ASSESSING YEAR 4 PUPILS' LEVELS OF PROFICIENCY IN MEASUREMENT FORMULAE

WONG SING IE

UNIVERSITI SAINS MALAYSIA

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ASSESSING YEAR 4 PUPILS' LEVELS OF PROFICIENCY IN MEASUREMENT FORMULAE

by

WONG SING IE

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LIST OF ABBREVIATIONS

GPN	Average National Grade
JPPP	Penang Education Department
KPM	Ministry of Education Malaysia
KSSR	Standard Curriculum for Primary Schools
MOE	Ministry of Education Malaysia
PMR	Lower Secondary Assessment
SK	National Type School
SJKC	National Type Chinese School
SJKT	National Type Tamil School
SPM	Malaysian Certificate of Education
TIMSS	Trends in International Mathematics and Science Study
UPSR	Primary School Evaluation Test

MENILAI TAHAP PROFISIENSI PELAJAR TAHUN 4 DALAM RUMUS UKURAN

ABSTRAK

Kajian ini direka untuk menilai tahap profisiensi murid tahun empat dalam rumus ukuran, iaitu rumus perimeter, luas dan isipadu dengan menggunakan tiga ujian pelbagai komponen profisiensi bagi rumus ukuran yang dibina berdasarkan model profisiensi matematik yang diperkenalkan oleh Kilpatrick et al. (2001). Berdasarkan empat pembolehubah demografi, iaitu jenis sekolah, lokasi sekolah, tahap pencapaian matematik, dan jantina, tahap profisiensi dalam rumus ukuran bagi murid Tahun Empat telah diprofilkan. Kajian ini juga bertujuan untuk menentukan sama ada terdapat perbezaan yang signifikan bagi tahap profisiensi murid Tahun Empat dalam rumus ukuran berdasarkan empat pembolehubah demografi tersebut. Tinjauan keratan rentas telah dilaksanakan dan kaedah persampelan berkelompok telah digunakan untuk memilih sampel kajian daripada populasi murid Tahun Empat yang belajar di negeri Pulau Pinang. Sampel bagi kajian ini melibatkan 600 orang murid Tahun Empat (286 lelaki dan 314 perempuan) dari enam sekolah rendah berlokasi di Pulau Pinang. Tiga ujian pelbagai komponen dalam rumus perimeter, luas dan isipadu masing-masing telah digunakan untuk menilai tahap profisiensi murid Tahun Empat dalam rumus ukuran dan satu ujian Pencapaian Matematik Tahun Empat telah digunakan untuk menentukan tahap pencapaian matematik murid Tahun Empat dan bahagikan murid Tahun Empat kepada tiga kumpulan yang berbeza berdasarkan tiga tahap pencapaian matematik. SPSS versi 22 telah digunakan untuk menganalisis data yang terdapat dalam kajian ini. Ujian Kruskal-Wallis menunjukkan terdapat perbezaan yang signifikan bagi tahap profisiensi murid Tahun Empat dalam rumus perimeter, luas, dan

isipadu berdasarkan jenis sekolah dan tahap pencapaian matematik. Ujian post-hoc menunjukkan murid Tahun Empat dari SJKC memiliki tahap profisiensi yang tertinggi dalam ketiga-tiga rumus ukuran di antara tiga jenis sekolah, dan juga menunjukkan murid-murid dengan tahap pencapaian matematik yang tertinggi memiliki tahap profisiensi yang lebih tinggi dalam rumus ukuran di antara tiga kumpulan yang berbeza dalam tahap pencapaian matematik. Ujian Mann-Whitney U juga menunjukkan terdapat perbezaan yang signifikan bagi tahap profisiensi murid Tahun Empat dalam rumus perimeter, manakala tiada perbezaan yang signifikan bagi tahap profisiensi dalam rumus luas dan isipadu di antara murid-murid dari kawasan bandar dan luar bandar. Selain itu, hasil kajian juga menunjukkan terdapat perbezaan yang signifikan bagi tahap profisiensi murid Tahun Empat dalam rumus isipadu, manakala tiada perbezaan yang signifikan bagi tahap profisiensi murid Tahun Empat dalam rumus perimeter dan luas di antara murid lelaki dan murid perempuan. Hasil kajian ini mencadangkan bahawa tahap profisiensi murid dalam rumus ukuran boleh dinilai dengan menggunakan ujian pelbagai komponen yang dibina berdasarkan model profisiensi matematik dan kajian ini telah memberikan gambaran keseluruhan tentang tahap profisiensi murid Tahun 4 murid dalam rumus ukuran bagi guru dan pendidik. Sebagai tambahan, kajian ini memerlukan perhatian para guru bahawa perlunya perkembangan profisiensi dalam kalangan murid ketika mempelajari rumus ukuran.

