EXPLORING THE PEDAGOGICAL FLOW OF CHINESE PRIMARY SCHOOL MATHEMATICS LESSONS BEFORE, DURING AND AFTER LESSON STUDY

By

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ABBREVIATIONS

	Full phrase	Short form
1.	Lesson Study	LS
2.	Ministry of Education	MOE
3.	The pupil(s) read the word problem, the teacher poses questions and the pupil(s) respond(s)	RPR
4.	The teacher prompts question, the pupil(s) respond(s) and the teacher illustrates the solution	PRI
5.	The teacher shows the teaching material and at the same time prompts questions to the pupil(s) and the pupil(s) respond(s)	SPR

LIST OF PUBLICATIONS

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MENEROKA ALIRAN PEDAGOGI PELAJARAN MATEMATIK SEKOLAH JENIS KEBANGSAAN (CINA) SEBELUM, SEMASA DAN SELEPAS *LESSON STUDY* (LS)

ABSTRAK

Kajian ini meneroka dan membanding aliran pedagogi pengajaran matematik Sekolah Jenis Kebangsaan (Cina) sebelum, semasa dan selepas implementasi *Lesson Study* (LS). Aliran pedagogi adalah proses pengajaran dan pembelajaran dalam kelas manakala LS adalah suatu model perkembangan professional guru Jepun. Reka bentuk kajian ini ialah kajian kes kualitatif. Terdapat tiga kumpulan LS matematik dari tiga buah sekolah projek dengan jumlah 15 orang guru matematik mengambil bahagian dalam kajian ini. Pelbagai sumber data kualitatif telah dikumpul termasuklah: 15 permerhatian pengajaran, sembilan sesi perbincangan berkumpulan, tiga temu duga individu guru dan pelbagai artifak dikumpul semasa permerhatian pengajaran. Berdasarkan rangka Teori Aktiviti, data telah dikategori kepada aktiviti guru, aktiviti murid dan penggunaan resos bilik darjah. Hasil dapatan kajian ini menunjukkan bahawa aliran pedagogi pengajaran sebelum implementasi LS adalah bercirikan pembelajaran pelajar yang pasif dengan pelajar duduk sambil membuat latihan secara individu sedangkan guru memberi contoh dan latihan secara rawak. Akan tetapi, aliran pedagogi pengajaran semasa dan selepas implementasi LS adalah menuju kepada pembelajaran pelajar yang aktif dan guru menggunakan lebih banyak resos bilik darjah. Hasil dapatan kajian ini memberi implikasi bahawa LS mempunyai potensi untuk mempertingkatkan amalan pengajaran guru. Namun hanya tiga kitaran LS sempat diimplementasikan dalam kajian ini, maka peningkatan dalam amalan pengajaran masih terhad. Sebenarnya, peningkatan berterusan ini banyak bergantung kepada kelestarian implementasi LS yang masih merupakan satu cabaran.

EXPLORING THE PEDAGOGICAL FLOW OF CHINESE PRIMARY SCHOOL MATHEMATICS LESSONS BEFORE, DURING AND AFTER LESSON STUDY

ABSTRACT

This study explored and compared the pedagogical flow of Chinese primary school mathematics lessons before, during and after the implementation of Lesson Study (LS) process. The pedagogical flow refers to the teaching and learning process in a classroom while LS is a Japanese model of teacher professional development. This study employed a qualitative case study research design. There were three mathematics LS groups from three project schools with a total of 15 mathematics teachers participated in this study. Multiple sources of qualitative data were collected: 15 lesson observations, nine group discussions, three individual teacher interviews and various artefacts collected during the lessons. Based on the framework of Activity Theory, the data was categorised into teacher's activities, pupils' activities, and the usage of classroom resources. The findings showed that the pedagogical flow of the lesson before the implementation of LS was mainly characterised by passive individual pupil seatwork and teachers giving random examples and exercises. However, the pedagogical flow of lessons during and after the implementation of LS geared toward more active pupils' learning and teachers used more variety of classroom resources. These findings imply that LS process has the potential in enhancing the teacher's pedagogical practices. Nevertheless, in this study, only three LS cycles were implemented, thus, the improvement in pedagogical practices was still limited. In fact, the upkeep of this improvement depends very much on the sustainability of the LS implementation which remains a challenge.

CHAPTER 1

INTRODUCTION

Mathematics is one of the core subjects in the Malaysian school curriculum. It is compulsory for every student to learn mathematics at primary and secondary school levels. Besides, mathematics plays a very important role, not only as a subject to learn in the class, but also as a skill that is needed in daily life and some careers. Hence, ensuring an effective teaching and learning of mathematics in schools are important in any education system.

