CHANGES IN MATHEMATICS TEACHERS' QUESTIONING TECHNIQUES THROUGH THE LESSON STUDY PROCESS

by

ONG EWE GNOH

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PERUBAHAN DALAM TEKNIK PENYOALAN GURU MATEMATIK MELALUI PROSES *LESSON STUDY*

ABSTRAK

Kajian ini bertujuan mengkaji perubahan teknik penyoalan guru matematik melalui proses *lesson study*. Dua objektif utama kajian ini ialah; i) menyiasat perubahan teknik penyoalan guru matematik dari segi mencungkil, membimbing dan penyoalan fakta; ii) mengkaji perbezaan perubahan teknik penyoalan dalam kalangan guru baharu dan guru berpengalaman. Kajian ini dilaksanakan di Sarawak, di mana sepuluh orang guru matematik (berpengalaman dan baharu) dari dua buah sekolah, Sekolah M (sekolah rendah) dan Sekolah P (sekolah menengah) telah melalui proses *lesson study* selama lima belas bulan. Kajian kualitatif ini menggunakan empat jenis kaedah pengumpulan data: pemerhatian, temubual, perancangan pelajaran dan penulisan jurnal. Taksonomi teknik penyoalan Graesser, Person dan Huber (1992) telah digunakan untuk mengelas dan menganalisa soalan-soalan yang digunakan oleh para peserta. Guru matematik berpengalaman menunjukkan bahawa mereka telah beralih daripada soalan faktual yang rutin yang mana jawapan murid adalah berdasarkan prosedur dan jawapan mutakhir. Pada akhir kajian ini, guru-guru matematik berpengalaman ini telah berjaya menjana soalan untuk mencungkil pemikiran murid-murid mereka. Perbezaan teknik penyoalan dalam kalangan guru menunjukkan bahawa guru yang berinteraksi dengan aktif dalam proses *lesson study* mengalami perubahan yang ketara berbanding dengan mereka yang sudah berpuas hati dengan teknik penyoalan mereka dan tidak merasai keperluan untuk perubahan lanjut. Kajian ini

mengesan perubahan teknik penyoalan yang paling besar dalam kalangan tiga daripada lima orang guru matematik yang berpengalaman. Guru-guru ini telah menambahkan bilangan soalan mencungkil dan membimbing. Mereka juga mula merancang soalan-soalan yang hendak ditanya dan lebih bersedia menangani soalan yang diajukan. Selanjutnya, teknik penyoalan guru-guru matematik menghala kepada mengurangkan tanggapan salah murid dengan menyediakan soalan yang berbentuk *scaffolding*. Sebaliknya, hanya seorang daripada tiga orang guru baharu menunjukkan perubahan dalam penyoalannya. Guru baharu tersebut berusaha menguji idea-ideanya dengan sokongan dan bimbingan guru-guru berpengalaman. Namun demikian, dua orang guru baharu yang lain tidak menunjukkan kecenderungan berubah dan kekurangan keyakinan untuk berubah. Kesimpulan utama kajian ini ialah perubahan telah berlaku selepas beberapa kitaran proses *lesson study* sambil guru-guru tersebut membina ilmu matematik dan kemahiran penyoalan mereka. Maka, *lesson study* telah menyediakan satu kerangka alternatif untuk pembangunan profesionalisme guru matematik terutamanya dalam teknik penyoalan. Guru-guru ini telah diupayakan untuk membawa inovasi dalam suasana yang menggalakkan.

CHANGES IN MATHEMATICS TEACHERS' QUESTIONING TECHNIQUES THROUGH THE LESSON STUDY PROCESS

ABSTRACT

This study aimed to examine the changes in the mathematics teachers' questioning techniques through lesson study process. Two main research objectives were: i) to examine the changes in the mathematics teachers' questioning techniques in terms of probing, guiding and factual questioning when teaching mathematics; ii) to investigate the differences in the changes in questioning techniques among novice and experienced mathematics teachers. This study was conducted in Sarawak whereby ten (experienced and novice) teachers from two schools, namely School M (primary) and School P(secondary) underwent the lesson study process for fifteen months. This qualitative study employed four data collection methods: observation, interview, lesson plans and journal writings. The Graesser, Person and Huber (1992) questioning techniques taxonomy was used to categorize and analyze the questions that the participants employed. The experienced mathematics teachers showed that they have moved from routine factual questions which focused on procedures and final answers. Towards the end of the study, these experienced mathematics teachers were able to generate questions to probe their pupils' thinking. The differences in the questioning techniques of the teachers showed that teachers who were actively interacting in the lesson study process experienced the most changes compared to the ones that were satisfied with their questioning technique and did not see the need for further changes. The study detected the most changes in three of the five experienced teachers. These teachers seemed to use more probing and guiding

