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Preservice Elementary Teachers' Proficiency in Solving Word Problems versus Computational Problems

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PRESERVICE ELEMENTARY TEACHERS' PROFICIENCY IN SOLVING WORD PROBLEMS VERSUS COMPUTATIONAL PROBLEMS

THESIS

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Abstract

The purpose of this study was to determine if preservice elementary teachers are able to solve word problems as proficiently as they can perform related computational problems on a word problem inventory. The subjects were 44 preservice elementary teachers at SUNY College at Brockport, Brockport, NY. They were enrolled in a course titled Methods in the Teaching of Elementary School Mathematics. A word problem inventory was created for this study by selecting word problems from the Addison-Wesley Mathematics series for grades 4 to 8. The inventory consisted of two parts, word problems on part 1 and computations on part 2. For the purpose of analysis, a dependent _t_ test was used to determine if there was a significant difference between the mean mathematics scores on part 2 computational problems and part 1 word problems. The amount of difference between the mean scores that was greater than the average of the related standard deviations will be the criteria which will determine if the results are educationally important. The coefficient of correlation was used to determine the degree to which computational proficiency explained word problem proficiency. The difference between the mean performance on computational problems and word problems was statistically significant. The mean scores that were obtained exceeded the criteria for educational importance. Thus, these results were educationally important. Only 50% of the variation in word problem test scores was explained by computational problem test scores. The other 50% of the variation in word problem solving ability remained unexplained.

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INTRODUCTION

Statement of the Problem

Each preservice elementary teacher, regardless of mathematical ability or inclination, is required to teach mathematics during student teaching. The mathematical backgrounds of preservice elementary teachers can be characterized as varied.

Pigge, Gibney, and Ginther (1980) surveyed approximately 300 inservice and 700 preservice elementary teachers in 1967-69 and a similar sample of teachers in 1975-77 to determine their mathematical background.

The number of years of high school mathematics that the elementary teachers completed in 1967-69 was reported to be: none--1%; one year--7%; two years--37%; three years--39%; and four or more years--16%. The percentages in 1975-77 are as follows: none--2.5%; one year--7.2%; two years--29.3%; three years--35.5%; and four or more years--25.5%.

The data for college mathematics courses indicated that in 1967-69, the majority of elementary teachers were classified in one of two categories: 39.8% had taken one college mathematics course, while 40.5% had taken two courses. Only 12.6% of the teachers reported taking three or more college mathematics courses. Seven percent of the teachers reported that they had not taken any college mathematics courses.

In contrast, 42.5% of the teachers in 1975-77 reported taking three or more college mathematics courses. A corresponding decrease in the percent of teachers taking two courses (35.5%) and one course (18%) was noted. Furthermore, only 4% of the teachers reported that they had not taken any college mathematics courses.

Book and Freeman (1986) surveyed the academic backgrounds of 174 elementary education majors at Michigan State University. Approximately one third of the students had completed less than three years of high school mathematics. Once in college, 36% of the students were required to take a remedial mathematics course.

The relationship between mathematical background and competency in mathematics has been investigated by Caraway (1985). A placement test and background questionnaire were administered to 78 entering elementary education majors at the University of Southern Mississippi. The placement test determined their competency on geometric and computational skills.

The three categories for mathematical backgrounds that were delineated for the study were: weak, average, and strong. Only 10% of the students displayed a weak background, which was identified by courses in general math, business math or algebra I. A majority of the students (59.7%) appeared to possess an average mathematics background because their courses included combinations of the three previous courses plus algebra II or geometry. Approximately 30% of the students augmented the courses in the average category with trigonometry, calculus or college level math courses to manifest a strong background in mathematics.

The results of Caraway's study revealed that a significant relationship existed between the mathematical background of the students and their competency in mathematics. It was found that the stronger the background in mathematics, the higher the mean competency score on the placement test.

Similar results on a test of mathematical understanding were reported by Pigge et al. (1980). The researchers assessed approximately 2,000 preservice and inservice elementary teachers' understanding of "principles of geometry, number theory, numeration systems, structural properties, sets, operations and fractional numbers" (p. 643).

Analysis of the data accentuated the relationship between background and performance. In both situations, the elementary teachers with more years of high school mathematics and more college mathematics courses received higher mean scores on the mathematical understanding test.

Thus, a diversity in mathematical background and competency of preservice elementary teachers is found in the current research studies. However, the fact remains that preservice elementary teachers must demonstrate an acceptable level of competence in mathematics to teach the topics in elementary mathematics, regardless of their aptitude and preparation.

For this study, a pertinent topic to investigate concerning competence is word problems. Davis and McKillip (1980) contended that "one of the most important objectives in the study of mathematics is the ability to solve [word] problems" (p. 80). This importance is underscored by the fact that word problems are encountered in almost every chapter of an elementary mathematics textbook.

Solving word problems is a complex process that incorporates reading, some form of problem interpretation, and computation. Caldwell and Goldin (1979) citing Paige and Simon (1966); Kinsella (1970); and Jerman (1973) expressed the process of solving word problems in terns of two stages: translation and computation. In the first stage, the problem solver translates, or sets up, the verbal statement as a mathematical expression or equation. Next, the problem solver computes the answer by performing the operation noted in the expression. Gagne (1983) suggested a third stage in the process that consists of validating or checking the answer to determine if the answer makes sense in the problem.

Although the research in mathematics education has extensively investigated word problems, this researcher searched the education journals and found no studies on preservice elementary teachers' proficiency to solve word problems. Therefore, a study examining their performance in solving word problems is of value in mathematics education research.

A significant aspect regarding word problems was disclosed in the second National Assessment of Educational Progress (NAEP, 1979). When the findings from the word problem section were compared with the computation section, the results revealed that "students typically did better on computational skill exercises than on word problems using the same numbers" (p. 14).

In view of those findings, it is appropriate in this study, to compare preservice elementary teachers' performance on two types of mathematical problems, word problems and computational problems. For comparison, each computational problem contains an identical mathematical operation and similar numbers to those given in the corresponding word problem.

Purpose

This research study compared preservice elementary teachers' performance in solving word problems to solving a matched set of computational problems by means of a word problem inventory. The intent of this study was to determine if preservice elementary teachers are able to solve word problems as proficiently as they can perform related computational problems. Specifically, two questions were addressed.

1. Can preservice elementary teachers interpret, set up and solve word problems to the same degree they can perform computational problems?

2. Can preservice elementary teachers obtain the correct answer for word problems to the same degree they can obtain the correct answer for computational problems?

Definition of Terms

Terms used in this study are defined as follows:

Preservice Elementary Education Teachers: College students who are completing a course of study in elementary education to become elementary teachers. In this study, the students are enrolled in a course titled Methods in the Teaching of Elementary School Mathematics prior to student teaching. The preservice elementary education teachers will be referred to as the subjects.

Word Problem: A particular type of mathematical problem that integrates a verbal statement and data. The verbal statement is interpreted or translated into a mathematical expression or equation before it is solved.

Computational Problem: A mathematical operation that is performed on a mathematical expression or equation to find the answer.