Pedagogy refers to the methods and practice of teaching, which can be an art (Benedict, 2007; Murphy, 1996) or an amalgamation of science, craft and art of teaching (Pollard, 2010). Teaching is an intellectual process between a teacher and a student over certain content in a classroom environment. During the process, the teacher employs certain strategies, which comprise of certain activities, patterns or features (Kaur, Low & Benedict, 2007; Shimizu, 2003, 2009; Stigler & Hiebert, 1999) to promote students' learning. Thus, the pedagogical flow of lesson is defined as the teaching and learning process that portrays how the teacher orchestrates his or her lesson and consists of four main components: content, teacher, students and classroom resources (Schmidt et al., 2002). Mathematics teaching and learning mostly occurs in the classroom. To get a more vivid picture of how a mathematics lesson is carried out in the classroom, there is a need to look at the pedagogical flow of the lesson.

Teaching and learning are inter-related whereby a teacher's teaching practices can affect the students' learning process. Thus, in order to improve learning process, there is a need to improve teaching practices. Furthermore, Hiebert and Stigler (2004) suggested three ways to improve teaching: a) understanding teaching practices and identifying the effectiveness of the pedagogical practices through reflection; b) providing vivid examples of implementation of effective strategies to the teachers; and c) understanding pupils' thinking and looking for suitable teaching practices. Hence, before any implementation of teaching practices, the teacher needs to explore his or her own pedagogical flow before he or she can identify teaching practices that can promote students' learning.

1.1. Problem Statement

First of all, the Malaysian students' performance in the recent Trends in International Mathematics and Science Study (TIMSS 2011) (Mullis, Martin, Foy & Arora, 2012) revealed a significant decline in the overall achievements of Grade 8 Mathematics. As compared with TIMSS 2007, analysis of TIMSS 2011 showed a decrease in Malaysian students' average scale score in all the three cognitive domains: knowing (from 473 to 444), applying (from 477 to 439), and reasoning (from 466 to 426) as shown in Table 1.1.

Table 1.1

Malaysian students' average scale score in three mathematics cognitive domains

TIMSS	Cognitive domains (Average scale score)		
	Knowing	Applying	Reasoning
2007	473	477	466
2011	444	439	426

(Source: Mullis et al., 2012)

This result reflected that Malaysian students were particularly weak in the cognitive domain of applying and reasoning. Even though this result was the achievement of the Grade 8 students, but mathematical concepts and skills are hierarchical. Hence, it implied that Grade 8 students have not mastered well the basic mathematical concepts and skills. As a result, many of them could not apply and give reasons in solving mathematical problems.

There are many possible factors that affect students' achievement in mathematics, as identified by Hattie (2003), namely from the student him/herself (50%), teachers (30%), home (5-10%), and/or the school environment (5-10%). Furthermore, from the review done by Brophy and Good (1986) and the study done by Hill, Rowan and Ball (2005) with data collected from 115 elementary schools, teacher's teaching could influence students' achievement. Similarly, Baumert et al. (2010) conducted a study to indentify the effect of content knowledge and pedagogical content knowledge on the quality of teaching practices and students' learning. They had collected data from 181 teachers, 194 classes and 4353 students and found that the teacher's pedagogical content knowledge had the greatest impact on students' achievement. Hence, one of the significant factors that affect the TIMSS 2011 result could be the pedagogical factors (such as teacher's pedagogical content knowledge, teaching strategies, teaching materials, and pedagogical flow).

Second, teaching is a very important process that will influence how the students learn a concept, how the students build a skill and how the students think. Especially for the average and below average students, their learning is highly dependent on the teacher's teaching (Skemp, 1986). Hence, the effectiveness of teaching becomes very crucial in students' learning process. According to Skemp (1986), "to know mathematics is one thing and to be able to teach it- to communicate it to those at a lower conceptual level- is quite another" (p. 34). Knowing the content and teaching the content are different kinds of aspect. As Shulman (1987) mentioned, teaching is a process of converting teacher's own understanding of the content to his or her students. In short, a teacher who is competent in content knowledge may not necessary teach the content well to his or her students.

Third, as proposed by Darling-Hammond, Wei, Andree, Richardson and Orphanos (2009), teaching practices can be improved through various teacher professional development programmes. In Malaysia, the Ministry of Education (MOE) have been offering different kind of in-service training courses to teachers. Yet, as commented by Chiew (2009), the impacts of these courses are still insufficient to improve the current teaching practices. Furthermore, Mullis et al. (2012) reported that the percentage of Malaysian students taught by teachers who participated in professional development programmes in mathematics for the past two years (year 2010 and 2011) was below international average as shown in Table 1.2. The results show that overall less than half of the Malaysian student population was taught by teachers who had participated in professional development programmes. Hence, any kind of teacher professional development programme (e.g. Lesson Study, Action research) which can improve and enhance the teachers' teaching practices and students' learning is very much needed.

