THE IMPACT OF PRE SERVICE TEACHERS' MATHEMATICAL KNOWLEDGE FOR TEACHING ON THE MATHEMATICAL QUALITY OF INSTRUCTION

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ABSTRACT

This study was aimed to investigate the impact of pre service teachers' (PSTs') Mathematical Knowledge for Teaching (MKT) on the Mathematical Quality of their Instruction (MQI). A case study involving three pre service teachers (PSTs) was carried out to detail the MQI and the domains of MKT they hold. The context of the study was the final practicum placement for three participants in the fourth year of their degree program (Bachelor of Teaching- Primary Mathematics). The study employed observational approach using video-recording of classroom teaching and interviews as its primary method. Observational notes, participants' lesson plans and reflective writing were used to compliment the video data. Two protocols, the Pre service Teachers' MKT protocol (PTMKT) and Pre service Teachers' MQI protocol (PTMQI) were developed to code and analyze the data. The MQI were coded and analyzed using the PTMQI protocol. Similarly, participants' MKT was determined through the analysis of interview transcripts, lesson plans and reflections of the lessons using the PTMKT protocol. Findings of the study not only supported claims that MKT held by PSTs impacts the MQI but also revealed that the reverse also occurs in instruction. In reviewing the domains of MKT held by PSTs, the domain that appeared more often than the rest was knowledge of content and teaching. The findings also showed that there are a number of important factors or influences that mediate the relationship between MKT and MQI either by enabling or hindering the enactment of MKT in instruction. These factors include the PSTs' personal beliefs and assumptions, the mentoring teacher's expectations and beliefs of mathematics teaching, past practicum experiences, reflective practices and self-correction, ability to utilize curriculum materials effectively and classroom management. This study offers theoretical and methodological contributions to the study of MKT and MQI. The implication of this study is the development of MKT enhanced the MQI and influenced the mentoring and evaluation of practicum among PSTs.

IMPAK PENGETAHUAN MATEMATIK GURU PELATIH UNTUK PENGAJARAN TERHADAP KUALITI MATEMATIK PENGAJARAN

ABSTRAK

Kajian ini bertujuan menyiasat impak Pengetahuan Matematik guru pelatih untuk Pengajaran (PMP) terhadap Kualiti Matematik Pengajaran (KMP). Satu kajian kes melibatkan tiga orang guru pelatih telah dijalankan bagi memperincikan KMP dan domain PMP yang guru pelatih amalkan. Konteks kajian adalah penempatan latihan mengajar fasa akhir bagi tiga orang peserta kajian dalam tahun empat program ijazah (Ijazah Sarjana Muda Perguruan - Matematik Pendidikan Rendah). Kajian ini menggunakan pendekatan pemerhatian melalui rakaman video pengajaran dalam bilik darjah dan temu bual sebagai kaedah utama. Nota pemerhatian, rancangan mengajar peserta kajian dan penulisan reflektif digunakan untuk melengkapkan data video. Dua protokol, iaitu protokol PMP guru pelatih (PPMP) dan protokol KMP guru pelatih (PKMP) telah dibina untuk mengekod dan menganalisis data. Kualiti Matematik Pengajaran telah dikodkan dan dianalisis menggunakan protokol PKMP. Begitu juga, PMP para peserta kajian telah ditentukan melalui analisis transkrip temu bual, rancangan mengajar dan refleksi pengajaran menggunakan protokol PPMP. Dapatan kajian menunjukkan bukan sahaja terdapat bukti yang menyokong PMP yang diamalkan oleh guru pelatih memberi impak kepada KMP tetapi sebaliknya juga berlaku dalam pengajaran. Melalui penelitian domain PMP yang diamalkan oleh guru pelatih, domain yang kerap muncul berbanding yang lain adalah pengetahuan isi kandungan dan pengajaran. Dapatan kajian juga menunjukkan bahawa terdapat beberapa faktor atau pengaruh yang penting yang menjadi pengantara hubungan PMP dan KMP, sama ada membolehkan atau menghalang enakmen PMP dalam pengajaran. Faktor-faktor ini termasuklah kepercayaan dan persepsi peribadi guru pelatih, ekspektasi dan kepercayaan guru pembimbing terhadap pengajaran matematik, pengalaman latihan mengajar yang lalu, amalan reflektif dan pembetulan kendiri, kebolehan menggunakan bahan kurikulum secara berkesan dan pengurusan bilik darjah. Kajian ini menyumbang secara teoritikal dan metodologi kepada kajian tentang PMP dan KMP. Implikasi kajian ini adalah pembangunan PMP meningkatkan KMP dan mempengaruhi pementoran dan penilaian latihan mengajar dalam kalangan guru pelatih.

