THE EFFECTS OF SPECIALIZED SKILL INSTRUCTION ON THE ABILITY OF SIXTH-GRADE STUDENTS TO SOLVE MATHEMATICAL WORD PROBLEMS

DISSERTATION

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The purpose of this study was to evaluate the effects of specialized skill instruction on the ability of sixth-grade students to solve mathematics word problems. Subjects were 578 sixth graders from eight elementary schools. Researcher-developed materials were used based on seven identified content strands. Specific sections of a widely used achievement test were used to identify ability groups in both reading and mathematics and served as the pretest and posttest measures.

Three sections of the achievement test were administered at the onset of the study to students of all eight schools. The students of the four experimental schools then began to use the six packets of developed material, one per week. The section of the instrument dealing with word problems was given again as a posttest measure. Results were analyzed with the analysis of covariance procedure.

The hypotheses of the study predicted that the experimental students, who were categorized by their scores on the MAT in both reading and mathematics computation, would

achieve a significantly higher adjusted posttest score after the treatment was administered than their corresponding control group. The seven ability groups under consideration were identified as (1) High Reading-High Mathematics, (2) Medium Reading-Medium Mathematics, (3) Low Reading-Low Mathematics, (4) High Reading-Medium Mathematics, (5) Medium Reading-High Mathematics, (6) Medium Reading-Low Mathematics, and (7) Low Reading-Medium Mathematics.

Results indicated that the material was highly beneficial with those students of average mathematics ability coupled with average to high reading ability. It did not benefit students who were at low levels of ability in mathematics or reading, or who were in the high level in mathematics computation.

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CHAPTER I

INTRODUCTION

Background

In light of the back-to-basics, accountability, and competency testing movements, the subject areas considered "basic" to curriculum have received a great deal of attention. Much emphasis has been put upon a content-oriented curriculum and the resulting performance on standardized tests. Reading and mathematics curricula have individually undergone careful examination.

In Texas the acquisition of the competencies deemed necessary are measured by the Texas Assessment of Basic Skills, which is administered to all third- and fifth-grade elementary students. In the examination of pupil scores, a trend emerged that was consistent with an age-old problem--*Why it is that some academically successful students in reading and mathematics can not work math word problems?* Studies such as that conducted by Collier and Redmond (7) concluded that pupils may be very successful in their reading performance and their computation skills, yet they are not able to combine the two disciplines in a problem-solving situation.

Research has failed to show that either reading or mathematics skills are more important to pupil success in word problem solution, yet Balow (1) found that the correlation between the two was high. In fact, studies by Chase (4), Corle and Coulter (8), Vanderline (13), Fay (9), and Lyda and Duncan (12) concluded that it was the interrelationship between the two that held the key. Numerous studies, including those by Glennon and Callahan (10), Cloer (5), Chase (4), Loftus and Suppes (11), Cohen and Stover (6), Barney (2), and Burns and Yonally (3), established that there was a specific set of skills necessary to solve a verbal problem, and that there were specific factors that were known to cause difficulty. Cloer (5) cited textbook readability as a major factor in relationship to several crucial skills, while Cohen and Stover (6) concluded that format variables present in texts did affect the ability to use comprehension skills with the problems.

This study was designed to integrate the specialized skills which have been identified as essential to the solution of mathematics word problems into a instructional format.

Statement of the Problem

The problem of this study was to integrate reading, problem-solving, graphic, language, and mathematics skills so that the ability to solve word problems was increased.

Purpose of the Study

The purpose of the study was to evaluate the effects of specialized skill instruction on the ability of sixth-grade students to solve mathematical word problems.

Significance of the Study

The study focused upon the effects of specialized skill instruction on the ability of sixth-grade students to solve mathematical word problems. As reported in the Synthesis of Related Literature, several studies have sought to identify specific problem causing elements, analyze pupil errors, and establish the relationship between reading, computation, intelligence, and problem solving skills. Instruction in isolated areas such as vocabulary or problem solving strategies has proven effective. The problems associated with current textbooks have also been documented. However, the effects of specialized instruction based on a combination of specified comprehension, vocabulary, and problem solving skills compiled from an analysis of current mathematics texts and research remained to be investigated. This study was significant in that it provided a possible approach to the solution of a persistent instruction problem by combining a number of skills which have in most studies previously been treated in isolation.

Hypotheses

The following hypotheses were tested.

1. When students are categorized by scores on the MAT as being both High Reading and High Mathematics ability, and the MAT mathematics word problem section scores are used as the covariate, the experimental group, after specialized skill treatment, will achieve a significantly higher adjusted posttest score on the MAT mathematics word problem section than will the control group.

2. When students are categorized by scores on the MAT as being both Medium Reading and Medium Mathematics ability, and the MAT mathematics word problem section scores are used as the covariate, the experimental group, after specialized skill treatment, will achieve a significantly higher adjusted posttest score on the MAT mathematics word problem section than will the control group.

3. When students are categorized by scores on the MAT as being both Low Reading and Low Mathematics ability, and the MAT mathematics word problem section scores are used as the covariate, the experimental group, after specialized skill treatment, will achieve a significantly higher adjusted posttest score on the MAT mathematics word problem section than will the control group.

4. When students are categorized by scores on the MAT as being both High Reading and Medium Mathematics ability, and the MAT mathematics word problem section scores are used

as the covariate, the experimental group, after specialized skill treatment, will achieve a significantly higher adjusted posttest score on the MAT mathematics word problem section than will the control group.

5. When students are categorized by scores on the MAT as being both Medium Reading and High Mathematics ability, and the MAT mathematics word problem section scores are used as the covariate, the experimental group, after specialized skill treatment, will achieve a significantly higher adjusted posttest score on the MAT mathematics word problem section than will the control group.

6. When students are categorized by scores on the MAT as being both Medium Reading and Low Mathematics ability, and the MAT mathematics word problem section scores are used as the covariate, the experimental group, after specialized skill treatment, will achieve a significantly higher adjusted posttest score on the MAT mathematics word problem section than will the control group.

7. When students are categorized by scores on the MAT as being both Low Reading and Medium Mathematics ability, and the MAT mathematics word problem section scores are used as the covariate, the experimental group, after specialized skill treatment, will achieve a significantly higher adjusted posttest score on the MAT mathematics word problem section than will the control group.

Definition of Terms

The following terms have restricted meaning and are operationally defined for this study.

Word problems are mathematical problem situations stated in sentence form. Synonymous terms include stated problems and verbal problems.

Problem solving is the process by which a person procedes in order to derive an answer to a word problem.

High group describes those students who scored one standard deviation or more above the mean on the Metropolitan Achievement Test in a respective subject area.

Medium group describes those students who scored between one-half standard deviation below and one-half standard deviation above the mean on the Metropolitan Achievement Test in a respective subject area.

Low group describes those students who scored one standard deviation or more below the mean on the Metropolitan Achievement Test in a respective subject area.

Basic Assumption

It was assumed that the experimental materials developed for this study were used by the cooperating teachers in accordance with the guidelines and briefing provided to them.