Informal Word Problem Inventory: A test created for this study which was constructed by selecting word problems from the chapters of a mathematics textbook series. The inventory is in Appendix A.

Chapter II

REVIEW OF THE LITERATURE

The literature was searched on four topics relating to preservice elementary teachers' proficiency in solving word problems. The topics are: knowledge and performance in mathematics, word problems, attitudes towards mathematics, and mathematics anxiety.

Knowledge and Performance

Preservice elementary teachers' ability to solve word problems is one facet of their overall knowledge and performance in mathematics. The literature contains a meager amount of research in the area of preservice elementary teachers' knowledge and performance in mathematics. The few studies that were found are summarized here.

Wheeler and Feghali (1983) investigated preservice elementary teachers' knowledge of zero by administering a group division test and individual interviews to 52 elementary mathematics methods students at a state university. The division test contained problems with and without zero as a dividend. Three open-ended questions for elaboration were considered. "What is zero?" "Is zero a number?" "What is zero divided by zero?"

The findings of this study indicated that the preservice teachers lacked the necessary knowledge concerning zero. Computationally, the subjects encountered difficulty dividing items in which the divisor or dividend was zero. Sixty-seven percent of the students did not know that zero divided by zero was zero. The majority of subjects were uncertain concerning the concept of zero. Only 19% of the subjects were able to answer that zero was a number.

In another study, Enochs and Gabel (1984) assessed 125 preservice elementary teachers' conceptions of volume and surface area. A 13 item multiple choice inventory was constructed that listed possible ways to calculate surface area and volume of a regular solid, a cylinder or an irregular solid. Each individual answered the items about the volume of one of the geometric figures and the surface area of another figure. The results suggested that a large majority of the preservice elementary teachers depended on the manipulation of formulas to solve the problems without fully understanding the concepts that were involved.

Olson (1977) analyzed the computational competencies of 117 prospective elementary teachers enrolled in Arithmetic for Teachers at Oklahoma State University. The prospective teachers answered 17 questions on the basic computational skills section from the National Assessment of Educational Progress (NAEP). The section assessed computational skills dealing with addition, subtraction, multiplication, and division of integers, decimals, and fractions.

When the percentage of correct responses for each item was tabulated, the results indicated that the prospective teachers demonstrated the necessary basic computational skills. Out of 17 test items, only 3 items showed a percentage of correct responses less than 90%. On each test item, the prospective teachers received higher or the same percentage of correct responses as a sample of subjects who previously took the NAEP.

Bestgen, Reys, Rybolt, and Wyatt (1980) investigated the performance of 187 preservice elementary teachers on computational estimation skills. The preservice teachers were alloted five minutes to estimate the answer to as many of the 60 computational problems as they could. On the pretest, approximately 40% of the computational problems were attempted. Of the problems attempted, only 62% were estimated correctly. After instructional estimation lessons, the post-test mean scores revealed consistent gains. In general, the preservice teachers did better on estimation problems involving addition and subtraction than on problems involving multiplication and division. It was also noted that more correct answers were given for whole number estimation problems than problems with decimals.

Word Problems

An extensive amount of literature has been published concerning word problems. The research encompasses a divergence of tasks and variables which affect word problem difficulty. For example, Caldwell (1979) cited the following eight distinct variables that had been researched in previous studies: context familiarity, number of words, sentence length, readability, vocabulary and verbal clues, magnitudes of numbers, the number and type of operations or steps, and the sequence of operations. Another variable that researchers have investigated (Muth, 1986; Threadgill-Sowder, 1983) concerns word problems with and without extraneous information. Carpenter (1985) examined the ability of young children to solve simple addition and subtraction word problems.

A survey of the literature regarding word problems includes many studies that are too diverse for the purpose of this study. Therefore, this section will focus on the one aspect of research that relates word problems to computations.

In reference to solving word problems, Ballew and Cunningham (1982) identified the following four necessary skills: reading, interpretation of the problem, computational skills, and integration of these skills into the solution of a problem. They tested a group of sixth graders to determine the proportion of students that manifested one of these skills as their main source of difficulty in solving word problems. The test consisted of three parts: problems to compute, problems to interpret, and problems to read and interpret correctly. The researchers' analysis of the data revealed that a comparable percentage of students had difficulty in each skill category. Therefore, one skill could not be identified as the main source of difficulty.

A comparison between computation and problem interpretation scores revealed that 45% of the students could compute at a higher grade level than they could interpret problems, while 17% of the students could interpret problems at a higher level. Only 12% of the students were at a higher grade level on a combination of reading and problem set up scores than they were at on computation scores.

However, 60% could compute correctly at a higher level than they could read and set up problems.

Marshall (1983) added the variable of sex differences by comparing the performance of boys and girls in solving word problems versus computational problems. Approximately 144,000 boys and 142,000 girls in the sixth grade completed the California Survey of Basic Skills. The survey was constructed following a matrix sampling basis in which each student answered only a sample of the total 68 questions dealing with whole numbers, fractions, and decimals. Although each student answered only four to six items, eighteen hundred responses were analyzed for each question. The findings indicated that as a group, the students were more successful in solving computations than in solving word problems. In regard to sex differences, the girls surpassed the boys in solving computations correctly. However, the boys were more successful in solving word problems than were the girls.

Muth (1984) studied the role of reading and computational skills in solving word problems. Two hundred sixth graders solved the arithmetic computational subtest and the reading comprehension subtest on the Comprehensive Test of Basic Skills. In addition, a 15 item word problem test was constructed and randomly administered to the students. Four versions of the test were developed by adding extraneous information and increasing the complexity of the word problems.

The grade-equivalent scores of the computational problems ranged from 1.0 to 11.9 with a mean score of 6.31. The results of the word problem test revealed that the students correctly set up 61% and correctly answered 58% of the word problems. Multiple regression analyses indicated that reading ability and computational ability accounted for 54% of the variance in correct answers. The findings suggested that success in solving word problems is dependent on reading ability and computational ability.

Attitudes Toward Mathematics

Preservice elementary teachers' attitudes towards mathematics may influence their mathematical proficiency. Several studies are presented on preservice elementary teachers' attitudes towards mathematics and how they can be improved.

It is generally believed that teachers' attitudes towards mathematics influence students' attitudes. In regard to that influence, Banks (1964) asserted that:

> the most significant contributing factor is the attitude of the teacher. The teacher who feels insecure, who dreads and dislikes the subject, for whom arithmetic is largely rote manipulation, devoid of understanding, cannot avoid transmitting her feelings to the children. On the other hand, the teacher who has confidence, understanding, interest and enthusiasm for arithmetic has gone a long way toward insuring success. (p. 17).

In a review of the mathematics attitude literature, Aiken (1970) summarized some studies that supported these opinions. However, in an update of the literature, Aiken (1976) cited a few studies that found no statistically significant relationships between teacher attitudes and the attitudes of the students.

In his update, Aiken (1976) called for more analytical research to investigate the relationships of teacher and student attitude. He declared that, "the attitudes of this group [of preservice elementary teachers] are especially important because of their potential influence on pupils" (p. 298).