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LIST OF ABBREVIATIONS

BPG	Teacher Education Division (*Bahagian Pendidikan Guru*)
CCK	Common Content Knowledge
E&I	Errors and Imprecision
EMK	*Elemen Merentas Kurikulum* (Cross-curriculum Elements)
KC	Knowledge of Curriculum
KCS	Knowledge of Content and Students
KCT	Knowledge of Content and Teaching
KMH	Knowledge at the Mathematical Horizon
KPM	*Kementerian Pelajaran Malaysia* (Ministry of Education)
KSSR	*Kurikulum Standard Sekolah Rendah*
MKT	Mathematical Knowledge for Teaching
ML	Mathematically Lacking (in Direction and Content)
MOE	Ministry of Education
MQI	Mathematical Quality of Instruction
PCK	Pedagogical Content Knowledge
PISMP	Degree of Bachelor of Teaching- Primary Mathematics ' Program *(Program Ijazah Sarjana Muda Perguruan- Matematik Sekolah Rendah)*
PST	Pre service Teachers

PTMKT	Pre service Teacher's Mathematical Knowledge for Teaching
PTMQI	Pre service Teacher's Mathematical Quality of Instruction
RM	Richness of Mathematics (Offered to Pupils)
SBE	School Based Experiences (Practicum)
SCK	Specialized Content Knowledge
SPM	Students Participating in Mathematics
TEDS-M	Teacher Education and Development Study in Mathematics
TSM	Teacher Working with Students and Mathematics
UPI	Unproductive Interaction (over Time and Content)

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This study investigates the Mathematical Knowledge for Teaching (MKT) of pre service teachers (PSTs) and its impact on the mathematical quality of their instruction (MQI). The findings from this study provides important information on how to develop PSTs' knowledge for teaching mathematics in the course of their degree program and also their school based practicum placements. This study also sheds light on knowledge held by PSTs and how it is enacted in classroom practice.

The section that follow presents the background of the study, the emergence of the problem, rationale for the study, the objectives of the study, the research questions and the potential significance of the study. Included in the following section is an introduction to the constructs; Mathematical Knowledge for Teaching (MKT) and Mathematical Quality of Instruction (MQI).

1.2 Background of the Study

Although there is agreement that teachers have a major impact on pupils' experience and achievement (Ulvik, Smith & Helleve, 2009), debates about 'the legitimacy and utility of teacher education as an enterprise' still arise about whether and how teacher education influences teachers' effectiveness, especially their ability to increase pupil learning (Klein, 2012).

Pupils' mathematical ability can be gauged nationwide and internationally using various valid and reliable assessment tools. Results of the Trends in International Mathematics and Science Studies (TIMSS) and the Program for International Student Assessment (PISA) have demonstrated the strengths and weaknesses in the teaching and learning of mathematics nationwide and internationally. Similar to other participating countries, the results of such studies in Malaysia have given rise to a lot of interest shown in doing studies on the mathematical quality of instruction (MQI), the amount of knowledge teachers need to possess to teach mathematics effectively and how this knowledge can be developed in pre service teachers (PSTs). One such study claims that teachers' weak knowledge of mathematics and failure to provide rich learning experiences to pupils resulted in poor attainment in mathematics (Pournara, Hodgen, Adler & Pillay, 2015).

What knowledge teachers need to possess to teach mathematics, how it affects their teaching and how this knowledge can be developed has preoccupied policymakers, researchers and teacher educators. Although these stakeholders recognize the importance and the role of knowledge for teaching mathematics, measuring it and developing it effectively and determining its impact on the quality of

instruction remains an unsolved problem for the improvement of mathematics teaching and learning.