Limitation

The instructional material developed was designed in the format of a text extender for the five mathematics textbooks currently adopted in the State of Texas. Therefore, the conclusions of this study must be limited to Texas or to those schools in which the same textbooks are used.

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CHAPTER II

SYNTHESIS OF RELATED LITERATURE

Research on several topics in both reading and mathematics education influenced the development of this study. For the purpose of discussion, this research is divided into four main areas: Problem Solving, Sources of Difficulty, Reading in Mathematics, and Instruction.

Problem Solving

Problem solving skills were identified as essential when dealing with mathematics word problems. This process was said to strongly reinforce the interplay between reading and mathematics skills, in that both are necessary if problem solving is to be effective (17).

Newcomb (63) devised a procedure for problem solving in the early 1920's that has withstood the test of time and research. In fact, it is the conceptual basis for many subsequent problem solving process designs. It involved the following eight steps: (1) understand each word in the problem; (2) read the problem intelligently; (3) add, subtract, multiply, and divide with speed and accuracy; (4) determine what is given in the problem; (5) determine the part required; (6) select the different processes to be used in the solution and the order in which these processes are to be used; (7) plan the solution wisely and systematically; and (8) check readily. In the Newcomb method, the pupil had to state the problem, determine what was given, select what was to be found, list the processes involved, give an approximate answer, arrive at a solution, and check the solution.

Polya (68) devised a model for solving problems with emphasis placed on the phases of the process. Greenes and Schulman (38) said that this model was a framework which nurtured student abilities. Generally, the phases were that the pupil (1) understood the problem, (2) devised a plan, (3) carried out the plan, and (4) looked back. Brewer (6) tested the Polya model on average fifth-grade students. No significant difference was found on the total test scores between the treatment and control groups. DeRidder and Dessart (26) designed a "directed lesson plan" based on Polya's model that they reported as highly successful. Greenes and Schulman advocated extensive use of the model because of its versatility in adapting to a variety of problem types, yet they stated that use of the traditional story problem and the Polya model "is not sufficient preparation for later mathematical problem solving" (38, p. 21). They stressed the need for nonroutine and multiple conditions formats in problems.

In 1961, Chase (17) made an effort to guide pupils through problem analysis and then to analyze results. He concluded that versatility of attack was more important than following prescribed steps in that a prescribed scheme of attack may have been incompatible with actual problem solving. Pace (65) concurred with the idea that pupils should be aware of a variety of ways and should be allowed to find and use their own methods for problem solving. He concluded that just providing the opportunities may be the most important variable, and that use of discussion to force children to clarify the structure of their methods was significant.

Wilson (88) devised her Wanted-Given Problem Structure in which pupils were taught to recognize the wanted-given structure of the problem, express the relationship in an equation, and compute the answer by using the operation indicated in the equation. Sousa (76) compared the wanted-given approach to the action sequence series approach with third-grade pupils. She concluded that the wanted-given approach was effective and educators should prepare materials in this format. Burch (10), however, found that the wanted-given approach did not improve progress and that, in fact, it was detrimental to success.

Dahmus (25) developed the DPPC (Direct, Pure, Piecemeal, Complete) Method. The key feature was to guide students through concrete translations of all the facts. Instructions were to translate the English of the problem into a series of mathematics statements. Operations were not performed and each element was translated as it occurred. Thus students had analyzed, translated, and condensed into mathematical statements all given information. Problem solving was then merely the process of working through the equations.

Maffei (58) combined variations of previously developed study skills devices which he applied to word problems. Using the SQ3R of Robinson (71) and the PQ4R of Thompson and Robinson (81) as the basis for his process, he interpreted their suggested steps uniquely. The PQ4R (Preview, Question, Read, Reflect, Recite, Review) was a "do-it-yourself" method of reading study attack which was a variation of Robinson's SQ3R (Survey, Question, Read, Recite, Review). Maffei changed the third "R" in the PQ4R method from "recite" to "rewrite." Designed for high school level, Maffei's PQ4R did find success with average and below average pupils because it gave them a system.

Krulik and Wilderman (51) reported that they found playing games beneficial in improving problem solving ability for ninth-grade students. They indicated that traditional techniques of problem solving were generally not taught in classrooms and were at best, tedious. The strategies used to play the games in their study involved the use of problem solving steps. Results indicated increased interest and enhanced analytic powers.

Cohen and Stover (20) chose thirty-five gifted sixth- and eighth-grade students with intelligence quotients of 132 and above to rewrite fifteen mathematics word problems. Analysis of data revealed twelve format changes. They then identified the variables that interfered with working mathematics word problems as the absence of a diagram, the presence of extraneous information, and incorrect order of the numbers in the stated problem. Cohen and Stover concluded that pupils who were taught to insert diagrams when working word problems were more successful and that format affected comprehension.

The research of Englehardt (32) on the effectiveness of systematic instruction, otherwise called the problem solving processes, could not be overlooked. He devised a study in which sixth-grade pupils received highly structured problem-solving process instruction from their regular teacher using normally available materials. Englehardt concluded on the basis of lack of significant difference on the posttest measure that if teachers are to significantly increase achievement, they need to use more than normally available classroom materials.

Gibney and Meiring (36) followed the instructional belief that the process was the key to problem solving, yet they took a somewhat varied instructional approach. They devised a study in which teachers, not pupils, were immersed in problem solving strategies during a two-week summer institute. Results of the study reported this tactic was highly successful. Teachers who had broader perceptions, fewer fears, and a great deal more experience in working through word problems via various processes were more competent and successful in their instruction.

Sources of Difficulty

Various studies have been conducted in an attempt to discern exactly what makes word problems difficult to master. Caldwell and Goldin, in a review of the research, effectively summarized this topic.

> Variables that have been shown to significantly affect word problem difficulty include the following: context familiarity (Brownell and Stretch, 1931), number of words (Jerman and Rees, 1972), sentence length (Jerman and Mirman, 1974), readability (Thompson, 1967; Linville, 1969), vocabulary and verbal clues (Steffe, 1967; Jerman and Rees, 1972), magnitudes of numbers (Suppes, Loftus, and Jerman, 1972), the number and type of operations or steps (Suppes et al., 1972; Whitlock, 1974; Searle, Lorton, and Suppes, 1974; Sherard, 1974), and the sequence of operations (Berglund-Gray and Young, 1940) (13, p. 323).

Chase (18) identified fifteen variables that affected a student's ability to solve a word problem. He concluded that the best three predictors of problem solving efficiency were the ability to compute the answers, noting details, and knowledge of arithmetic concepts.

Burns and Yonally (12) determined in their study of fifth graders that problems with two or three steps and mixed order problems created the most difficulty. They related the mixed order problem solution to mathematical reasoning and cautioned that lower ability pupils need special attention.

Quintero (69) also found that problems requiring two or more steps in the computation created a major source of difficulty. She concluded that there were various levels of understanding evident in the student population in regard to concepts and relationships. The concept of ratio was identified as the key source of difficulty in those problems in which it was contained.