To address the issue of attitude of preservice elementary teachers, Becker (1985) administered a revised version of seven of the Fennema-Sherman Mathematics Attitude Scales to 81 elementary education majors. The results found that the attitudes of the education majors were neither extremely negative nor positive. When compared to a control group of general astronomy students, the education majors possessed attitudes comparable to the astronomy group.

Bestgen et al. (1980) analyzed the attitudes of preservice elementary teachers toward computational estimation. The conclusions drawn from the data indicated that preservice elementary teachers consider estimation skills necessary, good, and beneficial.

Based on their estimation test scores, the preservice teachers were placed in an upper, average or lower group. A higher percentage of preservice teachers in the upper group indicated they liked estimation and thought it was understandable. When compared to the upper group, those in the lower group expressed less favorable attitudes.

In another study, Meeks (1982) investigated the attitude of preservice teachers in the four different concentration areas: Early Childhood Preschool, Early Childhood K-3, Intermediate 4-9, and Special Education. The results from the Revised Math Attitude Scale by Aiken and Dreger found that the four groups did not differ significantly in attitude toward mathematics. The findings suggested that, in mathematics classes, preservice elementary teachers experience fear and strain; and feel insecure and confused when solving mathematical problems. Generally speaking, these prospective teachers exhibited unfavorable attitudes toward mathematics.

Another approach in attitude research examined the relationship between attitude and achievement. Hosticka and Traugh (1981) administered the Revised Mathematics Attitude Scale (Aiken, 1974) and the Iowa Test of Basic Skills to preservice elementary and secondary students. Overall, the data indicated that the preservice teachers as a group possessed an acceptable level of skill and a reasonably positive attitude.

Aiken (1970) also compiled the findings of several previous investigators regarding the reasons preservice elementary teachers like and dislike mathematics. The major reasons for liking mathematics were practical applications and exactness. In contrast, the main reasons cited for disliking arithmetic were word problems, boring work, inadequate teachers and failure to understand.

The findings of Phillips (1973) underscored the relationship of teacher attitude to student attitude and achievement. Teacher attitude toward mathematics for the past three years was significantly related to student attitude toward mathematics. The teacher attitude was related in a positive, but weaker, way to student achievement in mathematics.

Many studies were undertaken to ascertain methods that would improve attitudes towards mathematics in preservice elementary teachers. Litwiller (1970) assessed the method of enrichment problems for changing those attitudes. One hundred forty-five preservice elementary teachers, who were enrolled in General Mathematics for Elementary Teachers, were alphabetically assigned to an experimental or control group for the duration of the course. Both groups were given Dutton's Attitude Scale as a pre- and post-test measure of attitude. The experimental group examined an enrichment problem each day during the study. The experimental group displayed a positive shift in attitude from the pre-test to the post-test. However, the control group did not exhibit as positive a shift. Litwiller concluded from his findings that enrichment problems are one means of positively changing the attitudes of preservice elementary teachers.

In a literature review, Aiken (1976) cited analogous studies that found the attitudes of preservice elementary teachers improved as a result of completing a method-content course in mathematics. However, he also presented other investigations that reported neutral results concerning experimental methods for improving attitude.

Mathematics Anxiety

Some researchers have focused on mathematics anxiety of preservice elementary teachers. That term has been interpreted as "uneasiness or apprehension regarding mathematics" (Widmer, 1982, p. 272). Kelly and Tomhave (1985) characterized mathematics anxiety as a "fear of failure when [an individual] attempts to learn the content and process of mathematics" (p. 51). Mathematics anxiety may be a factor in the degree of proficiency preservice elementary teachers exhibit in solving word problems.

Kelly and Tomhave (1985) measured the mathematics anxiety of four groups of college mathematics avoiders and a group of preservice elementary teachers with the Mathematics Anxiety Rating Scale (MARS). The preservice elementary teachers scored second highest in terms of expressing mathematics anxiety. Only the math anxious workshop group scored higher. When the scores of the women and men preservice elementary teachers were separated, the females still scored second highest on anxiety. However, the males scored lower or were less mathematics anxious than any group. Due to the small number of subjects (less than 15 in each group), the results of this study should be viewed as questionable.

In an initial investigation, Sovchik, Meconi, and Steiner (1981) tested the reliability of the Mathematics Anxiety Rating Scale (MARS) by administering it as a pre- and post-test to 59 prospective elementary teachers enrolled in a mathematics methods course. The reliability of the MARS proved to be extremely high in both cases. A tentative finding suggested that taking a mathematics methods course reduces mathematics anxiety.

In a recent study, Battista (1986) analyzed the relationship among preservice elementary teachers' success in a mathematics methods course, mathematics knowledge, and mathematics anxiety. The researcher administered a pre- and post-test of the Mathematics Anxiety Rating Scale, a mathematical competency test, and the Perdue Spatial Visualization Test to 38 preservice elementary teachers. Eight variables, which included test scores, projects, and exams were intercorrelated. The results of this inquiry indicated that preservice elementary teachers' mathematical knowledge was significantly related to their mathematics achievement. It was also found that preservice elementary teachers' mathematics anxiety did not inhibit their performance in a mathematics methods course. Furthermore, the findings of Battista supported the conclusion of Sovchik et al. (1981) that preservice elementary teachers can reduce their mathematics anxiety by taking a mathematics methods course.

Summary

This chapter reviewed some of the research findings concerning knowledge and performance of preservice elementary teachers, comparison of students' performance in solving word problems versus computational problems, and preservice elementary teachers' attitudes towards mathematics and anxiety.

The literature suggested that preservice elementary teachers lacked the necessary knowledge concerning the topics of zero and volume. The preservice elementary teachers' computational skills appeared adequate and their estimation skills improved with instruction.

The research on word problems examined the relationship among computations and a few other variables. Most results indicated that students were more successful in solving computations than word problems.

It is generally believed that teachers' attitudes towards mathematics influence students' attitudes. The findings in some of the studies investigating preservice elementary teachers' attitudes towards mathematics was conflicting. Unfavorable, reasonably positive, and neutral attitudes were reported. Enrichment and method-content courses were two methods reported to improve the attitudes of preservice elementary teachers.

The research studies measured the mathematics anxiety of preservice elementary teachers by means of the Mathematics Anxiety Rating Scale (MARS). It was suggested that mathematics anxiety can be reduced by taking a mathematics methods course.

Chapter III

DESIGN OF THE STUDY

Purpose

This research study compared preservice elementary teachers' performance in solving word problems to solving a matched set of computational problems by means of a word problem inventory. The intent of this study was to determine if preservice elementary teachers are able to solve word problems as proficiently as they can perform related computational problems. Specifically, two questions were addressed.

1. Can preservice elementary teachers interpret, set up, and solve word problems to the same degree they can perform computational problems?

2. Can preservice elementary teachers obtain the correct answer for word problems to the same degree they can obtain the correct answer for computational problems?