In light of these concerns, teacher educators are seeking to develop strategies for assessing the results of their efforts. The assessment tools commonly used for gauging PSTs' and abilities as well as teacher educators success in enhancing them include; PSTs' course assessments, PSTs' School Based Experience (SBE) assessments as well as perceptions of preparedness on the PSTs as well as their employers once they have been posted to schools. However, these alone do not provide evidence of the PSTs' knowledge for teaching mathematics and how it is enacted in the classroom.

The work of teaching primary mathematics is challenging; now more than ever. A good teacher not only knows the content but also how to get it across creatively and effectively to pupils. Mathematics teachers must be able to mediate pupils' mathematical ideas and reasoning, make choices about mathematical representations of content from textbooks and those given by pupils, analyze pupils' errors and teach pupils appropriate mathematical language. Mathematics teachers must find out what concepts or ideas pupils find difficult and how to model them with representations that are mathematically accurate as well as easily understood by pupils. To facilitate these efforts, they need to rely on their knowledge of and skill in understanding pupils' mathematical work and thinking. Teachers' knowledge is evident in the tasks they select, questions they pose, their interpretations of pupils' answers, their explanations, the models and representations they choose and in the

mathematical language they use and teach their pupils to use. Ability to do all these is the knowledge that make up the dimensions of MKT.

Before going further, it is important to explain how the construct; MKT evolved from prior domains of mathematical and pedagogical knowledge and how "Mathematical Quality" evolved as a dimension of classroom instruction. According to Ball, Lubienski & Mewborn (2001), the first approach to empirical support for the fact that teachers' MKT influences what and how pupils learn was focused on teachers and their mathematical qualifications. The studies by Begle (1979) and Monk (1994) indicated that comparison of the number of mathematics courses taken and student performance was inconclusive. However, Monk's findings indicated that teachers' skills and knowledge impact student performance.

The concept of Pedagogical Content Knowledge, PCK (Shulman, 1986) has since then shed light on the findings that mathematics methods courses in teacher education had more effect on student achievement than conventional mathematics courses. These findings corresponds to the curriculum of methods courses which focus more on knowledge of pedagogy, students and learning. Ultimately, knowing the qualifications of a mathematics teacher does not enable us to predict whether the teacher holds the mathematical knowledge needed to teach primary mathematics.

The recent studies (Ball, Thames & Phelps, 2008; Hill, Rowan & Ball, 2005; Ball et al., 2001) on the nature and development of domains of knowledge that facilitate effective teaching has further shed light on MKT; how to measure it and develop it among teachers. These studies also recognized that the content and depth of teachers' MKT influences instruction and ultimately what pupils learn. Although

mapping of critical dimensions of mathematics classroom instruction has been carried out by many researchers (Ball, Bass &Hill, 2011; Hill et al., 2008), the impact of knowledge, MKT on the Mathematical Quality of Instruction, MQI remains unexplored. It is only in a high mathematical quality environment that pupils can develop and explore mathematical ideas, make conjectures, reason logically and mathematically and justify various methods for solving problems. High quality instruction is not synonymous to high mathematical quality of instruction.

1.3 Emergence of the Problem

Various studies have linked teacher knowledge to student achievement (Marshall & Sorto, 2012; Hill et al., 2005; Rowan, Chiang, & Miller, 1997). Other studies have documented shortcomings in the mathematical knowledge of elementary mathematics teachers (Roche & Clarke, 2013; Ball, 1990; Ma, 1999).

Andrew (2006), commented that one problem in teacher education is that PSTs who had passed through twelve or more years of schooling, still held many misconceptions about fundamental concepts and operations. PSTs in many cases have come to know teaching as telling, demonstrating rules and procedures (Seaman, Szydlik, Szydlik & Beam, 2005). In teacher education, these PSTs are learners again. Alsup (2005) found that as learners in teacher education programs, PSTs adapt a teacher dependent, passive position, often preferring to rely on memorization, methods and procedures instead of the hoped for independent and creative pedagogical thought. Gellert (2000), found that during SBEs, prospective teachers who have little positive regard for the discipline of mathematics itself, often try to

compensate cognitively activating mathematical tasks with fun activities to merely make the learning of mathematics more palatable for their pupils.

