A STUDY OF THE RELATIONSHIP BETWEEN THE NUMBER SENSE AND PROBLEM SOLVING SKILLS IN MATHEMATICS OF MIDDLE SCHOOL STUDENTS

Aye Mon Mon Kyaw[1], Naing Naing Thein[2]

Abstract

The primary purpose of this research is to study the relationship between the number sense and problem solving skills in mathematics of middle school students. A descriptive research design was used to collect the data. In order to investigate students' number sense, their problem solving skills and the relationship of these two elements, a quantitative research method was used. A total of (600) Grade Seven students from eight high schools and four middle schools participated in this study. A number sense test and a test for students' problem solving skills were used as the research instruments. The number sense test was composed of (40) items. The test for students' problem solving skills involved (10) problems. To obtain the reliability of these tests, a pilot test was administered. The internal consistency for these two tests were (.778) and (.699). In this study, the data were analyzed by using the descriptive analysis techniques and Pearson product-moment correlation. The results revealed that 69.3% of the students possessed a moderate level of number sense. Among the five number sense strands (number concepts, multiple representations, effect of operations, equivalent expressions and computing and counting strategies), the lowest and highest means were found in multiple representations and effect of operations. Moreover, (73.7%) of the students were found in a moderate level of problem solving skills. According to Pearson product-moment correlation results, each strand of number sense was moderately and positively related with problem solving skills at (0.01) level. In addition, there was a high positive correlation of (.607) between students' number sense and their problem solving skills. Thus, the study could be concluded that Grade Seven students who were good at number sense were also good at problem solving skills or students who were weak in number sense were also weak in problem solving skills.

Keywords: number sense, problem solving, number concepts, multiple representations, effect of operations, equivalent expressions, computing and counting strategies

[1.] Junior Assistant Teacher, BEMS (Branch), Ywarthagyi, South Dagon Township, Yangon
[2.] Lecturer, Methodology Department, Yangon University of Education

Introduction

Education plays a key role in the acquisition of knowledge, skills and values of the 21st century. Similarly, the important requirement for the 21st century is sound mathematics education. To be successful in mathematics education, students must acquire a good sense of numbers early in their academic career (Witzel et al., 2012). Many mathematics educators have suggested that the process of learning and instruction of mathematics should focus towards students understanding of numbers. In this context, students should be able to understand why and how computations or algorithms are computed (Ghazali, 2001, cited in Mohamed & Johnny, 2010). Moreover, the section of number sense should be taken into account in mathematics instruction in order to develop students' number sense as a necessary skill.

The number sense component is a major topic for the understanding of mathematics since mathematics is a discipline in solving everyday problems using numbers, patterns and logic. Actually, one of the reasons for increasing focus on number sense development in the 21st century is that number sense is an essential characteristics which can distinguish man from computers. According to the researcher's experiences dealing with mathematics classrooms, students cannot perform well in solving problems including a sense of number. Therefore, it is really necessary to study whether students' number sense is correlated with their problem solving skills or not. This study will also expect to give suggestions that can improve number sense of every individual.

Statement of the Problem

In mathematics instruction, number sense and numerical operation area helps students to provide intuitions and insights and make critical judgments. Number sense is important for encouraging students to think flexibly and promotes confidence with numbers. Number sense is highly personalized and is related to what ideas about number have been established and also on how those ideas were established. However, students highly skilled at paper/pencil computations may or may not be developing number sense (Carlyle & Mercado, n. d., cited in Burns, 2007).Generally, most of the students cannot easily handle numerical problems including fractions,

decimals and percentage. They do not perform well and their scores in achievement tests are in unsatisfactory condition. Therefore, the current situation of number sense in students is one of the major problems for improving mathematics education.

Purposes of the Study

The main purpose of this research is to study the relationship between the number sense and problem solving skills in mathematics of middle school students. The specific objectives are stated as follows.

- To assess students' number sense.
- To examine students' problem solving skills in mathematics.
- To explore the relationship between students' number sense and their problem solving skills in mathematics.
- To give suggestions for developing students' number sense.

Research Questions

(1) To what extent do students possess number sense?
(2) To what extent do students possess problem solving skills?
(3) Is there a relationship between students' number sense and their problem solving skills in mathematics?

Scope of the Study

This research has its own particular limitations. The first limitation is related to the fact that the participants of the study came from only twelve selected schools from Yangon Region. Eight Basic Education High Schools and four Basic Education Middle Schools were included in this study. Participants in this study were (600) Grade Seven students from the twelve selected schools in the academic year (2016-2017). The second limitation is that number sense test items were constructed based on the number sense test published by McIntosh et al. (1997**)** to measure middle school students' number sense in this study. The final limitation is that the problems were constructed only based on six chapters from Grade Seven mathematics textbook volume I and four chapters from volume II in order to measure students' problem solving skills in mathematics.

Definition of Key Terms

Number Sense

Number sense refers to a person's general understanding of numbers and operations along with the ability and inclination to use this understanding in flexible ways to make mathematical judgments and to develop useful and efficient strategies for handling numbers and operations (McIntosh, Reys, &Reys, 1992).

Problem Solving

Problem solving refers to mathematical tasks that have the potential to provide intellectual challenges for enhancing students' mathematical understanding and development (NCTM, n. d.).