Hypotheses

Two hypotheses were formulated for this study:

1. Is there a statistical significant difference at the 95% confidence level between the mean mathematics scores of the preservice elementary teachers on part 2-C, computational problems calculated correctly and part 1-A, word problems correctly interpreted, set up, and solved on the informal word problem inventory? This will be tested in the null form.

2. Is there a statistical significant difference at the 95% confidence level between the mean mathematics scores of the preservice elementary teachers on part 2-D, computational problems with the correct answer only, and part 1-B, word problems with the correct answer only on the informal word problem inventory? This will be tested in the null form H_2.

Methodology

Subjects

Fifty-two preservice elementary teachers enrolled in Teaching Elementary School Mathematics at SUNY College at Brockport, Brockport, NY, served as subjects for the study. The subjects were identified as preservice elementary teachers because they had not completed student teaching and elementary teacher certification requirements.

Three subjects were eliminated from the study because they were absent for one part of the inventory. In addition, five students were deleted because they were unable to satisfactorily complete one or both parts of the inventory.

Thus, the scores of 44 subjects were analyzed for this study. Forty-two of the 44 subjects were females and 2 were males.

A survey of the mathematics courses taken by the 44 subjects revealed a diversity of mathematical backgrounds. Approximately 45% of the subjects indicated that they had not taken any mathematics courses in college. Almost an equal amount (41%) had taken one or two courses. However, only 11% had completed three to five mathematics courses. While 2%, actually one student, majored in mathematics.

Instruments

An informal word problem inventory was developed from the Addison-Wesley Mathematics series (1985) for grades 4 to 8. The inventory was divided into two parts: 1) word problem interpretation, set up, and solutions and, 2) computation. Part 1 contained 51 word problems. Part 2 contained 53 computational problems.

Word problems were selected from the basal mathematics series and assigned to the inventory by satisfying three requirements. First, each word problem was related to the topic of a specific chapter in the textbook. Also, two word problems were selected from the same page and required the same mathematical operation. The first word problem was alternately assigned to part 1, word problem interpretation, set up, and solution or part 2, computation. The second word problem was assigned to the other part. The word problems for part 1 were copied verbatim from the textbook. The word problems for part 2 were interpreted and set up in purely computational form. Two of the word problems assigned to part 2 posed an extra question. The two additional questions were interpreted and set up in computational form. Thus, part 2 contains two more questions than part 1. The informal word problem inventory is in Appendix A.

All the chapters in the basal mathematics series were not included in the inventory. Due to a publication error, chapter 1 in the seventh grade textbook was missing. Therefore, chapter 1 in the other grade level textbooks was eliminated from the inventory. Place value, measurement, and geometry were omitted from the inventory because several of these chapters did not contain two word problems on the same page or required diagrams or tables to solve the problems. The last four chapters in the eighth grade textbook were deleted because formulas were required to set up the word problems.

Procedure

The informal word problem inventory was administered to 52 subjects at the beginning of the spring 1987 mathematics methods course. The class was divided into two sections which met three times a week on alternating days. Part 1 of the inventory was administered during the first class to section one on January 21 and section two on January 23. Part 2 was administered during the second class for sections one and two on January 26 and 28, respectively. Approximately 70 minutes were allotted for the subjects to complete part 1 and 50 minutes to complete part 2.

The inventory was given to the subjects before they had received any formal class instruction for solving word problems and computation problems. The sequence that was followed in giving part 1 and part 2 was important. Part 1, which required the subject to interpret and set up the word problem, was given before part 2, which contained the word problem already interpreted and set up. This sequence prevented the subjects from receiving a clue from part 2 for the correct set up of a word problem on part 1.

The scoring of the inventory was complex. Each subject received two scores for part 1. The first score, A, signified the number of word problems correctly interpreted, set up , and solved. This score assessed the subject's ability to completely solve the word problems correctly. The second score, B, signified the number of word problems with the correct answer. Some subjects obtained the correct answer by mathematical manipulations without the correct interpretation and set up. For example, the correct answer for a proporation can be determined by manipulating the numbers as equivalent fractions. The answer will be correct although the procedure is not standard. The manipulated problems were added to score A to obtain score B.

On the second part of the inventory, each subject received two scores. The first score, C, indicated the number of computational problems with the correct answer. This score is similar to the second score on part 1. The subject manipulated the given problem into an unconventional set up and obtained the correct solution. An example of this type of answer would be a given percent calculation that was set up and solved as a proportion instead of a standard multiplication problem with a decimal.

Data Analysis

Raw scores on parts 1-A, 1-B, 2-C, and 2-D of the informal word problem inventory will be used to calculate the mean and standard deviation. The dependent _t_ test will be used to determine if there is a significant difference between the mean scores of computational problems calculated correctly, part 2-C, and word problems correctly interpreted, set up, and solved, part 1-A. In addition, the mean scores of computational problems with the correct answer only, part 2-D, and word problems with the correct answer only, part 1-B, will be analyzed with the dependent _t_ test for a significant difference. A difference between the mean scores of parts 2-C and 1-A and a difference between the mean scores of parts 2-D and 1-B that is more than the average of the related standard deviations will be the criteria which will determine if the results are educationally important. The coefficient of correlation will be used to determine the relationship between computation scores on part 2 and word problem scores on part 1. This will determine to what degree computation proficiency explains word problem proficiency.

Chapter IV

RESULTS OF THE STUDY

Analysis of Data

The data generated from the scores on the informal word problem inventory is compiled in several tables for ease of reporting. Each subject's score for computations, part 2, and word problems, part 1, with related statistical calculations are recorded in Tables 1 and 2. The scores in Table 1 are comprised of computations that are calculated correctly and word problems that are correctly interpreted, set up, and solved. Therefore, the problems were entirely correct. In table 1, the $\sum D = 418$ and the $\sum D^2 = 4{,}876$. For the scores in Table 2, the set up and calculations of each problem were not examined for correctness. Thus, these scores contain computations and word problems with the correct answer only. In table 2, the $\sum D = 289$ and the $\sum D^2 = 2{,}987$.

Table 1

Computation and Word Problem Scores for Entirely Correct Problems

Subject	Part 2-C	Part 1-A	D	D^2
1	48	35	13	169
2	43	32	11	121
3	51	44	7	49
4	47	35	12	144
5	42	28	14	196
6	47	33	14	196
7	44	33	11	121
8	43	32	11	121
9	32	28	4	16
10	43	32	11	121
11	33	33	0	0
12	46	39	7	49
13	45	34	11	121
14	32	23	9	81
15	41	27	14	196
16	41	45	4	16
17	47	34	13	169
18	35	24	11	121
19	30	25	5	25
20	47	33	14	196
21	45	40	5	25
22	45	41	4	16
23	40	34	6	36
24	42	35	7	49
25	41	36	5	25
26	49	41	8	64
27	37	26	11	121
28	44	35	9	81
29	33	25	8	64
30	51	33	18	324
31	42	34	8	64
32	46	39	7	49
33	42	34	8	64
34	49	36	13	169
35	48	35	13	169
36	48	40	8	64
37	37	33	4	16
38	48	28	20	400
39	29	20	9	81
40	46	32	14	196
41	40	32	8	64
42	35	22	13	169
43	51	34	17	289
44	49	42	7	49