ASSESSING YEAR 4 PUPILS' LEVELS OF PROFICIENCY IN MEASUREMENT FORMULAE

ABSTRACT

This study was designed to assess Year 4 pupils' levels of proficiency in measurement formulae, namely in perimeter, area and volume using three multi-strand tests in measurement that were developed based on the mathematical proficiency model introduced by Kilpatrick et al. (2001). Based on the four demographic variables, namely type of school, location of school, mathematics achievement level and gender, Year 4 pupils' levels of proficiency in measurement formulae were profiled. This study also determines if there is any significant difference in Year 4 pupils' levels of proficiency based on the four demographic variables. A cross-sectional survey was conducted and cluster sampling was used to select the sample of this study from a population of Year 4 pupils who are studying in the state of Penang. A sample of 600 Year 4 pupils (286 males and 314 females) from six public primary schools located in Penang were involved in this study. Three multi-strand tests in perimeter, area and volume formulae, respectively were used to assess Year 4 pupils' levels of proficiency in measurement formulae and a Year Four Mathematics Achievement Test was used to determine Year 4 pupils' mathematics achievement level and grouped the Year 4 pupils into three different mathematics achievement levels. SPSS version 22 was used to analyse the data obtained from this study. The Kruskal-Wallis Test revealed that there is a significant difference in Year 4 pupils' levels of proficiency in perimeter, area and volume formulae based on type of school and mathematics achievement level. The post-hoc test indicated that Year 4 pupils from SJKC possessed the highest level of proficiency in the three measurement formulae among the three types of schools,

and also indicated the pupils with high mathematics achievement level possessed higher level of proficiency in the measurement formulae among the three different levels of mathematics achievers. The Mann-Whitney U Test also revealed that there is a significant difference in Year 4 pupils' levels of proficiency in perimeter formulae, but no significant difference in their levels of proficiency in area and volume formulae among the pupils from urban and rural areas. Besides that, the results also revealed that there is a significant difference in Year 4 pupils' levels of proficiency in volume formulae, but no significant difference in Year 4 pupils' levels of proficiency in perimeter and area formulae between male and female pupils. The findings of this study suggested the pupils' levels of proficiency in measurement formulae can be assessed using the multi-strand test developed based on the mathematical proficiency model and have provided an overview of Year 4 pupils' levels of proficiency in measurement formulae for the teachers and educators. In addition, this study has called an attention for the teachers that there is a need to concern about the development of proficiency within pupils while learning measurement formulae.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Measurement formulae in this study refers to three basic formulae, namely perimeter, area and volume formulae. These three formulae gently relate with space and shape. As in everyday life, we are surrounded by space and shape of things, measurement formulae have become one of the important and classical mathematical knowledge that must be learnt from school. In order to understand why the world come with shape, one must learn about the measurement formulae, which require the development of logical thinking on spatial relationships and able to restructure operations with spatial dimensions (Piaget et al., 1960). In Curriculum and Evaluation Standards for School Mathematics, the National Council of Teachers of Mathematics (1989) had recognized the importance of geometry and spatial sense.

The world which is highly compacted with scientific and technological fields require the knowledge of measurement. Those with high level of mathematical proficiency is highly demanded as we can see that the application of measurement and their practical uses in real life. Construction of buildings, production of huge machines, car or mechanical accessories, all of these works need to be done with the application of mathematical knowledge related to measurement. When planning various construction projects, shape and space are always the issues that need to be concerned. While producing tools and accessories, we cannot neglect the important issues related to their size and shape. Furthermore, when we want to calculate the amount of materials that need to be used for fencing, we need to possess strong basic knowledge of measurement to complete these jobs. We cannot deny that it has been a long time that mathematics had occupied most of the job scope in our civilisation (Milgram, 2005).

Without a strong background of mathematical knowledge, one's option in this society will be limited and can only participate in few areas of job (Fatima, 2015). Thus, in order to develop a community that can live a better life in this country, development of mathematical proficiency among the new generations are always a concern for Malaysian Education.

Schools and universities are always the good sources for learners to acquire the mathematical knowledge and skills. Based on the Malaysian Primary School Mathematics Curriculum, Mathematics Education aims to provide opportunities for pupils to obtain mathematical knowledge, develop higher-order problem solving skills and decision making skills which they can apply in their daily life (Malaysian Ministry of Education, 2006). In order to develop mathematical proficient pupils, the responsibilities of teachers and educators cannot be solely focus on teaching mathematical knowledge and skills. One way to get to this point is to assess pupils' mathematical proficiency to ensure that their pupils have developed deep understanding, and able to use and differentiate the knowledge that their pupils had learnt.

This next section of this chapter presents the background of the study regarding measurement in the Malaysian Mathematics Curriculum and the performance of Malaysian students in the Trends in International Mathematics and Science Study (TIMSS). This is followed by the statement of problem, objectives of the study, research questions and null hypotheses of the study. The significance and limitations of the study are also discussed in this chapter. Definitions of some important terms will be presented at the end of this chapter.

