Developing Pupils' Understanding of Comparing and Ordering Decimal Numbers Using Multiple Representations

Jamilah Yusof, Haslinah Mahmud
Sultan Hassanal Bolkiah Institute of Education, Universiti Brunei Darussalam, Brunei Darussalam
Curriculum Development Department, Ministry of Education, Brunei Darussalam
jamilah.yusof@ubd.edu.bn, haslinamahmud@yahoo.com

Keywords: Decimal numbers, Primary school, multiple representations

Abstract. This study aimed to identify the type of misconceptions pupils made when comparing and ordering decimal numbers among Year 4 pupils in Brunei Darussalam, and to investigate the effect of using multiple representations on developing pupils' understanding of decimals. In addition, the study also examined the different modes of multiple representations teachers used to teach the concepts of comparing and ordering decimal numbers. A combination of quantitative and qualitative methodologies was used to answer the three formulated research questions in this study. The study samples involved twenty-four Year 4 pupils and seventy Year 4 mathematics teachers from the four districts in Brunei Darussalam. Four research instruments were used to collect data which are pre- and post-tests on decimals, pupils' interview, teachers' questionnaire and lesson observations. The pre- and post-tests pupils' written responses and pupils' interviews responses revealed that the pupils experienced misconceptions as they lacked fundamental skills in working with decimal values. In addition, the pupils tended to have limited understanding and knowledge related to decimal concepts.

Results from the pre- and post-tests indicated that the intervention lessons had successfully improved the pupils' overall performance in decimals tasks. The overall performance of the sample pupils showed that there was a significant increase in the achievement from the pre-test as compared to the post-test. This suggests the importance of using multiple representations in teaching decimal concepts to help pupils develop understanding in mathematics and provide meaningful learning experiences. Findings from teachers' questionnaires showed that the instructional materials (i.e. base-ten cards, place value board, decimal grids, number lines and play money) suggested by the researcher in this study were less frequently used by teachers when teaching the concept of comparing and ordering decimal numbers. This was supported by the findings from classroom observations where teachers used the traditional 'chalk and talk' approach in mathematics lessons by presenting numerous rules and procedures to the class.

In view of the importance of incorporating the use of multiple representations in mathematics curriculum framework, there is a need for continual professional development to equip teachers with relevant skills, content knowledge and pedagogical knowledge to enhance their competency in mathematics

ISBN: 978-605-64453-0-9

1. Introduction

The primary school mathematics instruction should help pupils understand all mathematical concepts taught and this includes fractions and decimals. They need to be guided to explore their relationship, and build initial concepts about order and equivalence. Evidence from studies like Copley (2010) has shown that children possess a large amount of intuitive mathematical knowledge and they continually construct mathematical ideas based on their experience, they construct those mathematical ideas slowly. It is therefore crucial that teachers use physical materials, diagrams, and real-world situations in conjunction with ongoing efforts to relate their learning experiences to oral language and symbols. This approach may help to reduce the amount of time spent in the upper primary level in correcting pupils' misconceptions and procedural difficulties. In the upper primary level, children begin to encounter decimals in many situations, such as when calculators and metric measures, in tables of data, and in daily activities when using a digital stopwatch. Thus, the curriculum needs to emphasize the development of decimal concepts. The approach in teaching decimals should be similar to fractions that are by placing a strong and continued emphasis on models and oral language and then connecting this work with symbols. This approach is necessary so that pupils can make sense of decimals and use them insightfully

Pupils learn mathematics at greatly differing speeds, which results in differences in attainment between pupils of the same age. Evidence from research and from pupils' performance in public examinations indicates that there are serious problems with the teaching and learning of mathematics in Brunei Darussalam's primary and secondary schools. Analysis of errors observed in pupil's performance in public examinations (Veloo, 1993; Veloo & Lopez-Real, 1994; Veloo, 1996) suggests that the application of rules and formulas is drilled into pupil's minds, at the expense of mathematical understanding of 'why' or 'how' the rule works. Eggen and Kauchak (2001) have argued that where pedagogical content knowledge is lacking, teachers commonly paraphrase information in learners' textbooks or provide abstract explanations that are not meaningful to their students.

