Modeling the relationship between the basic computational and problem-solving skills of Fourth-Year high school students in the Division of Zambales, Philippines

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Abstract

The study aimed to derive a model of relationship between the basic computational and problem-solving skills of fourth-year high school students under the Basic Education Curriculum during the school year 2012-2013 using the simple linear regression analysis. A 4-item test on basic computational skills consisting of one problem each for addition, subtraction, multiplication and division of fractions, decimals, and integers was given to 324 fourth-year high school students in Zone II, Division of Zambales. Students' performance in problem-solving on number, work, distance, and geometry was evaluated using the rubrics. Index of problem difficulty was determined using item-analysis. The test scores were highest for integers; lowest for fractions. The level of performance in solving problems on integers was proficient, developing for decimals and fractions. The basic computational skills tests involving fractions and subtraction were the most difficult; tests involving integers and addition were the least difficult. The relationship between the basic computational skills in fractions and work problem-solving was described by the equation $y = 0.63x + 0.45$; $y = 0.34x + 1.74$ between decimals and geometry; $y = 0.08x + 1.68$ between integers and distance. There was a weak to moderate relationship between the test scores in basic computational and the problem-solving skills.

Keywords: Basic computational skills, Problem-solving skills, Geometry, Distance, Work

1. Introduction

For decades, the Philippines was one of the countries in Asia with high literacy level. However developing countries like Indonesia, Malaysia, Thailand, and Vietnam have achieved higher enrollment rates and achievement levels as reported by UNESCO (2003) and World Bank (2003).

The children in the Philippines are being consistently outperformed by children in other nations in mathematics achievement. According to the Trends in International Mathematics and Science Studies (TIMSS), scores of Philippine students were below average in all areas of mathematics achievement test in 2003 and placed 41st among 45 participating countries. Of the specific content areas (algebra, number sense, data analysis and probability, measurement, and geometry), the Philippines received low ranking in geometry and measurement. Mathematics is still one of the disciplines young Filipinos find difficult.

Early understanding and establishing environments for exploring mathematics play a role in judging the developmental stage of each student (Reys, Lindquist, Lambdin, Smith & Suydam, 2003). Mathematics achievement in middle school years is closely linked to the successful establishment of foundation skills in number sense in the first years of schooling. Higher level conceptual structures depend on core concepts typically acquired at age 5 or 6. Students whose core structure is not in place at the expected age will have difficulty catching up (Griffin, 2004).

Success for students in solving problems is dependent on their experience with arithmetic (Warren, 2003). Some of the common types of mathematical difficulty among students are memory for arithmetical facts, word problem-solving, representation of place value and the ability to solve multi-step arithmetic problems (Dowker, 2004). Basic knowledge and skills are taught and learned at the elementary school level that equip the learners with more advanced knowledge and understanding of basic concepts at the secondary school level. Mastery of basic knowledge and skills is a pre-requisite to achieve proficiency in Mathematics.

Difficulty in evaluating fractions, decimals and integers is attributed by many secondary school students to lack of mastery during the elementary level. Gaining knowledge of the concepts on fractions, decimals and integers has become significant learning obstacles for students at the secondary school level. These issues have been supported by the result of the examination conducted by the National Assessment of the Educational Progress (NAEP) on their seventh mathematics assessment in 2005. Findings of NAEP (2005) showed that concepts and models underlying fractions are not well-developed by grade 4 pupils. These provide probable proof of the struggle of many school children to master the concepts of fractions and decimals, and consequently its application to problem-solving.

In many schools including schools in the Philippines, lessons on decimals are taught prior to lessons on fractions, following the Philippine Elementary Learning Competencies (PELC) in Mathematics among grade 4 pupils. In the Philippines, educational reforms are continuously being implemented to develop strong educational foundation to attain lasting conceptual understanding. Despite the numerous educational reforms implemented and the various teaching strategies advocated, difficulty in problem- solving involving fractions, decimals and integers still manifests and persists among fourth-year high school students. The study on was undertaken to assess: (1) the basic computational skills in fractions, decimals and integers in problem-solving among Fourth-year High School Students in Zone II, Division of Zambales and (2) the relationship between the basic computational skills problem-solving skills.