questions. They had also begun to plan their questions that they wanted to ask and were more equipped to handle questions. Moreover, the teachers' questioning techniques were geared towards reducing pupils' misconceptions through rich scaffolding questions. In contrast, only one of the three novice teachers displayed changes in his questioning techniques. He attempted to try out his ideas with the support and guidance of the experienced teachers. However, the other two novices showed inertia and lack of confidence to change. The principal conclusion revealed that changes have gradually taken place over multiple lesson study cycles as the participating teachers built mathematical knowledge and questioning skills. Hence, lesson study has provided an alternative professional development framework for mathematics teachers in questioning techniques whereby the teachers had been empowered to innovate in an encouraging environment.

CHAPTER ONE

INTRODUCTION

The Malaysian National Education Blueprint (2006-2010) presented on the 16th of January 2007 (National Education Blueprint: 2006-2010, 2007) had a vision to produce pupils who would be confident, inquisitive, and enthusiastic workforce for the job market. This recent review in the national curriculum on the development of human capital advocated that our pupils need to be able to think critically and creatively to solve problems and have the ability to adapt themselves to a constant changing global environment.

A critical aspect in developing critical thinking and creativity in problem solving was in mathematics teaching. Hence, the importance of mathematics teaching which would be able to produce quality mathematics pupils who could solve problems and were able to communicate confidently so that they would be competitive in the global world (Baroody,1993a and Gardner,1983). Mathematics teachers ought to have efficient communication skills such as questioning, explaining and representing so that pupils would be able to understand what was being communicated. Ultimately, pupils need to apply their knowledge appropriately so that they would be able to develop deeper understanding of mathematical concepts and processes so as to solve problems by reasoning and communication.

There is therefore a need to examine whether mathematics teachers have the communication skills in teaching mathematics as Skemp (1993) aptly argued

that "...the learning of mathematics, especially in its early stages and for the average pupils very dependent on good teaching. Now to know mathematics is one thing and to be able to teach it and to communicate it to those at a lower conceptual level is quite another matter, and I believe that it is the latter which is most lacking at the moment." (p.34). Perhaps it was then not surprising that the research done at the National Center for Research in Teacher Education (McDiarmind & Wilson, 1991) also showed that teachers who majored in the subject they taught were not necessarily able to explain fundamental concepts in their discipline more clearly than other non-majored teachers. This observation was supported by Ma (1999) in her studies comparing teachers from United States of America (USA) and China. She noted that American mathematics teachers whether novice or experienced were observed to be lacking a deep conceptual understanding of many topics covered in the elementary mathematics syllabus. Hence, there was a need for mathematics teachers to have effective communication skills to ensure that they would be able to help their pupils to make sense of mathematics and develop their skills through deeper understanding of mathematical concepts.

1.1. Background of the Study

In 2003, the Malaysian Government implemented a national policy of teaching and learning of science and mathematics in English (Pengajaran dan Pembelajaran Sains dan Matematik dalam Bahasa Inggeris-[PPSMI]). Besides teaching science and mathematics in English, this policy had provided information communication technology (ICT) resources such as teaching coursewares and

computers for the teaching and learning process. In actual fact, some studies done by Chiew and Lim (2003) and Koh (2006) had observed that mathematics teaching had not shown much change as it had just moved from the traditional chalk and talk approach to the click and show method. Koh (2006), a science officer attached to the Sarawak District Education Office observed that the 27 PPSMI teachers who were using teaching courseware became so engrossed with it that the basic communication between teachers and pupils was neglected. He cited an example that he observed a teacher teaching the topic of polygon based on a teaching courseware. The teacher was observed to use the passive click and show approach instead of using the inductive strategy to foster meaningful learning. Koh (2006) also observed that some teachers did not use models or manipulatives such as papers and scissors to help the pupils gain experiential knowledge. When teachers were teaching mathematical algorithms, pupils were observed to have little interaction with one another, except copying down the notes from the screen. Koh (2006) remarked that this kind of teaching might cause pupils not to have much confidence with earlier skills learned if their teachers kept using the teaching courseware without pausing to give other examples to reinforce the concepts.

