of recruiting participants has the advantage of ensuring voluntary participation and total commitment of teachers.

Procedure

To provide participating teachers the necessary concepts of lesson study and experiences of mathematical thinking and communication activities, a series of six workshops were conducted. Table 1 shows the workshop schedule and aims for each workshop.

Table 1: The workshop schedule and aims and content for each workshop

Dates	Workshops	Aims and content
31 January 2008	Half-day workshop 2.30 p.m. – 4.30 p.m.	Brief introduction to the research project.
14 February 2008	Workshop 2.30 p.m. – 4.30 p.m.	Workshop on teachers experiencing tasks that focus on mathematical thinking.
28 February2008	Workshop 2.30 pm. – 4.30 p.m.	Workshop on teachers experiencing tasks that focus on mathematical communication.
13 March 2008	Workshop 2.30 p.m. – 4.30 p.m.	Introduction to Lesson Study concept and process
27 March 2008	Workshop 2.30 p.m. – 4.30 p.m.	Lesson Planning
April 2008 – May 2008	*Actual lesson carried out in schools*	*Teaching based on planned lesson, video taping of observed lessons and reflection on lesson taught*
5 June 2008	Workshop 2.30 – 4.30 p.m.	Analysis of lesson with the aim of improving lesson plan

As shown in Table 1, each workshop was conducted for two hours in the afternoon once a fortnight. This arrangement is to ensure that teachers would not miss their classes. This poses extra workload for teachers and it challenges the commitment of the participating teachers. Initially we invited 10 schools but only six schools complete the series of workshop and lesson study cycle.

Data collection

Data for this study were collected through reflection questionnaire after each workshop, interview and video taped lesson observation. Questions that guided the interview and reflection questionnaire include:

a) to what extent have the workshop series helped to enhance their mathematical thinking and communication concepts and skills ?

b) Do they know better now and how to promote these skills?

c) To what extent has lesson study process helped in this process?

d) Any future needs or support needed?

e) What are the changes or difference in teaching strategies after lesson study?

Findings and Discussion

For the purpose of discussion in this conference, we only focus on one lesson study group in one National Type Chinese primary school. This lesson study group consisted of three mathematics teachers: EH, LH and AN. Both EH and AN were trained teachers with teaching experience ranged from 3-5 years. LH was a young teacher who was still undergoing her teaching practice in the participating school. This lesson study group was also assisted by one master teacher, PL who was formally teaching in the same school but she has just transferred to another nearby school last year. PL was awarded as master teacher in mathematics teaching in view of her excellent performance.

This school completed two lesson study cycles during April to July 2008. For the first cycle, the topic of the lesson plan was ‘Division’ while the topic selected for the second cycle was ‘Time’. In accordance to the lesson study model, discussions, teaching-observation, reflection and revised and re-teaching of the lesson was conducted. In the first cycle, one lady teacher (LH) taught the lesson in Mandarin while another two women teachers (EH and AN), re-taught together the same lesson in another class using English language. Our observation of the two lessons indicates that the first teaching in Mandarin ran comparatively smoother than the second teaching which was conducted in English language. In the second cycle, the first teaching in Mandarin has been carried out but the second teaching in English is planned to be carried out in September.

The lesson

We reported briefly here the first lesson and discussed how the lesson attempt to promote mathematical thinking and communication. The first discussion began with brain-storming the choice of topic and grade level. After much discussion, the teachers chose the topic ‘Division’ and the target group is Grade 3 pupils. The topic division was

chosen because it is more challenging than the concept of ‘addition’ and ‘subtraction’ for this group of pupils. The master teacher, PL proposed to design problems or activities that will need pupils to think and to present their ideas or solution in multiple ways. She suggested to use manipulative and objects that are familiar in pupils’ daily life. The objective of the lesson was to provide pupils with the concept of division as ‘sharing equally’. The pupils were expected to have the idea of ‘remainder’ once the amount of object given could not be divided equally. Lesson plan is shown in Appendix I.