Significance of the Study

Numbers and operations on numbers play a major role in helping individuals make sense of the world around them. Four basic mathematical operations, comparing prices, calculating and solving problems in daily life cannot be made proficiently without number sense. So, a sense of number is one of the fundamental needs for every individuals so as to manipulate various problems.

According to Yang and Wu (2010, cited in Akkaya, 2016), the necessity of teaching and learning number sense on four rationales: (i) number sense is a way to engage in flexible, creative, efficient and logical thinking; (ii) number sense is a concept that pertains to quantities, numbers, operations and their relationships with one another; (iii) digital representation and mathematical reasoning in adults depend in part on number sense; (iv) the focus on written calculation restricts not only the development of children's number sense but also their mathematical thinking and understanding.

According to McIntosh, Reys, and Reys (1992), an understanding of number and operations together with an ability and inclination to use this in flexible ways to make mathematical judgments, to develop useful strategies for handling numbers and to communicate, process and interpret information is essential in order to develop number sense.

So, it is necessary to study students' number sense and their problem solving skills which are the indispensable areas of mathematics education. Thus, this study intends to find out the relationship between students' number sense and their problem solving skills in mathematics at the middle school level. Since the middle school level is the bridge of the primary and the higher levels, it hopes to study the students' existing number sense and their problem solving skills and to provide foundations for developing number sense required at the higher level.

Theoretical Framework

Necessity of Mathematics Education

An information and technology based society requires individuals who are able to think critically about complex issues, analyze and adapt to new situations, solve problems of various kinds, and communicate their thinking effectively. The study of mathematics equips students with knowledge, skills and habits of mind that are essential for successful and rewarding participation in such a society.

The National Council of Teachers of Mathematics (1989, cited in Wynn, 2009) developed five imperatives or needs for all students in a commission. These are as follows.

(i) All students learn to value mathematics.
(ii) All students become confident in their ability to do mathematics.
(iii) All students become mathematical problem solvers.
(iv) All students learn to communicate mathematically.
(v) All students learn to reason mathematically.

According to National Council of Teachers of Mathematics (NCTM, 2000), in the 21st century, individuals who understand and can do mathematics will have significantly enhanced opportunities and options for shaping their futures. Mathematical competence opens doors to productive futures. A lack of mathematical competence keeps those doors closed. Therefore, everyone needs to understand mathematics. All students should have the opportunity and the support necessary to learn significant mathematics with depth and understanding.

Importance of Number Sense in Mathematics

According to Willoughby (1990, cited in Wynn, 2009), mathematics is a systematic approach to solving everyday problems using numbers, patterns, and logic because it encompasses number sense, estimation skills, ability to analyze data intelligently, knowledge of two and three dimensional geometry, and knowledge of probability.

Teaching mathematics with a focus on number sense encourages students to become problem solvers in a wide variety of situations and to view mathematics as a discipline in which thinking is important. Number sense was a term that become popular in the late 1980s. Number sense is a topic of great interest in school mathematics. The more clearly number sense is understood, the more likely there will be progress made in curriculum development and instruction (Walle, 2003). Therefore, number sense is an important theme in mathematics education.

Number Sense Strands

On the basis of the framework proposed by McIntosh, Reys, and Reys (1992), the following strands are developed. They are described with appropriate examples as below.

(i) Understanding of the meaning and size of numbers (Number concepts)

Understanding of the base 10 number system (whole numbers, fractions, and decimals) includes patterns and place value which provide clues to the meaning/size of a number (e.g., $\frac{5}{6}$ is a fraction less than one, it is close to one because of the relationship between the numerator and denominator). It involves relating and/or comparing numbers to standard or personal benchmarks. It includes comparing the relative size of numbers within a single representational form.

(ii) Understanding and use of equivalent forms and representations of numbers (Multiple representations)

This strand includes recognition that numbers take many different numerical and representational forms (e.g., fraction as a decimal, a whole number in expanded form, or a decimal on a number line) and can be thought about and manipulated in many ways to benefit a particular purpose. It also includes the ability to identify and/or reformulate numbers to produce an equivalent form; the use of decomposition and recomposition to reformulate numbers for ease in processing; relating and/or comparing size of numbers to a physical referent (e.g., collection of items, shaded region, or position on a number line); and crossing among various representational forms.

(iii) Understanding the meaning and effect of operations (Effect of operations)

This strand includes understanding the meaning and effect of an operation either generally or as it relates to a certain set of numbers (e.g., division means breaking a number into a specified number of equivalent subgroups or multiplying by a number less than 1 produces a product less than the other factor). It includes judging the reasonableness of a result based on understanding the numbers and operations being employed.

(iv) Understanding and use of equivalent expressions (Equivalent expressions)

This strand includes the translation of expressions to equivalent forms, often to reevaluate and/or more efficiently process a computation. It includes understanding and use of arithmetic properties (commutativity, associativity, distributivity) to simplify expressions and to develop solution strategies (e.g., the use of distributive property to multiply 7×52).

(v) Computing and counting strategies

This strand involves applying various number sense components previously described in the formulation and implementation of a solution process to a counting or computational (estimation, mental computation, paper/pencil, calculator) situation (e.g., is 29×38 more or less than 400? or how many birds do you estimate there are in this picture?).

Research Method

Research Design

The research design for this study was a descriptive research design, in which the researcher sought to determine a degree of the relationship between two or more quantifiable variables (number concepts, multiple representations, effect of operations, equivalent expressions, computing and counting strategies, and problem solving skills).