From the researcher's own experience as a school inspector, it was observed that the usual method of rote memorization was not meaningful because pupils could not fully understand what they were learning. Pupils were not encouraged to share amongst themselves and frequently worked in isolation. Baroody (1993b) shared that this method of rote memorization could cause some pupils to be fearful, anxious and could ultimately lead to avoidance of mathematics.

When teachers seldom facilitate or take into account the pupils' potential while at the same time frequently emphasizing stimulus-response in teacher-pupils' interactions, pupils may ultimately conclude that mathematics learning were assessed based on their ability to remember. Raman (2003), a school inspector of the Ministry of Education (MOE), felt that because of this strategy, pupils may not know what their misconceptions were as they did not have much practice in communicating with one another or with their teachers. This view was supported by the Office for Standards in Education (OFSTED) in 1996 who argued that the characteristics of successful teaching should involve regular interaction with pupils which the teacher could utilize perceptive questioning, giving careful attention to misconceptions, while providing help and constructive responses to their pupils.

Hiebert and Wearne (1993) as well as Klinzing, Klinzing-Eurich and Tisher (1985) observed that teachers rarely asked "higher order" questions even though these had been identified as important tools in developing better pupil understanding. Mathematics teachers ought to view questions from within the context of the kind of instruction that was taking place and in relation to the mathematical context. Moreover, rich questions (William, 1999) or questions that promoted mathematical thinking were necessary as standard mathematical tasks could be opened up for exploration with skilful teacher questioning (Lampert, 2001). Since, questions were a way that teachers used to bring pupils around to the correct mathematical concepts and procedures through "the negation of meaning for necessary condition of learning" (Voight, 1992, p. 43), it was important to emphasize teacher's questioning as a critical part of a teacher's work. The act of asking a good question was cognitively demanding because it required

considerable pedagogical content knowledge and it necessitated that teachers knew their learners well.

On the other hand, Leung (2006) based on his observation of the teaching and learning process in Hong Kong argued that even though mathematics teachers were generally competent, he observed that they deliberately taught in a procedural manner for pedagogical reasons and for the sake of efficiency. Apparently they perceived that it would be inefficient or even confusing for school children to be exposed to rich concepts and opted for clear and simple procedures. Therefore these prevailing beliefs caused teachers to believe that giving clear explanation with suitable examples were practical and sufficient to achieve most of their teaching objectives. In addition, they were not confident that their pupils have acquired enough knowledge and skills if they were allowed to explore by themselves as teachers felt more certain if they can control the teaching and learning pace of their pupils.

Conversely, Watson (2002) argued that mathematics teachers' questioning techniques could be developed through observation, reading, use, reflective thought and awareness through working together. First, there was a need to work on questioning before the observed lessons. The teacher ought to ask whether pupils could be asked to conjecture before tackling a task and how would conjecturing aid motivation and interest, subsequently can the pupils pose their own questions because of their conjectures? Second, the articulation of purposes and strategies could be used by teachers to discuss the effectiveness of the lesson and alternatives to questioning after a lesson. Third, these questioning techniques could be further supported and enhanced through their discussion with their peers.

When they watched other teachers, they could begin to identify the question type which conformed to their beliefs about what the pupils could do.

Koh (2006) also raised some concern pertaining to the present remedial measures undertaken by the Malaysian Ministry of Education, specifically the English for Teaching Mathematics and Science (ETeMS) courses and Kursus Orientasi Semakan Kurikulum (KOSEM). He commented that these efforts may not have any major impact or changes in the way teachers taught except for the production of many sample lesson plans and yearly plans. He also recommended teachers to work together and provide opportunities for pupils to construct concept through communicating with one another. Presently, many mathematics teachers faced the uphill and lonely task of teaching as the current top-down efforts engaged in helping them may not be effective or sufficient. Therefore, from the above literature reviews and observations, it could be concluded that mathematics teachers who did not communicate well may also not encourage their pupils to communicate well. This could be attributed to the ubiquitous examination culture and the lack of sustainable and effective professional development program in Malaysian schools.

Lesson Study. Stigler and Hiebert (1999) who set out to discover the difference in teaching methods between eighth grade mathematics classes in the Third International Mathematics and Science Study (TIMSS) analysis concluded that the Japanese mathematics teaching and learning process was more effective for present and future generation of learners compared to the ones from USA and Germany based on several critical factors like the coherence of the lesson,

collaboration of teachers and problem-solving strategies (Stevenson & Nerison-Low, 2002; Stigler & Hiebert, 1999).