PSTs' desire to teach procedures rather than facilitate their students' engagement in reasoning processes was also highlighted by Nicol (2006). In her study, she observed that PSTs became very uneasy thinking that they would need to engage their future pupils in lively mathematics discussions, facilitate pupils' sense-making in mathematics and ask pupils to explain and justify their responses. The PSTs in Nicol's study admitted that teaching in ways that respect students thinking and sense making were not worth the time, the effort or the consequences. Obviously the PSTs' notion of the knowledge for teaching mathematics contradicts teacher educators' notion of knowledge for teaching.

Both Andrew (2006) and Nicol (2006), noted that ways of being a teacher of mathematics have been constituted over 12 or more years of schooling. Due to this, PSTs who know little Mathematics and/or are anxious about teaching it are especially happy to find refuge in procedural practices when placed in schools. Bullock (2011) and Hirsch (2012) also present compelling evidence that PSTs enter teacher education armed with knowledge, beliefs and assumptions delivered from 12 years of schooling and personal observations from prolonged exposure to classroom and school experiences. It is only sensible that teacher education programs take initiatives to audit PSTs prior knowledge for teaching mathematics and readdress prior knowledge that may conflict with teacher knowledge for instruction of high mathematical quality.

Hence the question arises; 'What knowledge is required for teaching Mathematics effectively?' A skilled teacher requires a highly developed knowledge

of content, access to a wide repertoire of teaching strategies and a deep understanding of students (Ball & Bass, 2000; Lampert, 2001). Such knowledge is not simply the result of various advance mathematics courses nor having teaching experience. Rather it is knowledge that is specialized to the teaching of mathematics, and has its roots in Shulman's (1986) introduction of PCK and pioneering sketch of a taxonomy of knowledge for teaching. Most educators and policymakers have acknowledged its contribution to effective teaching and student learning. Effective teachers utilize this unique knowledge to translate strong subject matter knowledge and knowledge of learners and learning to make effective instructional decisions.

While mapping the knowledge for teaching mathematics, Ball et al., (2008), found that the conventional mathematics content knowledge seems to be insufficient for skillfully handling the mathematical tasks of teaching. PCK though more related to the task of teaching was also found to be unable to equip teachers with the flexibility to manage the complexity of classroom practice (Ball et al., 2008). Their studies suggest that the knowledge needed to meet the demands of teaching primary mathematics is a special type of mathematical knowledge that is pedagogically useful and ready but not bundled in advance without considering the irregularities of teaching practice. Other studies concluded too that no amount of PCK can prepare a teacher for all the tasks of teaching because a significant portion of classroom practice is uncertain (Ball, 1996; Ball & Cohen, 1999).

Acknowledging the uncertainty of teaching does not mean it is impossible to prepare PSTs with the knowledge they need to teach effectively. Taking into consideration both the regularities and uncertainties of classroom practice, teachers

must equip themselves with content and pedagogical knowledge in order to teach pupils of diverse abilities and interests effectively. MKT allows teachers to a certain extend anticipate what pupils may think, how some topics or ideas may evolve in the classroom and the need for new representation, model or explanation when pupils' understanding falter. MKT is a kind of pedagogically useful mathematical understanding that reflects the dynamic interplay of content with pedagogy in teachers' real-time problem solving (Ball, 2000).

The quality of the learning process adhered to in teacher education programs is crucial to the development of this robust and comprehensive knowledge for teaching mathematics. Authentic investigations in classroom situations can offer more valid information of MKT than traditional tests. The rich information they provide about PSTs' knowledge for teaching mathematics (MKT) and how it impacts the mathematical quality of their instruction (MQI), can be useful to inform curriculum changes and teacher education program improvements.

Authentic investigations into classroom teaching of mathematics will enable researchers to investigate the enactment of MKT and its interplay with other elements of classroom practice and how together they impact the MQI. Mathematical Quality of Instruction (MQI) describes a composite of several dimensions that characterize the rigor and richness of the mathematics of the lesson, including the presence or absence of mathematical errors, mathematical explanation and justification, mathematical representation, and related observables. A study on how the domains of MKT are translated into classroom instruction and how it impacts the MQI will divulge