Glennon and Callahan (37) cited general reading skills as the most important factors in problem solving efficiency. Knowledge of the vocabulary, comprehension of the problem statement, selection of relevant details, mechanical computation, and spacial factors were the skills they deemed as crucial.

Searle, Lorton, and Suppes (75) studied format variables and their affect upon CAI performance of deaf and disadvantaged pupils. They based their study upon the work of Loftus and Suppes (56) and Suppes and others (80). Loftus and Suppes (56) identified five format variables that frequently caused difficulty. They were, in order of difficulty, sequence, operation, depth, length, and conversion. Searle and Lorton (75), however, determined that there were seven variables that were key to the variation in student response. These were identified as word order, operations, algebra, addition, subtraction, division, and number of steps. Word or sentence length did not contribute significantly to the variation in student response. Thus, they concluded that a substantial portion of variability in student responses to word problems was due to structural features of the problems. The work of Threadgill-Sowder (82) further supported this conclusion. She found that question placement in word problems had no effect on problem solving ability regardless of length or complexity of the problem or age of the students.

Rosenthal and Resnick (72) studied the problem solving success of third-grade students. They found that the order of mention and the identity of the unknown set or element of the problem were significant factors in determining student success. They also found that the type of verb associated with the change set was not a determining factor in student success.

Clements (19) analyzed pupil errors of students from grades five through seven. Using data from both Newman's and Casey's studies, Clements found a large proportion of errors were in the Newman categories of Comprehension, Transformation, Process Skills, and Carelessness.

Another study examining sources of difficulty was conducted by Cohen and Stover (20). In their experimental research using sixth-grade students, they identified three format variables that caused difficulty. These were the absence of a diagram, the presence of extraneous information, and incorrect information order. Cohen and Stover reported that these variables were amenable to instruction and that as little as three class hours of direct instruction accounted for 60 per cent of the total variance.

Burns and Richardson (11) were in agreement with Zweng (90) and the National Assessment of Educational Progress Survey reported in 1980 in that they cited the operation as the key to successful problem solution. They felt that for a problem to make sense, a pupil must connect the process to the situation, and that it was in the connecting where the difficulty lay.

Reading in Mathematics

Reading in mathematics was reviewed in terms of key studies involving four areas: (a) relationship of reading and mathematics, (b) content area reading, (c) language and reading mathematics, and (d) mathematical vocabulary.

There is a wide research base which supports the theory that success in mathematics is directly related to the ability to read and interpret (18, 22, 29, 33, 57, 85). Some studies have sought to ascertain the specific relationship that exists between the disciplines of reading and mathematics. Wilson (88), in one of the earliest studies, concluded that specific training in the reading of arithmetic problems improved performance. Lessenger (54) analyzed errors on the Stanford Achievement Test to determine "mean loss" in arithmetic scores due to faulty reading. He found that after one year of instruction in which emphasis was placed on specific reading skills, poor readers showed the equivalent of nine months' growth in their arithmetic test scores. Both Marlan (59) and Stretch (79) found a rather high correlation between problem solving and reading comprehension. Balow (2) found that reading ability does have an effect on problem solving in arithmetic.

The interrelationship between reading ability, mathematics ability and intelligence has also been investigated. Riedesel (70) and Barth (4) found that direct practice on computation alone did not improve the pupil's ability to reason or solve problems. Success depended upon the learner's ability to decode the language in which the problem was stated. A dilemma arose, however, in isolating the exact variables that gave the learner the ability to work word problems. Intelligence quotients and reading ability were found to have a high correlation by both Monroe (61) and Strong (78). Brueckner (8) concluded that intelligence quotients and comprehension had a low correlation, yet intelligence quotients and mathematics vocabulary correlated to a high degree. Fay (33) identified good and poor readers with the same intelligence quotients and found that arithmetic achievement was constant. Russell (73) reported that general reading ability did not correlate highly with problem solving ability. Hansen (39) found no significant difference between good and poor arithmetic students in comprehension abilities, but poor achievers were faster readers.

Balow (2) studied this complex area of interrelationships with sixth graders. Based on standardized test results, he concluded that (1) general reading ability did affect problem solving; (2) if intelligence quotient was controlled, it reduced the correlation of reading and problem solving; (3) computation ability did affect problem solving; and (4) for a given level of computation ability, problem solving increased as reading ability increased, and for any given level of reading ability, problem solving increased as computation increased. He concluded that both computation and reading factors were important.

O'Mara (64), in her critical review of pertinent research, came to several important conclusions. These conclusions were based on studies by Harvin and Gilchrist (42), Cottrell (24), and Treacy (83). She determined that mental age scores and teacher rating were far more useful than reading ability scores as predictors of algebra achievement. Also, good readers were not necessarily good problem solvers and poor readers were not necessarily poor problem solvers. Good problem solvers were characterized by a variety of reading levels, although poor problem solvers generally had low reading levels. O'Mara went on to state that poor reading may further hinder underachievers in mathematics, but since reading ability was not directly related to problem solving ability, one cannot expect poor problem solvers to benefit from remedial reading instruction. She stated that the poor quality of research in this area may have created studies with erroneous results.

The exact relationship that exists between reading and mathematics is not known. Research has identified language ability, reading ability, computation ability, and problem solving ability as essential factors in word problem solution, yet in no study were those four areas combined and addressed instructionally.

Content Area Reading

This category of research included studies in which reading was the focus. In some cases, the characteristics of reading in other content areas were applied to mathematics (4, 41, 53). In other studies, the skills and problems associated with reading mathematics were identified and instruction suggestions were made (21, 27, 43).

Call and Wiggin (14) studied the effects of special reading instruction on word problem performance with second-year algebra students. They identified students who were good in computation but were not good in solving word problems. For ten days two teachers covered the same material, the reading teacher keying on comprehension skills and the mathematics teacher using a traditional format. They concluded that there is merit in teaching specific reading skills and that difficulty in mathematics comes from a special reading disability which may not be measured on standard measuring instruments.

Collier and Redmond, after review of important research, concluded that "not only do 'poor' readers have a problem with the language of mathematics, but pupils characterized as 'good' readers sometimes experience difficulty in reading mathematics" (21, p. 804).

Hater and others (43) identified thirteen skills used in reading the language of mathematics. These skills included knowing what to read next; finding the main idea; identifying words with many meanings; using mathematics words; seeing and understanding symbols; the speed of reading; reading with paper and pencil (note taking); reading charts and graphs; seeing what is on the page; problem solving; helps in computing; object, idea, word, symbol; and searching for meaning. Under the skill of problem solving it was suggested that the teacher could help students by teaching them to discover the question, identify relevant information, translate the information from verbal to symbolic form, use concrete situations to act out problems, recognize concepts and operations from word forms, and construct appropriate mathematical models such as number sentences and diagrams.

Dunlap (27) advocated that there was a complex process between reading story problems and computing the answer. A child must decode the story's general message, translate the general message to technical terms, and encode the concept into symbolic sentences. In those three steps alone, a child was asked to use general reading skills, decoding and encoding skills, technical and general vocabularies, and use of context clues. He suggested several activities to assist pupils, and related these activities to Bruner's levels of representation in the language experience approach.