2. Statement of the Problem

The study answered the following questions:

2.1 How may the basic computational skills of selected fourth-year high school students be described in terms of their test scores in:
- 2.1.1 fractions;
- 2.1.2 decimals; and
- 2.1.3 integers?

2.2 How may the problem-solving skills of selected fourth-year high school students be described in terms of their rubric scores using numerical and descriptive values in:
- 2.2.1 number problem;
- 2.2.2 work problem;
- 2.2.3 distance problem; and
- 2.2.4 geometry problem?

2.3 How may the students' basic computational skills be described in terms of difficulty index using item analysis?

2.4 Is there a significant relationship between the basic computational skills and the problem-solving skills?

3. Methodology

3.1 Research locale and respondents

The study used the descriptive design. It was conducted in 9 public secondary schools in Zone II, Division of Zambales, Philippines, namely: Botolan National High School, Beneg High School, New Taugtog National High School, Loob-Bunga High School, Zambales National High School, Jesus F. Magsaysay High School, Amungan National High School, Rofulo M. Landa High School and Locloc National High School. The respondents were the 324 fourth-year high school students from the first section and from the Special Science Curriculum and Special Programs for Sports.

3.2 Administration of the tests

All the respondents in the selected schools were given the tests on the basic computational skills and problem-solving skills. The respondents were given one hour to complete the tests. The 4-item test on the basic computational skills consisted of one problem each for addition, subtraction, multiplication and division of fractions, decimals and integers respectively. The test on the number, work, distance, and geometry problem-solving skills consisted of one item each on the application of the addition, subtraction, multiplication and division of fractions, decimals and integers.

3.3 Scoring of the tests

The performance in the test on the basic computational skills corresponded to the number of correct answers. The rubrics (Table 1) was used as basis for scoring the test on the problem-solving skills (adapted from TeAch-nology.com).

Table 1

Criteria	Scoring Guide (points)				Score
	4	3	2	1	
Use of Visuals	Clear diagram or sketch with some detail.	Clear diagram or sketch.	Inappropriate or unclear diagram.	No diagram or sketch.	
Mechanics	No math errors.	No major math errors or serious flaws in reasoning.	May have some serious math errors or flaws in reasoning.	Major math errors or serious flaws in reasoning.	

Demonstrated Knowledge	Shows complete understanding of the questions, mathematical ideas, and processes.	Shows substantial understanding of the questions, mathematical ideas, and processes.	Response shows some understanding of the problem.	Response shows a complete lack of understanding of the problem.
Requirements	Go beyond the requirements of the problem.	Meet the requirements of the problem.	Hardly meet the requirements of the problem.	Do not meet the requirements of the problem.
Counter Examples	Includes counter examples.		Does not include counter examples.	
Total Score				
Mean Score				

Rubrics for Evaluating Problem-solving Skills

The arithmetic mean of the rubric scores corresponds to the level of conceptual understanding and procedural skills in problem-solving. It is described as exemplary (4.0 points), proficient (3.1-3.9), developing (2.1-3.0), and emerging (1.0-2.0) following the criteria in Table 2 (adapted from TeAch-nology.com).

Table 2
Rubrics for Level of Conceptual Understanding and Procedural Skills

Points	Category of Performance	Description of Points
4.0	Exemplary	The student always exhibits clear, correct and complete interpretation and integration of the given data, the problem goal, and conditions. The student always exhibits full conceptual understanding and use of appropriate procedures for solving all the problems.
3.1-3.9	Proficient	The student shows clear, correct, and complete interpretation and integration of the given data, the problem goal, and conditions. The student shows full conceptual understanding and use of procedures for most of the problems or expressions.
2.1-3.0	Developing	The student exhibits little clear, correct and complete interpretation and integration of the given data, the problem goal, and conditions. The student exhibits little conceptual understanding and did or did not exhibit adequate use of appropriate procedures forthe problems or expression.
1.0-2.0	Emerging	The student always misinterprets or at times makes no attempt to solve the problem. The student always exhibits inadequate or no conceptual understanding and always uses incorrect procedures for the problems or expressions.