The tasks

There were two activities in the lesson. The first activity asked the pupils to divide equally a group of objects using as many ways as possible. Pupils were given concrete manipulative such as spoons, chopsticks, sweets, stars etc. to assist them. They have to present their solutions mathematically on a piece of mahjong paper.
The second activity was given as a problem:

> *A big box can fills 20 ping pong balls while a small box can only fills 10 ping pong balls. The big box costs RM1.50 while the small one costs RM1.00. If there are 90 ping pong balls, how many big boxes and small boxes are required to fill the balls? What will be the maximum and minimum cost*?

The pupils were asked to solve the problem and to state the minimum and maximum cost of different sizes of boxes required.

This problem was challenging because it involves multiple steps and multiple operations. To solve this problem, the pupils must carry out the following steps:

a) Understand the capacity of each type of box. The big box can contain 20 ping-pong balls while the small box can only contain 10 ping-pong balls.

b) Identify the amount of ping-pong balls given is 90;

c) Differentiate the cost for each type of box: A big box costs RM1.50 while a small box costs RM1.00;

d) Design a model that simulates the possible ways of packing the ping-pong balls into the different sizes of boxes. This operation involves division.

e) Estimate the total cost for each possible way. This operation involves addition.

f) Evaluate the way that will cost the minimum and the maximum. This operation involves comparison or subtraction.

We observed that in both activities, pupils struggle to present their solutions mathematically. They were not sure how to write out their answers logically and systematically. Some were thinking very hard and some show frustration. But to everyone’s surprise, all groups except one successfully presented their solutions. In fact, two groups were able to show their thinking model logically and systematically.

Teachers' reflection

Upon reflection after the teaching observation, all the teachers were amazed at the variety of possible answers from the pupils. They did not expect their pupils were able to suggest so many different types of solution and different ways of presentation. One teacher observed that one group which was given the spoons as manipulative, did not use the spoons at all. Instead, they based their division on multiplication tables or formulae. They also noticed that all pupils were so engaged in the activities that even the dismissal bell has rung, they were not prepared to go home yet.

Further analysis of the data from observation and interviews highlighted the following findings:

(i) Teachers gained better conceptual understanding of mathematical thinking and communication

The interview data revealed that prior to this study, two women teachers, LH and EH admitted that they did not have many ideas about the role of mathematical thinking and communication in mathematics teaching. Consequently, they have not emphasised these two aspects in their normal mathematics teachings. But one of them, AN claimed that she has heard about mathematical thinking and communication but she had very little knowledge of these concepts and was unable to integrate them in her lessons.

In fact, the participants were still struggling with these concepts during the workshop. As EH explained, "*Previously, in my teacher training, I learned only the theory but I don't know how to apply it. During the workshop also not much, more about the theory. But when you [researchers] came to the school and explain further, we then understood and got it"* (Interview, 30 July 2008). Hence, it was when these teachers started their lesson study process, planning and discussing their lesson plan, teaching and re-teaching that they gradually grab the concepts of mathematical thinking and communication.

(ii) Enhanced teachers' self confidence and interest in promoting mathematical thinking and communication

Having engaged in the lesson study process EH acknowledged that her teaching has somehow changed. She said, *"Sometimes, I applied it [mathematical thinking] during my set induction and the pupils of 5M noticed the difference in the [my] teaching. One of the pupils revealed to me that my teaching for today was so interesting"* (Interview, 30 July 2008). This reflection indicates that the lesson study process had impacted on EH's teaching.

Likewise, LH reflected that her teaching has changed towards more pupil-centred after her participation in lesson study. During interview, she commented the following, "*Now, I let my pupils to speak more. They have to find the answer themselves and understand why it is like this? Not like before this, I talk more in the classroom. Last time, my teaching focus on the teacher but now I focus more on my pupils. I give them more opportunity to engage and express themselves . . . not like my previous teachings"* (Interview, 30 July 2008). In short, the participants had gained a positive perception on

mathematical thinking and communication and this impacted on their teaching. As LH emphasized, *"This [mathematical thinking and communication] is important. The pupils who learn on their own will memorise better and in-depth than what we [teachers] said to them"* (Interview, 30 July 2008).