Understanding decimal notation is an important part of basic numeracy. Our society makes widespread use of metric measurement for scientific and everyday purposes. Computers and calculators use decimal digital displays so making sense of input and output of decimal numbers is essential (Moloney & Stacey, 1996). The understanding and correct use of decimals is a foundation topic necessary for understanding more advanced mathematical topics.

Learning difficulties that pupils have encountered or misconceptions that they may have can be identified at an early stage so that immediate and effective remedial help can be given. A student who holds an incorrect view of what decimals are will probably spend most of their schooling rote-learning meaningless algorithms for the manipulation and comparison of decimals (Stacey & Steinle, 2003).

Students often develop misconceptions about decimals because instruction does not promote connections between decimals and other mathematical content (Thompson & Walker, 1996). Mathematics instruction in Brunei Darussalam has far too long emphasized a "chalk and talk" rote-learning pedagogy (Leong , 2003; Veloo,1993) .The children learn rules and procedures by rote memorization on the preparation of students for forthcoming tests and examinations (Hayati, Kamisah, Zaharawati & Madihah, 2005).

The primary mathematics curriculum embedded in the new National Education System for the 21st Century, implemented fully in January 2009 (SPN21) encourages inquiry and the development of mathematical reasoning and engages students in mathematical activity to develop an understanding of

ISBN: 978-605-64453-0-9

mathematics concepts as well as mathematical skills. Active involvement of children through the use of a variety of representations is the predominant instructional strategy in this new instructional environment. The manipulation of concrete materials provides a base and a starting point upon which children can actively build mathematical ideas. Pupils can be expected to learn better and with greater interest if an idea is presented in a variety of forms or modes of representation.

Therefore, children should be actively involved in learning mathematics through the use of a variety of representations. In the very early years, concrete materials will help children to develop basic mathematical concepts. Later, diagrams, real world examples, verbal representations, ICT, and symbolic representations will help children to move from concrete to more abstract ways of thinking (CDD, 2008). Teachers must use a variety of strategies to reach all students when teaching mathematics

The use of multiple representations of a concept or procedure in mathematics is highly recommended by NCTM and other mathematics education experts. The Principles and Standards for School Mathematics (NCTM, 2000) emphasized the role of representation in mathematics stating that pupils should "…create and use representations to organize, record, and communicate mathematical ideas; select, apply, and translate among mathematical representation to solve problems; and use representations to model and interpret physical social and mathematical phenomena" (p. 67).

The abstract nature of mathematics requires the communication of mathematical ideas through multiple representations such as words, symbols, pictures, objects, or actions. Building representational fluency involves using mathematical representations, flexibility and being able to interpret and translate among these different models and mathematical concepts (Suh, Johnston, Jamieson &Mills, 2008).

Representational fluency, the ability to use multiple representations and translate among these models, is key to the process of building pupils' mathematical understanding (Fennell & Rowan, 2001; Goldin & Shteingold, 2001; Lamon, 2001). The Lesh Translation Model (Refer to Figure 1) highlights the importance of being able to represent mathematical ideas in multiple ways, including with manipulative, real life situations, pictures, verbal symbols, and written symbols (Lesh, 2003). A pupil's ability to translate among different representations allows teachers to assess conceptual understanding.