4. Results and discussion

4.1 Test scores on basic computational skills

The mean score (Table 3) was highest for the basic computational skills (addition, subtraction, multiplication and division) test on integers (3.44) and lowest for fractions (2.60). The grand mean was 3.12 out of 4 items.

Table 3
Mean score on the basic computational skills test

Expression of numerals	Mean Score
Fractions	2.60 ± 1.01
Decimals	3.31 ± 0.97
Integers	3.44 ± 0.73
Grand mean	3.12 ± 0.45
Total number of items = 4	

Fractions are among the most complex mathematical concepts and learning fractions is one of the most serious obstacles to the mathematical competence of students. One of the predominant factors contributing to the complexities of teaching and learning fractions is that the written form of fractions is comparatively complicated (Brousseau, Brosseau & Warfield, 2004). Finding the common denominator is an additional step that makes adding or subtracting fractions more confusing than multiplying or dividing. Many students find it difficult to remember the need to find a common denominator (Macrae, n.d.).

4.2 Rubric scores on problem-solving skills

The test on the number, work, distance, and geometry problem-solving skills consisted of one item each as application of the addition, subtraction, multiplication, and division of fractions, decimals and integers. Table 4 presents the data on the numerical and descriptive ratings (determined using the rubric scale from Table 1 and Table 2) for the test in solving problems.

Table 4
Numerical and descriptive ratings in problem-solving

Word problem	Fractions		Decimals		Integers	
	Numerical Rating	Descriptive Rating	Numerical Rating	Descriptive Rating	Numerical Rating	Descriptive Rating
Number	2.3	Developing	2.9	Developing	3.6	Proficient
Work	2.1	Developing	2.7	Developing	3.9	Proficient
Distance	3.3	Proficient	2.8	Developing	1.9	Developing
Geometry	1.3	Emerging	2.9	Developing	3.4	Proficient
Grand mean	2.3	Developing	2.8	Developing	3.2	Proficient

The selected students were proficient in solving number (3.6), work (3.9) and geometry (3.4) problems involving integers and in solving distance problems (3.3) involving fractions. Full or adequate conceptual understanding and use of procedures in most of the problems was shown by the students. The students manifested developing level of performance in solving the number (2.9), work (2.7), distance (2.8), and geometry (2.9) problems involving decimals. The students also showed developing level of performance in solving the number (2.3) and work (2.1) problems involving fractions. The selected students did not show adequate use of appropriate procedures in problem-solving. The emerging level of performance was shown in solving geometry problems (1.3) involving fractions. There was inadequate or no conceptual understanding of the problem, and appropriate procedures to solve the problem were not used.

Overall, the level of performance in solving problems involving integers was proficient (3.2), developing (2.8) for decimals, and developing (2.3) for fractions. These findings are consistent with the mean scores on the basic computational skills test shown in Table 3.

Computational skills are important and teaching those skills in a problem-solving context ensures that students not only understand the skills but see the meaning of learning the skill and understand how to apply it to real world situation (Ibe, 2010). The readiness of the students determines their success and their failure in the subject. If prerequisite skills are inadequate, the succeeding level will result to more complicated difficulties. The mathematics disciplines are skill-based and as such, the required skills must be mastered before moving on to the next (Silva, Tadeo, Delos Reyes &Dadigan, 2006). Word problems are the frustration of every algebra student. The main problem is usually translating the words of the problem into mathematical notation or algebraic expressions. Students know how to manipulate symbols but do not grasp the language (Macrae, n.d).

4.3 Item analysis of the basic computational skills test

Table 5 presents data on item analysis expressed as a measure of difficulty. For the basic computational skills involving fractions, the test in division where the fewest students answered the test items correctly, was the most difficult; addition was the least difficult. The measure of difficulty was 0.44 for division, and 0.99 for addition involving fractions.