1.2 Background of the Study

1.2.1 Measurement in Malaysian Mathematics Curriculum

The measurement formulae in this study refer to the perimeter, area and volume formulae that will be learnt by primary pupils starting from Year Four in Malaysia. Measurement forms a vital part in our daily life and it had formed a unique part in mathematics programs (Baroody & Coslick, 1998; Pope, 1994). According to Hart (1984), after asking most of the mathematics teachers' opinions about the important topics that need to be taught in the mathematics curriculum, measurement would most likely appear in their opinions list. It is believed that the measurement topic can be classified as a fundamental topic in mathematics education. Therefore, as mathematics teachers or educators, we cannot deny the great impacts that will be brought by this topic in our daily life. It is important that the students should not only know "how to measure" but also "what does the measurement mean" (Tan Sisman & Aksu, 2012b, p.2).

The topics of perimeter and area formulae can be categorized as the fundamental parts of mathematics because they are the foundation for understanding other aspects of geometry such as volume and mathematical theorems that help students to understand algebra, trigonometry and calculus. According to TIMSS 2007 Assessment Framework, the Mathematics Curriculum in Primary School emphasizes on the ability of pupils to identify two- and three- dimensional shapes, calculate perimeter, area and volume, and solve problems involving perimeter, area, and the volume of squares, rectangles, cubes and cuboids (Mullis, Martin, Ruddock, O'Sullivan, Arora, & Erberber, 2005). These abilities are the crucial knowledge that are needed in order to have good understanding and skills in solving problems regarding measurement formulae.

Based on the new Standard Curriculum for Primary Schools (*Kurikulum Standard Sekolah Rendah, KSSR*), primary pupils in Year Four begin to learn the basic parts of measurement formulae like finding the perimeter of squares, rectangles, triangles and regular polygons. They also begin to calculate the area of squares, rectangles and triangles using square grid and formulae as well as calculate the volume of cubes and cuboids using 1 cm^3 unit cubes (*Kementerian Pelajaran Malaysia*, 2013).

In Year Five, primary pupils learn to calculate the perimeter and area of composite two-dimensional shapes involving squares, rectangles and triangles as well as to solve problems involving perimeters of composite two-dimensional shapes in the new Standard Curriculum for Primary School (*Kurikulum Standard Sekolah Rendah, KSSR*). They also begin to calculate the volume of composite three-dimensional shapes involving cubes and cuboids as well as to solve problems involving volume of composite three-dimensional shapes (Malaysian Ministry of Education, 2006a).

In Year Six, primary pupils learn to calculate the perimeter and area of composite two-dimensional shapes involving two or more quadrilaterals (squares and rectangles only) and triangles in the new Standard Curriculum for Primary School (*Kurikulum Standard Sekolah Rendah, KSSR*). They also learn to solve problems in real context involving perimeter and area of two-dimensional shapes (Malaysian Ministry of Education, 2006b).

Since the pupils start to learn the measurement formulae in Year 4, the pupils should have a good basic knowledge on measurement formulae when they are progressing to their secondary schools and able to solve problems related to measurement formulae effectively. However, based on the information stated in the

Malaysian Education Blueprint (2013-2025), our students' performance in the Trends in International Mathematics and Science Study (TIMSS, 2011) had slipped below the international average in Mathematics (Malaysian Ministry of Education, 2012).

1.2.2 Performance of Malaysian Students on Measurement Formulae in TIMSS

Trends in International Mathematics and Science Study (TIMSS) is one of the international assessments that provides information to assist policymakers, researchers, educators and the public to obtain a comprehensive picture of how students perform in the particular topics in mathematics and science (Neidorf, Binkley, Gattis, & Nohara, 2006). In 1999, Malaysia had participated in TIMSS for the first time.

According to the Malaysian Education Blueprint 2013-2025, the average score of Malaysian Form Two students (519) was higher than the international average for Mathematics in 1999, in which Malaysia was ranked in the 16^{th} position among 38 countries. In 2003, though the ranking of Malaysia had increased to 10^{th} among 47 countries, yet the average score had decreased from 519 (1999) to 508 (2003). In 2007 and 2011, the performance shown by Malaysian Form Two students were less satisfactory as compared with their previous performance. In 2007, 18% and 20% of Malaysian Form Two students failed to meet the minimum proficiency levels in Mathematics, in which the average score fell from 508 (2003) to 474 (2007). In 2011, the performance did not go well too as the average score fell from 474 (2007) to 440 (2011) (Malaysian Ministry of Education, 2012).

Further, in the topic related to measurement formulae, Malaysian Form Two students' performance in the four TIMSS released items involving measurement formulae was unsatisfactory. For the first released item (ID_M052084) on calculating the area of a square with a given perimeter of 36 cm, only 40% of Malaysian Form

Two students were able to answer it correctly as compared to 89% of their Singaporean counterparts. As a result, Malaysian Form Two students' performance was ranked 27th while their Singaporean counterparts was ranked first.