Hence, Stigler and Hiebert (1999) argued that although there were many different factors which were out of the control of the teacher, yet teaching methods were within the ability of the teacher's initiative and teachers could affect real change by improving themselves. No matter who or where they were, if teachers taught more effectively, then schools would improve (MacFarlane, 2000). In view of that, Stigler and Hiebert (1999) suggested that lesson study may empower teachers in a culture that they could pass on from one generation to another.

Indeed, it was Yoshida (1999) who first coined the word lesson study, which was derived from the Japanese word *jugyokenkyuu*, i.e., *jugyo* which meant lesson and *kenkyuu* meant study or research. Nevertheless, Fernandez and Chokshi (2002) quickly cautioned that lesson study was more than a study of lessons because it involved a systematic inquiry into teaching practice.

Lesson study was a quality cycle for establishing long-term goals, where each piece of work was measured against the longer goals thereafter changes were made accordingly (Yoshida, 1999; Fernandez & Chokshi, 2002; Richardson, 2001). Many researches on lesson study have been conducted in Japan. For example, Peterson (2005) has studied on pre-service student teachers' teaching in Japan, while Shimizu (2008) focused on professional development through lesson study. Besides Japan, many countries have embarked on the lesson study collaboration among mathematics teachers. White and Southwell (2003) from Australia concluded that the lesson study project conducted in some schools in

New South Wales had been a promising model for teachers' development as it provided a clear framework to map their pupils' understanding of mathematics.

In the USA, Chokshi and Fernandez (2004, 2005) shared many insights of the challenges they faced in importing Japanese lesson study in the U.S.A. Chokshi and Fernandez strived to move from procedural aspects towards a more sustainable practice. In addition, Lewis, Perry, Hurd and O'Connell (2006) concluded that lesson study which typified the dominant form of professional development for teachers in Japan has spread rapidly in the U.S, while sharing about the growth and success of lesson study in California's San Mateo-Foster City School District.

Meanwhile, in Chile, Galvez (2006) described how mathematics teachers collaborated to solve problems and analyzed the techniques that they used as well as the mathematical and didactic knowledge that they have employed. Leung (2006) acknowledged that although there were some limitations in the Hong Kong lesson study project, this research development system was worth trying in schools as it was a self-evaluation and self-correction process wherein the pupils, teachers and school would benefit from it. Sukirman (2006) concurred that the results of the Indonesian lesson studies among secondary mathematics teachers had shown a significant improvement in terms of the mathematics teachers' competencies and pupils' motivation. In addition, Thailand, Philippines, and Vietnam who had taken tentative steps in lesson study collaboration have reported encouraging progress among the mathematics teachers (Inprasitha, 2006; Ulep, 2006; & Vui, 2006).

1.2 Statement of the Problem

In the Malaysian mathematics curriculum, according to the Curriculum Development Division, "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...Through effective communication pupils will become efficient in problem solving and are able to explain concepts and mathematical skills to their peers and teachers" (CDC, 2006, p.11). This implies that effective communication in teaching was necessarily a two way communication involving talking, questioning, and answering although questioning was quite often taken for granted. However, to what extent has questioning been used in mathematics communication? Based on Jamaliah Kamal's (2001) and Ruslan Ali's (2007) observations on classroom practices, they found that questioning in the mathematics classroom has yet to play an important role in most Malaysian classrooms. Jamaliah Kamal (2001) in her study of Malaysian rural school teachers observed that traditional teaching style was still prevalent within the Malaysian classrooms. She shared that "the teacher would present the day's lessons in the form of questions-answers or present a brief explanations of the topic through examples either taken from the textbooks or workbooks, followed by drill exercises" (p. 164).

Ruslan Ali's (2007) study supported Jamaliah Kamal's (2001) observation as he noted that the teachers' questioning dominated the uni-directional interaction between teachers and pupils, whereby teachers always asked the questions and pupils answered them. He established that the reason for asking questions was to check for understanding and frequently they asked simple questions that required

only short answers. Ruslan Ali (2007) further expressed his concern that the type of knowledge gained from such questions may not support the achievement of the intended Malaysian mathematics curriculum. He voiced his skepticism that the Malaysian classrooms where teaching focused on procedural competence was falling short of the intentions encapsulated within the curriculum. He supported his conclusion with two observations that classroom interaction was almost always closed and generally procedural and there was no substantive evidence to indicate that the teachers elaborated upon the children's responses, therefore there was no interaction. Ruslan Ali's second observation showed that teacher's responses to pupils' answers were simply accepted as part of the next step in developing a procedure. He felt that "there was virtually no evidence of 'incorrect responses' which suggested that during the lessons children were largely responding to questions that invoked memory of past procedures" (Ruslan Ali, 2007, p.350).

