MATHEMATICS TEACHERS' PROFESSIONAL KNOWLEDGE: DISCREPANCY BETWEEN STANDARDS AND TEACHERS' PERCEPTIONS

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Abstract

The purpose of this study is to examine the discrepancy between Southeast Asia Regional Standards for Mathematics Teachers (SEARS-MT) and teachers' perceptions on professional knowledge. A total of 28 item measures were developed based on the local descriptors of SEARS-MT. The data were collected from 27 mathematics teachers from primary and secondary schools in the state of Kedah. The data were analysed using IBM SPSS 20.0 and WINSTEPS 3.57.0. The findings show that 77.7 per cent of the sample agreed with the importance of mathematics professional knowledge as stated in SEARS-MT. However, little discrepancy was observed between SEARS-MT and mathematics teachers' perceptions on the ICT integration in teaching and learning process. Findings support the need to include bigger sample size and develop more items that cover a wide range of difficulty so that mathematics teachers' perception on their professional knowledge can be measured along a continuum.

Keywords: Mathematics teachers; Professional knowledge; ICT; Southeast Asia Regional Standards for Mathematics Teachers (SEARS-MT)

Introduction

Teacher is one of the most school-related factors influencing student achievement (Hattie, 2003; Rivkin, Hanushek, & Kain, 2005). Hattie (2003) argues that teachers contribute about 30 per cent of the variance explained on student achievement compared with other factors, such as student background with approximately 50 per cent; home, school and head teacher characteristics, as well as peer effects account for five to ten per cent of variances. In addition, research supports that the capable teachers are the essential link between public aspirations for high-quality of schooling and student achievement (Nunnery, Kaplan, Owings, & Pribesh, 2009). Good teachers indeed play a variety of roles that influence the life of students, for example, as friends, protectors, mentors, and disciplinarians in order to ensure students'

success (Davis, 2002). This is because student learning outcomes can be improved when teachers are warm and sensitive to student needs, well-organised in the classroom environment, monitoring and providing feedback of the classroom learning (Perry, Donohue, & Weinstein, 2007).

So far, literature shows no consensus on how to define teacher's quality. But interestingly, the attributes of good teacher are commonly related to teachers' quality (Darling-Hammond, 2000). From researchers' point of view, teacher's quality is operationalised as a construct that is related to student or teacher outcome measures (Bolyard & Moyer-Packenham, 2008). For policymakers, teacher's quality is conceptualised as a benchmark against which individuals can be identified as meeting or not meeting given standard of quality (Blank & Langeson, 1999). Meanwhile, for classroom teachers, teacher's quality is viewed as a continuous process of self-renewal and professional development where teachers work to impact and improve the quality of their teaching.

In the specific subject area of mathematics, teacher's quality is mainly focused on six individual teacher characteristics: general ability, experience, pedagogical knowledge, subject matter knowledge, certification status, teacher behaviours as well as practices and beliefs (e.g., Cochran-Smith & Zeichner, 2005; Darling-Hammond, 2000; Wayne & Youngs, 2003). The existing empirical evidences have supported the positive relationship between the six individual teacher characteristics and student achievement (Hill, Rowan, & Ball, 2005; Rivkin et al., 2005).

In Malaysian context, the focus of mathematics teacher's quality has grown due to the challenge to improve the student achievement in the international large scale assessment such as Trends in the International Mathematics and Science Studies (TIMSS) and Program for International Student Assessment (PISA). In relation to this, the Southeast Asia Regional Standards for Mathematics Teachers (SEARS-MT) is documented by SEAMEO Regional Centre for Education in Science and Mathematics (RECSAM) in year 2013 through series of consultative workshops (SEARS-MT, 2013).