In addition, the percent correct of Malaysian Form Two students was significantly lower than the international average of 47% (Foy, Arora, & Stanco, 2013). For the second released item (ID_M042201) on finding the length of a rectangular box with a given volume of 200 cm^3, only 42% of Malaysian Form Two students were able to answer it correctly as compared to 92% of their Singaporean counterparts. Consequently, Malaysian Form Two students' performance was ranked 23rd while their Singaporean counterparts was ranked first. Further, the percent correct of Malaysian Form Two students was slightly lower than the international average of 43% (Foy et al., 2013).

For the third released item (ID_M032116) on finding the perimeter of a square with a given area of 144 cm^2, only 43% of Malaysian Form Two students were able to answer it correctly as compared to 79% of their Singaporean counterparts. As a result, Malaysian Form Two students' performance was ranked 25th while their Singaporean counterparts was ranked first. Furthermore, the percent correct of Malaysian Form Two students was slightly lower than the international average of 45% (Foy et al., 2013).

For the fourth released item (ID_M032623) on finding the area of a shaded region in cm^2 using the area of rectangle minus the area of right-angled triangle, only 29% of Malaysian Form Two students were able to answer it correctly as compared to 80% of their Singaporean counterparts. Consequently, Malaysian Form Two students' performance was ranked 23rd while their Singaporean counterparts was ranked third.

Moreover, the percent correct of Malaysian Form Two students was significantly lower than the international average of 36% (Foy et al., 2013).

1.3 Problem Statement

Though TIMSS results had shown the deterioration of mathematics education in Malaysia, surprisingly, this is contrary to the results shown in the national examinations like Primary School Achievement Test (*Ujian Pencapaian Sekolah Rendah, UPSR*), Lower Secondary Assessment (*Penilaian Menengah Rendah, PMR*) and Malaysian Certificate of Education (*Sijil Pelajaran Malaysia, SPM*).

In fact, the national examination results were getting better from year 2009 to 2010. For example in UPSR, the percentage of passes in mathematics subject for three different types of schools had increased from year 2008 to 2010. The percentage had increased from 77.44% (2008) to 85.30% (2009), followed by 86.93% in 2010 for SK. For SJKC, the percentage increased from 94.82% (2008) to 95.66% (2009), followed by 96.04% in 2010. For SJKT, the percentage of passes in mathematics subject increased from 75.77% (2008) to 86.23% (2009), followed by 88.78% in 2010 (Munirah & Santi, 2014).

For the PMR mathematics achievement results, the Average National Grade (GPN) improved from 2.83 (2008) to 2.78 (2009), followed by 2.74 (2010) and 2.71 (2011) (the lower the score, the higher the grade). The students who obtained A's in mathematics had also shown an increase from 26.7% in 2010 to 28.9% in 2011. In SPM papers, the scores had improved from 5.19 in 2010 to 5.04 in 2011 (the lower the score, the higher the grade).

It is believed that the disparity between the results shown in TIMSS and Malaysian national examinations is due to difference in the context of assessment. The mathematics assessment of TIMSS is organized around two dimensions, namely content domains and cognitive domains. The cognitive domains assessed by TIMSS are the domains of knowing, applying and reasoning (Mullis, Martin, Foy, & Arora, 2012). Thus, the test items that were used in TIMSS not only focused on the procedural knowledge, but also assessed students' ability to apply their knowledge and understanding in solving problems, and reasoning skills in solving non-routine problems.

However, in Malaysian national examinations, though the mathematics curriculum has changed, in which it is not solely focused on students' procedural knowledge, yet reasoning and thinking skills are still considered as peripheral domains when compared with the context of assessment in TIMSS. Since Malaysia is still considered as one of the heavily examination-based countries, most of the teaching methods in classroom are designed and geared towards exam preparation in which most of the test items emphasise on the computational skills and deemphasise on reasoning skills (Zul & Anas, 2013). As a consequence, the students did not perform well when they encounter questions that require them to interpret, evaluate problems based on real situation and reasoning. Though the grades obtained by the students are high in public examinations, the students' proficiency in mathematics seems to be unlikely to be assessed and teachers were hardly to know their pupils' real understanding of the topic they teach. To develop new generation of pupils who are mathematically proficient, we need to know more specific characteristics about the mathematical knowledge of the pupils. Thus, in this study, the researcher intended to assess Year 4 pupils' levels of proficiency in measurement formulae, namely perimeter, area and volume formulae.

Researchers view mathematical proficiency as the ability to understand, compute, solve and reason, and have positive attitudes towards mathematics (Yunus, Razak, & Kharani, 2012). One of the model that was introduced in 2001 by Kilpatrick, Swafford and Findell in National Research Council (2001) is the five strands of mathematical proficiency model that can be incorporated in the development of assessment, and enable teachers to assess different strands of proficiency of their pupils. In this study, the researcher focused on Year 4 mathematics topic of shape and space, involving three measurement formulae, namely perimeter, area and volume formulae for the following reasons.