Table 5
Item analysis of the basic computational skills test

Computational Skills	Fractions			Decimals			Integers			Mean
	Rc[a]	N[b]	Difficulty measure	Rc[a]	N[b]	Difficulty measure	Rc[a]	N[b]	Difficulty measure	
Addition	322	324	0.99[d]	270	324	0.83	310	324	0.96[d]	0.93[d]
Subtraction	228	324	0.70	351	324	0.78[c]	214	324	0.66[c]	0.71[c]
Multiplication	146	324	0.45	280	324	0.86[d]	301	324	0.93	0.75
Division	141	324	0.44[c]	275	324	0.85	293	324	0.90	0.73
Mean			0.65			0.83			0.86	

[a] Number of respondents who answered the test items correctly
[b] total number of respondents
[c] most difficult
[d] least difficult

Averaged across fractions, decimals and integers, the test in subtraction was the most difficult; the test in addition where most of the students answered the test items correctly, was the least difficultwith difficulty measure of 0.71 and 0.93 respectively. Averaged across addition, subtraction, multiplication and division, the test on fractions was the most difficult; the test on integers where most of the students answered the test items correctly, was the least difficult, with difficulty measure of 0.65 and 0.86 respectively. The basic computational skills tests involving fractions and subtraction were the most difficult while the tests involving integers and addition were the least difficult.

Fractions are difficult because they cannot be counted. The number of fractions between any two fractions or between any two whole numbers is infinite. Problems involving fractions require several steps. Students have to decide whether to add, subtract, multiply or divide; when to use and how to find the least common denominator, and when to reduce fractions (Smydo, 2009). The features of decimals that make them difficult for students are length, comparison, presence of zero digit and similarity with each other (Stacey, Helme, Steinle, Baturo, Irwin & Bana, 2001). Some students have not adequately made the decimal to fraction link and others have place-value difficulties. The learners assume that digits after the decimal point make another whole number.

4.4 Relationship between test scores

The model of the relationship between scores on the basic computational skills and the problem-solving skills test, described using the simple regression analysis and the Pearson-r is shown in Table 6. For the regression equation, the x- and y-variables represent the test scores on basic computational skills and problem-solving skills respectively.

The increase in the test score was highest for work (0.63) and lowest for distance (0.17) for every one unit increase in the test score on fractions. For every one unit increase in the test score on decimals, the increase was highest for geometry (0.34) and lowest for the number (0.21) test scores The increase in the test score was highest for distance (0.08) and lowest for geometry (-0.09) for every one unit increase in the test score on integers.

The data from the linear regression equations also show the y-intercept test score that refers to the test score in the problem-solving skills when the basic computational skills test score is zero. The test scores were highest for the number (3.70), work (3.75), and geometry (3.77) problem-solving skills involving integers when the score in the basic computational skills test is zero.

Table 6
Relationship between test scores

Problem-solving skill	Regression Equation	Pearson-r	
		Numerical value	Descriptive rating[a]
Fractions			
Number	y = 0.61x + 0.72	0.4185	Moderate (positive)
Work	y = 0.63x + 0.45	0.4637	Moderate (positive)
Distance	y = 0.17x + 2.84	0.1488	Modest (positive)
Geometry	y = 0.18x + 0.80	0.2212	Modest (positive)
Decimals			
Number	y = 0.21x + 2.20	0.1802	Modest (positive)
Work	y = 0.23x + 1.93	0.1824	Modest (positive)
Distance	y = 0.23x + 2.02	0.1568	Modest (positive)
Geometry	y = 0.34x + 1.74	0.2291	Modest (positive)
Integers			
Number	y = -0.04x + 3.70	-0.0274	Weak (negative)
Work	y = 0.04x + 3.75	0.0607	Weak (positive)
Distance	y = 0.08x + 1.68	0.0488	Weak (positive)
Geometry	y = -0.09x + 3.77	-0.0591	Weak (negative)

[a]Dancey and Reidy (2004)

There was moderate relationship between test scores on the basic computational skills on fractions and solving skills test on the number (0.4185) and work (0.4637) problems respectively but was modest for distance (0.1488), and geometry (0.2212) respectively. There was modest relationship between scores on the test involving decimals and scores on the number (0.1802), work (0.1824), distance (0.1568) and geometry (0.2291) problems respectively. There was weak relationship between scores on the test involving integers and scores on the number (-0.0274), work (0.0607), distance (0.0488), and geometry (-0.0591) problems respectively. Some of the causes associated with difficulties in Mathematics among Filipino students are occasional laziness, boredom, personal problems, and deficiencies in vocabulary, comprehension and study skills (Silva et al., 2006). The descriptive rating was patterned after Dancey andReidy's (2004) description of the strength of the correlation coefficient.