SEARS-MT is used as an inspirational guide to conceptualise the Malaysian mathematics teacher's quality based on the characteristics and attributes of mathematics teachers which are unique to the Southeast Asian region. The following four dimensions of mathematics teacher's quality are formally articulated and outlined in SEARS-MT: (1) Professional knowledge, (2) Professional teaching and learning process, (3) Personal and professional attributes, and (4) Professional communities. In fact, SEARS-MT covers a wide range of teacher's quality characteristics compared to the literature (e.g., Cochran-Smith & Zeichner, 2005; Darling-Hammond, 2000; Wayne & Youngs, 2003). Details of SEARS-MT could be retrieved from http://www.recsam.edu.my.

Conceptualisation of Professional Knowledge

The domain 'Professional Knowledge' is conceptualised in SEARS-MT (2013) as knowledge and understanding of the fundamental ideas, principles and the structure of mathematics. This knowledge is intertwined with effective pedagogy in the teaching and learning of mathematics, including in-depth knowledge of the characteristics of the students and implications for the use of appropriate strategies for students of varying abilities and socio-cultural background. This dimension also emphasises the role of teachers' knowledge that is relevant to use of ICT to enhance student learning by promoting a deep engagement with the concepts and the procedures of mathematics. The following are the key aspects of professional knowledge.

Knowledge of Mathematics. This domain encompasses the indicators of (1) knowledge of the discipline of mathematics; (2) understanding of fundamental mathematical ideas and principles, and teaching approaches; (3) mathematics curriculum; (4) relationships within and with other disciplines; (5) students' diverse background; (6) students' physical, social, psychological and intellectual characteristics; and (7) students' ICT knowledge.

Knowledge of Students' Learning of Mathematics. This domain consists of the indicators of (1) knowledge of the characteristics of students and their implications for learning; (2) students' conceptions and misconceptions about mathematics; (3) students' potential difficulties in learning mathematics concepts; (4) application of learning and instructional theories in teaching mathematics; and (5) repertoire of effective teaching strategies.

Knowledge of Intellectual Quality. This domain includes the indicators of (1) the knowledge of strategies for supporting creativity and innovation; (2) strategies for developing students' higher order thinking skills in mathematics; (3) making complex relations between and representations of core topics; (4) supporting students to develop complex mathematical thinking and decision making; and (5) using cross-curricular relations with mathematics.

Knowledge of ICT. This domain encompasses the indicators of (1) the knowledge of ICT integration in the teaching in the teaching and learning; (2) knowledge of how particular software supports mathematics concepts; (3) use of ICT to model context and solve problems; and (4) software development specifically on mathematics lessons.

Research Objectives

In reality, there is always a discrepancy between standards and reality on mathematics teachers' quality. Knowing the gaps between the four dimensions of SEARS-MT and the current extent to which the mathematics teachers attained is very much important to enhance and improve the quality of mathematics teachers, and further inform the future professional development intervention programs. Considering these factors, the purpose of this study is to examine the discrepancy between mathematics teachers' quality standards and their perception on one specific dimension of SEARS-MT, i.e. 'professional knowledge'. Specifically, this study seek to answer the following research questions:

1) What does a good teacher mean based on mathematics teachers' perception on their professional knowledge?
2) What are the differences between what mathematics teachers should attain as stated in SEARS-MT and teachers' perceived levels of importance on the descriptors of the dimensions of mathematics teachers' professional knowledge?

Method

A total of 27 secondary and primary school teachers who have attended a motivational seminar conducted by the education department in the state of Kedah participated in the study. Table 1 shows that more than 50 per cent of the sample was female teachers. The major group of the sample was selected from Malaysian Primary National schools. About 63 per cent of the sample have the teaching experience of 11 years and above.

Table 1
The Demographic Characteristics of Samples

Demographic	Number	Per cent (%)
Gender		
Male	9	33.3
Female	18	66.7
School Type		
Secondary National	5	18.5
Secondary National Type	3	11.1
Primary National	19	70.4
Teaching Experience		
5 years and below	4	14.8
6 – 10 years	6	22.2
11 – 15 years	11	40.7
16 years and above	6	22.2

The teacher data were collected using a self-developed questionnaire with 28 items using 4-point Likert scale (1 = not important, 2 = quite important, 3 = important, 4 = very important). The items were developed based on the local descriptors of SEARS-MT. The teachers' responses to the items could be used to examine the discrepancy between the standards and how mathematics teachers perceive the in terms of the levels of importance that the professional knowledge should be attained. The data were analysed using IBM SPSS 20.0 to present descriptive statistics. In addition, the WINSTEPS version 3.81.0 software program was used to illustrate the level of person ability and item difficulty as well as to identity item that is the most difficult to endorse agreement. There is one missing value each for Item L17, L18, L19, L20, L21, L22, L23, L24, L25, and L26.