Language Development and Mathematics

Research strongly indicates the connection between levels of language development and a pupil's performance in mathematical settings. Earp and Tanner stated that research strongly suggests that "students' success in mathematics is inextricably interwoven with their level of language sophistication" (31, p. 32). Hargis (40) found that a significant number of normal children did not have adequate language mastery for success in mathematical settings. Linville (55) concluded, in what was basically a vocabulary study, that both vocabulary and syntax of statements intended to present mathematical situations had a significant effect on students' success in problem solving.

According to Fox (34), exposure to children's literature provided real possibilities for language growth. Many literature selections were available for the development of mathematics language in particular. In fact, Margaret McIntyre (60) developed an annotated bibliography of books that relayed mathematics concepts to young children.

Burns and Richardson (11) felt that children were only ready for working with the symbols of word problems after they had developed the facility of language of the operations involved in working the word problems. A child could not connect the process to the situation in a word problem if there was no language on which to base thought. The writings of Vygotsky (86) agreed with this assumption.

Recently, Johnson (47) cited the need to refine writing in a mathematical context to enhance language skill development. He stated that students need to rewrite problems, generate their own, and begin writing computer programs. He saw writing as "a device that can greatly aid in the problem-solving process and stimulate creative thought by the student" (47, p. 19).

It is Jones (48), however, who not only advocated this line of thought, but also supplied specific instructional ideas. By basing teacher generated word problems on world records, she believed that both teacher and pupil interest were raised, discussion was stimulated, and the interrelated reading and mathematics skills would be the focus of more instructional activity.

Knight and Hargis effectively summarized the need for attention in this area.

> It may be reasonable to assume that part of the problem some children experience with math (particularly story problems) is a reading problem, and that the problem may be related to a language inadequacy. Tysinski (1963) has indicated that activities involved in teaching units in the various content areas should not only provide information about the subject area, but also recognize the child's language deficiencies and needs . . . (they) should provide the needed information <u>and</u> develop the language arts skills (50, p. 423).

It has been shown that many children do not have an adequate mastery of the language for success in mathematical situations. However, no research indicated the effects of combining language experience skills in a mathematical context with other comprehension and problem solving skills for instructional purposes.

<u>Vocabulary and Mathematics</u>

Vocabulary seems to be one aspect of reading mathematics that lends itself to more empirical research than some of the comprehension and language experience skills. Several studies of vocabulary were conducted in the format of text analysis.

Kerfoot (49) examined primary mathematics texts and compared the vocabulary to the Dale Chall list and Gates word list. In the second grade text, 17 per cent of the words were not on either list, but in the first grade text, all of the vocabulary was on both lists. He concluded that reading difficulty involved more than vocabulary, but that instruction in the anticipated vocabulary may have reduced the reading problem and may, thus, have contributed to the understanding of arithmetic concepts.

Several other studies compared reading texts to mathematics texts. Stauffer (77) found a rather extensive mismatch between the vocabulary of basal readers and mathematics texts. At the third-grade level, some 43 per cent of the words in three mathematics texts were not included in seven current basal reading texts. Willmon (87) analyzed eight series of primary level texts in which she identified 490 words used in a mathematical way, yet less than 200 of these words were repeated as many as fifty times.

The readability complications inherent in mathematics texts were examined by several studies. Schell stated that, "Research indicates that math is the most difficult content area material to read, with more concepts per word, per sentence, and per paragraph than any other area" (74, p. 544). She went on to identify the unique features of reading mathematics in an excellent summary of the topic. The readability problem of mathematics texts was also addressed by Barth (4), Hater and others (43), and Heddins and Smith (44). Beattie (5) focused upon this topic and the problems which result with special needs students. Coulter (23) was concerned with the sharp departure in both format and style of mathematics texts from reading texts, while Moulder (62) noted the extremely high concept load of the mathematics texts.

Earp and Tanner (31) studied sixth-grade students in an effort to gain further information concerning students' mastery of the vocabulary found in the basic mathematics text. Common words were decoded and comprehended with almost perfect accuracy (97.4 per cent/98.1 per cent), while the mathematical words were decoded with 92.4 per cent accuracy and comprehended with only 49.9 per cent accuracy. They concluded that the mathematics terms were not frequently used in a child's own speech and that the use of contextual clues was a powerful skill. The phraseology found in the mathematics texts, however, was not particularly helpful.

Kuzminski (52) examined the word problems found in the five currently adopted mathematics texts in Texas. Vocabulary terms were categorized by their function and placed on composite lists. She concluded that the vocabulary was limited to the extent that instruction, based upon the reinforcement of words found on her composite lists, would be both possible and profitable.

Other studies viewed the effects of vocabulary instruction. Johnson (46) found that direct instruction of arithmetic vocabulary which appeared in conjunction with the problems pupils were to solve improved their problem-solving performance. Their retention three months later was also significantly higher.

Vanderline (85) stated that knowledge of vocabulary is an essential part of instruction and that it is more important than reasoning ability. In her study of vocabulary at the fifth-grade level, she concluded that direct study was best for mastering technical and semi-technical terms but not for general vocabulary or reading comprehension. A variety of methods was desirable overall.

Capoferi (15), in a vocabulary analysis of mathematics texts, concluded that the student must be able to translate the words, phrases, sentences, and sentence combinations. This process required that the student possess four vocabularies; a verbal symbol vocabulary, a numerical symbol vocabulary, a literal symbol vocabulary, and an operational symbol vocabulary. A student must also have had possession of the ability to attack new words which may not have been encountered to be successful.

Pachtman and Riley (66) stated that without a grasp of vocabulary, students were unable to work word problems. They needed more than "talking and chalking." Citing Herber (45) and his suggestion that pupils needed a framework so that they could visually see the interrelationships, they constructed a nine-step structured overview in which vocabulary terms were arranged in a diagram format which depicted relationships.

Dunlap and McKnight (28) developed a three-level translation which described the reading and thinking process involved in conceptualizing mathematics word problems. According to them, as the child reads mathematical material, he must

> (1) perceive the written words; (2) decode these words using context, phonic, or structural analysis skill; (3) integrate the general definitions of each decoded word to arrive at a general message being conveyed in the word problem through semantic and syntactic elements; (4) translate this general message into the technical message being conveyed; (5) encode the technical message into symbolic vocabulary and sentences; (6) perform mathematical calculations on these symbols; (7) decode mathematical calculations and translate to technical vocabulary; (8) encode the technical meaning in terms of response to the technical message, i.e., translate to general vocabulary (28, pp. 183-184).

O'Mara (64) reached several conclusions concerning vocabulary based upon her review of the research. First, knowledge of general vocabulary in isolation was not significantly associated with problem solving performance. She cited the work of Arnold (1), Johnson (46), and Chase (17) in conjunction with this statement. Second, she cited Treacy (83) in the conclusion that good problem solvers had a significantly greater knowledge of the meaning of vocabulary, particular to mathematics, than did poor problem solvers. Finally, she drew from the work of Johnson (47), Vanderline (85) and Lyda and Duncan (57) to state that many experimental studies indicated little transfer of learning occurred to mathematical tasks involving other vocabulary.