Lim (2006) noted that the prevalent examination culture in Malaysia has caused many mathematics teachers to resort to what Lim (2006) termed as the common beliefs of "practice make perfect." For this reason, mathematics teachers gave many routine problems and questions to their pupils in an attempt to ensure high achievements in public examination. Hence, Chiew and Lim (2003) observed that although teachers seemingly were aware of the emphasis of student-centered teaching in the curriculum, they may have sidelined it in their lesson preparation, including preparing higher level questions and actual teaching practices due to the present examination culture and time constraints that they faced.

Furthermore, Lim, Fatimah and Tan's (2003) study on the impact of culture on the teaching and learning of mathematics is schools observed that there was

insufficient continuous collegial support for mathematics teachers as most school mathematics panel's meetings were merely used to discuss and analyze strategies to improve pupils' mathematics achievements in examinations. Even though the panel of mathematics and science teachers met at least three times a year, its agenda dealt mainly with administration and not specifically on the teaching and learning issues. Thus, the lack of teacher professional development program in the school may possibly hamper efforts to enhance teacher's teaching knowledge and collaboration experiences such as confidence to engage in active and deep discussion or interacting with their pupils using effective questioning techniques.

An alternative school-based professional development program may need to be considered to address the problems and challenges stated above. Lesson study which was a school-based professional development program has shown to be successful in empowering teachers and could be an alternative that we sought. However, as reviewed earlier in the background of the study, reviewed studies on lesson study had not dwelt extensively on questioning technique and due to the lack of appropriate questioning among mathematics teachers, therefore this study sought to investigate if lesson study collaboration could change mathematics teacher's questioning techniques in teaching mathematics.

1.3 Purpose of the Study

The purpose of this study was to examine the changes of the mathematics teachers' questioning techniques in teaching mathematics through the lesson study process.

1.4 Research Questions

More specifically, after the lesson study process,

a) What are the changes in the mathematics teachers' questioning techniques in terms of probing, guiding and factual questioning when teaching mathematics?

b) What are the differences in the changes in questioning techniques among novice and experienced mathematics teachers?

1.5 Significance of the Study

It was hoped that the findings of this study would offer an alternative model to the present top-down reforms initiative by the Ministry of Education (MOE). The Malaysian Government had spent tremendous amount of money and resources on training and retraining mathematics teachers to improve their teaching and learning skills. The MOE namely the Curriculum Development Division may also glean some useful information pertaining to issues on in-service program for the thousands of mathematics teachers. Lesson study could be one of the long-term strategies which would enhance the teacher's development program. Although this study set out to address mathematics teachers' questioning techniques with PPSMI in the background, nonetheless the findings from this research may still be relevant even when the policy has reverted to the pre-PPSMI era.

For the school administration, the findings of this study may provide an alternative to their staff development program by incorporating lesson study to improve mathematics teachers' questioning techniques in teaching mathematics.

As this study explored the potential and strengths of lesson study as a school-based teacher professional development, lesson study may be a tool used by the schools in their implementation of their staff development programs.

The present pre-service training of teachers under the auspices of the Malaysian government may benefit from the findings of this study as lesson study was a continuous long-term professional effort to help pre-service mathematics teachers to work together to improve themselves in their communication skills. This process could be used as a supplement to the present micro teaching which was commonly practiced in Teacher Education Institutes.

Mathematics teachers may also take advantage of such findings for their own professional development. As lesson study was a school-based and teacher-led professional development program, two key features were teacher collaboration and peer observation of classroom teaching which would enhance pedagogical content knowledge and skills via peer's discussion, review and comments. Subsequently, this process of self-reflection would improve the teacher's own instructional strategies (Chiew & Lim, 2005).

The School Inspectorate and District Education Offices could use this process to encourage greater networking and collaboration among mathematics teachers. In that way, teachers would take up their professional responsibility to continue their life-long learning process.

Expert teachers may also use lesson study framework as one of the on-going process to expressly assist novice teachers to gain confidence and build on their repertoire of strategies specifically on their questioning techniques in their mathematics classroom.