Results and Discussion

Table 2 reflects the respondents' perceived levels of importance on the mathematics teachers' quality from the professional knowledge perspective. It is examined in response to the first research question.

The analysis of data as shown in Table 2 reveals that the maximum number of teachers who are not fully agreed with the descriptors of SEARS-MT is six out of 27 teacher respondents in L26. This implied that at least 77.7 per cent of the participants fully agreed in terms of their perceived levels of importance on the professional knowledge that a mathematics teacher should attain. The responses from the participants hence showed that there is consensus among mathematics teachers' perceived levels of importance on the professional knowledge on several aspects. The findings also informed that mathematics teacher respondents should at least have the general knowledge of understanding on the fundamental principles of mathematics if not its definition and mathematical reasoning. In addition to perceive the importance of mathematics teachers to know the mathematics content and curriculum, the knowledge of using mathematical problem solving, reasoning, communicating, representing, and making connections either within or between mathematics and other subject areas are considered important to be conceptualised as a knowledgeable mathematics teacher. A knowledgeable mathematics teacher is expected to use various effective teaching strategies to stimulate students' creativity and innovation. More importantly, they are also expected to be able to provoke students' higher order thinking skills through a variety of teaching techniques and activities towards developing complex mathematical thinking and decision making skills.

Table 2
Number of Teachers Responded to Each Indicator of Mathematics Teachers' Professional Knowledge Dimension (N=27)

Indicators	Label	Descriptors	Scale@					% of fully agreed
			1	2	3	4	m	
Discipline of knowledge	L1	The nature and scope of mathematical concept throughout the curriculum		1	16	10	0	96.3
	L2	Understand the fundamental principles of mathematics in general			18	19	0	100
	L3	The fundamental principles of mathematics in terms of definitions and reasoning		2	16	9	0	92.6
	L4	Subject matter concepts			14	13	0	100
	L5	Mathematics content at a particular level		1	15	11	0	96.3
Mathematical concepts, procedures, and processes	L7	Mathematics problem solving, reasoning, communicating, representing, and making connections			16	11	0	100
	L6	Concepts and Skills			15	12	0	100
Knowledge of mathematics curriculum	L8	Mathematics curricular goal, objectives, learning standards, pedagogical emphases and assessment practices			17	10	0	100
Relationship within mathematics and other area	L9	Relationship inherent in concepts and procedures			16	11	0	100
	L10	Connection within mathematics, between mathematics and other subject area			18	8	1	96.3
Students' diverse backgrounds	L11	Differences of students' SES		4	14	9	0	85.2
Physical, social, psychological and intellectual characteristics of the students	L12	Differences of students' physical abilities, social competence and prior knowledge			14	13	0	100
Students' ICT Knowledge	L13	Students' knowledge, preferences, experiences and competencies in ICT		4	16	7	0	85.2
Student's learning of mathematics	L14	Students' prior knowledge in mathematics		1	18	8	0	96.3
	L15	Students' thinking when listening to their explanation			16	11	0	100
	L16	Identify and remediate students' misconceptions		1	13	13	0	96.3
Students' potential difficulties of learning	L17	Knowing students' learning difficulties such as conceptual understanding and procedural computation		3	11	12	1	88.9
Students' application of learning	L18	Knowing how student learn mathematics from different perspective		2	15	9	1	92.6
Repertoire of effective teaching strategies	L19	Knowing various teaching strategies, methods and techniques			13	13	1	96.3
Strategies for supporting creativity and innovation	L20	Use higher order thinking skills to explore new ideas			19	7	1	96.3