It was demonstrated that instruction in reading skills in isolation increased mathematics performance; however, the effect of integrated reading and problem solving instruction was not demonstrated.

Instruction

The ideas regarding instruction keyed to increase pupil ability to deal with word problems were as varied and inconclusive as in other aspects. Barney (3) concluded that no one technique of instruction was best, while Cohen and Stover (20) stressed the large effects of instruction. Earp (29) stressed the need for specially sequenced instruction of reading skills. Freeman (35) advocated use of a study guide of programmed instruction, yet Englehardt (32) concluded that systematic instruction with normally available material did not increase achievement. Burns and Richardson (11), Dunlap (27), Bruner (9), and Piaget (67) advocated the necessity of instruction centering upon the language experience approach. Brown (7) suggested a totally individualized format using peer tutors. Carpenter (16) saw the importance of inclusion of nonroutine problems in instruction while Collier and Redmond (21) felt that instruction should include problems in which computation was not the goal.

Summary

It is thoroughly documented that word problems represent an area of instructional and learning difficulty (12, 14, 27, 29, 75, 85). Burns and Richardson (11) went so far as to surmise that because word problems were regarded as so difficult, they were deemphasized in the curriculum and, thus, instruction was reduced to the rote level. That, however, was the point at which consistent agreement ends. Since the 1920's, educators have been attempting to discern exactly why these seemingly simple written statements were so difficult for both teachers and pupils. Numerous elements and processes were isolated, revised, and tested. There were those educators who focused upon the process aspect of problem solving. Others keyed their research to those elements of word problems that caused difficulty and to error analysis. Both learning styles and instructional methods have been investigated. A large body of literature has been written concerning the importance of reading skills in mathematics, especially those dealing with vocabulary studies. Several attempts have also been made to establish the exact relationship which existed between reading skills, problem solving skills, intelligence, cognitive process, and mathematical computation, all necessary to solve a word problem successfully. The importance of readiness and the importance of developing an experiential base for the language of mathematics was also addressed.

All of the above mentioned studies dealt with various aspects of competency in solving word problems, but none of the studies cited specifically addressed the task of direct skill instruction which involved vocabulary skills, comprehension skills, study skills, problem solving processes, and mathematics language experience activities designed to supplement the current textbooks. This study sought to combine all those elements into a practical instructional format.

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CHAPTER III

METHODS AND PROCEDURES

The procedures of the study were carried out in several phases. First, based on the criteria generated from research in the field, an analysis of the currently adopted mathematics texts was conducted. Second, instructional material was created and validated. Third, an appropriate instrument was chosen to measure student improvement in ability to work mathematics word problems. Next, subjects were obtained and grouped. Fifth, separate meetings were held in order to brief teachers who would be teaching both the experimental and control groups. A pretest was administered to the students, and the treatment sessions were held. A posttest followed. Finally, the data were analyzed to test the hypotheses of the study.

Materials Development

The review of related research cited numerous educators who have expressed their concern over the characteristics and deficiencies of the word problems found in mathematics texts (3, 6, 19, 23, 25, 26, 31, 32, 35, 37, 50, 53). Begle (4), Cloer (15), and West (50) further emphasized the importance of quality texts concluding that the text was the one variable which determined what was learned. In response to the lack of quality instructional materials dealing with word problems in texts, the use of supplemental materials or text extender was suggested (31, 50). In fact, one study concluded that even systematic instruction was not sufficient to increase achievement in a classroom setting when regular teachers used normally available classroom materials (23).

The material developed for this study was based on a combination of the research findings cited earlier and "An Analysis of Stated Problems Found in Currently Adopted Fifth Grade Mathematics Texts in Texas." In that study, the following conclusions were presented.

> Data collected presented some interesting trends among the five texts. In most cases, the vocabulary was limited to the extent that instruction reinforcing the words found on the composite lists would be both possible and profitable. The inclusion of work with various comprehension skills was in no way consistent. Problems showed very little creativity in their design. In most cases, the use of mathematics stories and other devices using more than a minimum of language were not to be found. Sentence length was found to differ among books, along with the number of technical clue/signal words, and possibly misleading terms. . . . If students are faced with problems involving few difficult features, they then will never learn to deal with these functions. Only through instruction and practice can they become familiar with and proficient in using the various specialized comprehension and vocabulary skills necessary to solve many stated problems. None of the texts examined appeared to offer a planned sequence of experiences specifically designed to improve problem solving skills, even though children are held responsible for solving stated problems by all of the competency tests currently in vogue. These facts clearly indicate the need for supplementary materials focused upon the development of this complex set of concepts and skills (31, pp. 23-24).

In preparation for this study, input was gathered regarding materials development. An informal survey of selected intermediate grade teachers demonstrated a willingness to use the projected program in a design calling for two and one-half hours of instruction per week. They also stated a preference for a mixed activity format utilizing whole class and small group activities. No interest was expressed in using learning centers.

Theoretical Model

The materials developed for this study were designed using an interrupted spiral as the curriculum model (see Figure 1). Common strands ran throughout the material, yet various areas were stressed in some instances. The material format was a packet. Each packet, developed around a particular theme, contained two and one-half hours of instructional material, including complete teacher's directions and the activities for the students. Guidelines for the teachers were included which specified the exact procedure and sequence to be used in this study. Also, each teacher's page for each activity contained the stated purpose, the necessary skills, the content strands on which the activity was based, the materials, a time allotment, a suggested class organization, activity preparation, and guidelines for the activity. The six packets were manageable in size, required little teacher preparation, and approached a text