Procedure

To obtain the required data, the researcher carried out the following procedure in this study.

Step 1: Formulating the problem

Students have more difficulties in mathematics than in the other disciplines and their achievements in solving mathematical problems are not satisfactory. Moreover, their performance in solving problems involved fractions, decimals, percentage, etc. are not still mastered. In order to manipulate numbers comfortably and solve problems confidently, students must possess a sense of numbers. Furthermore, problem solving skill is an essential skill to achieve in mathematics education. In 2005, Louange and Bana also pointed out that the number sense is highly related with the problem solving skills in their research. Thus, Myanmar students' number sense, their problem solving skills, and the degree of relationship between these two elements become necessary to study.

Step 2: Compiling related literature

The researcher explored the relevant literature concerned with the research through reading the resources. Moreover, the researcher also studied the literature from the Internet sources.

Step 3: Choosing the study area

From the related literature, the researcher found five strands, such as number concepts, multiple representations, effect of operations, equivalent expressions, and computing and counting strategies, that could represent number sense. Besides, students' problem solving skill was used to study in this research. Because the researcher's purpose was to explore the relationship between students' number sense and their problem solving skills in mathematics.

Step 4: Constructing instruments and validation

The researcher constructed two tests: one for measuring the students' number sense, and the other one for measuring the students' problem solving skills in mathematics. After preparing the instruments, in order to get validation, an expert review was conducted by five experienced teachers in the field of teaching mathematics from the Department of Methodology, Yangon University of Education.

Step 5: Pilot testing

The instruments were validated through a pilot test with (50) Grade Seven students from B.E.H.S (1) East Dagon. The pilot testing for the instruments was conducted in December, 2016. The internal consistency of the number sense was (.778). The internal consistency of the test for the students' problem solving skills was (.699) by Cronbach's Alpha.

Step 6: Sampling

After the pilot test, the sample schools for this study were selected by using a stratified random sampling technique to conduct the major survey. Two high schools and one middle school from each township in Yangon Region were selected as the sample. Therefore, eight high schools and four middle schools were involved in this study. There were (600) Grade Seven students from the selected schools participated in this study.

Step 7: Data collection

The number sense test and the test for students' problem solving skills were administered to all the participants of the twelve sample schools with the help of the principals of those schools in January, 2017. The time allowed for the number sense test was anhour. The test for students' problem solving skills took for (45) minutes. After testing, the students' answer sheets for these two tests were scored manually according to the marking schemes that were validated. Then, all the data were entered into the computer data file.

Step 8: Analysis of the data

The obtained data were systematically analyzed by using the Statistical Package for the Social Science (SPSS 22) as it has been widely used in quantitative research.

Instruments

In this study, two tests, one for measuring students' number sense and the other for measuring their problem solving skills were used as the research instruments.

(i) Number Sense Test

In order to measure the students' number sense, a number sense test was constructed. It was based on number sense test published by McIntosh et al. (1997). Number sense test comprises a total of (20) multiple choice items and (20) completion items exploring five strands of number sense (see Table 1). Each correct item was scored (1) mark and thus, the total score was (40) marks. The number sense test used in this study was adapted to Myanmar version to be suitable for middle school Myanmar students.

Table 1: Table of Specifications for Number Sense Test

Strand	Number of Item								Total
	Whole Number		Fraction		Decimal		Percentage		
	MCI	CI	MCI	CI	MCI	CI	MCI	CI	
(1) Number Concepts	2	2	1	1	1	1	-	-	8
(2) Multiple Representations	2	2	1	-	-	1	1	1	8
(3) Effect of Operations	2	2	-	1	1	-	1	1	8
(4) Equivalent Expressions	2	2	1	1	1	1	-	-	8
(5) Computing and Counting Strategies	2	2	1	-	-	1	1	1	8
Total	10	10	4	3	3	4	3	3	40

Note: MCI = Multiple Choice Items, CI = Completion Items

(ii) Test for Students' Problem Solving Skills

A test for mathematical problem solving skills was constructed so as to measure the problem solving skills of the students. It was based on the content areas of Grade Seven mathematics textbooks, volume I and II, prescribed by the Department of Education, Basic Education Curriculum, Syllabus and Textbook Committee, (2015-2016) academic year. Ten problems were included for testing students' problem solving skills (see Table 2). The score of each item was (5) marks. Therefore, the total score was (50) marks.

Table 2: Table of Specifications of Test for Problem Solving Skills

Volume	Content Area	No. of Item	Mark
I	Exponents	1	5
	Square and Square Roots	1	5
	Special Products and Factoring	1	5
	Rational Algebraic Equations	1	5

Population and Sample Size

All the participants in the sample were Grade Seven students. This study was conducted in Yangon Region. There are four districts in Yangon Region. One township from each district was randomly selected for this study. The sample schools for the study were selected by using a stratified random sampling technique. Two high schools and one middle school from each township were selected as the sample. Therefore, twelve schools (eight high schools and four middle schools) were included in this study. Fifty Grade Seven students from each selected school were selected as the subjects by an equal-sized (nonproportional) random sampling technique. Therefore, the number of participants in this study was (600).

Data Analysis

The descriptive analysis techniques were used to calculate means, standard deviation and percentage. Moreover, Pearson product-moment correlation was used to describe the relationships between students' number sense and their problem solving skills in mathematics.