First, measurement holds an important part in our daily life, in which we can see lots of application of measurement outside the classroom especially in the construction work (Sherard, 1981). Other than construction work, knowledge in measurement is also crucial in artistic expertise such as design, art and animation.

Second, there is an increased emphasis on measurement in the Mathematics Curriculum after being revised by the Malaysian Ministry of Education (Lie & Hafizah, 2011). In the revised secondary mathematics curriculum, the focus in geometry had increased from 42% to 46% (Malaysian Ministry of Education, 1998). The researcher focused on Year 4 pupils because measurement formulae are only formally introduced to Year 4 pupils, in which they learn about the two- and three- dimensional shapes. It is important to assess pupils' proficiency when they first learn a particular topic to ensure that they have a good basic knowledge which will benefit them in their future study.

Third, despite of the increased amount of time devoted to mathematics curriculum in emphasizing measurement, the performance shown by Malaysian Form

Two students in TIMSS was less satisfactory. From the results reported in TIMSS 1999 and 2003, the average score in the content domain of geometry measurement is 497 in 1999 and 495 in 2003 (Mullis, Martin, González, & Chrostowski, 2004; Mullis, Martin, González, Gregory, Garden, O'Connor, Chrostowski, & Smith, 2000). Though the average score for both 1999 and 2003 were significantly higher than the international average score of 467, the score is still lower than Singapore, which obtained the average score of 560 in 1999 and 580 in 2003 (Mullis et al., 2004; Mullis et al., 2000). In TIMSS 2007, the achievement shown by the students in the domain of geometry declined, where the average score is 477, which is significantly lower than the international average score of 500 (Mullis, Martin, & Foy, 2008). This situation is worrying and thus, there is an urgent need for primary teachers to take actions in assessing different strands of pupils' proficiency in measurement formulae in order to identify the strengths and weaknesses of their pupils in learning measurement formulae.

In Malaysia which is a multi-cultural country, the uniqueness of the education system is that the pupils can take the liberty to choose the type of school they want to enrol. There are three different types of schools in Malaysia: (a) National Type School (SK) which used Malay language as the medium in teaching and learning; (b) National Type Chinese School (SJKC) which used Chinese language as the medium in teaching and learning; and (c) National Type Tamil School (SJKT) which used Tamil language as the medium in teaching and learning. Based on several cross-cultural studies on mathematics, it was found that the language used in teaching and learning process is an important factor in mathematics achievement of pupils (Stigler & Perry, 1988). According to Lim (2003), the difference of languages used in classroom has created cultural difference among the three types of schools. Though all types of schools follow the same mathematics curriculum, it is found that the cultural difference can affect the level of achievement in the subject of mathematics, where the results in UPSR obtained by the pupils from SJKC were consistently better than the other two types of schools (Lim, 2003).

Apart from different types of schools, location of schools can also be one of the factors influencing mathematics performance among pupils. From the study conducted by Parmjit (2010) in measuring pupils' achievement in Mathematics among rural and urban Primary Four pupils, the results indicated that the rural pupils were weaker in mathematics compared to the urban pupils. This result concurred with the findings of Robiah Sidin (1994) that the performance shown by rural students were not as good as urban students. Thus, the researcher aims to profile Year 4 pupils' levels of proficiency in perimeter, area and volume formulae and determine if there is a significance difference in the levels of proficiency in perimeter, area and volume formulae based on type of school and location of school.

The context of assessment in most of the schools in Malaysia are practically geared towards assessment of achievement rather than assessment of proficiency. The terms "achievement" and "proficiency" seems to confuse the researchers in the field of mathematical research study (Azeem, Gondal, & Faisal, 2014). The achievement assessment depends on the syllabus, modules and learning objectives after the teaching instructions were given by the teachers (Sectic & Huttunen, 2006). As such, achievement assessment refers to an assessment to see if the students can demonstrate their retention after learning and achieve a specific goal or objectives which were initially set before the teaching and learning process start (Azeem et al., 2014). It is used to see if the learning and teaching process is successful by testing on the materials that have been taught in the classroom.

However, proficiency assessment is independent on the syllabus and in relation to the branch of knowledge that are developed after the learning process (Azeem et al., 2014). Unlike achievement assessment, proficiency assessment does not only assess what has been taught within the modules and what does a student know after he or she learned a content domain, but also assess on how well the student can apply the knowledge they have learnt in the real world, emphasis on their ability to achieve a specific task and evaluate on the acquisition of cognitive knowledge and skills (Azeem et al., 2014).