4.5 Test of significance of the relationship between test scores

The t-computed values (Table 7) for the number (8.269), work (9.392), distance (2.700), and geometry (4.070) skills test were greater than the t-tabular value (1.964).There was significant relationship between the test scores on fractions and the scores on the problem-solving skills test at the 0.05 level of significance.

Table 7
Test of significance of the relationship between test scores

Problem-solving skill	Pearson-r	Sample size (n)	Degree of freedom (df)	t-computed	t-tabular[c]
Fractions					
Number	0.4185	324	322	8.269*	1.964
Work	0.4637	324	322	9.392*	1.964
Distance	0.1488	324	322	2.700*	1.964
Geometry	0.2212	324	322	4.070*	1.964
Decimals					
Number	0.1802	324	322	3.287*	1.964
Work	0.1824	324	322	3.329*	1.964
Distance	0.1568	324	322	2.849*	1.964
Geometry	0.2291	324	322	4.223*	1.964
Integers					
Number	-0.0274	324	322	0.492^{ns}	1.964
Work	0.0607	324	322	1.091^{ns}	1.964
Distance	0.0488	324	322	0.877^{ns}	1.964
Geometry	-0.0591	324	322	0.000^{ns}	1.964

[c]alpha level of significance (α) = 0.05, two-tailed test
* significant at $\alpha = 0.05$
ns not significant at $\alpha = 0.05$

The t-computed values for the number (3.287), work (3.329), distance (2.849), and geometry (4.223) skills test were greater than the t-tabular value (1.964).There was significant relationship between the test scores on decimals and the scores on the problem-solving skills test at the 0.05 level of significance.

The t-computed values for the number (0.492), work (1.091), distance (0.877), and geometry (0.000) skills test were less than the t-tabular value (1.964). There was no significant relationship between the test scores on integers and the scores on the problem-solving skills tests at the 0.05 level of significance.

Students find solving fractions difficult because the natural numbers are used more often than fractions. The written form of the fractions is comparatively complicated. It is not easy to put fractions in order of size on the number line. For the arithmetic of fractions, there are many rules that are more complex than those for natural numbers or integers (Hongyu, n.d.). Some students pick shorter decimals to be larger numbers because of their inability to coordinate the numerator and denominator of a fraction (Steinle, 2001). Some students are unable to place decimal numbers in the correct order from smallest to largest.

The study of Bautista, Mulligan, and Mitchelmore (2009) showed that most of the children could not solve word problems when presented solely in written English. The children's unfamiliarity with English may prevent them from going through the recommended problem-solving steps.

5. Conclusions

1. The fourth-year high school students obtained the highest score in the basic computational skills test on integers and the lowest score in the test on fractions.

2. The level of performance in solving problems involving integers was proficient, developing for decimals, and developing for fractions.

3. For fractions, decimals, and integers, the test in subtraction was the most difficult. The test in addition was the least difficult.

4. The relationship between test scores on the basic computational skills (addition, subtraction, multiplication, and division of fraction, decimals, and integers) and the problem-solving skills (number, work, distance, and geometry) ranged from weak to moderate. There was a significant relationship between test scores on basic computational skills test on fractions and on decimals respectively and test scores on problem-solving skills.

6. Recommendations

1. The teacher should consider background knowledge before the introduction of newer, more advanced skills.

2. The teacher should provide step-by-step instruction to explain the importance of, and to illustrate when and how to apply the skill.

3. The teacher should emphasize writing of algebraic equations to learn math skills.

4. The teacher should use simple language for word problems.

5. The teacher should use a combination of demonstration by showing the students how to solve a problem, and feedback by allowing the students to solve problems on their own when introducing a new math concept.

6. To improve computation and problem-solving skills, the teachers in collaboration with parents should encourage perseverance, endurance, hard work, and dedicated practice among their students.

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