Although EH remained sceptical about promoting mathematical thinking and communication in mathematics classroom due to the time constraint, she acknowledged the benefits of implementing mathematical thinking and communication in teaching, *"The good thing is it doesn't make the pupils boring. Usually in mathematics teaching, the teacher explains and the pupils just do it. By incorporating the mathematical thinking and communication, the teaching became more lively."* (Interview, 30 July 2008).

(c) Language Proficiency and Thinking and Communicating Mathematically

We observed that both teachers and pupils showed much more confident and fluent in using Mandarin to think and communicate mathematically. Even though the second teaching was conducted in English, both teacher and pupils were communicating in Mandarin during small group discussions. During presentation of results, some pupils were able to express their responses in simple English, but some need great assistance from the teacher. This highlighted the importance of language proficiency in thinking and communicating mathematically.

Conclusion

In this paper, we only focus on one lesson study group which has just gone through two lesson study cycles. We acknowledge that it might be too early to claim that the study has significant impacts on the participating teachers and pupils. Nevertheless, we were greatly encouraged by the positive feedback from the participating teachers and the pupils' active engagement in the tasks given. The variety of solutions and representations given by the pupils is another indication that given appropriate context and opportunity, pupils can be scaffold to explore new ground and to communicate mathematically.

Even though mathematical thinking and communication were explicitly stated as one of the objectives in Malaysian Primary and Secondary Mathematics curriculum, many mathematics teachers still lack the knowledge and skills in promoting mathematical thinking and communication in classroom. Due to the examination oriented culture, many teachers have not experienced themselves activities that promote mathematical thinking and communication during their school days. With the same reason, these teachers have opted for teacher-cantered approach such as instrumental learning (Skemp, 1976) that takes shorter time to prepare pupils for effective examination preparation. Activities that promote mathematical thinking and communication are deemed too time consuming. Teachers could not afford to lose time because they need to complete the syllabus and to prepare the pupils for public examinations.

In spite of the constraints, we are glad to observe that through lesson study collaboration and scaffolding from a master teacher and the researchers, this group of teachers were able to design activities that promote mathematical thinking and communication. Consequently, encouraged by the active engagement of their pupils,

they have gradually incorporated the concepts of mathematical thinking and communication into their daily teaching too.

Language is a tool for thought and communication. We observed that in a bilingual classroom where the medium of instruction is English language while the mother tongue of both teachers and pupils were Mandarin. Both teachers and pupils were seen to be more confident and comfortable to use Mandarin to think and to discuss. To fulfil the requirement of the Malaysian policy, teachers are required to teach mathematics in English. Several research studies (e.g. Lim, Fatimah & Tang, 2007; Noraini et. al., 2007) revealed that many mathematics and science teachers were still lacking in English language competency and hence they were not confident to teach mathematics and science entirely in English. Many teachers tended to code-switch between English and pupils' mother tongue language (Mandarin, Malay or Tamil). Therefore in this case study, we have allowed the teachers to teach the lesson in Mandarin during their first teaching and then the second teaching in English using the revised lesson plan. We argue that our focus here is not the type of language but language as a tool for thought and communication. We observed that both teachers and pupils were much more confident and comfortable in the first teaching when Mandarin was used. Perhaps the first class was a weaker class, the pupils were seen to struggle to present their thought mathematically. In comparison, during the second teaching, two teachers used English to teach the lesson. Both teachers were not very fluent in English but they managed to convey the necessary message clearly, with some explanation in Mandarin. The second class was a better performing class than the first class. The pupils were observed to discuss mainly in Mandarin with their peers and teachers. Nevertheless, with some struggle initially, these pupils were able to present their solutions mathematically using simple English.