Research Findings

Finding of Students' Number Sense

To assess students' number sense, a number sense test was administered. Descriptive analysis techniques were used to calculate means, standard deviation and percentage of students who possessed number sense. So, all the participants were classified into three groups (low, moderate, and high) based on the mean and standard deviation of all the participants. The total score of the number sense test was (40). When the mean and standard deviation for all the participants were calculated, (22.61) and (6.603) were obtained. And then, $(+1)$ standard deviation from the mean and (-1) standard deviation from the mean were carried out. Thus, based on these results, students with scores less than (16) were identified as low group. Students with scores from (16) to (29) were considered as moderate group. Then, students with scores greater than (29) were identified as high group. In order to assess the levels of number sense, the percentage of various groups was presented in Table (3).

Table 3: Students' Level of Number Sense

Level of Number Sense	Score	No. of Student	Percentage (%)
Low	0 - 15	87	14.50%
Moderate	16 - 29	416	69.30%
High	30 - 40	97	16.20%
Total		**600**	**100%**

Finding of Students' Problem Solving Skills

To examine students' problem solving skills, a test for problem solving skills was administered. In order to calculate means, standard deviation, and percentage of students who possessed problem solving skills, descriptive analysis techniques were used. Therefore, all the participants were categorized into three groups (low, moderate, and high) based on the mean and standard deviation of all the participants. The total score of test for students' problem solving skills was (50). After the mean and standard deviation for all the participants were calculated, (19.03) and (10.407) were

received respectively. And then, (+1) standard deviation from the mean and (−1) standard deviation from the mean were performed. Thus, according to these results, students with scores less than (9) were identified as low group. Students with scores from (9) to (29) were considered as moderate group. Then, students with scores greater than (29) were identified as high group. In order to examine the levels of problem solving skills, the percentage of various groups was presented in Table (4).

Table 4: Students' Level of Problem Solving Skills

Level of Problem Solving Skills	Score	No. of Student	Percentage (%)
Low	0 - 9	68	11.30%
Moderate	10 - 29	442	73.70%
High	30 - 50	90	15.00%
Total		**600**	**100%**

Finding of Relationships between Students' Number Sense and their Problem Solving Skills

Further analysis was conducted to explore the relationships between students' number sense including five strands and their problem solving skills (see Table 5). For this purpose, Pearson product-moment correlation was used.A correlation coefficient is a decimal number which is ranged from (+1.00) to (−1.00). According to Ravid (2011), an interpretation of correlation coefficients is stated as follows.

.00 to .20 Negligible to low (a correlation of .00 would be defined as 'no correlation')
.20 to .40 Low correlation
.40 to .60 Moderate correlation
.60 to .80 High correlation
.80 to 1.00 **Substantial/Very high** (a correlation of 1.00 would be defined as a 'perfect correlation')

Table 5: Correlations between Students' Number Sense and their Problem Solving Skills

Correlation		
Number Sense Strand		**Problem Solving Skills**
Number Concepts	Pearson Correlation	**.540****
	Sig. (2-tailed)	.000
	N	600
Multiple Representations	Pearson Correlation	**.469****
	Sig. (2-tailed)	.000
	N	600
Effect of Operations	Pearson Correlation	**.412****
	Sig. (2-tailed)	.000
	N	600
Equivalent Expressions	Pearson Correlation	**.508****
	Sig. (2-tailed)	.000
	N	600
Computing and Counting Strategies	Pearson Correlation	**.505****
	Sig. (2-tailed)	.000
	N	600
Total	Pearson Correlation	**.607****
	Sig. (2-tailed)	.000
	N	600

Note: ** Correlation is significant at the 0.01 level (2-tailed)

Discussion, Suggestions, and Conclusion

Discussion

In learning mathematics, number sense is regarded as an essential area. Number sense encourages students to handle various numerical situations, to develop multiple relationships among numbers and operations, to compute comfortably and judge solutions reasonably and to make sense of the mathematics they learn rather than master rules and algorithms. Number sense is a process which is nurtured gradually. It is a foundational skill in

mathematics which can help students to become both good problem solvers and good estimators. Therefore, number sense is necessary for students in learning mathematics.

In determining the percentage of students who possessed number sense, (14.5%) of the students possessed low level of number sense, (69.3%) of the students possessed moderate level of number sense and (16.2%) of the students possessed high level of number sense. Therefore, most Grade Seven students had a moderate level of number sense. Thus, these findings revealed the answer to the first research question: To what extent do students possess number sense?

In examining the percentage of students who possessed problem solving skills, (11.3%) of the students possessed low level of problem solving skills, (73.7%) of the students possessed moderate level of problem solving skills and (15%) of the students possessed high level of problem solving skills. Therefore, most Grade Seven students had a moderate level of problem solving skills. Thus, these findings revealed the answer to the second research question: To what extent do students possess problem solving skills?

In exploring the relationship between students' number sense and their problem solving skills, there was a positively high relationship between them. Consequently, students' number sense could contribute to their problem solving skills directly. Thus, this finding revealed the answer to the final research question: Is there a relationship between students' number sense and their problem solving skills in mathematics?