In brief, students with high proficiency in mathematics are expected to obtain better mathematics achievement level. However, the study on the relation of mathematics achievement level and students' mathematical proficiency level is still sparse in Malaysia. Based on the Malaysian Examination Syndicate, the results obtained in the national examination seems to be improved, and yet the Year 6 pupils have weak conceptual understanding in perimeter, area and volume formula (Malaysian Examinations Syndicate, 2005, 2007, 2008, 2010). Thus, the researcher aims to profile Year 4 pupils' levels of proficiency in perimeter, area and volume formulae and determine if there is a significance difference in the levels of proficiency in perimeter, area and volume formulae based on mathematics achievement level.

In regard with the students' mathematics performance based on gender, it is found that the average score obtained by the girls in Malaysia for the content domain related to geometry were slightly higher than the average score obtained by the boys (Mullis, Martin, Foy, & Arora, 2012). The average score for the content domain of geometry obtained by the girls is 438 whereas the average score obtained by the boys is 425. These results show that the girls are performing better than boys in the domain of geometry. One of the research in determining the mathematics achievement and self-efficacy beliefs in geometry has also shown that there was a significant difference in geometry achievement in which women performed significantly higher than men (Erdoğan et al., 2011).

However, these results are in contrary with some of the research which have found that boys scored slightly higher than girls on different strands of proficiency such as mathematical reasoning (Stage et al., 1985). Thus, the researcher also aims to profile Year 4 pupils' levels of proficiency in perimeter, area and volume formulae and determine if there is a significance difference in the levels of proficiency in perimeter, area and volume formulae based on gender.

1.4 Objectives of the Study

This study aims to assess Year 4 pupils' levels of proficiency in measurement formulae. Specifically, the objectives are as follows:

i. To profile Year 4 pupils' levels of proficiency in (a) *perimeter formulae*, (b) *area formulae*, and (c) *volume formulae* based on type of school, location of school, mathematics achievement level and gender.

ii. To determine if there is a significant difference in Year 4 pupils' levels of proficiency in (a) *perimeter formulae*, (b) *area formulae*, and (c) *volume formulae* in terms of type of school, location of school, mathematics achievement level and gender.

1.5 Research Questions

In line with the objectives of this study, the following research questions are formulated to guide the study:

RQ1: What is the profile of Year 4 pupils' levels of proficiency in perimeter formulae based on (a) type of school, (b) location of school, (c) mathematics achievement level, and (d) gender?

RQ2: What is the profile of Year 4 pupils' levels of proficiency in area formulae based on (a) type of school, (b) location of school, (c) mathematics achievement level, and (d) gender?

RQ3: What is the profile of Year 4 pupils' levels of proficiency in volume formulae based on (a) type of school, (b) location of school, (c) mathematics achievement level, and (d) gender?

RQ4: Is there a significant difference in Year 4 pupils' levels of proficiency in perimeter formulae in terms of (a) type of school, (b) location of school, (c) mathematics achievement level, and (d) gender?

RQ5: Is there a significant difference in Year 4 pupils' levels of proficiency in area formulae in terms of (a) type of school, (b) location of school, (c) mathematics achievement level, and (d) gender?

RQ6: Is there a significant difference in Year 4 pupils' levels of proficiency in volume formulae in terms of (a) type of school, (b) location of school, (c) mathematics achievement level, and (d) gender?

1.6 Hypotheses of the Study

To answer research questions 4, 5 and 6, the null hypotheses are proposed as follows:

Null hypotheses for Research Question 4:

H_0 1: There is no significant difference in Year 4 pupils' levels of proficiency in perimeter formulae in terms of type of school.

H_0 2: There is no significant difference in Year 4 pupils' levels of proficiency in perimeter formulae in terms of location of school.

H_0 3: There is no significant difference in Year 4 pupils' levels of proficiency in perimeter formulae in terms of mathematics achievement level.

H_0 4: There is no significant difference in Year 4 pupils' levels of proficiency in perimeter formulae in terms of gender.

Null hypotheses for Research Question 5:

H_0 5: There is no significant difference in Year 4 pupils' levels of proficiency in area formulae in terms of type of school.

H_0 6: There is no significant difference in Year 4 pupils' levels of proficiency in area formulae in terms of location of school.

H_0 7: There is no significant difference in Year 4 pupils' levels of proficiency in area formulae in terms of mathematics achievement level.

H_0 8: There is no significant difference in Year 4 pupils' levels of proficiency in area formulae in terms of gender.

Null hypotheses for Research Question 6:

H_0 9: There is no significant difference in Year 4 pupils' levels of proficiency in volume formulae in terms of type of school.

H_0 10: There is no significant difference in Year 4 pupils' levels of proficiency in volume formulae in terms of location of school.

H_0 11: There is no significant difference in Year 4 pupils' levels of proficiency in volume formulae in terms of mathematics achievement level.

H_0 12: There is no significant difference in Year 4 pupils' levels of proficiency in volume formulae in terms of gender.