Table 1.2

Malaysian mathematics teachers' participation in professional development in mathematics for the past two years

Country	Percent of Students by Teacher's Area of Professional Development					
	Mathematics Content	Mathematics Pedagogy/ Instruction	Mathematics Curriculum	Integrating Information Technology into Mathematics	Improving Students' Critical Thinking or Problem Solving Skills	Mathematics Assessment
Malaysia	40 (4.2)	42 (4.1)	35 (3.7)	41 (4.1)	36 (3.8)	46 (4.2)
International average	55 (0.5)	58 (0.6)	52 (0.5)	48 (0.5)	43 (0.6)	47 (0.5)

( ) Standard errors appear in parentheses. Because of rounding, some results may appear inconsistent.
(Source: Mullis et al., 2012)

Lesson Study (LS) is a mode of professional development program, which originated from Japan (Baba, 2007; Lewis, Perry & Murata, 2006b; Makinae, 2010). A LS cycle consisted of setting goals, planning and refining the lesson, conducting and observing the lesson, and reflecting the lesson. The main features of LS include: collaboration among LS group members throughout the whole LS process; real lesson implementation and observation; and post-lesson reflection (Baba, 2007; Fernandez, 2002; Lewis, Perry, Hurd & O'Connell, 2006a; Lewis et al., 2006b).

Review of literature on features of an effective teacher's professional development programme (e.g. Blank & de las Alas, 2009; Darling-Hammod et al., 2009; Yoon, Duncan, Lee, Scarloss, & Shapley, 2007) included: school-based learning, focus on students' learning, relate to teacher's content knowledge and pedagogical content knowledge, actual lesson observation and reflection and collaboration among teachers. Furthermore, Lewis, Perry, Friedkin and Roth (2012) suggested that three main components required to improve teaching include: "high-quality instructional resources", "opportunities for learning within practice" and "collaboration within colleagues" (p.369). Hence, LS comprising the features mentioned could be incorporated as one of the professional development programmes to improve teaching and learning process as proposed by other researchers (e.g. Chiew, 2009; Chiew & Lim, 2005; Lewis et al., 2012; Lim, Chiew & Chew, 2010; Stigler & Heibert, 1999; White, & Lim, 2008). In short, LS was chosen in this study as a teacher professional development programme with the aim to improve the pedagogical flow of mathematics lessons.

Local researchers have conducted several studies related to LS. For examples, Chiew and Lim (2005) and Chiew (2009) investigated the impact of LS; Goh (2007) examined the implementation of LS to enhance mathematics teacher's content knowledge and confidence in teaching mathematics using English; Lim and Kor (2010) studied the innovative use of Geometer's Sketchpad (GSP) through LS; and Lim, Chiew and Chew (2011) examined the implementation of LS to promote mathematical thinking and communication. However, exploring the pedagogical flow of LS lessons through lesson observation is still a new area of research in Malaysia. Furthermore, exploring the pedagogical flow of LS and the post-LS lessons can contribute to the understanding of a LS lesson and whether the implementation of LS can contribute to the improvement of teaching practices or not.

In addition, recent research had been very focused on lesson observation in the classroom as carried out by Clarke, Keitel and Shimizu (2006), Hiebert et al. (2003), Huang and Li (2009), Kaur et al. (2007), Lin and Li (2009), Schmidt et al. (2002), Shimizu (2002, 2003, 2009), Shimizu, Kaur, Huang and Clarke (2010), Stigler et al. (1999), and Stigler and Hiebert (1999). Students' learning mostly happens in the classroom, where the teacher guides the students to learn by conducting a lesson. Whilst, Clarke et al. (2006) and Hiebert et al. (2003) mentioned that to improve students' learning, there was a need to examine what happened during the lesson in the classroom. Hill, Rowan and Ball (2005) stated that effective teaching depended on how teacher used what he or she knows in the classroom. Yet in Malaysia, only a few studies were carried out to identify the characteristics of mathematics lessons and teaching practices through lesson observation (e.g. Lim & Kor, 2012; Mohd. Majid Konting, 1997; Rudzlan Md. Ali, 2007; Tan, 1995; Tan, 2012). Among those studies, Tan (1995) and Rudzlan Md. Ali (2007) conducted lesson observation on in-service teachers' mathematics lessons, while Lim and Kor (2012), Mohd. Majid Konting (1997) and Tan (2012) conducted studies to observe expert teacher's mathematics lessons.

Thus, more studies on lesson observation to explore the pedagogical flow of the lesson still need to be conducted, especially lessons delivered by in-service teachers. By exploring the pedagogical flow of the lesson, it helps to understand the way the teacher crafts a lesson, how the teacher helps his/her students to understand the concepts, and the social interaction during a lesson.

In sum, more studies have to be carried out to unfold the pedagogical flow of mathematics lessons and to understand the teaching and learning activities in the Malaysian mathematics classroom. Besides, by investigating the pedagogical flow of LS mathematics lessons, only could researchers search for effective teaching and learning practices, and ways to improve teaching and learning process in the context of Malaysia.

1.2. Research Objectives

The main aim of this study was to explore the pedagogical flow of mathematics lessons delivered by the primary mathematics teachers before, during and after the implementation of LS process. More specifically, the objectives of this study were:

1. To identify the pedagogical flow of mathematics lessons before, during and after the implementation of LS process.
2. To compare the similarities and differences of the pedagogical flow of mathematics lessons before, during and after the implementation of LS process.

1.3. Research Questions

Based on the objectives of the study, this research intends to address the following research questions:

1. What is the pedagogical flow of mathematics lessons before, during and after the implementation of LS process?
2. What are the similarities and differences of the pedagogical flow of mathematics lessons before, during and after the implementation of LS process?