To summarize, according to the research findings mentioned above, students' number sense are neither low nor high. This result indicated that Grade Seven students possessed a moderate level in the understanding of the number system, representations of numbers, and numerical operations. And then, they had in the moderate level of the use of arithmetic properties and various computation strategies such as estimation and mental computation. Especially, they were weak in multiple representations involved converting between fractions, decimals and percentage. They also had difficulty in producing the representations of fractions, decimals and percentage on the number line. Furthermore, some weaknesses were found in the performances of Grade Seven students in the test for problem solving skills. Particularly,

they had difficulties in formulating solutions from word problems and solving geometrical figures. Moreover, research findings also revealed that Grade Seven students' number sense was positively and significantly correlated with their problem solving skills. Thus, it could be concluded that number sense must be mastered in order to solve mathematics problems proficiently.

Suggestions

Number sense is a major topic for the understanding of mathematics. It is one of the essential constituents in teaching and learning mathematics. If a person has good number sense, he or she will work confidently with numerical problems both in text and in real situations. Thus, students should be equipped with such number sense in order to become good problem solvers in the future.

The most challenging strand among five number sense strands for students was multiple representations. Similarly, students had also difficulty in the area of magnitude of numbers. This causes additional difficulty in learning such as relationships between fractions, decimals and percentage. So, it is necessary for mathematics teachers to start focusing on the relationships between fractions, decimals and percentage. Moreover, the importance of the relationships of fractions, decimals and percentage to each other should be addressed and stressed in teaching and learning mathematics.

On the basis of related literature, some suggestions are given under four headings: role of teacher in developing number sense, establishing classroom atmosphere with full of number sense, teaching strategies for building number sense and for further research studies.

(i) Role of teachers in developing number sense: In order to promote number sense in students, one of the essential requirements is their teacher. Teachers play a key role in building number sense, in creating classroom atmosphere which is full of number sense, in implementing teaching strategies and in selecting activities which are the most appropriate for developing number sense. Teachers should use questions that require more than a simple factual response. Such questions can stimulate discussion of an idea, which can lead to further exploration and the use of oral language to explain and justify students' thought.

Moreover, giving oral work can improve students' performances in estimation and mental computation which are essential skills in developing number sense. So, teachers should suitably use oral work in teaching-learning process to develop number sense among the students. By selecting appropriate classroom activities, teachers should cultivate number sense during all mathematical experiences. Process-oriented activities also convey the idea of mathematics as an exciting, dynamic discovery of ideas and relationships. Integration of number sense activities into mathematics instruction will play a crucial role in increasing the performance levels of students on number sense. In this way, teachers should keep in mind and implement these suggestions to cultivate students' number sense which can foster the higher achievement in mathematics.

(ii) Establishing classroom atmosphere with full of number sense: It is important to establish a classroom atmosphere which can facilitate number sense development. Teachers can build a sense of numbers in students by creating classroom environment. Teachers should establish an atmosphere in which students are able to:

- work with concrete materials and familiar ideas,
- investigate the realistic uses of numbers in their everyday world,
- gather, organize, display and interpret quantitative information,
- explore number patterns and number relationships, and
- create alternative methods of calculation and estimation.

(iii) Teaching strategies for building number sense: To become increase in number sense, teaching strategies, such as modelling different methods for computing; asking students regularly to calculate mentally; having class discussions about strategies for computing; making estimation an integral part of computing; questioning students about how they reason numerically; and posing numerical problems that have more than one possible answer, should be utilized appropriately. Teachers should consider and apply these strategies in building number sense in students.

(iv) Further research studies: Since number sense is necessary for all the individuals, further studies concerned with students' number sense should be carried out at other various school levels. Moreover, in this study,

sample schools were randomly selected from Yangon Region. So, further studies should be carried out in other States and Regions for replication. Although other countries did a lot of experimental research about students' number sense, there was little experimental research about students' number sense in Myanmar. So, it seems to be good to conduct further studies concerned with number sense by using an experimental design. In addition, this study was dealt with five strands such as, number concepts; multiple representations; effect of operations; equivalent expressions; and computing and counting strategies, fostered number sense developed by McIntosh et al. (1997). There are other strands or components such as number estimation and using benchmarks for number sense can be developed by other educators. So, further studies using other strands or components of number sense should be conducted. Moreover, further studies which explore different methods that can improve number sense should be conducted and also extended to a larger population. Number sense is one of the foundations for promoting achievement level in solving problems. Therefore, any studies that can facilitate number sense development should be carried out in the future.

Conclusion

Today, mathematics plays a prominent role in education to cultivate thinking skills of everyone. Foundational knowledge and fundamental skills are important tools for later mathematics learning. Number sense, which is one of the essential elements in learning mathematics, must be acquired and mastered so as to become comfortable in later mathematics learning. Number sense as a sense-making activity plays a crucial role in teaching and learning mathematics. So, a substance that should not be forgotten for higher achieving in mathematics is number sense.

Similarly, problem solving skills are also important in teaching and learning mathematics. Problem solving is the heart of mathematics since mathematics is composed of various kinds of problems. To become problem solvers is one of the major aims of teaching mathematics. In the 21st century, number sense and problem solving become necessary. So, educators and researchers are highly interested in these two elements. Thus, many

researchers have been conducted various studies concerned with the number sense and problem solving skills in different areas. In the same way, the researcher would like to study the conditions of Myanmar students' number sense and problem solving skills.

Therefore, this study was conducted for investigating middle school students' number sense and problem solving skills. Thus, this study can give evidence that number sense and problem solving skills are closely related with each other. In order to become a good problem solver, the essential requirement is to make sense of numbers. Both number sense and problem solving skills are basic skills needed by today's learners. So, this study highlighted that these skills were important in teaching and learning mathematics. Thus, it is expected that this study can support, to a certain extent, the development of number sense and problem solving skills, which are crucial to get higher achievement in mathematics.