1.7 Significance of the Study

This study allows mathematics teachers to look into each strand of proficiency of Year 4 pupils in measurement formulae which are interwoven and interdependent. When the teachers get more feedback on their pupils' proficiency, the teachers can identify the strengths and weaknesses of their pupils in learning measurement formulae. Based on the detailed information, teachers can develop a better teaching plan or method that suits their pupils' learning and design or develop a better assessment task which does not only focus on the skills in solving problems that is the strand of procedural fluency, but cover all the other strands of proficiency.

From the perspective of students, this study enables them to have a clearer image of their own proficiency in measurement formulae. Gradually, the students will start to realize that learning mathematics is not only about solving problems, but it is about understanding the concepts, learning the procedures with meaning, solving problems using efficient strategies, justifying their reasoning and seeing mathematics as sensible and useful in their daily life. When the students understand that the five strands of proficiency are important and connected strongly like an interwined rope, they will start to focus on every strand of proficiency during their learning in measurement formulae. As a result, this will enhance their learning effectively.

For the curriculum developers, the instrument can be used as a guideline for them to enhance the development of mathematics curiculum which covers all the interwined strands of proficiency. The curriculum developers can refer to the developed instrument to rearrange the learning content, make sure the students learn the mathematics content from simple to abstract. Other than improving the arrangement of learning contents, the curriculum developers can create and suggest more contents and activities that is not only highly skewed to problem solvings, but also focus on activities that can engage students during their learning to make the students have the feeling of appreciation and motivation in learning measurement formulae. When students are educated mathematically, indirectly, this will increase the students' competency, and improve the development of society in Malaysia.

In sum, the assessment guideline of this study can help in improving students' proficiency in measurement formulae, achieving Malaysia's aspiration to be ranked in the top third of countries in TIMSS within 15 years.

1.8 Limitations of the Study

There are certain limitations in this study in which there will be some influences or conditions that cannot be controlled by the researcher. First, the sample involved in this study will be from 2 National Schools, 2 National Type Chinese Schools and 2 National Type Tamil Schools .The findings from these groups of sample could not be generalized to other Year Four pupils' mathematical proficiency in measurement formulae and this might not be representative all the primary schools in Malaysia.

Second, the findings obtained may not be accurate to indicate the mathematical proficiency of that particular pupil due to the time constraint during the actual study. The pupils might just leave the answer space blank if they do not have enough time to finish the test paper and this can affect the researcher to assess their mathematical proficiency based on the framework that was developed.

Third, this study only assessed the levels of proficiency in three measurment formulae, namely perimeter, area and volume formulae. Therefore, the results cannot be generalized as the overall level of mathematical proficiency of Year 4 pupils.

1.9 Definition of Terms

Year Four Pupils

Year Four pupils in Malaysia refers to the pupils who are having primary education in public primary schools in Malaysia. All the Year Four pupils have completed their level one (Year 1 to Year 3) studies in public primary schools before they proceed to level 2 (Year 4 to Year 6) studies in Malaysia (Education in Malaysia, n.d.).

Type of School

Public primary schools in Malaysia are categorised into three different types, which are National Type (*Sekolah Kebangsaan, SK*), National Type Chinese School (*Sekolah Jenis Kebangsaan Cina, SJKC*) and National Type Tamil School (*National Type Tamil School, SJKT*). These three different types of schools use the same syllabus for non-language subjects. The medium for teaching of non-language subjects in National Type School, National Type Chinese School and National Type Tamil School are Malay, Mandarin and Tamil respectively.

Location of School

Malaysia is a developing country that is unique with its geographical condition. The locations in Malaysia are divided into urban and rural areas where the physical infrastructure in rural areas differs from urban areas. Schools located in urban areas are the schools with good quality of school facilities, good teaching and learning environment and located in the areas with more than 2500 people. School located in rural areas are the schools which have a higher potential to be placed in the condition without good quality of school facilities, without good teaching and learning environment and located in areas with less than 2500 people (Arnold, 2004; Marwan, Sumintono, & Mislan, 2012; McClure et al., 2003; Mitra et al., 2008).

Measurement Formulae

Measurement formulae are the formulae used for measuring geometric figures. In this study, the measurement formulae refers to perimeter, area and volume formulae. Perimeter formula is a formula used to measure the distance or length around the outside of a shape. The area formula is a formula used to measure space contained within the edges of a 2-D shape. The volume formula is used to measure the volume, or capacity, of a 3-D shape that is how much space is contained within the shape.

Conceptual Understanding in Measurement Formulae

Conceptual understanding in measurement formulae refers to the comprehension of perimeter, area and volume formulae (Kilpatrick et al., 2001).

Procedural Fluency in Measurement Formulae

Procedural fluency in measurement formulae refers to the skill in carrying out the procedures using perimeter, area and volume formulae flexibly, accurately, efficiently and appropriately (Kilpatrick et al., 2001).

Strategic Competence in Measurement Formulae

Strategic competence in measurement formulae refers to the ability to formulate, represent and solve problems using perimeter, area and volume formulae (Kilpatrick et al., 2001).