1.4. Significance of the Study

The findings of this study will contribute to both pre-service and in-service teachers, school administrators, educators and researchers in the following ways:

First, by exploring mathematics lessons before the implementation of LS can contribute to better understanding of the teaching and learning process in Malaysian mathematics classrooms. For example: How the teacher arranged the content or examples that led the pupils to the learning objectives? What type of resources that the teacher used to help the pupils' learning? What type of activities that made the pupils actively participated and acquired the related concept or skill? What types of questions were posed during the lesson? Through the lesson observation, it helps to identify the hidden problems that occur during the flow of the lesson delivered by the in-service teacher. Then, we can seek for better solutions to improve classroom teaching and learning.

Second, by researching on the pedagogical flow of LS lesson, it helps us to see how the research lesson carried out in real classroom context can contribute to effective teaching and learning. The researcher acknowledges that not all the implemented LS lessons were effective. However, by documenting the flow of the LS lessons will provide a guide to pre-service and in-service teachers on how they can arrange their lesson flow for better learning of mathematics. Furthermore, analysis of the pedagogical flow of LS lessons can help to identify possible factors that improve or hinder pupils' learning during the lesson. The documentation of LS lessons can serve as references for further research as well.

Third, characterising the pedagogical flow of mathematics lessons is still a new idea in Malaysia. This study focuses on the sequence of activities in a single lesson where mainly the teacher activities and student activities that can unfold during a lesson in the classroom. Systematically recording lesson observation before, during and after LS and characterising the pedagogical flow of the lessons can be a documentary of mathematics lesson in the context of Malaysia. This can provide school administrators, educators and researchers to have a better understanding of the complexity of teaching and learning process in the classroom before, during and after the intervention of LS.

1.5. Operational Definitions

Pedagogical flow

Pedagogical flow in this study refers to a continuous process of how a lesson is orchestrated in the classroom, which consists of a sequence of activities that involved the entire composition of the classroom: teacher, pupils, content and classroom resources (Schmidt et al., 2002).

Lesson Study (LS)

Lesson Study (LS) in this study refers to a mode of professional learning program originated from Japan (Baba, 2007; Lewis et al., 2006b; Makinae, 2010). A LS cycle consisted of setting goals, planning and refining the lesson, conducting and observing the lesson, and reflecting the lesson. A LS group is a group mainly formed by teachers from the same school to study about their own lesson collaboratively (Baba, 2007; Fernandez, 2002; Lewis et al., 2006a; Lewis et al., 2006b). This can help the novice teachers to improve their teaching, while the experienced teachers who participated in LS can also gain new insight of teaching practice through the discussion and reflection.

Teacher's activities

Teacher's activities in this study refer to teacher instructions during the lesson, which include: classroom management, explaining the concept, revising the previous concept, summarising the lesson of the day, questioning the students and uses of resources in the class.

Pupils' activities

Pupils' activities in this study refer to activities that pupils engage in the lesson, such as board work, seatwork, group work, presentation and whole class discussion.

Episode

Episode in this study refers to a part of a larger sequence in the pedagogical flow of a lesson. An episode consisted of a starting point and an ending point, which mainly determined by the teacher's instruction. It is a particular period in the lesson which consists of one or more teacher's activities or pupils' activities or both overlapping and interacting with content and classroom resources.

CHAPTER 2

LITERATURE REVIEW

This chapter presents the literature review of this study. The first section is the literature on pedagogical flow and the two main activities of the pedagogical flow of a lesson, which are the teacher's activities and pupils' activities. Next, the teacher's knowledge of teaching which is strongly related to the pedagogical flow of the lesson is presented. Then, it is followed by a review of international and local studies about the pedagogical flow of the mathematics lessons. The fifth section is regarding Lesson Study (LS) that was implemented in this study. Subsequently, the relevant theory that underlines theoretical framework of this study is discussed. Finally, a conceptual framework is formed to guide this study.

2.1. Pedagogical flow

Pedagogy is always related to teaching, but it is a complex term to define. Watkins and Mortimore (1999) give a broader definition of pedagogy as "any conscious activity by one person designed to enhance the learning of another" (p.3), while Benedict (2007, p.2) defined pedagogy as "the art of teaching, and the principles and methods of instruction". Moreover, pedagogy as described by Murphy (1996, p.35) was an art that related to "interactions between teachers, students and the learning environment and learning tasks". In addition, the Oxford Advanced Learner's dictionary (2010) defined it as "the study of teaching methods" (p.1119). Furthermore, Pollard (2010) defined pedagogy as an amalgamation of science, craft and art of teaching as follows:

a. The science of teaching – research-informed decision making;

b. The craft of teaching – mastery of a full repertoire of skills and practice; and

c. The art of teaching – the responsive, creative and intuitive capacities. (p.5)

Besides that, as defined by Hiebert and Grouws (2007) teaching is an interaction between teachers and students with the content toward accomplishment of learning goals. Thus, pedagogy can be defined as the science, craft and art of teaching that interrelated with teachers, students, content and learning environment to improve students' learning.