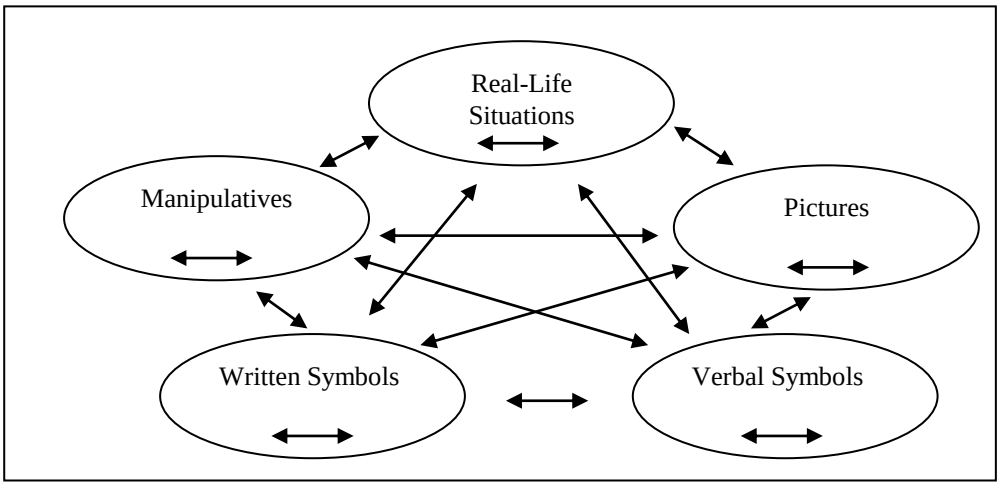

Figure 1. *Five distinct types of representations.*

ISBN: 978-605-64453-0-9

2. Methodology

2.1 Sample

The sample of the study was twenty-four Year 4 pupils in one of the government primary schools in Brunei Darussalam. Six of them were selected for the more in-depth interview. In addition, the sample included seventy Year 4 government primary school mathematics teachers (53 female and 17 males) in Brunei Darussalam who responded to the questionnaire items. Classroom observations on three lessons on Decimals were conducted from the selected schools involved in the main study.

2.2 Research questions

The study was guided by the following research questions:

1. What misconceptions do pupils make when comparing and ordering decimal number exercises?
2. Can a variety of multiple representations improve pupils' understanding when comparing and ordering decimal number exercises?
3. What modes of multiple representations do Year 4 teachers currently use to teach comparing and ordering of decimal numbers?

2.3 Research instruments

Four research instruments were used to collect data namely: Pre- and post-test on decimals, pupils' interview, teachers' questionnaire and lesson observation. Four intervention lessons were carried out between the pre and post-tests.

The pre-test was administered before instructional intervention lessons. The post-test was administered after instructional intervention lessons. The class was taught by the actual mathematics teacher and utilized the suggested instructional materials for the study. The intervention lessons took place over a period of 2 weeks. Data obtained from the pupils' written responses in the pre-test and post-test enabled the researchers to identify the type of misconceptions pupils made when comparing and ordering decimal number exercises. In addition, the pre-test and post-test were also used to measure if there were improvement in pupils' performance after being taught using the instructional materials suggested by the researcher.

The teachers' questionnaire was designed to elicit information on the modes of multiple representations teachers used in teaching comparing and ordering of decimal numbers.

The findings from pupils' interviews and lesson observations were used to contrast or strengthen quantitative data. Thus by obtaining data through different sources, one can argue that the study has measured its validity (what it set out to measure) and reliability (consistent responses on a number of different occasions) (Bell, 2005). The purpose of the pupils' interview analysis was to identify and investigate misconceptions that pupils exhibited when comparing and ordering decimal numbers.

2.4 Data analysis

Data was analyzed by using SPSS Version. .Descriptive statistics were used to analyze the frequency distribution of the identified misconceptions pupils made related to comparing and ordering decimal numbers. The decimal misconceptions as categorized by Stacey and Steinle (1998) were used as the

ISBN: 978-605-64453-0-9

main source in identifying the type of pupils' misconceptions related to comparing and ordering decimal numbers. This was used to answer Research Question 1. The t-test was the major test statistic deployed in data analysis in answering Research Question 2. The t-test was used to determine whether two means are significantly different in terms of pupils' overall achievement scores in the post-test as compared to the pre-test.