In the field of research, the findings in this study may be a modest contribution to the field of mathematics education, namely in facilitating the effective teaching and learning process of mathematics through questioning techniques. The findings might help to fill the research gap pertaining to on-going, school-based professional development of mathematics teachers in Malaysia.

1.6 Operational Definitions

Some operational definitions were needed to clarify the words that were frequently used in this study.

Communication skills are skills that enabled people to communicate effectively with one another. Effective communication skills involved the choice of the best communications channel for a specific purpose and the technical knowledge to use the channel appropriately, the presentation of information in an appropriate manner for the target audience, and the ability to understand messages and responses received from others.

Lesson study focused on the examination of teaching practice through the direct observation by colleagues of each other's practice and through the examination of classroom artifacts (Stigler, Gallimore & Hiebert, 2000). This collaboration process involved a small group of teachers working as a lesson study team who met regularly to plan, design, implement, evaluate and refine their lessons. The lessons might be sequential in nature or target specific focus areas within the chosen topic area (White & Lim, 2007).

Questions in mathematics class were defined as an utterance, statement or command with an interrogative form or function, either as instructional cues or stimuli that communicate to pupils the core materials to be learned and directions associated with what they were to do and how they were to do it, and subsequently sought an answer or evoke a spoken response (Cotton 2001, Galton, Simon, Croll, Jasman & Wilcocks,1980).

Questioning techniques was defined as the mechanism that teachers incorporate to determine the type of knowledge the questions were designed to measure. It also described how the teacher structured the phrasing and direction of the question and reorganized some concepts required

Probing questions are questions that asked pupils to explain or elaborate their thinking, use prior knowledge and apply it to a current problem or idea and to justify and prove their ideas

Guiding questions are questions that provided pupils a specific suggestion of hint about the next step of solution, a general heuristics (Polya, 1947), and a sequence of ideas or hints that scaffold or led towards convergent thinking

Factual questions are questions that asked student for a specific fact or definition (Vacc, 1993), an answer to an exercise and to provide the next step in a procedure

Change in this study referred to an on-going process which takes time. Change is not linear but change in one area could affect change in another, often as a catalyst and/or a model. Change is accomplished by individuals who react at different rates and in different ways and intensities to new and continuous challenges (New Jersey State Department of Education, 2006).

Experienced mathematics teachers are classified as trained mathematics teachers who have taught mathematics for more than 5 years in the school (Humphrey, 2003).

Novice mathematics teachers are classified as trained mathematics teachers who have just begun to teach mathematics in the school for a period that is not more than five years. Berliner (1988) speculated that novice stage might last for the first year of teaching and most teachers would reach the competence stage within 3-4 years. However, only a modest proportion of teachers moved to the next stage of proficiency and even fewer to the expert stage.

CHAPTER TWO

REVIEW OF THE LITERATURE

2.1 Introduction

This chapter aimed to expound on mathematics teachers' questioning techniques in the teaching of mathematics. Dominant themes in the literature such as questioning in the mathematics classroom, the need for a professional development program, lesson study as one of the viable options for professional development and the comparison of novice and experienced mathematics teachers were discussed.

2.2 Questioning in the Mathematics Classroom

Interest in questioning in the teaching of mathematics had been revived by several notable researchers such as Cotton (1998), Harrop and Swinson (2003), Ilaria (2002), Kawanaka and Stigler (1999), Martino and Maher (1999) as well as Sahin, Bullock and Stables (2002).

Cotton's (1998) research showed that questioning was second in popularity as a teaching method and classroom teacher spent 35-50 percent of their instructional time conducting questioning session.

Hohn (1995) and Harrop and Swinson (2003) argued that asking pupils appropriate questions was a valuable teaching accessory and one of the most important skills that a teacher should have. However, Reynolds and Muijs (1998) cautioned that this teaching strategy should not be equated to a conventional

lecturing and drill approach in which pupils remained passive, since effective teachers asked a lot of questions and involved all the pupils in class discussion. The National Numeracy Project (1998) and Dickinson (2000) concurred that high quality direct teaching was oral and interactive. It was not achieved by adopting a simplistic formula of drill and practice but rather "interactive carried the meaning of lively questioning which can probe children's thinking" (p. 4). Dickinson further elaborated that the quality of interaction was "not about whether we ask questions, or how much, but about the nature of the questions we ask and what we do with the responses" (p.4). This was in line with Skemp's (1991) vision of mathematics teachers and their pupils to possess relational understanding (knowing both what to do and why) rather than instrumental learning which subscribed to learning mathematics rules without meaning.