Upon retrospection, the participating teachers also agreed that as the teachers are more fluent with Mandarin, they felt more confident in promoting mathematical thinking and communication in class. They can ask questions in different ways and different levels that encourage pupils to think. For pupils who are in the better class and are assumed to have better language proficiency and content knowledge, the type of language used might not be a barrier for them. This is because they can use one language to think and communicate with their peers, and then present their ideas using another language. In brief, we observed the significant role of language played in a bilingual classroom. Ideally, if both teachers and pupils are allowed to think and communicate in the language that both are most proficient at, then promoting mathematical thinking and communication would be easier. However, in bilingual classroom where teacher and pupils are not communicating in the same language, effort in promoting mathematical thinking and communication might need to be doubled then.

The last implication from our study is that lesson study process can be an effective teacher professional development programme to promote any innovative approaches such as mathematical thinking and communication. However, intensive guidance and both academic and moral supports from external advisers are very much needed to ensure the successful implementation of the approaches.

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Appendix I:

LESSON PLAN

Subject : Mathematics
Date : 20 May 2008 (Tuesday)
Time : 12.45 – 1.45 p.m. (60 minutes)
Class : 3M
Number of pupils: 37
Average age : 9 years old
Topic : Whole Numbers
Learning area : Division with the highest dividend of 1000.
Pupils' prior knowledge: The pupils already have the concept of simple division as sharing equally and division that were encountered in daily life experiences.
Learning outcome: To foster pupils' mathematical thinking and communication through group discussion and learning activities pertaining division.
Learning objective : At the end of the lesson, the pupils should be able to:
- understand the concept of sharing equally in division
- solve problems involving division in real life situations

Teaching and learning aids: plastic spoons, sweets, pencils, paper stars, chopsticks, gift box, poster, marker pens, mahjong paper.
Thinking skills : Making connection and relationship
Moral values : Cooperative, thrifty

Set Induction (8 minutes)

The teacher holds a gift box and asks the pupils what it is? The pupils answer "gift box." The teacher discloses that their names have been written and put in the box. She then randomly selects 5 names. The pupils read out the names and the selected pupils come out to the front of the class.

The teacher reveals that they have been selected as group leaders. Teacher poses a question, "How many pupils in a group if all groups have equal number of pupils?"

Based on the total number of pupils in the class, the pupils attempt and answer the question. The group leaders are then told to recruit their classmates as members in their group. The teacher ensures that every pupil in the class has a group.

Step 1: Activity 1(22 minutes)

The group leaders are asked to draw ballot and take the corresponding boxes that contain the same number of manipulative: “48”.

The teacher gives the following instruction:

> Write as many answers as possible that the number (dividend) of 48 can be shared or equally divided.

[Possible answers: 48 ÷ 2 = 24; 48 ÷ 3 = 16; 48 ÷ 4 = 12; 48 ÷ 6 = 8;
48 ÷ 8 = 6; 48 ÷ 12 =4; 48 ÷ 16 = 3; 48 ÷ 24 =2]

The pupils work in group with the manipulative such as spoons, chopsticks etc provided and write their solution on the mahjong paper provided. They are required to think, discuss and communicate mathematically among themselves. The teacher observes and facilitates the pupils’ group discussion whenever necessary.

A member from each group comes forward to present their answer to whole class.

Step 2: Activity 2 (20 minutes)

The teacher poses the following problem on the poster:

> A big box can fills 20 ping pong balls while a small box can only fills 10 ping pong balls. The big box costs RM1.50 while the small one costs RM1.00. If there are 90 ping pong balls, how many big boxes and small boxes are required to fill the balls? What will be the maximum and minimum cost?

The pupils discuss and write their answers on the mahjong paper provided. The teacher facilitates the discussion accordingly.

A member from each group comes forward to present their answer to whole class.

Closure (10 minutes)

The teacher holds the box that contains 48 sweets and asks the pupils, “If these sweets are divided equally among all of you, how many sweets will each of you get?”

The pupils give their answer orally, e.g. 1, 2 or 3.

The teacher then distributes the sweets to the pupils to confirm or justify their answers.