Table 2

Computation and Word Problem Scores for Correct Answer Only Problems

Subject	Part 2-D	Part 1-B	D	D^2
1	50	47	3	9
2	44	34	10	100
3	51	47	4	16
4	50	43	7	49
5	46	32	14	196
6	47	40	7	49
7	45	40	5	25
8	49	40	9	81
9	34	34	0	0
10	47	37	10	100
11	36	38	-2	4
12	50	45	5	25
13	45	40	5	25
14	34	24	10	100
15	45	31	14	196
16	45	49	-4	16
17	47	37	10	100
18	38	30	8	64
19	32	30	2	4
20	48	38	10	100
21	45	48	-3	9
22	51	50	1	1
23	44	40	4	16
24	43	39	4	16
25	42	40	2	4
26	49	47	2	4
27	41	32	9	81
28	47	39	8	64
29	34	27	7	49
30	51	42	9	81
31	45	37	8	64
32	46	44	2	4
33	46	38	8	64
34	49	42	7	49
35	51	48	3	9
36	49	44	5	25
37	41	39	2	4
38	49	28	21	441
39	32	24	8	64
40	48	33	15	225
41	44	37	7	49
42	35	25	10	100
43	53	37	16	256
44	53	46	7	49

The mean, median, standard deviation, and skewness for the scores on the computational part and the word problem part of the informal word problem inventory are presented in Table 3. The average of the standard deviations for parts 2-C and 1-A for Entirely Correct Problems is 5.90. The difference between the means is 9.50. The correlation between the two variables, computations part 2-C and word problems part 1-A, is expressed in terms of $r = .70$ and $r^2 = .49$. Figure 1 furnishes a graphic representation of the relationship between the scores. For Correct Answer Only, the average of the standard deviations for parts 2-D and 1-B is 6.36. The difference between the means is 6.57. The correlation between the two variables is $r = .70$ and $r^2 = .49$. Figure 2 provides a graphic representation of the relationship between the scores.

Table 3

Analysis of Scores for Computations Part 2 and Word Problems Part 1

Part	Mean	Median	s.d.	Skewness
		Entirely Correct Problems		
2-C	42.59	43.50	5.98	-.46
1-A	33.09	33.50	5.81	-.21
		Correct Answer Only Problems		
2-D	44.80	46.00	5.79	-.62
1-B	38.23	39.00	6.93	-.33

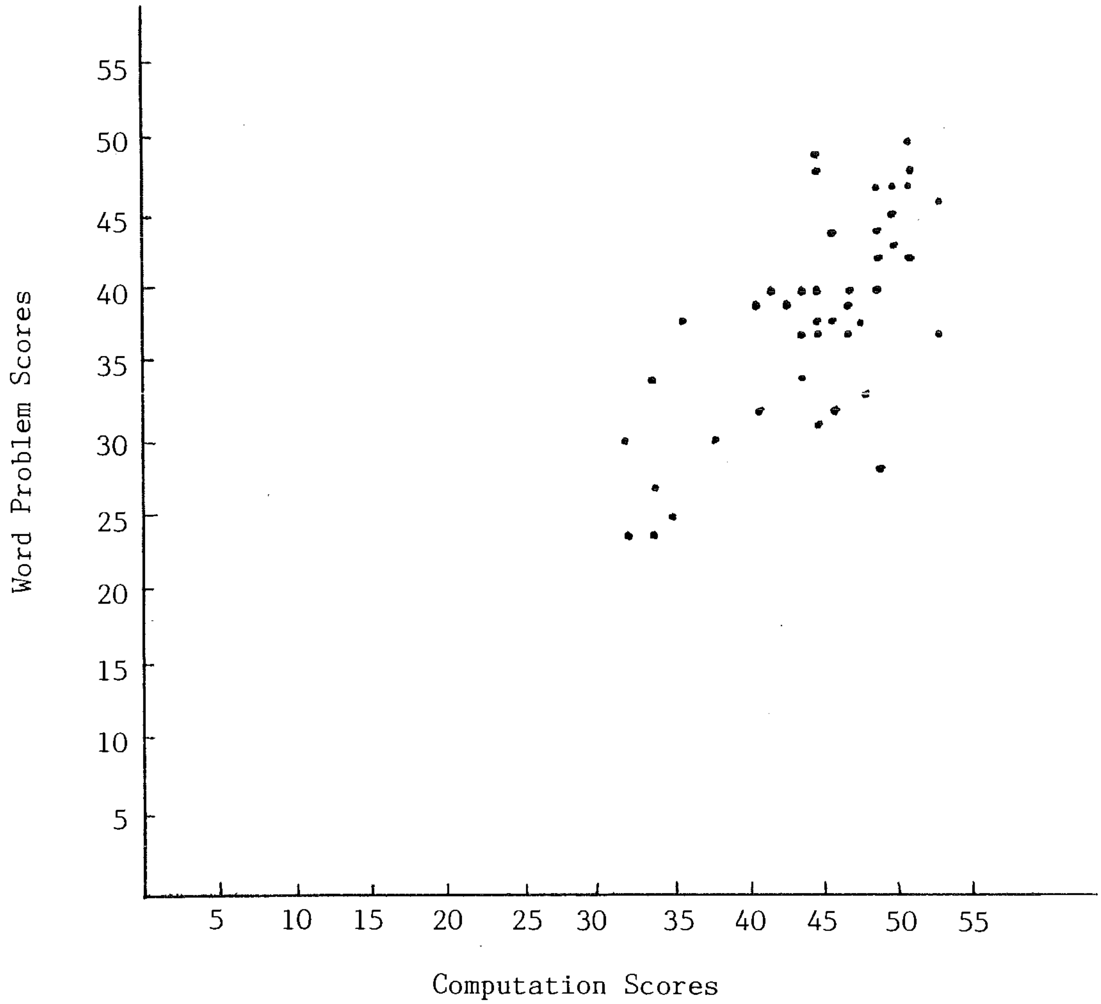

Figure 1. Relationship Between Computation Scores and Word Problem Scores Entirely Correct