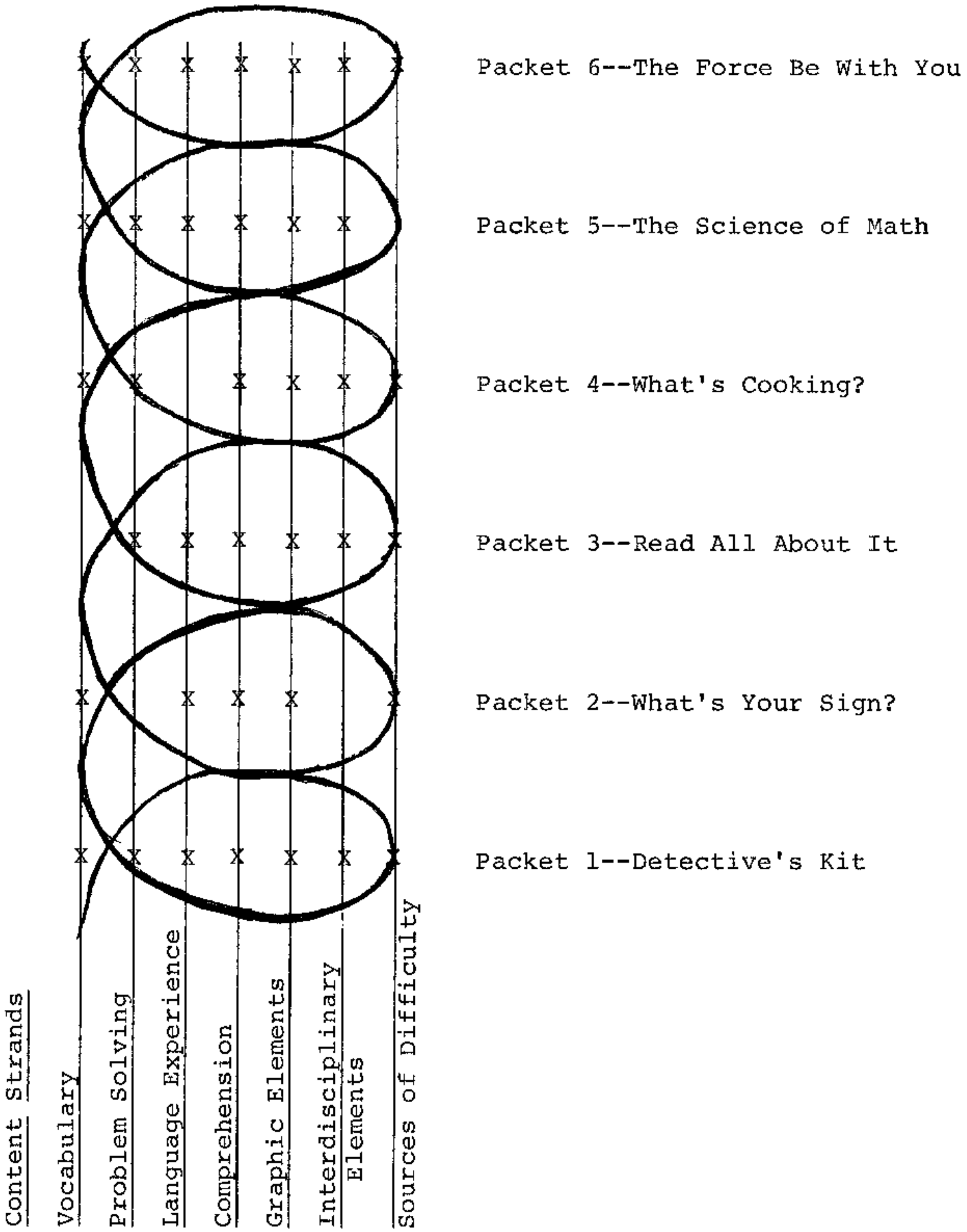

Fig. 1--Theoretical Model (Note: X denotes that instructional material dealt with in that content strand.)

format. They were carefully sequenced, and, in appropriate situations, the materials gradually increased in difficulty and complexity.

Content selected for the packets was based on current research. Throughout a review of the research, it was apparent that no one area of instruction, process, or isolated set of skills was solely responsible for increasing pupil success in working word problems. Several significant categories of these elements, however, emerged. It was these categories that were the basis for the content strands that run throughout the packets in differing degrees of intensity.

Each content strand contained several component parts. The vocabulary strand encompassed the necessary technical, operational, and multi-meaning words as well as the importance of the verb and significant abbreviations. Items were included based on the work in this area of Barney (1), Hater and others (28), Kerfoot (30), Schell (46), Coulter (19), Earp and Tanner (22), Kuzminski (31), Johnson (29), Vanderline (49), Capeferi (11), and Pachtman and Riley (40).

Another strand, that of the problem solving process, introduced several different process models and interjected the skills of note-taking and diagraming. The research base for this strand came from the work of Newcomb (38), Polya (42), Chase (13), Pace (39), Wilson (51), Maffei (34), and Cohen and Stover (16).

The language experience strand addressed the crucial element of verbal interaction. Not only did the students practice writing in the language of mathematics, they also talked to each other and with the teacher. Discussion and direct instruction were key features found throughout the material. Burns and Richardson (6), Dunlap (20), Bruner (5), and Piaget (41) all stressed the importance of this.

Comprehension was another area of concern. Skills in this strand included mainly common reading activities tailored to the special area of mathematics reading. Main ideas, details, sequencing, and use of context clues were representative of the skills presented as suggested by Chase (13), Corle and Coulter (18), Barth (2), Less (32), Call and Wiggin (9), Collier and Redmond (17), Hater and others (28), and Dunlap (20).

The graphic skills strand encompassed the use of charts, reading in different directions, and practice with numerous mathematics symbols. Collier and Redmond (17), Hater and others (28), Schell (46), and Smith and Kepner (47) all cited the need for these skills.

Another strand, the interdisciplinary one, presented mathematics in a larger scope for students in that it interwove this study of word problems with literature, science, and social studies. The importance of this interdisciplinary approach was advocated by Kuzminski (31), Carpenter (12), Fox (24), and McIntyre (36).

In the final category, the material contained some instruction and practice in dealing with the elements identified as potential sources of difficulty. Areas addressed included information out of order, problems with several steps, multi-conditional problems, varying sentence length, and extraneous and insufficient data. Caldwell and Goldin (8), Chase (13), Burns and Yonally (7), Loftus and Suppes (33), Rosenthal and Resnick (45), Clements (14), and Burnes and Richardson (6) have all done extensive work in these areas.

Specific activities within each content strand were selected and designed on the criteria that they provide practice in one or more of the identified content areas, were simple to implement, and could be adjusted to approach a mathematics text format. The material was unique in that much of it was based upon the analysis of word problems in five currently adopted mathematics texts in Texas. Vocabulary and problem elements known to be in the texts were reinforced and then extended. Relevance and practicality in the classroom setting were paramount (see Appendix for material).

Material Validation

The content validity of the developed material was based upon the judgment of a panel of experts. This panel consisted of one mathematics educator, one reading educator, one upper-level elementary teacher familiar with mathematics and reading at the elementary level. At least three of the four experts were in agreement as to the validity of each activity for it to be included in the instructional packets. Revisions based on the suggestions made by the experts were incorporated into the material so that the highest degree of validity was obtained.

Instrument

The instruments selected as the pretest measure were specific sections of the Metropolitan Achievement Test (MAT), Intermediate Form F. Test 2: Reading Comprehension and Test 5: Mathematics Computation served as the criteria for the ability grouping of the students. Test 7: Mathematics Problem Solving was the actual pretest measure. This widely used achievement battery was copyrighted in 1970 by Harcourt Brace Jovanovich, Inc. For the purposes of this study, only Test 7: Mathematics Problem Solving was given as the post-test measure. In examining the MAT, it was determined that the problems closely paralleled in format and difficulty those found in the currently adopted mathematics texts in Texas. This fact was of particular importance because the designers of this test state that the MAT has content validity for each situation only "if the test items adequately cover the curricular areas that the test is supposed to evaluate" (21, p. 16). The content of the packets was, however, developed after extensive analysis of current curricular materials, including leading textbook series, syllabi, state guidelines, and other curricular sources. The MAT has undergone extensive classroom tryout, detailed and selective item analysis, and a national standardization process. The reliability data for the Intermediate Battery provided the split-half (odd-even) coefficients, corrected by the Spearman-Brown formula, Saupe's estimate of the Kuder-Richardson Formula 20 reliability, and standard errors of measurement in terms of raw score, standard score, and grade equivalence. The standard errors of measurement were based on use of the split-half coefficient. Data for the Mathematics Problem Solving Test indicated that the overall reliability was .89.