Adaptive Reasoning in Measurement Formulae

Adaptive reasoning in measurement formulae refers to the capacity for logical thought, reflection, explanation and justification of solving non-routine problems involving perimeter, area and volume formulae (Kilpatrick et al., 2001).

Productive Disposition in Measurement Formulae

Productive disposition in measurement formulae refers to the habitual inclination to see the concepts involving perimeter, area and volume formulae as sensible, useful and worthwhile, coupled with a belief in diligence and one's own efficacy (Kilpatrick et al., 2001).

Levels of Proficiency in Measurement Formulae

Levels of proficiency in measurement formulae are a means of describing the students' ability in demonstrating the five strands, namely conceptual understanding, procedural fluency, strategic competence, adaptive reasoning and productive disposition to solve mathematical problems on three multi-strand test related perimeter, area and volume formulae in terms of level (Kilpatrick et al., 2001).

Mathematics Achievement Level

Mathematics achievement level described the students' performance on the mathematics achievement test based on a syllabus, modules and learning objectives after the teaching instructions are given in the classroom (Sectic & Huttunnen, 2006).

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter combines the related literature review and conceptual framework of this study. The review of the related studies included the mathematical proficiency model, students' mathematics performance in measurement formulae, research related to pupils' mathematical performance based on gender, location of school and sociocultural aspects, and lastly the conceptual framework of the study.

2.2 Mathematical Proficiency Model

Over the past decades, the Mathematics Curriculum had shifted their focus bit by bit in response to the changes according to the demand of society. Based on Brownell (1935), computational skill played a dominant role in mathematics learning and most of the educators in teaching students from pre-kindergarden to eighth grade emphasized a lot on the learning of computational skill in the first half of the century. However, the educators had started to realize the importance of understanding mathematics concepts rather than just focus on the computational skill in the 1950s and 1960s (Kilpatrick et al., 2001). In the 1980s and 1990s, someone who is successful in mathematics is defined as having good understanding and computational skill and the reform movement in mathematics had also included the importance of reasoning, problem solving skills and communicating skills. Thus, with the changes in mathematics movement, different schools at different places reflected different definitions of mathematical proficiency.

Previously, in many traditional classrooms, there is a strong emphasis on the computational skills rather than understanding and reasoning skills while teaching mathematics (Suh, 2007) as most of the teachers or educators think that the first job of the education system is to teach the students to read and the second job is to develop the basic mathematics skills among the learners (Milgram, 2005). This has permeated the culture among teachers and educators in which they think that their students are considered as good in mathematics if they are able to solve mathematics problems with basic mathematics skills.

When it comes to the international perspective, learning mathematics is not only about basic mathematics skills but it is an interesting performance which is much more complex than just the skills. According to Burkhardt (2007), mathematics performance should be assessed holistically and analytically but not assess only one separate part of the performance. It is just like judging the participants in a story telling competition. The judges not only judge the participants' through the story structure of the story tellers, but the judges evaluate the body language and gesture of the story teller to see if the participants can express the meaning of the text using non-verbal communication, evaluate the pacing throughout the story telling session to see if the story is presented efficiently and keeps listeners' interest throughout the whole session. The performance is always evaluated comprehensively and holistically to see if the participant is an effective story teller.

With the high demand of the society for effective mathematicians in this century, teachers, educators, public and private sectors always want to develop students who are mathematically proficient. Mathematically proficient possessed different meanings from different groups. There are various conceptions that define mathematically proficient students such as good in mathematics, being good in number sense, being proficient in algorithm and have good mathematics logic and good in reasoning (Siegfried, 2012). The National Assessment of Educational Progress (NAEP) had specified three mathematical abilities in defining mathematical proficiency which are conceptual understanding, procedural knowledge and problem solving with addition of specifications for reasoning, connections, and communication.

As there was no framework that can holistically describe all the mathematics skills, knowledge, ability and attitude, Kilpatrick et al. (2001) had introduced a mathematical proficiency model which consists of five strands that can represent a comprehensive view of their thoughts regarding the characteristics that constitute proficiency in mathematics. The theory in cognitive science supported the ideas of these five strands of mathematical proficiency model (Kilpatrick et al., 2001). Conceptual understanding is important for mathematics learning as cognitive scientists concluded that one's ability in learning an area is not only depending on the knowledge that was stored but it depends on the knowledge that were organized and connected to their prior knowledge. With the good connection of their knowledge, students will be able to know what method they can use to solve problems, thus the strand of strategic competence is strongly connected with the strand of conceptual understanding. Moreover, cognitive science studies of problem solving have emphasised on metacognition which is the knowledge to monitor one's own understanding and problem-solving activity (Kilpatrick et al., 2001). Thus, knowledge about one's own thinking is related to the strand of strategic competence and adaptive reasoning. In the report of the National Research Council [NRC] (2001), positive attitude is also playing a crucial role in ensuring pupils learn mathematics effectively in the classroom. Thus, this is related to the strand of productive disposition.