The term flow is defined in two meanings. First, flow means the experience flow (Csikszentmihalyi, 1990). It is a routine for the teacher to conduct the lesson and the teacher can unconsciously make certain decisions in his or her familiar setting. The teacher "flows" the lesson follows his or her planning and intuition, it seems as though there exists a script in the teacher's mind of how to represent and present the idea, how to address to students' questions and how the lesson is going to be. All these activities are mainly guided by the teacher's "past experience, training, and beliefs" (Schmidt et al., 2002, p.71). Second, as defined by Oxford Advanced Learner's dictionary (2010), it means a "continuous movement" (p.595). It can be referred as a process, in this study it refers to the teaching and learning process of a particular lesson, like the river flow or a drama performance, which is visible to others. By combining these two definitions, flow can be defined as the teaching and learning process that consists of teacher's flow of experience in orchestrating it.

Review of literature related to the pedagogical flow of a lesson showed that different terms were used by different researchers for example: pedagogical practices (Anthony & Walshaw, 2009), lesson structure (Clarke et al., 2006; Mesiti, Clarke, &

Lobato, 2003; Shimizu, 2002), instruction flow (Lin & Li, 2009), classroom activities (Mohd Majid Konting, 1997; Schmidt et al., 2002), pedagogical strategies (Schmidt et al., 2002; Shulman, 1987), classroom practices (Mok, 2012; Shimizu, 2009), teaching practices (Clarke et al., 2006), lesson pattern (Stigler & Hiebert, 1999), and activities structure (Stodolsky, 1988). Thus, the pedagogical flow of a lesson is strategies, practices and approaches used during the lesson which consist of certain structures and patterns that can be separated or divided into several important moments, activities segment (Kaur et al., 2007; Stodolsky, 1988), lesson segment (Hiebert et al., 2003), or lesson event (Clarke, 2003; Mesiti et al., 2003; Shimizu, 2003).

In brief, the pedagogical flow of mathematics lesson is a complex teaching and learning process, which the teacher uses certain strategies and practices that consist of certain activities, patterns or features (Kaur et al., 2007; Shimizu, 2003, 2009; Stigler & Hiebert, 1999) to enhance students' learning in a lesson. Whilst, Schmidt et al. (2002) defined pedagogical flow as teaching strategies and approaches that familiarly practiced in a certain classroom setting. Schmidt et al. (2002) further suggested three key dimensions in characterising the pedagogical flow which included: "the complexity and representation of a lesson's content, how the content is presented to and encountered by students, and how the teacher and students interact around the lesson's content" (p.83). Similarly, Hiebert et al. (2003) studied the structure of mathematics lesson included: the time spent on mathematics, the role of mathematics problem presented, the intention of various lesson segments, the interaction during the lesson, the role of homework and other factors that affect the flow of lesson. Thompson (2005) explored the pedagogy of a professor in two aspects: the teaching practices and the task that the students engaged in. However, Kaur, et al. (2007) presented the pedagogical flow in the eighth grade mathematics classrooms as three phases: "the nature of teachers' instructional approaches, the role of textbooks, and the nature and role of homework" (p.16).

Therefore, based on the review of these studies, the pedagogical flow in this study can be defined as a continuous teaching and learning process, which consists of a sequence of activities that involved the four main compositions of the classroom: teacher, pupils, content and classroom resources.

2.1.1. Teacher's activities and instruction

This section discusses several teacher's activities based on the teacher's instruction as the pedagogical flow of a lesson is very much relied on the teacher's instruction (Clarke et al., 2006; Hiebert et al., 2003; Kaur et al., 2007; Schmidt et al., 2002; Shimizu, 2003; Shulman, 1987; Stigler et al., 1999; Stigler & Hiebert, 1999). As Shulman (1987) defined instruction as an essential aspect of teaching which included: "organising and managing the classroom; presenting clear explanations and vivid descriptions; assigning and checking work; and interacting effectively with students though questions and probes, answers and reactions, and praise and criticism" (p.17).

Stigler and Hiebert (1999) had categorised the lesson pattern observed mainly as: reviewing the previous material or lesson, demonstrating and developing the solution steps, students solving the problem individually or in-group, discussing possible solution, summarising the lesson, and correcting the solution and assigning new problems. Similarly, in the Third International Mathematics and Science Study (TIMSS 1995) video study, five dimensions of teacher instruction were analysed in the lesson investigated: "setting, content, participant, organisation and scripts and goal" (Stigler et al., 1999, p.41). Hence, according to the literature review of similar studies done by other researchers (see also Clarke et al., 2006; Hiebert et al., 2003; Mesiti et al., 2003; Schmidt et al., 2002; Shimizu, 2002, 2003, 2009; Stodolsky, 1988) the following teacher's activities were identified as basic activities in a lesson in order to characterise the pedagogical flow of a lesson:

i. Revising previous concept: revisiting the previous lesson or material or prior knowledge of the students (Hiebert et al., 2003).