Further investigation was conducted in ensure the suitability of the MAT for the study. It was confirmed by several sources that the reliability estimates based on internal consistency were typically .90 or higher for each of the various tests (27, 52). Wolf (52) reported that the reading tests were outstanding, the word problems were good, the standard error was low, and the overall battery was satisfactory. Riedesel (43) stated that the reading level of the problem solving section was well controlled, the technical vocabulary was suitable, and that the MAT was superior in the problem solving area when compared to other comparable tests.

The MAT was developed as a result of three years of prepublication research involving approximately 250,000 pupils and their teachers. The content was valid in regard to current local curriculum, and the reliability was satisfactory.

Selection of the Sample

Approval to conduct the study was obtained from the curriculum director of a metropolitan school district. The administrator presented the proposal to a meeting of principals, none of whom expressed interest.

Next, the administrator met with the researcher. Based on the scores of each school's fifth graders' performance on the 1982 TABS test of word problems, and the administrator's knowledge of the wide diversity of the socioeconomic populations of the various schools, schools were carefully matched. Thus, four experimental and four control schools were chosen for the study.

Time

Permission was given to conduct the study in the early fall for a period of six weeks. The study began on September 7, 1983 and was concluded on October 21, 1983.

Population

The subjects for the study consisted of all sixth-grade students in the four schools designated as being experimental. Non-English speaking children and students who had never attended the regular sixth-grade classes were excluded from the study. Otherwise, students of all levels of ability received the treatment. The same exceptions were made in the four control schools. In all, 578 students were originally tested. The groupings, however, forced the elimination of 336 students so that only 242 students were considered in the analysis.

Teacher Training

Teacher training was conducted two days prior to the initiation of the study. The teachers had received the written material one week earlier so that it could be previewed. The training session consisted of a teachers' meeting at the central administration building. Its intent was to familiarize the teachers of the experimental groups with the purpose of the study, to overview the instructional material and answer questions about it, and to describe the procedures to be followed during testing and treatment sessions.

The teachers of the control groups met the following afternoon under exactly the same conditions. Instead of keying upon word problems, however, they received material and instruction in using simple Chisanbop as a motivational device to enhance their review of addition and subtraction. Sample worksheets and directions were available. Teachers were asked to use this method at least once a week in addition to the use of their regular textbook material. Also, they received exactly the same directions and information in regard to procedures to be followed during testing sessions.

Procedures for the Collection of Data

Three subtests of the Metropolitan Achievement Test were administered prior to the study, two to serve as the basis for grouping and one as the actual pretest measure. Each school set aside a two-hour block of time in which the testing was conducted. The classroom teachers administered the tests, using the MAT Teacher's Handbook as their script to ensure uniformity in testing conditions. The tests were delivered to the schools just before the testing began and picked up immediately at the end of the session.

When the first round of testing was complete, the tests were scored. Each participating student was assigned an identification number, and test scores were recorded along with the pupil's sex and birthdate.

After six weeks, the MAT: Test 7 was administered once more as the posttest measure. Testing schedules were set up in advance. Once again, the classroom teachers conducted this half-hour session. Also at this time, teachers were asked to have students report their primary language or languages spoken at home. The tests were delivered and picked up as before.

The posttest measure was then graded and matched by identification number with the earlier data. Only those 578 students participating in both testing sessions were included in the study.

Research Design

In this study, a two-by-nine factorial design was utilized. Factors were the various combinations of ability groups in mathematics and reading, and treatment condition (experimental and control).

This design was employed as a type of nonequivalent control group design, described by Campbell and Stanley (10). According to the authors, this quasi-experimental design is appropriate when the groups to be compared do not have pre-experimental sampling equivalence. The design is particularly suited to studies using small to moderate numbers of naturally assembled collectives such as classrooms.

The nonequivalent control group design was preferable to a true experimental design in which subjects are taken out of the natural classroom setting for treatments, thus greatly increasing awareness of the experiment and threatening external validity. A true experimental design using classrooms as units would have been impractical for this study, since 120 or more classes would be required (44, p. 184).

Procedures for Analysis of Data

The hypotheses of the study were restated in the null form and tested with the analysis of covariance technique using the program SPSS (48). Scores from the two subtests used for grouping the pretest score which served as the covariate, and the posttest score were entered on IBM cards, as was the information regarding the school, sex, age, and language(s) of each pupil. Computation was done by the Data Processing Center at North Texas State University.

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CHAPTER IV

RESULTS

The purpose of this study was to compare the effectiveness of specialized skill instruction upon the ability of sixth-grade students to work mathematical word problems. To carry out this purpose, the following hypotheses were tested.

1. When students are categorized by scores on the MAT as being both High Reading and High Mathematics ability, and the MAT mathematics word problem section scores are used as the covariate, the experimental group, after specialized skill treatment, will achieve a significantly higher adjusted posttest score on the MAT mathematics word problem section than will the control group.

2. When students are categorized by scores on the MAT as being both Medium Reading and Medium Mathematics ability, and the MAT mathematics word problem section scores are used as the covariate, the experimental group, after specialized skill treatment, will achieve a significantly higher adjusted posttest score on the MAT mathematics word problem section than will the control group.

3. When students are categorized by scores on the MAT as being both Low Reading and Low Mathematics ability, and

the MAT mathematics word problem section scores are used as the covariate, the experimental group, after specialized skill treatment, will achieve a significantly higher adjusted posttest score on the MAT mathematics word problem section than will the control group.

4. When students are categorized by scores on the MAT as being both High Reading and Medium Mathematics ability, and the MAT mathematics word problem section scores are used as the covariate, the experimental group, after specialized skill treatment, will achieve a significantly higher adjusted posttest score on the MAT mathematics word problem section than will the control group.

5. When students are categorized by scores on the MAT as being both Medium Reading and High Mathematics ability, and the MAT mathematics word problem section scores are used as the covariate, the experimental group, after specialized skill treatment, will achieve a significantly higher adjusted posttest score on the MAT mathematics word problem section than will the control group.

6. When students are categorized by scores on the MAT as being both Medium Reading and Low Mathematics ability, and the MAT mathematics word problem section scores are used as the covariate, the experimental group, after specialized skill treatment, will achieve a significantly higher adjusted posttest score on the MAT mathematics word problem section than will the control group.

7. When students are categorized by scores on the MAT as being both Low Reading and Medium Mathematics ability and the MAT mathematics word problem section scores are used as the covariate, the experimental group, after specialized skill treatment, will achieve a significantly higher adjusted posttest score on the MAT mathematics word problem section than will the control group.