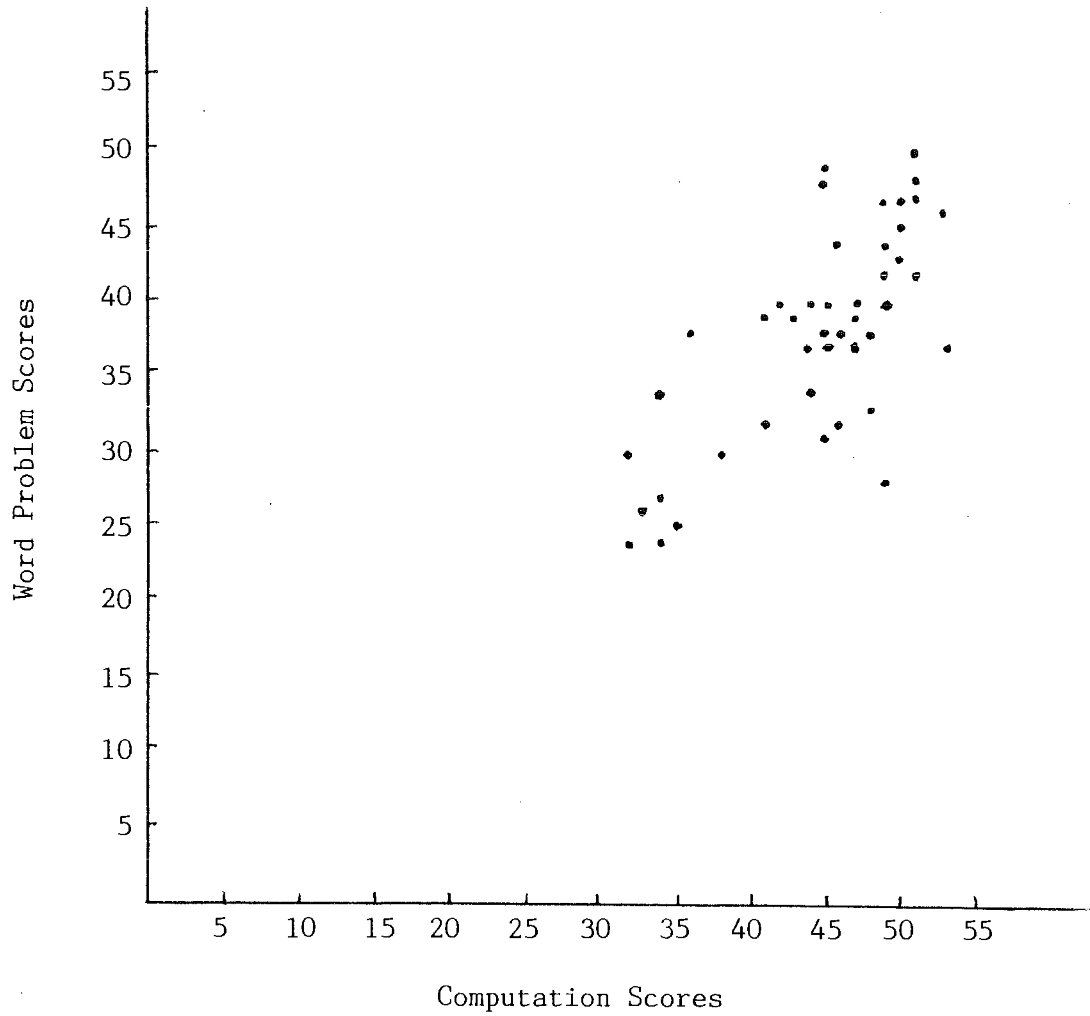

Figure 2. Relationship Between Computation Scores and Word Problem Scores With Correct Answer Only

Findings and Interpretations

t obtained for H_1

$$t = \frac{42.59 - 33.09}{\sqrt{\frac{44 * (4876) - (418)^2}{(44)^2 * 43}}} = \frac{9.50}{\sqrt{\frac{214544 - 174724}{1936 * 43}}} =$$

$$\frac{9.50}{\sqrt{\frac{39820}{83248}}} = \frac{9.50}{\sqrt{.48}} = \frac{9.50}{.69} = 13.77$$

Findings for H_1

The t required for 86 degrees of freedom at the 95% confidence level is ±2.000 and since the t obtained is 13.77, the null hypothesis is clearly rejected.

Interpretation for H_1

In this study, testing at the 95% confidence level, it was found that there is a statistical significant difference between the mean mathematics scores of the preservice elementary teachers on part 2-C, computational problems calculated correctly, and part 1-A, word problems correctly interpreted, set up, and solved, on the informal word problem inventory.

t obtained for H_2

$$t = \frac{44.80 - 38.23}{\sqrt{\frac{44 * (2987) - (289)^2}{(44)^2 * 43}}} = \frac{6.57}{\sqrt{\frac{131428 - 83521}{1936 * 43}}} =$$

$$\frac{6.57}{\sqrt{\frac{47907}{83248}}} = \frac{6.57}{\sqrt{.58}} = \frac{6.57}{.76} = 8.64$$

Findings for H_2

The *t* required for 86 degrees of freedom at the 95% confidence level is ±2.000, and since the *t* obtained is 8.64, the null hypothesis is clearly rejected.

Interpretation for H_2

In this study, testing at the 95% confidence level, it was found that there is a statistical significant difference between the mean mathematics scores of the preservice elementary teachers on part 2-D, computational problems with the correct answer only, and part 1-B, word problems with the correct answer only, on the informal word problem inventory.

Chapter V

CONCLUSIONS AND SUMMARY

Conclusions

The results that were obtained in this study are educationally important. For hypothesis H_1, the difference between the mean performance on computations and the mean performance on word problems for entirely correct problems is 9.5. The mean difference of 9.5 is educationally important because it is considerably greater than the 5.9 points established by the criteria of the average of the two standard deviations. Even when the condition of correct answers only is considered for hypothesis H_2, educational importance is still established. The difference between the mean performance on computations and the mean performance on word problems is 6.57. That value is slightly greater than the 6.36 points established by the criteria of the average of the two standard deviations.

Statistical significance is of primary importance in this study. Since the $\underline{t}$ obtained for entirely correct problems is 13.77, and since the $\underline{t}$ required at $p < 0.05$ is 2.00, the difference between the mean performance on computational problems and the mean performance on word problems is statistically significant. Furthermore, statistical significance is also established for correct answers only. Since the $\underline{t}$ obtained is 8.64, and since the $\underline{t}$ required at $p < 0.05$ is 2.00, the difference between the means is statistically significant.

Consequently, the difference between the means for both hypotheses is not ascribed to the chance of sampling. Thus, generalization of the results of this study to the population of subjects with similar characteristics is warranted.

If computational ability by itself was a good predictor of word problem solving ability, a coefficient of determination above 80% would be expected. However, in this study, r^2 equals 0.49. Thus, only 50% of the variation in word problem test scores is explained by computational problem test scores. The other 50% of the variation in word problem solving ability remains unexplained. This means that other skills in reading and organization as well as other factors such as mental set or psychological reaction are as important as computational ability in arriving at correct answers to mathematical problems that are written in a verbal statement rather than abstract numerical notation.

Discussion

The findings of this study indicated that preservice elementary teachers performed related computational problems more expertly than they were able to interpret, set up, and correctly solve word problems. In fact, when only the answers of the preservice elementary teachers were compared, computations were still performed more proficiently than word problems. The preservice elementary teachers encountered more difficulty in solving word problems because they had to first formulate the equation and operation from the given verbal data and then compute the answer.

The findings of this study supported the conclusions of the National Assessment of Educational Progress (1979). In both studies, the subjects did better in solving computations than word problems.