ii. Explaining the concept: giving explanation either by demonstrating the solution steps or verbal explanation of the concept (Stodolsky, 1988).

iii. Questioning: posing questions to the whole class or individual students. From past studies (Boaler & Brodie, 2004; Sinclair & Coulthard, 1975), questions were referred as any utterance that required response from pupils. For example: "Two multiply by two equal to…". In this study, questions related to mathematical concept only were analysed. The types of questions simplified to three main categories: a) prompting (low cognitive level question) which included factual information (Hiebert & Wearne, 1993) indicated by "What" and "Which" that required short and direct answer. b) probing (high cognitive level question) which indicated by "Why" and "How?" that required pupils to give explanation, reason or judgment (Sahin & Kulm, 2008). c) wondering (high cognitive level question) that required pupils to extend their thinking such as "I wonder would this work?"

iv. Checking answer (Kaur, et al., 2007): whole class reviewing the students' solution written on the board.

v. Desk instruction: or known as Kikan-Shido (O'Keefe, Xu & Clarke, 2006) where the teacher walking from desk to desk to check students' work or to guide weaker students.

vi. Summarising the lesson: the teacher summarising the lesson (Shimizu, 2002, 2003, 2009).

2.1.2. Pupils' Activities and Learning

This section discusses several pupils' activities that related to pupils' learning. Pupils' activities can be defined as the activities that pupils engaged in the lesson, which related to the task assigned to the pupils (Ho & Hedberg, 2005; Stodolsky, 1988) such as board work, seatwork and group work.

Board work refers to activity that required pupils to write their solution on the blackboard or whiteboard in front of the class (Ho & Hedberg, 2005). Seatwork is an activity whereby pupils try to complete the exercises or questions assigned by the teacher individually (Ho & Hedberg, 2005; Stodolsky, 1988). Whereas, pupils worked in pairs or groups will be denoted as group work (Ho & Hedberg, 2005; Stodolsky, 1988).

Based on studies done by several researchers (Hiebert et al., 2003; Hiebert & Wearne, 1993; Mok, 2012; Stigler & Hiebert, 1999; Stodolsky, 1988), pupils' learning was strongly related to pupils' engagement with the content and activities assigned. Hiebert and Wearne (1993) conducted study focused on the relationship between instructional task and classroom discourse with the pupils' learning outcomes in six Grade 2 classes for 12 weeks. The result suggested that pupils' involvement in task, which related to giving idea or reflection, produced higher achievement in the score at the end of the lessons than pupils who were involved in procedural instructional task. Similarly, Stigler and Hiebert (1999) reported that the level of the content was related to pupils' learning opportunities. The higher the level of difficulty of the content, the higher the chance for the pupils to learn more content that is mathematical.

Thus, pupils' active interaction, which involves giving idea or reflection (during presentation, group work or whole class discussion) during the lesson is considered as active engagement. Besides, pupils' participation in *doing* mathematics for example: pupils solved challenging problem and presented the alternative or possible solution, can provide more learning opportunities.

The researcher acknowledges that high levels of involvement of pupils in the activities during lesson observation did not fully imply the occurrence of deep learning. However, as Stodolsky (1988) pointed out that pupils' active engagement in the activities during lesson observation still can be as an indicator that learning was more likely to occur compared to passive involvement in the activities. In conclusion, besides the types of pupils' activities, the content and the level of pupils' active engagement were taken into account in this study.

2.2. Teacher's Knowledge for Teaching

As defined in the earlier section 2.1 the four main components of the pedagogical flow of a lesson include: teacher, pupils, content and classroom resources. However, to ensure a smooth pedagogical flow of the lesson, the teacher needs to have certain knowledge which is more than the knowledge of content to orchestrate it. Shulman (1986, 1987) introduced the idea of knowledge for teaching that included content knowledge, general pedagogical knowledge, curriculum knowledge, pedagogical content knowledge, knowledge of learners and their characteristics, knowledge of educational contexts, and knowledge of educational ends, purposes, and values. Later, the idea of teacher's knowledge categories was further expanded by Ball and her colleagues (e.g. Ball & Bass, 2000, 2003; Ball, Hill, & Bass, 2005; Ball, Thames & Phelps, 2008; Hill, Rowan & Ball, 2005; Hill, Schilling & Ball, 2004; Rowan, Schilling, Ball, Miller, Atkins-Burnett & Camburn, 2001). The following section will review mainly studies related to pedagogical content knowledge (PCK) and content knowledge of mathematics for teaching.