3. Results and Discussion

3.1 What misconceptions do pupils make when comparing and ordering decimal number exercises?

In answering Research Question 1, data analysis from the pupils' written responses both from the pre and post-tests and pupils' interviews for the purpose of exploring the misconceptions pupils made when comparing and ordering decimal number exercises, it shows that the pupils tended to exhibit the 'string length thinking' and the 'reverse thinking' which is under 'Longer-is-larger Misconceptions' category. With the 'reverse thinking', the pupils misapplied rules for comparing whole numbers in decimal situations. With the 'string length thinking', the pupils had a thought that decimals with more digits were always larger because they have more numbers. The pupils had not developed sufficient understanding and knowledge about decimal concepts. Findings from the written responses from the pre and post-tests and the interviews indicated that Bruneian pupils also developed the similar misconceptions as categorized by Stacey and Steinle (1998) in their study on the misconceptions of decimal notations. The intervention lessons had a significant impact on the pupils' way of thinking about decimal notation. The pupils were able to figure out decimals in the form of money value and used the number line to imagine and locate the position of the decimal numbers**.**

3.2 Can a variety of multiple representations improve pupils' understanding when comparing and ordering decimal number exercises?

T-tests were carried out in order to answer Research Question 2. A paired-sample-t-test was used to compare the differences in achievement of the pupils between the pre- and post-tests. The t-test for each category was analyzed to find out if there was any significant improvement between the pre-test and post-test relative to the categories. It was used to identify which categories the pupils performed well in before and after the intervention activities. The t-test for the overall performance of the pupils in comparing and ordering decimal numbers was used to verify the effect of the intervention lessons towards the pupils' achievement when comparing and ordering decimal number exercises.

In order to find out the difference in achievement between pre-test (before intervention) and post-test (after intervention) on decimals, the paired t-test was conducted. The results from the paired sample t-test are shown in Table 1

Table 1
Paired- Sample T-Test and Effect Size between Pre-Test and Post-Test on Decimals

		Mean	N	Std. Deviation	*t*-value	df	Significance (2-tailed) (p)	Effect Size *(d)*
Pair1	Pre-test	61.39	24	15.35	12.09	23	0.000	2.55
	Post-test	91.67	24	6.88				

ISBN: 978-605-64453-0-9

Result of analysis in Table 1 indicates a distinct difference between the pre-test and the post-test scores. The overall performance of the sample pupils showed that there was an increase in the achievement from the pre-test as compared to the post-test. Using the paired sample t-test, it was found that there was a significant increase in the score from pre-test (M=61.39, SD=15.35) to post-test (M=91.67, SD=6.88) before and after the intervention with a large effect size (d=2.55). This suggests that the pupils performed significantly better in their post-test as compared to their performance during their pre-test at 0.01 level [t (23) = 12.09, p=0.000]. This is an indication that the intervention activities have contributed a significance improvement in the pupils' performance on decimals. Specifically, in the intervention lessons, suggested instructional materials namely base-ten cards, place value board, decimal grids, number lines and play money were used and they have proven to have contributed a greater impact on the pupils' performance in the post-test

Looking at the 3 subdivision of the Decimal work tested i.e. Reading, Comparing and Ordering Decimals; all divisions have shown an increase in means. The highest increase is shown in the Ordering of Decimals with an increase of 0.88 (Pre-test 0.08 and Post-test 0.75), followed by Comparing Decimals with an increase of 0.87 (Pre-test 0.13 and Post-test 1.0), while Reading Decimals shows an increase of 0.17 (Pre-test 0.83 and Post-test 1.0). It is suggested that the pupils' improved performance in the Post-test has been influenced by their better conceptual understanding derived from the intervention lessons which exposed them to the multiple representations used by the teacher.

3.3 What modes of multiple representations do Year 4 teachers currently use to teach comparing and ordering of decimal numbers?

The types and frequency of mathematical representations teachers used to teach comparing and ordering decimal numbers are discussed according to their responses to items in the questionnaire; using the 5 point Likert scores i.e. Always (5); Almost Always (4); Sometimes (3); Almost Never (2) and Never (1). Table 2 shows the varieties of multiple representations that the teachers have been using.