It was observed that some of the preservice elementary teachers omitted word problems on part 1 of the inventory. This omission may be explained in two ways. First, time constraints may have prevented some preservice elementary teachers from answering all the problems. It was necessary to work quickly and efficiently to complete all 51 word problems. If a preservice elementary teacher worked too slowly, he or she would not finish part 1. Secondly, some problems were omitted because the preservice elementary teacher did not know how to interpret and set them up. Given more time, they still would be unable to answer some questions due to lack of comprehension.

Furthermore, out of 51 word problems, 7 were incorrectly answered by more than one-half of the preservice elementary teachers. The inventory in Appendix A contains the following most often missed word problems: 18, 27, 32, 39, 43, 47, and 51. However, this research study did not attempt to determine why a majority of the preservice elementary teachers encountered difficulity in solving those particular problems.

Implications

The evidence in this study suggested that preservice elementary teachers are not adequately proficient in solving word problems. Since the preservice elementary teachers satisfactorily performed the related computations on part 2 of the word problem inventory, computations did not appear to cause this inadequacy. A possible explanation for the difficulties that preservice elementary teachers encountered in solving word problems involves their understanding of mathematical concepts.

The difficulty of understanding mathematical concepts was emphasized in a report on the results of the National Assessment of Educational Progress (NAEP). "Students appear to be learning many mathematical skills at a rote manipulation level and do not understand the concepts underlying the computation" (Carpenter, Kepner, Corbitt, Lindquist, and Reys, 1980, p.47).

In this study, it was evident that the preservice elementary teachers were able to choose an operation and compute with the numbers given in the word problems. However, this understanding was at a rote manipulation level because the depth of their mathematical understanding did not appear to extend to the rationale inherent in each word problem.

Caraway (1985) spoke of the importance of understanding mathematics and the teacher's role in the transmission of that understanding.

> If mathematics is to be taught so that children acquire a real understanding of processes and concepts, it seems obvious that teachers of mathematics must possess these understandings before attempting to transmit them to their students. (p.3).

Thus preservice elementary teachers' effectiveness in teaching word problems depends on their own understanding of the reasoning behind mathematical concepts. A thorough understanding of the rationale will guarantee that the mathematical concepts are not merely taught as formulas and operations to follow, but as relevant concepts.

Recommendations for Further Research

This study was a first-step in examining the proficiency of preservice elementary teachers in solving word problems. Therefore, further research is warranted in regard to several concerns.

Since the word problem inventory was administered at the beginning of the semester, before the preservice elementary teachers had taken the mathematics methods course, it would be valuable to administer the inventory at the end of the semester. By testing after the mathematics methods course is completed, the improvement, if any, of the preservice elementary teachers in solving word problems could be measured.

In order to gain a better understanding of why preservice elementary teachers have difficulty in solving word problems, other factors, such as reading ability and extraneous data in word problems, should be examined. Furthermore, research should attempt to determine the grade level of word problems that preservice elementary teachers can correctly solve.

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APPENDICES

APPENDIX A

Informal Word Problem Inventory - Part 1

Name:______________________________ Date:__________________

Directions: Solve the following word problems. Set up each problem and show work.

1. Yellowstone Lake is at an altitude of 2,356 m. Mt. Sheridan is 783 m higher than the lake. How high is Mt. Sheridan?

2. There are 5 packages of muffins. There are 4 muffins in a package. How many muffins are there in all?

3. There were 48 students who left the picnic early. 8 rode in each station wagon. How many station wagons were needed?

4. A penguin swims 14 km/hr. A dolphin swims 4 times as fast as a penguin. How many kilometers per hour can a dolphin swim?

5. The cook needs 250 glasses of juice for breakfast. A can of juice fills 7 glasses. How many cans should the cook open?

6. Felix brought 15 cans of juice to the party. $\frac{2}{5}$ of the cans were grape juice. How many cans of grape juice did Felix bring to the party?

7. The muffin recipe calls for $\frac{3}{4}$ c. milk and $\frac{1}{4}$ c. honey. How much more milk is used than honey?

8. Jessica sold 40 bags of tulip bulbs. There were 25 bulbs in each bag. How many bulbs did she sell?

9. The orchestra practiced 225 minutes in one week. Each practice session was 45 min. long. How many sessions did they have?

10. There are 17.9 grams of protein in a serving of lamb. The same size serving of fish has 25.2 grams of protein. How much more protein does the fish have?

11. A food stand at a zoo sold 123,678 bags of peanuts one year and 137,458 the next year. How many more bags were sold the second year?

12. A bag of plant soil cost $3.64. How much change would you give a customer who paid with a $5 bill?

13. A delivery truck travels a 96 km route each day for 19 days during the month. It also makes one longer trip of 238 km. How many kilometers of travel is that altogether for the month?

14. Each of 3 school clubs has the same number of tickets to sell for Fun Night. There are 825 tickets to sell in all. How many does each club have?

15. A mail carrier drove 6912 km. in 72 days. What was the average number of kilometers he drove each day?

16. Dave had $\frac{5}{6}$ yd. of cloth. He used $\frac{3}{4}$ yd. How much did he have left?

17. Ned sold $1\frac{3}{4}$ cases of juice on Sat. On Sun. he sold $2\frac{1}{3}$ cases. How many cases did he sell over the weekend?

18. Emilia used $\frac{1}{4}$ of $\frac{2}{3}$ of a bulletin board for announcements. What part of the bulletin board did she use?

19. Four clubs working together made $338.76 from paper they sold for recycling. If they shared the earnings, how much did each club receive?

20. There are 28 students in Tad's class. 3 out of every 4 of them play a musical instrument. How many students play a musical instrument?

21. The Excelsior diamond was the world's second-largest rough diamond. It weighed 995 carats. How much less was its weight than that of the 3,106 carat Cullinan?

22. Pete bought 3 felt-tip pens for $2 each and a calendar for $1.75. How much did he spend altogether?

23. The record speed for a space vehicle is 68 times as fast as the record speed for a jet plane. The fastest jet plane flew 3,529 km/hr. What is the record space vehicle speed?

24. A plane flew 3,520 km from San Francisco, California to Cleveland, Ohio in 4 hrs. What was the rate of speed?

25. A motor-driven camera takes a picture every 0.06 sec. How many pictures can it take during the 4.8 sec. it takes for an egg to hatch?

26. The suggested amount of overlap for a certain siding is $1\frac{1}{2}$ inches. A carpenter decided to overlap by only $1\frac{1}{8}$ inches. How much greater is the suggested overlap than the amount actually used?

27. Vicky's recipe called for $\frac{3}{4}$ c. of flour. How much flour should she use to make $\frac{1}{2}$ of the recipe?

28. The person is 2 m tall and has a shadow 3 m long. The TV tower has a shadow 90 m long. How tall is the tower?

29. Sam borrowed $500 to buy a TV set. The interest rate was 12%. How much interest must Sam pay at the end of a year?

30. Past experience shows that $\frac{3}{4}$ of Ella's customers for weekday newspapers also take the Sunday paper. Ella hopes to get 28 new customers this month. How many of the new customers might she expect to take the Sunday paper?

31. A rectangular room is 5.75 m long and 3.5 m wide. What is the area of the room's floor?

32. How much higher is an elevation of 2 km below sea level ($^{-}2$) than an elevation of 7 km below sea level ($^{-}7$)?