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Appendix A
(Number Sense Test)

owårwef; ausmif;om;/olrsm;\ udef;*Pef;qdkif&mem;vnfodjrifEdkifrIppfaq ;vTm

nTefMum;csuf/ /

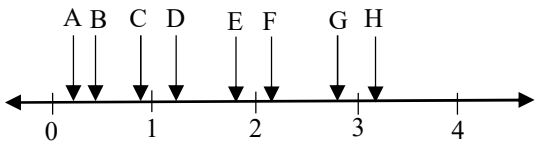
atmufygar;cGef;rsm;udkajzqdkyg/

cGifhjyKcsdef (1) em&D tydkif; (u) udef;rsm;\ t"dyÜÜg,fESifh t½G,ftpm;wdkYudk em;vnfjcif;

Understanding of the meaning and size of numbers (Number concepts)

1. 16, *, 4, 2, 1
   ay;xm;aomuddef;tpDtpOfwGif(*
)jyxm;aomae&müjznfh&rnfhudef;rSm-
   (A) 12 (B) 10 (C) 8 (D) 6 jzpfonf/
2. atmufygudef;rsm;teufrS20000ESifhfteD;qHk;udef;rS
   m-
   (A) 21536 (B) 21356(C) 21365 (D) 23165 jzpfonf/
3. atmufygwdkYrStMuD;qHk;tydkif;udef;rSm-
   (A) $\frac{5}{6}$ (B) $\frac{5}{7}$ (C) $\frac{5}{8}$ (D) $\frac{5}{9}$ jzpfonf/
4. 0.4 ESifh0.6 tMum;ü 'orudef;ta&twGufrSm-
   (A) wpfckrsSr&Sdyg/
   (B) wpfck&Sdygonf/
   (C) tenf;i,f&Sdygonf/
   (D) ajrmufjrm;pGm&Sdygonf/
5. $0 \times 3, 1 \times 4, 2 \times 5, 3 \times 6, \square$
   txufygudef;tpDtpOft&uGufvyfwGifjznfh&rnfhtajzr
   Sm -------jzpfonf/
6. 2 \qefYusifbufudef;rSm-------- jzpfonf/
7. 2ESifh3Mum; &Sdudef;wpfckudk udk,fpm;jyKrnfh
   tydkif;udef;wpfck&&Sd&ef atmufyg uGufvyf wGif
   jznfh&rnfhudef;rSm --------jzpfonf/

$\square$
8

8. 

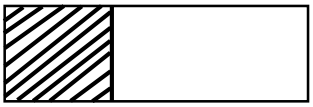
txufygudef;rsOf;t&B +
F\wefzdk;ESifhwlnDaomtu©&mrSm -------- jzpfonf/

tydkif; (c)
udef;rsm;\wlnDaom
yHkpHrsm;ESifhudk,fpm;jyKazmfjyrIrsm;udk em;vnfjcif;/ toHk;jyKEdkifjcif;

Understanding and use of equivalent forms and representations of numbers (Multiple representations)

1. ‘okn’udk-
(A)obm0udef;
(B)tajr§mufxyfwl&udef;
(C)ok'¨udef;
(D) taygif;xyfwl&udef; [kac:onf/

2. atmufygwdkYteufrStBuJD;qHk;yuwdwefzdk;rSm-
(A) -19 (B) -17 (C) 15 (D) 13 jzpfonf/

3. 

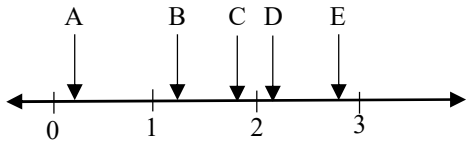
yHkwGifjc,frIef;xm;aomtpdwftydkif;udktydkif;udef;jzifhazmfjyvsSif-
(A) $\frac{1}{2}$ (B) $\frac{1}{3}$ (C) $\frac{1}{4}$ (D) $\frac{1}{5}$ jzpfonf/

4. $\frac{3}{8}$ udk&mcdkifEIef;jzifhazmfjyrnfqdkvsSif-
(A) 30% (B) 35% (C) 37.5% (D) 35.7%jzpfonf/

5. (7 × 10000) + (2 × 1000) + (4 × 10) + (8 × 1)\tajzrSm-------- jzpfonf/

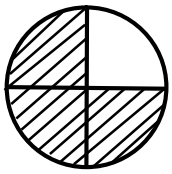
6. |−***x***|=3jzpfvsSif***x*** \wefzdk;rSm--------jzpfonf/

7.



ay;xm;aomudef;rsOf;ay:wGif 2.19 udkudk,fpm;jyKonfhtu©&mrSm -------- jzpfonf/

8.



yHkwGifjc,frIef;xm;aomtydkif;onf -------- %ESifhnDrsSonf/

tydkif; (*)

udef;qdkif&mtajccHvkyfxHk;vkyfenf;rsm;udkem;vnfjcif;

Understanding the meaning and effect of operations (Effect of operations)