Skemp's (1991) admonition had been resounded by the submissions to the Education and Employment Committee for its Report on the Highly Able (1999) quoted in Westminster Institute of Education (2000) which urged the increased use of effective questioning techniques with gifted and talented pupils so that they would take risks to think divergently and creatively.

There were many reasons why teachers used the questioning approach in their class. One, some teachers may use questions to facilitate classroom management so as to maintain pupil's interest, keep them quiet or promote involvement. However, this type of question was usually low-level arithmetic which the teachers expected the pupil to be able to answer if they had been paying attention. Sometimes, certain pupils who may be suspected of not being fully engaged with the lesson may be chosen by the teachers to answer questions.

These questions were actually used to reinforce behavior patterns and reinforce the message of "Why are you talking when I'm talking?" (Dickinson, 2000; Hargreaves, 1984)

Two, teachers used questions to test knowledge in order to find out who knew what or to inform the pupils whether he can move on (Ainley, 1987). Three, questions were used to create knowledge or to promote learning (Dickinson, 2000) but Cotton (1998) observed that on the average, 60% of the questions asked were lower level, 20% of higher order and 20% were procedural.

Brown and Wragg (1993) argued that asking questions in the classroom could contribute to cognitive-related aspects, which included stimulating recall, deepening understanding, developing imagination and encouraging problem solving. Dunne and Jennings (1998) further cautioned that questions were considered useful only if they enabled pupils to respond in such a way that they were progressively more inducted into a mathematical view of the object. Based on the arguments above, Schoenfeld (1994) advocated that the mathematics classroom should be the venue to guide pupils to construct and build up their understanding of mathematics. Therefore, this implied that mathematics teaching should include appropriate use of questioning so that the teacher could understand the pupils' thinking processes, while using pupil's deviations from expected understanding to enhance their learning.

Sadly, Brown and Wragg (1993) discovered that teachers asked the vast majority of questions in their classrooms for various reasons such as to check knowledge, understanding, recall of facts, diagnose pupils' difficulties but only 10% used questions to encourage pupils to think. They postulated that some teachers

were anxious that giving more emphasis on thinking skills with its associated dialogues and questioning could divert attention from the content required by the National Curriculum.

2.2.1 Definitions of Questions

In 1971, Rosenshine (cited in Hargreaves, 1984) suggested two types of questions: factual and interpretative questions. Factual questions were used when pupils recalled information on the contrary interpretative questions demanded an answer involving some form of reasoning, analysis, evaluation or the formulation of an opinion or judgments.

Subsequently, Ainley (1987) as well as Mason and Watson (1998) proposed that the first category of questions was the pseudo-question which was often used to establish or re-iterate acceptable behavior practices. Second, it may be genuine question in which the teacher sought information because they did not know the answer, or a testing question for which the teacher knew the answer and the pupils recognized this. Third, the directing question which aimed to provoke a pupil to think further and explore or to help him organize his thinking.

Boaler and Brodie (2004) and Ruslan (2007) researched on six different categories of questions that were usually asked by mathematics teachers. First, the closed-procedural questions were described as the questions that the teachers asked as he or she explained the procedure or steps in solving a problem mechanically. This type of question involved the collection of acceptable information, often facts, or checking of a correct method as the pupils were being led to arrive at a solution. Second, the closed-routine questions were asked more

for the purpose of classroom management. Third, the closed-complete questions required pupils to complete or add-in one or two syllables at the end of the statement. Fourth, the closed-verification questions were used by the teacher to check with the pupils almost immediately after an answer had been given, so that the pupils can think again about a statement or their answer. The fifth category was the closed-terminology type question which required pupils to state the correct mathematical language or term for the context under discussion. Finally, the sixth category was the closed rhetorical question that teachers asked but answered without giving the opportunity for pupils to respond to it.

Watson (2002) wrote that "an open question is usually taken to mean one with several answers," (p.34) to which many learners could contribute. For example, an examples of these two questions could be; "If the answer is 4, what could the question be?" and "I want you to make up three questions to which the answer is 4, and each questions must come from a different topic we have studied this term." She contrasted these two open questions and commented that the first question was wide open and was likely to generate low arithmetical operations using small whole number. The second was more constrained and pupils could not resort to simple mathematical procedures. Consequently learners were forced to think beyond the obvious. Although both questions were open questions, she emphasized that "one is more likely to involve grappling with concepts than the other" (p.34).