2.2.1. Pedagogical Content Knowledge (PCK)

In late 1980s, after reviewing some researches, Shulman (1986) found that there were "missing paradigm" (p. 6) in the researches of teaching, which were the content, the questions and the explanation. Hence, Shulman (1986) proposed the categories of content knowledge for teaching which included: "subject matter content knowledge, pedagogical content knowledge and curricular knowledge" (p. 9). Shulman (1986) suggested that teaching required more than just an understanding of the concept of subject. Furthermore, Shulman (1987) conducted studies to observe the growth of content and pedagogy knowledge of a group of teacher students, as a learner to become a teacher or gradually to be an expert in teaching. At the same time, they compared knowledge and skills equipped by novice and expert teachers. After Shulman (1987) and his colleague observed how the expert teachers prepared and conducted their lessons, they refined the teacher content knowledge categories into seven categories which included:

i. Content knowledge;
ii. General pedagogical knowledge, with special reference to those broad principles and strategies of classroom management and organization that appear to transcend subject matter;

iii. Curriculum knowledge, with particular grasp of the materials and programmes that serve as "tools of the trade " for teachers;
iv. Pedagogical content knowledge, that special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding;
v. Knowledge of learners and their characteristics;
vi. Knowledge of educational contexts, ranging from workings of the group or classroom, the governance and financing of school districts, to the character of communities and cultures;
vii. Knowledge of educational ends, purposes, and values, and their philosophical and historical grounds (p.8).

In two of his papers, Shulman (1986, 1987) particularly highlighted about the pedagogical content knowledge (PCK). PCK is a kind of knowledge that bridges the content to the pedagogy. Shulman (1986) defined PCK as a special kind of professional knowledge required *for teaching* that built over time by teachers which included:

a. Identifying how to constitute and present the subject matter, the type of instructional methods to be used.
b. Understanding of learning of the subject matter, the kind of learning task that can be implemented and assigned;
c. Recognising of learners' understanding of the subject matter, content that considered learners' misconception and difficulties.

Shulman (1987) mentioned PCK represented "the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organised, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction" (p. 8). PCK is amalgamation of content and pedagogy with learner and learning and it is different from other categories of knowledge. Shulman and colleagues' work on PCK was not for finding of what teachers should know, but seek for knowledge that contributes to better teaching practices. In brief, Shulman's work provided a conceptual framework for PCK which allowed more researches to be done. Several studies had been conducted regarding PCK using different approaches such as: interview (Ma, 1999), observation of the teaching practices (Ball & Bass, 2000, 2003; Ball et al., 2008), and survey (Hill, Schilling & Ball, 2004; Rowan et al., 2001).

Ma (1999) conducted interviews to investigate the mathematical knowledge of teachers from two different countries- China and the United States. Ma used questions developed by Teaching Education and Learning to Teach Study (TELT) at the National Centre for Research on Teacher Education (NCRTE) to interview 72 teachers from China and 23 teachers from the United States. Ma (1999) found that there existed a "profound understanding of fundamental mathematics" (p. xxiv) in teachers from China where they acquired it gradually during their teaching career rather than when they were student teachers. Ma (1999) mentioned that profound understanding of fundamental mathematics constituted four features: connected, portray multiple perspectives, understanding of the fundamental ideas of mathematics and longitudinal coherence. She believed that teacher with this kind of understanding was able to understand the mathematical concept and taught the concept to their students in a better approach.

On the other hand, Rowan et al. (2001) conducted an exploratory survey that attempted to measure PCK of 104 elementary teachers. They found that there was possibility of developing reliable items to measure teachers' PCK in particular "finegrained" areas such as reading/language arts and mathematics curricula of elementary school. Later, Hill, Schilling and Ball (2004) presented the result of preliminary analysis of their survey study. They developed a test based on theory of instruction to measure teacher's content knowledge and found that organisation of knowledge for teaching mathematics was to some extent "domain specific" (p.24) and not merely depended on the teacher's intelligence or mathematical competence or the ability to teach.

However, Ball and Bass (2000, 2003) carried out research regarding mathematical knowledge for teaching based on Shulman's idea of PCK, where they observed and analysed mathematics used in teaching practice in order to find out what and how mathematical knowledge is applied in practice. Ball and Bass (2000) defined PCK as a unique type of knowledge exists in bundles of knowledge interweaving between mathematics, learners, learning and pedagogy, which was essential for mathematics teaching. They believed that teacher equipped with PCK is able to predict students' difficulties or misconception in learning and ever ready to offer an alternative explanation or solution in response to those difficulties or misconception. In addition, Ball and Bass (2003) argued that teaching quality did not depend only on teacher's understanding of the mathematical content.

Thus, the work of Ball and colleagues on PCK focusing on the teacher's knowledge of subject and pedagogy has been switched to what mathematical work teacher needs to do and how teacher puts mathematics in practice. Ball and Bass (2000) defined the concept as "knowledge in practice" or "mathematical entailments of practice" (p.90).

2.2.2. Content Knowledge of Mathematics for Teaching

The content knowledge of mathematics for teaching can also be referred as subject knowledge for teaching (Ball & Bass, 2000) or mathematical knowledge for teaching (Ball & Bass, 2003; Ball et al., 2005). This section discusses the reviews on the type of knowledge suggested by Ball and her colleague based on their research projects. The content knowledge of mathematics for teaching here does not mean the type of content course or subject that has been taken by the teachers. It also does not mean the content that the students require to learn during the lesson (Ball & Bass, 2000). The content knowledge of mathematics for teaching involves more than just merely an understanding of mathematics as the subject. However, it involves how to teach the subject to students.