Table 2

Means and Standard Deviations for the Frequency of Types of Mathematical Representations Teachers used to teach Comparing and Ordering Decimal Numbers (N=70)

	N	Mean	SD
Q(1) Pictorial representations	70	2.87	1.191
Q(2) Number lines	70	2.49	1.018
Q(3) Base-10 blocks, flats, longs & units	70	2.53	1.032
Q(4) Place value boards and base-ten cards	70	2.47	0.928
Q(5) Decimal grids	70	2.47	1.032
Q(6) Abacus/bead counting frames	70	2.43	1.001
Q(7) Real money or 'play money'	70	2.50	0.929
Q(8) Rulers/tape measures	70	3.31	1.084
Q(9) Weighing balances, scales	70	2.73	1.227
Q(10) Calculators	70	2.49	1.151
Q(11) ICT	70	3.16	1.002
Q(12) Real-life	70	3.43	1.098
Q(13) Games	70	3.53	1.100
	Overall mean: 2.80		

ISBN: 978-605-64453-0-9

The result shows that the mean scores are 2.49 (Item 2), 2.47 (Item 4), 2.47 (Item 5) and 2.50 (Item 7) referring to number lines, place value board and base-cards, decimal grids and real money or play money respectively were less frequently used by teachers to teach comparing and ordering decimal numbers. A mean score of 3.53 (Item13) indicates that teachers often use games to teach comparing and ordering decimal numbers. Having games in mathematics teaching can easily engage pupils for a long period of time. The result suggests that teachers were not aware of the uses of the available teaching materials in schools like base-ten blocks, base-ten materials, place value boards, decimal grids, empty number lines. Teachers were not conscious of the use of these teaching materials to convey mathematical ideas and concepts relating to comparing and ordering of decimal numbers.

From the observations made, only one teacher used the base- ten blocks and real money but they were used for explanation and demonstration purposes only. In one of the lessons, the teacher used ICT to show the place value board with number symbols on it. However, the explanation was mainly done by giving rules and procedures for comparing and ordering decimal numbers. No manipulative activities were done to promote pupils' understanding on decimal notations particularly when comparing and ordering decimal number exercises. The lessons were comprised more of teachers' explanations and worked examples on the board. The lessons were highly teacher – dominated.

This observation concurred with another study done by Zurina (2003) where she also observed in her study that teachers in Brunei introduced the lessons by just writing decimal numbers on the board and asked the pupils to read the numbers. It was noted that most of the pupils in the three classes observed tended to read the numbers incorrectly. For example, in one of the lessons, the teacher asked the pupils to read 5.23, the pupils read the numbers as 'five point twenty-three'. The pupils misapplied the knowledge of whole numbers when reading decimals and ignored the decimal point and this may led to misconceptions when doing the comparing and ordering decimal numbers.

The study of the misconceptions of decimal notations by Stacey and Steinle (1998) has shown that sometimes pupils' misconceptions about decimals are as a direct result of instruction. The observations revealed that these teachers tended to give the abstract definitions and rules pupils could use to compare and order decimal numbers rather than using physical models or diagrams. For example, in one of the lessons the pupils were asked to compare 4.7 and 1.2, the teacher only explained the rule to the class such that 'compare the digits in each place-value position, moving from left to right until the digits differ. At that point, the decimal number having the digit of greater value is the greater number.' This eventually did not help develop pupils' understanding and skills when comparing and ordering decimal number exercises.

Widjaja, Stacey and Steinle (2009) reported that understanding misconceptions is important because it provides clues for targeting instruction better suited to learners' needs. It was observable that these teachers didn't encourage pupils to explain how they obtained their answers or justify their thinking. For example, the teacher instructed pupils to compare 3.6 and 2.17 on the board without explaining the reasons why such number was greater or smaller. It is important for teachers to ask pupils to give reasons of getting their answers in order to identify their misconceptions. Teachers should modify their instructions in order to address the needs of the pupils. But this was not happening in the three classes observed.