So the challenge for the mathematics teacher was not which kind of question, either open or closed was good or bad but the important motivation was to encourage pupils to engage with mathematical concepts, for example through

the process of how the teacher structured the phrasing and direction of the question and reorganized some mathematical concepts. Watson (2002) saw the need to go beyond the open/closed classification by asking "what else can be said and what other variations are there in my questions?" (p.34)

Presently, from the search of literature, Sahin (2007) categorized questioning into three categories, i.e., probing, guiding and factual questions. One, although probing questions was not a frequent practice in many classrooms (Newmann, 1988), the Maryland State Department of Education (1991) pointed out that probing questions extended pupils' knowledge beyond factual recall and copying of learned skills, and also pushed pupils to use previous knowledge to figure out unknown knowledge. Krupa, Selman, and Jaquette (1985) echoed the same opinion that "teachers who encourage pupils to elaborate on and explain their thinking through the use of probing questions to promote learning because such questions push pupils to think more deeply about the topic being discussed" (p.453). Moyer and Milewicz (2002) agreed that asking probing questions helped the teachers to better focus on pupil's thinking.

Two, according to Kawanaka & Stigler (1999) guiding questions steered pupils towards discussing problems and deriving mathematical concepts and procedures to solve problems. Ortenzi (2002) equated leading or helping questions as guiding questions. It was used when pupils were not sure how to proceed. Thus, a teacher could help by asking "which method do you need to use now?" leading pupils into convergent thinking the way the teacher wanted them to think. Helping questions were frequently used when pupils were not sure which method to use. So, a teacher could intervene and help the pupil by saying, "I think

this method is a good choice here, isn't it?" Watson (2002) shared that "pupils tend to agree that questions like 'Which has been the easiest so far?' or 'Can you show me how you did number 8?' work rather better than 'How are you getting on?' or 'Everything alright?'" (p.3)

Therefore, although guiding questions may be varied as a teacher moved from a continuum of when he/she decided to provide information, clarify an issue, model, lead, or let a pupil struggle with a difficulty. In this manner, the teacher was able to monitor the pupil's participation in discussion and decide when and what to encourage each pupil to participate in.

Three, factual questions were mostly questions which asked pupils for a specific definition, facts or quantities as mentioned above in Boaler and Brodie (2004) and Ruslan (2007) categories of questions.

2.2.2 Types and levels of questions

One of the question taxonomies commonly used in the literature is Lehnert's (1978) which was further developed for the educational field by Graesser, Person and Huber (1992). The taxonomy was both grounded theoretically in cognitive science and had been successfully applied to a large number of questions. According to Graesser and his colleagues, (Graesser, Person & Huber (1992) and Graesser & Person (1994)), there were 18 different types of questions based on semantic, conceptual and pragmatic aspects (see Table 2.1). Graesser et al. (1992) organized the 18 question types into three levels: shallow, in-depth and other. Five types were considered shallow, eleven types were considered in-depth and the remaining two types fell into the other level. The categories were defined

according to the content of the information sought rather than on question signal words (who, what, why, when, how, etc). The question categories could be recognized by particular generic question frames which were comparatively distinctive but not simply by ambiguous signal words. Categories 1-8 were shallow comprehension questions that did not required deep insight into the topic. Categories 9-16 were deep comprehension questions that required more than dictionary or encyclopedic knowledge, inferences were needed to answer the deeper questions. It was these deep comprehension questions that helped learners in constructing knowledge that supported the deeper levels of Bloom's taxonomy (specifically levels 4-7). In this study, probing questions were used to prompt concerted efforts towards a specific problem which included the retrieval of relevant concepts, skills as well as the execution of generating, analyzing and interpretation of data (Flick, 1998). Hence, categories 15-18 were coded as probing questions.

Meanwhile, Collins, Brown and Holum (1991) advocated that any cognitive scaffolding or support given by teachers was necessary to complete a task or solve a problem which was not likely to be achieved by pupils on their own. Guiding questions would help to support the pupil's thinking processes whilst the teachers could draw out discrepancies as well as stimulate new ideas. Hence, in a teacher-pupil discussion, the teacher was able to probe and affirm correct concepts and hypotheses thus preventing pupils from abandoning a sound investigation path. These structured discussions would then allow the teacher to guide pupils to give focus to main principles and to avoid pursuing a fruitless line of solution (Lewis, Stern & Linn, 1993). Socratic questioning was a form of cognitive scaffolding to