Indicators	Label	Descriptors	Scale@					% of fully agreed
			1	2	3	4	m	
Strategies for developing students' higher order thinking skills	L21	Stimulate students' thinking using various challenging strategies			17	9	1	96.3
Making complex relationships between representations of core topics	L22	Use instructional strategies that require students to apply and transfer mathematical knowledge within or between different content areas			16	10	1	96.3
Supporting students to develop complex mathematical thinking and decision making	L23	Provoke students to develop complex mathematical thinking and decision making		2	15	9	1	92.6
Cross-curricular relations with mathematics	L24	Emphasis interdisciplinary connections to mathematics learning by using mathematics concepts		1	18	7	1	96.3
ICT integration in teaching and learning	L25	Use technology to enhance students' learning opportunities		5	14	7	1	81.5
Use particular software to support mathematical concepts	L26	Use appreciate technology tools to facilitate understanding of mathematical concepts		6	14	6	1	77.7
Use of ICT to solve problem	L27	Use appreciate technology tools to solve mathematical problems		3	16	8	0	88.8
Software in mathematics lessons	L28	Aware of rapid development of software development in mathematics lessons	2	2	17	6	0	85.2

Note@: 1 = not important at all, 2 = quite important, 3 = important, 4 = very important
m indicates the number of missing value.
% of fully agreed = (number of respondents' perceived levels of importance and very important)/total number of participants.

On the other hand, data analysis as summarised in Table 2 to address the second research question revealed that not all the participatns fully agreed to several aspects that are required for knowledgeable mathematics teacher as mentioned in the SEARS-MT. Firstly, four respondents disagreed on the importance of knowing the students' socioeconomic status in the aspects of cultural, ethnic and religious backgrounds of the students. Secondly, the application of ICT knowledge to facilitate the mathematical understanding and the mathematical problems in mathematics teaching. Two participants responded that the awareness on the availability of software in mathematics lessons is not important to be considered as a knowledgeable teacher. The results show a slight discrepancy between the SEARS-MT and the mathematics teachers' perception on their professional knowledge in Malaysian context.

The findings above were supported with the details illustrated by Wright map as shown in Figure 1. The Wright map provides an illustartive information about the item quality by placing

the difficulty of the items on the same measurement scale as the person ability (Bond & Fox, 2007). Specifically, the Wright map provides the readers with a comparison of person ability and item difficulty. Figure 1 shows that the Wright map is organised in a way that the left side shows the person ability in which the distribution of the measured person ability is arranged from the most able at the top to the least able at the bottom; and the items at the right side are distributed from the most difficult at the top to the easiest at the bottom.