Therefore, in summary, it shows that the use of base-ten cards, place value board, decimal grids, number lines and play money to teach comparing and ordering decimal numbers were not popular among teachers. It was observed that the teachers did not employ the readily available teaching materials like empty number line, place value board and base-ten materials in teaching the expected

ISBN: 978-605-64453-0-9

skills relating to decimals. This encouraged the researcher to plan activities related to the use of base-ten cards, place value board, decimal grids, number lines and play money in teaching comparing and ordering decimal numbers in the intervention lessons.

4. Summary

The study was designed to identify the type of misconceptions pupils made when comparing and ordering decimal number exercises and to investigate the effect of using multiple representations on developing pupils' understanding related to decimal tasks. In addition, the study also examined the different modes of multiple representations teachers used to teach comparing and ordering decimal numbers.

Results from the pre- and post-tests indicate that the intervention lessons to some extent had successfully improved the pupils' overall performance in decimals tasks. The overall performance of the sample pupils showed that there was a significant increase in the achievement from the pre-test as compared to the post-test. There is a strong indication that the use of instructional materials (i.e. base-ten cards, place value board, decimal grids, number lines and play money) suggested by the researcher in this intervention lessons were effective in improving the pupils' understanding and skills in comparing and ordering decimal numbers.

The findings of this study suggest that the use of multiple representations did help pupils construct meaningful relationships and understanding on decimals concepts as reflected in their post-test performance. The results findings from teachers' questionnaires indicate that the instructional materials (i.e. base-ten cards, place value board, decimal grids, number lines and play money) suggested by the researcher in this study were less frequently used by teachers when teaching comparing and ordering decimal numbers. The data collected from the classroom observations show that teachers were not using multiple representations when they were teaching decimals. The use of the instructional materials suggested in this study was not evident in the three lesson observations. It is expected that pupils should be exposed to the use of multiple representations even in the early grades. Suh and Moyer (2007) reported that use of multiple representations in classroom teaching help to promote pupils' thinking and pupils should be able to use different representational forms to express their thinking. Through the use of representations, pupils develop their own mental images of mathematical ideas. Therefore, this study suggests that using multiple representations should be central to the work pupils do in mathematics classrooms to promote the pupils' conceptual and procedural understanding of decimal numbers.

This study also shows that the instructional materials such as base-ten cards, place value board, decimal grids, number lines and play money were less frequently used by teachers when teaching comparing and ordering decimal numbers. This was further supported by the findings from classroom observations where teachers used the traditional 'chalk and talk' approach in mathematics lessons by presenting numerous rules and procedures to the class. Therefore, teachers are encouraged to practice a pupil-centered approach by incorporating multiple representations in their teaching approaches to help pupils develop appropriate conceptual and procedural understanding in mathematics learning.

In conclusion, in view of the importance of incorporating the use of multiple representations in mathematics teaching as outlined in the Brunei Darussalam newly implemented Education System for the 21st Century (SPN21) primary school mathematics curriculum framework, there is a need for continual professional development to equip teachers with relevant content knowledge and

ISBN: 978-605-64453-0-9

pedagogical knowledge to help them become more competent in teaching not only decimals but also all topics in the primary school mathematics curriculum.

References

[1] Bell. J (2005) Doing Your Research Project: A Guide for First-time Researchers in Education, Health and Social Science, McGraw-Hill International, Jun 1, 2005

[2] Curriculum Development Department (2008). Framework and guidelines for curriculum and assessment, mathematics Year 4, Brunei Darussalam. Ministry of Education, Brunei Darussalam.

[3] Copley, J.V. (2010). *The Young Child and Mathematics.* NCTM, Reston, Virginia.

[4] Eggen, P., & Kauchak, D. (2001). *Educational psychology*: *Windows on classrooms*. New Jersey: Prentice Hall, Inc.

[5] Fennell, F., & Rowan, T. (2001). Representation: An important process for teaching and learning mathematics. Teaching Children Mathematics 7, 288-92.

[6] Goldin, G., & Shteingold, N. (2001). Systems of representations and the development of mathematical concepts. In the Roles of Representations in School Mathematics, Yearbook of the National Council of Teachers of Mathematics (NCTM).