Based on their designed item to measure teacher's knowledge, Ball and colleagues (2005) proposed another new form of knowledge where they named it as "mathematical knowledge for teaching" (p.17) which served as a special mathematical knowledge that only catered for the teaching profession. They suggested two key elements of this practice-based knowledge which were general mathematical knowledge for everybody and specific mathematical knowledge that only for teaching. This concept derived from their preliminary survey (in Hill, Schilling & Ball, 2004) suggested there existed "common content knowledge" and "specialised content knowledge" (p.22) in teacher's knowledge.

Ball et al. (2008) in their later work, proposed "specialised content knowledge" (p.390) as enhancement to the concept of PCK based on two of their projects: observed teachers' work in teaching mathematics (e.g. Ball & Bass, 2000, 2003) and survey to measure of content knowledge for teaching mathematics (e.g. Hill, Schilling & Ball, 2004; Rowan et al., 2001). They suggested specialised content knowledge as a special kind subject matter knowledge which only needed by teaching profession and not the other profession. Ball et al. (2008) investigated actual teaching and analysed the mathematical problems took place in teaching to explore both the subject matter knowledge and PCK based on the domains shown in Figure 2.1.

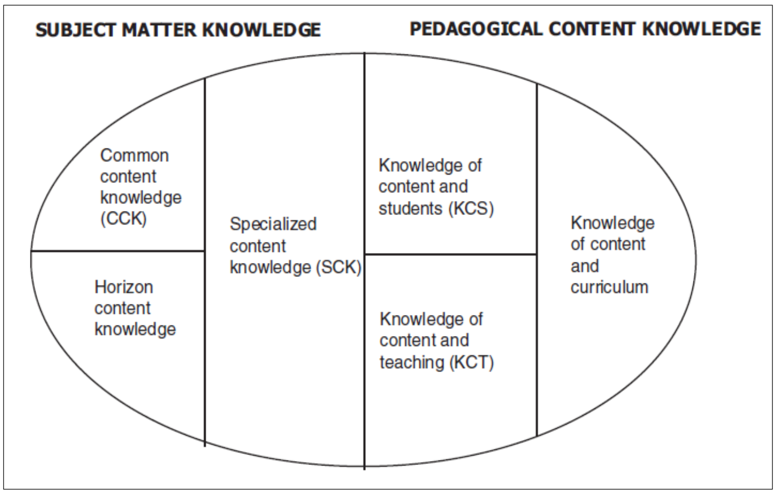

Figure 2.1. Domains of mathematical knowledge for teaching (adopted from Ball et al., 2008, p.403)

In short, Ball and colleagues' work had enriched and extended the exploration and definition of PCK that founded by Shulman and his colleague. Their studies also served as a new platform to investigate the teaching and learning process that unfolds the knowledge needed behind all the mathematical task of a lesson.

2.3. International Studies About the Pedagogical Flow of Mathematics Lesson

Based on the literature review, observation of teaching practices was not a new idea internationally. It had started since the 1970s where researchers started to look into the teaching practices (e.g. Andreson, 1969; Smith & Geoffrey, 1968) and become more popular during the 1980s (e.g. Brophy & Good, 1986; Peterson, 1988). Lesson observation even started much earlier in Japan during the Meiji period (Baba, 2007) through Lesson Study, where the discussion was at the coming section. Recently, there have been increasing amount of research to find out the pedagogical flow of mathematics lesson for example: Clarke et al. (2006), Hiebert et al. (2003), Huang and Li (2009), Kaur et al. (2007), Leung (1995), Lin and Li (2009), Mesiti et al. (2003), Schmidt et al. (2002), Shimizu (2002, 2003), Stigler et al. (1999), and Stigler and Hiebert (1999). Due to the large amounts of lesson observation studies that had been conducted, this section presented only result from mathematics lesson observation done by international researchers.

Leung (1995) had conducted a total of 112 lesson observations, which comprised of first-grade to third-grade mathematics lessons from three countries: Beijing, Hong Kong and London. He found that the pedagogical flow of mathematics lessons in Hong Kong and Beijing could be described as: teacher revised the previous lesson; teacher conducted whole class teaching; teacher assigned board work; whole class discussion upon the solution; teacher summarised the lesson and assigned individual seatwork. Nevertheless, the pedagogical flow of mathematics lesson in London reported was: teacher made sure pupils received the material needed; pupils completed the material individually with teacher provided individual guidance; teacher made sure pupils had returned the material.

Schmidt et al. (2002) through the Survey of Mathematics and Science Opportunities (SMSO) carried out lesson observations over two years in 127 classrooms that involved six countries: France, Japan, Norway, Spain, Switzerland, and the United States. The SMSO study focused on two student age groups: nine years-olds and thirteen year-olds. Schmidt et al. (2002) reported that mathematics lesson in France school consisted of uniform pattern of: teacher reviewed previous homework; teacher presented the concept; teacher posed question to the class; students worked on the problem in pair or groups; teacher responded to the given problems; teacher assigned homework to the class. In Japan, Schmidt et al. (2002)