33. When hit, a golf ball had a speed of 28.361 m/sec. After 3 sec. in the air, the speed dropped to 19.5 m/sec. How much slower was the speed after 3 sec. in the air?

34. Lisa is covering a rectangular table with small square tiles. It will take 32 rows of tiles with 48 tiles in each row. How many tiles are needed to cover the table?

35. A ballpoint pen costs $0.69. The sales tax is 0.06 of the cost. What is the sales tax, rounded to the nearest cent? What is the total cost of the pen, including sales tax?

36. How many 0.27 liter servings are there in 3.78 L of milk?

37. When 586 m is subtracted from the height of Wheeler Peak in New Mexico, the result is the height of Mt. Hood in Oregon. Mt. Hood is 3,425 m in height. What is the height of Wheeler Peak?

38. The school record for the standing broad jump was $20\frac{1}{2}$ ft. Bonnie made a jump of $18\frac{5}{6}$ ft. How much shorter than the school record was her jump?

39. An aquarium tide pool is to be filled $\frac{7}{8}$ full of water. It takes 5 minutes to fill the tide pool $\frac{1}{4}$ full. How many minutes will it take to fill the tide pool $\frac{7}{8}$ full?

40. At a recording company, 2 out of every 7 employees are technicians. The company employs 21 people. How many are technicians?

41. On a semester test, Hanna got 65 out of 75 problems correct. What was her test score? (round to the nearest whole percent)

42. A travel agent read that the probability of rain for any day of the year in San Juan, Puerto Rico is about 55%. About how many rainy days a year are expected in San Juan?

43. Rob rode 9 km west. Then he rode 6 km east and 5 km west. How far and in what direction was he from his starting point? Write an integer equation.

44. Blair ran the first lap of a race in 59.4 sec. and the second lap in 58.7 sec. The last two laps were each 1.4 sec. longer than the second lap. What was the total time in seconds?

45. A steel beam weighs 237.6 kg and is 2.5 m long. What is the weight of each meter of length of the beam?

46. A plumber needed a pipe for a water heater connection that was $44\frac{7}{8}$ inches long. He cut that length from a pipe that was 62 inches long. What was the length of the remaining pipe?

47. Stacy found a ladybug that was $\frac{3}{16}$ in. long. She also found a cricket that was $1\frac{1}{8}$ in. long. How many times the ladybug's length was the cricket's length?

48. A cup of applesauce has 230 calories. If 190 is subtracted from the number of calories in a cup of raisins, the difference is the number of calories in a cup of applesauce. How many calories are there in a cup of raisins?

49. The temperature rose 11° to reach a high temperature of $^{-}6$°C. What was the low temperature? (Let t = the low temperature and write an integer equation.)

50. Most airlines expect that out of 85 people who have reserved tickets for a flight, 7 people will not show up. If a flight has 340 reserved tickets, about how many people will be "no shows"?

51. Helen Chinn's insurance pays for 75% of the cost of her dental surgery. The insurance paid $933.75. What was the overall cost of the surgery?

Informal Word Problem Inventory - Part 2

Name:______________________________ Date:________________

Directions: Solve each problem.

1) $\begin{array}{r} 2{,}400 \\ +\ 950 \\ \hline \end{array}$

2) 6 X 2 =

3) $9\overline{)54}$

4) $\begin{array}{r} 16 \\ \times\ 5 \\ \hline \end{array}$

5) $2\overline{)471}$

6) $\frac{2}{5}$ of 25 =

7) $\frac{5}{8} - \frac{3}{8} =$

8) $\begin{array}{r} 30 \\ \times\ 10 \\ \hline \end{array}$

9) $304 \div 38 =$

10) $\begin{array}{r} 62.35 \\ -\ 37.50 \\ \hline \end{array}$

11) $\begin{array}{r} 101{,}025 \\ -\ 93{,}791 \\ \hline \end{array}$

12) $\begin{array}{r} \$10.00 \\ -\ 3.69 \\ \hline \end{array}$

13) $\begin{array}{r} 36 \\ \times\ 24 \\ \hline \end{array}$

14) $5\overline{)760}$

15) $52\overline{)3100}$

16) $\frac{3}{5} - \frac{1}{3} =$

17) $9\frac{4}{5} + 8\frac{7}{10} =$

18) $\frac{1}{2}$ X $\frac{3}{4} =$

19) $3\overline{)35.46}$

20) find X when:

$\frac{2}{9} = \frac{X}{36}$

21) $\begin{array}{r} 1,368 \\ \underline{+\ \ 764} \end{array}$

22) $\begin{array}{r} 968 \\ \underline{+\ 787} \end{array}$

23) $\begin{array}{r} \$\ 0.65 \\ 0.45 \\ \underline{+\ \ 1.09} \end{array}$

24) $\begin{array}{r} 1,460 \\ \underline{X\ \ \ \ 7} \end{array}$

25) $4\overline{)2,760}$

26) $3 \div 0.05 =$

27) $4\frac{3}{4} - \frac{3}{8} =$

28) $\frac{2}{3}$ X $\frac{3}{4} =$

29) find X when:

$\frac{1}{2} = \frac{X}{24}$

30) 14% of $250 =

31) $\frac{2}{5}$ X 40 =

32) $\begin{array}{r} 1.75 \\ \underline{X\ 0.86} \end{array}$

33) $^{+}5 - {}^{-}3 =$

34) $\begin{array}{r} 63.111 \\ -\ 44.556 \\ \hline \end{array}$

35) $\begin{array}{r} 29 \\ \text{X}\ 24 \\ \hline \end{array}$

36) round to the nearest cent:

$\begin{array}{r} \$1.33 \\ \text{X}\ 0.06 \\ \hline \end{array}$

37) $7.5 \div 0.3 =$

38) find X when:

$X - 339 = 1{,}286$

39) $6\frac{7}{12} - 4\frac{3}{4} =$

40) $\frac{2}{3} \div \frac{1}{4} =$

41) find X when:
$\frac{2}{15} = \frac{X}{45}$

42) express as a whole percent:
$\frac{27}{32} = \qquad \%$

43) round to the nearest whole number:
$\begin{array}{r} 365 \\ \text{X}\ 0.32 \\ \hline \end{array}$

44) $^{+}8 + {}^{-}13 =$

45) $\begin{array}{r} 0.25 \\ \text{X}\ \ 25 \\ \hline \end{array}$

46) $\begin{array}{r} 1.030 \\ 1.042 \\ 1.048 \\ +\ 1.061 \\ \hline \end{array}$

47) $96.4 \overline{\smash{)}627.50}$

48) $32\frac{1}{2} - 10\frac{9}{10} =$

49) $2\frac{5}{8} \div 2\frac{7}{8} =$

50) find X when:
$X - 21 = 80$

51) find the integer X:
$X - {}^{+}8 = {}^{-}3$

52) find X when:
$\frac{64}{100} = \frac{X}{750}$

53) find X when:
$24\% \times N = 6$