[7] Hayati Ismail, Hjh Kamsiah Hj Janadie, Zaharawati Jatin & Madihah Khalid. (2005). A brief look at teaching and assessing mathematical thinking at primary level. *Science, Mathematics & Technical Education in the 20th and 21st Centuries.* Gadong, Universiti Brunei Darussalam.

[8] Lamon, S.J. (2001). Presenting and representing from fractions to rational numbers. In the Roles of Representations in School Mathematics, Yearbook of the National Council of Teachers of Mathematics (NCTM).

[9] Lesh, R., Cramer, K., Doerr, M. H., Post, T., & Zawojewski, J. (2003). Using a translation model for curriculum development and classroom instruction . In Beyond Constructivism, Models and Modeling Perspectives on Mathematics Problem Solving, Learning and Teaching.

[10] Leong, Y. P., Marzuki, M., NurAmalina, A., Sannay, M., Veloo, P. K., Mariah, S., Maimunah, G., & Shak, J. P. K. (2003). *Report of the task force on mathematics achievement of lower secondary students.* Unpublished Report, Ministry of Education, Brunei Darussalam.

[11] Moloney, K., & Stacey, K. (1996). Understanding decimals. The Australian Mathematics Teacher, 52, 1, 4-8.

[12] National Mathematics Advisory Panel. (2008). Foundations of success. The final report of the National Mathematics Advisory Panel. Washington, DC: U.S.Department of Education.

[13] Stacey, K., & Steinle, V. (1998). The incidence of misconceptions of decimal notation amongst students in Grades 5 to 10. In C. Kanes, M. Goos & E. Warren (Eds.), Teaching mathematics in new times (pp.548 – 555). Brisbane: Mathematics Education Research Group of Australasia.

[14] Stacey, K., & Steinle, V. (2003). Grade-related trends in the prevalence and persistence of decimal misconceptions. In N. Pateman, B. Dougherty, & J. Zilliox (Eds.), *Proceedings of the 2003 Joint Meeting of PME and PMENA.* Honolulu: International Group for the Psychology of Mathematics Education, 4, 259-266.

[15] Suh, M. J., Johnston, C., Jamieson, S., & Mills, M. (2008). Promoting decimal number sense and representational fluency. Mathematics Teaching in the Middle School.

ISBN: 978-605-64453-0-9

[16] Thompson, C. S., & Walker, V. (1996). Connecting decimals and other mathematical content. *Journal of Teaching Children Mathematics*, *2, 8*, 496-502.

[17] Veloo, P. K., Leong, Y.P., Lopez-Real, F., Lim, H. B. G., Lee, K. P., Sakdiah Ladi, & Mastan (1993). *Laporan jawatankuasa mata pelajaran matematik bagi peperiksaan Brunei-Cambridge GCE 'O' level.* Unpublished report. Ministry of Education, Brunei Darussalam.

[18] Veloo, P.K., & Lopez-Real, F. (1994). Drawing diagrams and solving word problems: A study of a sample of Bruneian primary and secondary school children's' in challenges in mathematics Education: Constraints on construction. *Proceedings of the Seventeenth Annual Conference of the Mathematics Education Research Group of Australasia, Lismore, Mathematics Education Research Group of Australasia*, 2, 667-764.

[19] Veloo, P.K. (1996). Using pupils' performance in public examinations to improve classroom instruction in assessment and evaluation in science and mathematics education: Innovative Approaches. *Proceedings of the 1st Annual Conference of the Department of Science and Mathematics Education*. Universiti Brunei Darusslam.

[20] Widjaja, W., Stacey, K., & Steinle, V. (2009). Locating negative decimals on the number line. *Insights into the Thinking of Pre-service Primary Teachers.*

[21] Zurina, H. (2003). The development of fraction and decimal concepts among Form 4 N-level students at a girls' secondary school in Brunei Darussalam. Unpublished M. Ed. dissertation. Universiti Brunei Darussalam.

ISBN: 978-605-64453-0-9