1. *Pef;ESpfvHk;ygaomudef;ESpfckwdkY\ ajr§mufv'frSm-

(A)*Pef;oHk;vHk; (odkY) av;vHk;ygaomudef; &\/

(B)tpOftNrJ *Pef;av;vHk;ygaomudef; &\/

(C)wpfcgwpf&H *Pef;ig;vHk;ygaomudef; &\/

(D) *Pef;oHk;vHk; (odkY) av;vHk; (odkY) ig;vHk;ygaomudef; &\/

2. atmufygudef;rsm;teuf45 × 105\tajzESifhteD;qHk;udef;rSm-

(A) 4000 (B) 4600 (C) 5200 (D) 5800jzpfonf/

3. $29 \div 0.8$\tajzonfcefYrSef;ajctm;jzifh-
(A) 29atmufi,fonf/
(B) 29ESifhnDonf/
(C) 29 xufBuD;onf/
(D) 29 xufBuD;vnf;BuD;onf/ (odkY) nDvnf;nDonf/

4. a&avSmifuefwpfuefwGifig;aumifa&1000&Sd\/ 15%xyfwdk;vmaomfxdka&avSmifuefü&Sdaomig;aumifa&-
(A)150
(B)1015
(C)1050
(D)1150 aumif&Sdonf/

5. $(-3)+8+(-12)$\ tajzrSm------- jzpfonf/

6. $(9)\times(-2)\times(-6)$\tajzrSm -------- jzpfonf/

7. $\left(\frac{-3}{4}\right)\div\frac{9}{10}$udk&Sif;vsSiftajzrSm -------- jzpfonf/

8. jrjrüaiG 4000 usyf&Sd\/ olronf&Sdaom ydkufqH\ 90%udk tuÐs0,fvdkufaomf usefaiGrSm ------ jzpfonf/

tydkif; (C)

wlnDaomazmfjycsufrsm;udkem;vnfjcif;/toHk;jyKEdkifjcif;

Understanding and use of equivalent expressions
(Equivalent expressions)

1. $5\times \boldsymbol{w} = (5\times 20)+(5\times 3)$
ay;xm;aomnDrsSjcif;t&'$\boldsymbol{w}$'\wefzdk;rSm-
(A) 23 (B) 32 (C) 60 (D) 203jzpfonf/

2. $38 + (-27) =$ ----- + [----- + (-27)]

taygif;ajymif;jyef*kPfowådudktoHk;jyKítxufygu GufvyfESpfckwGifjznfh&rnfhudef;pHkwGJrSm-

(A) 18, 20 (B) 16, 22
(C) 11, 27 (D) 9, 29 jzpfonf/

3. atmufygwdkYteuf $\frac{-3}{2}$ ESifhwlnDaomudef;rSm-

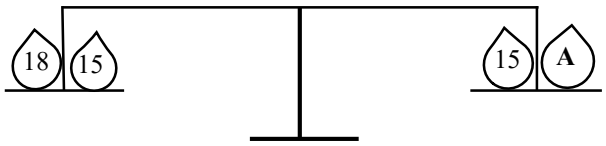
(A) $\frac{2}{3}$ (B) $\frac{3}{2}$ (C) $\frac{-3}{-2}$ (D) $-\frac{3}{2}$ jzpfonf/

4. 243 × ----- = ----- × 24.3

uGufvyfESpfckvHk;wGifjznfh&rnfhudef;rSm-

(A) 1 (B) 0 (C) 0.1 (D) 0.01jzpfonf/

5.



yHkwGifjyxm;onfhtwdkif; oauFw'**A**'\wefzdk;rSm ---------- jzpfonf/

6. [3 × -----] × $(-4) = 3 \times$ [-----× (-4)] = 24

ajr§mufjcif;qdkif&m zufpyf&*kPfowåd t& uGufvyfESpfckvHk;wGif jznfh&rnfhudef;rSm ---------- jzpfonf/

7. oknr[kwfaomudef;wpfckESifh 4if;\vSefudef;wdkYajr§mufv'frSm --------- jzpfonf/

8. $(-0.03)\,[\boldsymbol{p} + (-0.05)] = [(-0.03)(-0.04)] + [(-0.03)(-0.05)]$

txufygnDrsSjcif;rS***p***\wefzdk;rSm --------- jzpfonf/

tydkif; (i)

wGufcsufjcif; ESifha&wGufjcif; qdkif&menf;vrf;rsm;

Computing and counting strategies

aMumifwpfaumifonf4&ufwGifig; 600gudkpm;\/

· 6&ufwGifxdkaMumifonfig;-

(A) 800 g
(B) 900 g
(C) 1000 g
(D) 1100 g udkpm;onf/

c&D;wpfckudkwpfem&DvsSif 80 kmjzifhoGm;&m 6em&D

· Mum\/ tjyefc&D;wGif 4 em&D Mumonf/ toGm;tjyefc&D;ESpf&yfaygif;twGufwpfem&DvsSifysrf ;rsSoGm;EIef;rSm-

(A)96 km (B) 72 km (C) 48 km (D) 24 kmjzpfonf/

z&JoD;wpfvHk;udkav;pdwfpdwf\/xdkYaemufwpfpdwfpDu

· dkESpfydkif;pDjyefydkif;onf/ wpfzefxyfrHí wpfydkif;pDudk xuf0ufydkif;jzwfjyefaomf aemufqHk;&&Sdvmaom z&JoD;pdwf ta&twGufrSm-(A) 4 (B)8 (C)12 (D) 16pdwfjzpfonf/