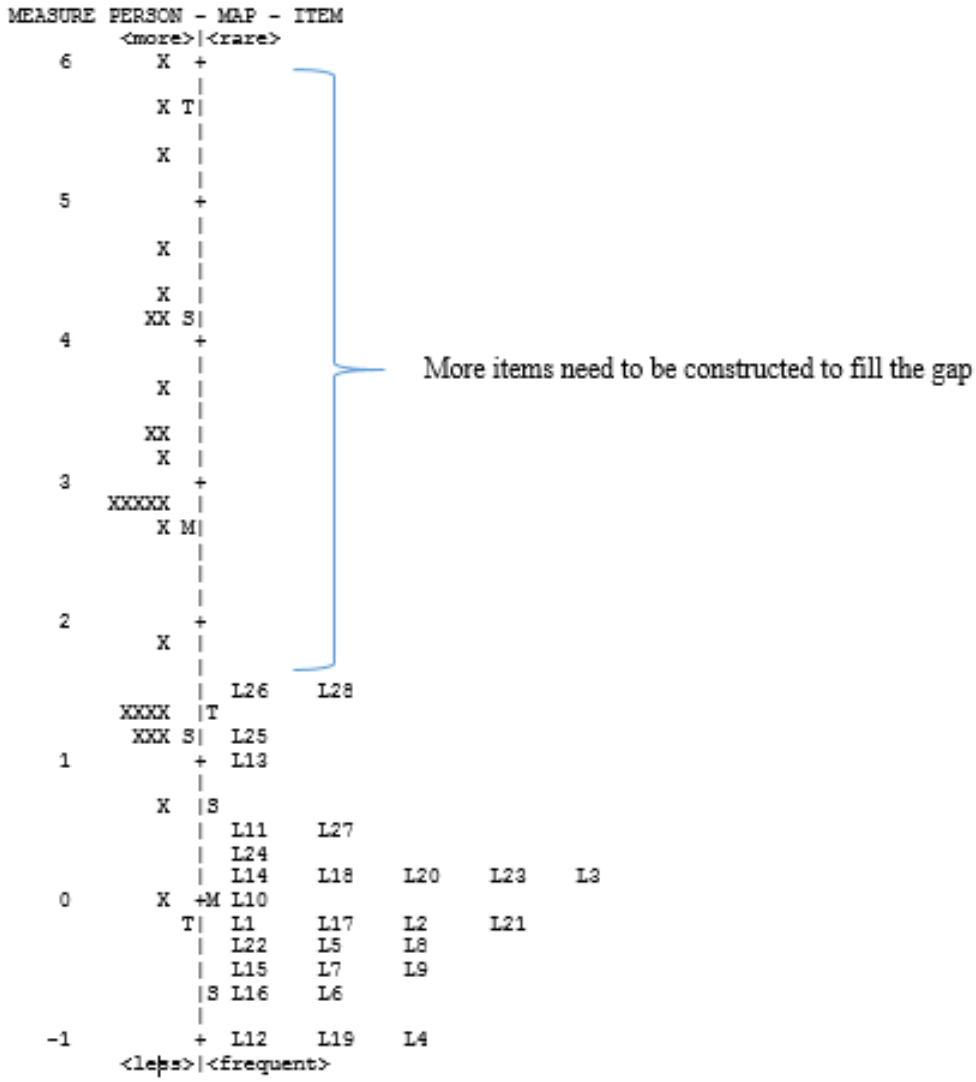

Figure 1. Wright Map.

Figure 1 shows that Item 26 (*Use or appreciate technology tools to facilitate understanding of mathematical concepts*) and Item 28 (*Aware of rapid development of software available in mathematics lessons*) are the most difficult items to be endorsed or agreed upon. In line with the results as shown in Table 2, Item L4 (*Subject matter concepts*), L12 (*Differences of students' physical abilities, social competence and prior knowledge*), and L19 (*Knowing various teaching strategies, methods and techniques*) are the easiest endorsed items. The findings implied that subject matter knowledge, knowing students' socioeconomic background and their prior knowledge as well as professional teaching serve as the most important aspects of a knowledgeable mathematics teacher. On the other hand, enhancing the knowledge of ICT is not a priority in conceptualising a knowledgeable mathematics teacher.

Concluding Remark

This study was conducted as a preliminary analysis to examine the discrepancy between the aspired descriptors prepared for SEARS-MT and the mathematics teachers' perceived levels of important on their professional knowledge. The findings showed that mathematics teachers' perception on the importance of their professional knowledge is closely aligned with the dimensions of professional knowledge of SEARS-MT. However, the findings deliver an important message to the educational stakeholders that mathematics teachers need more exposure and training to the ICT integration in teaching and learning process in mathematics classroom, including the usage of software to assist students in solving mathematical problems.

It is worthy to note that the study is mainly based on the local descriptor of SEARS-MT and constrained with the limited sample as well as items in measuring teachers' perception on their professional knowledge. This indicated that there may be an absence of other important aspects of mathematics teachers' professional knowledge but not taken into consideration in this study. As illustrated in Figure 1, the items are too easy to endorse agreement about the importance of the local descriptors of mathematics teachers' professional knowledge with a big gap before item L26 and L28. Overall, the findings support the need to include bigger sample size and develop more items that cover a wide range of difficulty so that mathematics teachers' perception on their professional knowledge can be measured along a continuum.

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