250\40%onfatmufygwdkYteuf-(A)200 (B)150 (C)100 (D) 50

· ESifhwlnDonf/

0ESifh20Mum;&Sd ok'¨udef;ta&twGufrSm-------- vHk;

· &Sdonf/

reDwGifaiG750usyf&Sd\/ olr\ aiGonfrvSwGif&Sdaom

· aiGatmuf150usyf avsmhenf;vsSif rvSü&SdaomaiGrSm-- --- jzpfonf/

ausmfausmfonf

· wpfrdepfvsSifpmvHk;a&28vHk;&dkufEdkif\/ xdkEIef;jzifh 5.5 rdepfMumvsSif pmvHk;a& ----- jyD;atmif&dkufEdkifonf/

vGefcJhaomwpfywfu pmtkyfwpftkyfvsSif 350usyf

· ay;&\/ ,ck 10%avsSmha&mif;vsSif pmtkyf\wefzdk;rSm -------- jzpfonf/

Appendix B
(Test for Students' Problem Solving Skills)

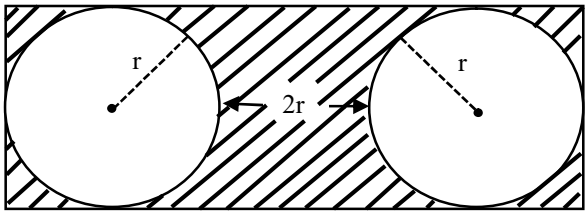
owårwef; ausmif;om;/olrsm;\ jyóem/ykpämrsm;ajz&Sif;jcif;qdkif&muRrf;us ifrIppfaq;vTm

nTefMum;csuf / / atmufygar;cGef;rsm;udkajzqdkyg/ cGifhjyKcsdef (45) rdepf

1. $2\times(\sqrt{2})^{5}\times(\sqrt{2})^{\frac{-2}{3}}=(\sqrt{2})^{a+1}$ jzpfvsSifaudk&Smyg/

2. pwk&ef;yHkoP²mef&SdaomMurf;jyifwpfck\{&dd,monf 53 pwk&ef;udkuf 7 pwk&ef;ay&Sdaomf 4if;\ tem;wpfzufudk&Smyg/

3. atmufygyHk&SdrIef;jc,fxm;aom{&d,mudkqcGJudef;yH kpHjzifhjyyg/



4. ypönf;wpfck\ wefzdk;udk 6% wdk;vdkufaomtcg xdkypönf;\ wefzdk;onf80usyfjzpfvm\/ rlvwefzdk; udk&Smyg/

5. rlvwef; ausmif;wpfausmif;ü ausmif;om; 400a,muf&Sd&m a,mufsm;av; OD;a&rSm rdef;uav;OD;a&xuf 80 a,muf ydkaomfa,mufsm;av;OD;a&ESifh rdef;uav;OD;a& toD;oD; rnfrsSpD&Sd oenf;/

6. $\ell = a + (n-1)d$ yHkaoenf;rSd y"meudef;&SdaomyHkaoenf; odkYajymif;yg/ $\ell = 200$, $a = 50$ ESifh $n = 26$ jzpfvsSif d udk&Smyg/

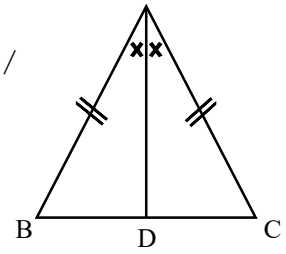
7. yHkwGif ΔABC onfESpfem;nDBwd*Hjzpfí AB =AC jzpfonf/ AD onf $\angle BAC$ \ xuf0ufydkif;rsOf;jzpfonf/

(i) $\Delta ABD \cong \Delta ACD$ jzpfygovm;/

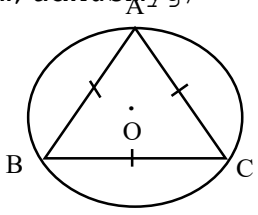
(ii) DonfBC\ tv,frSwfjzpfygovm;/

(iii) $\angle ADC = 90°$ jzpfygovm;/

taMumif;jycsufjzifhajzqdkyg/

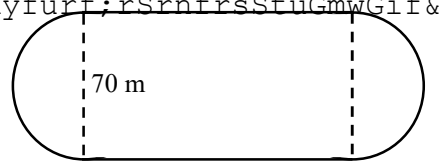


8. oHk;em;nDBwd*H\ axmifhywfpuf0dkif;ay:&Sd t0ef;ydkif;BuD; BCESifh t0ef;ydkif;i,f BCwdkY\ 'D*&Dtwdkif;twmrsm;udk&Smyg/



9. oabFmwpfpif;onfqdyfurf;rStaemufpl;pl; 8 km
tuGmodkYxGufcJhjyD; wpfzefajrmufpl;pl; 15 km
tuGmodkYxGufcJhjyef\/
oabFmonfrlvqdyfurf;rSrnfrsStuGmwGif&Sdaeoenf;/

10.



yHkonf abmvHk;uGif;wpfuGif;\ yHkjzpfonf/
*dk;aemufydkif;onf puf0dkif;jcrf;yHk jzpfonf/
tu,fí axmifhrSefpwk*HyHkabmvHk;uGif;onf tvsm;
100 m? teH 70m jzpfvsSif puf0dkif;jcrf;rsm;
tygt0if uGif;\ywfvnftem;onfrnfrsSjzpfrnfenf;/