Independent variables were reading ability, mathematics ability, and treatment condition (experimental or control). The dependent variable was the number of correct responses on the Metropolitan Achievement Test, Test 7, which was used as the posttest measure. Used as a pretest, this instrument also served as the covariate in the study. All hypotheses were tested in the null form.

Data pertaining to Hypothesis 1, the High Reading-High Mathematics group, are presented in Table I. These data indicate that a significant difference was not found at the .05 level. The difference of the adjusted posttest means of 1.59 was not significant. The null hypothesis was retained. When considering students who are of high ability in both reading and mathematics, specialized skill instruction does not significantly improve their ability to solve mathematics word problems.

TABLE I

ANALYSIS OF COVARIANCE FOR EXPERIMENTAL AND CONTROL GROUPS FOR HIGH READING-HIGH MATHEMATICS (N=36)

Source	Sum of Squares	df	Mean Squares	F	Level of Significance
Main effects	21.441	1	21.441	2.225	0.145
Residual	318.033	33	9.637		
Total	510.306	35	14.580		

Adjusted Posttest Means: Experimental 29.48, Control 27.89

Data pertaining to Hypothesis 2, the group identified as Medium Reading-Medium Mathematics are presented in Table II.

TABLE II

ANALYSIS OF COVARIANCE FOR EXPERIMENTAL AND CONTROL GROUPS FOR MEDIUM READING-MEDIUM MATHEMATICS (N=70)

Source	Sum of Squares	df	Mean Squares	F	Level of Significance
Treatment group	96.830	1	96.830	8.404	0.005
Residual	771.984	67	11.522		
Total	1296.800	69	18.794		

Adjusted Posttest Means: Experimental 21.88, Control 19.52

The data presented in Table II indicate that a significant difference was found beyond the .05 level. The difference of the adjusted posttest means of 2.36 was significant. The null hypothesis was rejected. Therefore, it can be concluded that specialized skill instruction does significantly improve the ability of students who are in the medium range in both reading and mathematics to solve mathematics word problems.

Data pertaining to Hypothesis 3, the Low Reading-Low Mathematics groups, are presented in Table III.

TABLE III

ANALYSIS OF COVARIANCE FOR EXPERIMENTAL AND CONTROL GROUPS FOR LOW READING-LOW MATHEMATICS (N=37)

Source	Sum of Squares	df	Mean Squares	F	Level of Significance
Treatment group	0.014	1	0.014	0.001	0.980
Residual	808.001	34	23.706		
Total	818.757	36	22.743		

Adjusted Posttest Means: Experimental 11.09, Control 11.05

The data presented in Table III indicate that a significant difference was not found at the .05 level. The difference of the adjusted posttest means of .04 was not significant. The null hypothesis was retained. When considering those pupils who are of the low level of ability in both reading and mathematics, specialized skill instruction does not significantly improve their ability to solve mathematics word problems.

Data pertaining to Hypothesis 4, the High Reading-Medium Mathematics groups, are presented in Table IV.

TABLE IV

ANALYSIS OF COVARIANCE FOR EXPERIMENTAL AND CONTROL GROUPS FOR HIGH READING-MEDIUM MATHEMATICS (N=26)

Source	Sum of Squares	df	Mean Squares	F	Level of Significance
Treatment Group	58.145	1	58.145	7.314	0.013
Residual	182.851	23	7.950		
Total	352.615	25	14.105		

Adjusted Posttest Means: Experimental 25.18, Control 22.13

The data presented in Table IV indicate that a significant difference was found beyond the .05 level. The difference of the adjusted posttest means of 3.05 was significant. The null hypothesis was rejected. Therefore, it can be concluded that specialized skill instruction does significantly improve the ability of students who are of high ability in reading and average ability in mathematics to solve mathematics word problems.

Data pertaining to Hypothesis 5, the Medium Reading-High Mathematics groups, are presented in Table V.

TABLE V

ANALYSIS OF COVARIANCE FOR EXPERIMENTAL AND CONTROL GROUPS FOR MEDIUM READING-HIGH MATHEMATICS (N=18)

Source	Sum of Squares	df	Mean Squares	F	Level of Significance
Treatment group	1.112	1	1.112	0.183	0.675
Residual	91.234	15	6.082		
Total	109.611	17	6.448		

Adjusted Posttest Means: Experimental 26.63, Control 26.10

The data presented in Table IV indicate that a significant difference was not found at the .05 level. The difference of the adjusted posttest means of .53 was not significant. The null hypothesis was retained. Thus, specialized skill instruction on mathematics word problems is not significantly effective for students who are of average ability in reading and high ability in mathematics.

Data pertaining to Hypothesis 6, the Medium Reading-Low Mathematics groups, are presented in Table VI. These data indicate that a significant difference was not found at the .05 level.

TABLE VI

ANALYSIS OF COVARIANCE FOR EXPERIMENTAL AND CONTROL GROUPS FOR MEDIUM READING-LOW MATHEMATICS (N=29)

Source	Sum of Squares	df	Mean Squares	F	Level of Significance
Treatment group	8.404	1	8.404	0.300	0.589
Residual	729.071	26	28.041		
Total	737.862	28	26.352		

Adjusted Posttest Means: Experimental 17.60, Control 16.50

The difference of the adjusted posttest means of 1.10 was not significant. The null hypothesis was retained. When considering students who are of average ability in reading and low ability in mathematics, specialized skill instruction does not significantly improve their ability to solve mathematics word problems.

Data pertaining to Hypothesis 7, the Low Reading-Medium Mathematics groups, are presented in Table VII. These data indicate that a significant difference was not found at the .05 level. The difference of the adjusted posttest means of -1.16 was not significant. The null hypothesis was retained. Thus, specialized skill instruction on mathematics word problems is not significantly more effective for students who are of low ability in reading and average ability in mathematics.

TABLE VII

ANALYSIS OF COVARIANCE FOR EXPERIMENTAL AND CONTROL GROUPS FOR LOW READING-MEDIUM MATHEMATICS (N=26)

Source	Sum of Squares	df	Mean squares	F	Level of Significance
Treatment group	8.416	1	8.416	0.563	0.461
Residual	343.718	23	14.944		
Total	899.115	25	35.965		

Adjusted Posttest Means: Experimental 14.06, Control 15.22

CHAPTER V

DISCUSSION

The problem of this study was to determine the effectiveness of specialized skill instruction upon the achievement of sixth-grade pupils to work mathematical word problems. The population consisted of pupils in four experimental schools. Four control schools were carefully matched to the four experimental schools. The teachers of the experimental groups, using the materials provided, conducted this specialized mathematics instruction in their mathematics classes for a period of six weeks. The _Metropolitan Achievement Test, Test 7_, which served as the pretest measure, was then administered as the posttest measure. Analysis of covariance was the statistical technique applied to the data.

The results of the study are discussed in terms of (a) those ability groups that did not significantly benefit from the treatment and (b) those ability groups that did benefit significantly from it. Suggestions for further research conclude the chapter.

Ability Groups Not Showing Significant Gain

Findings

This study examined the effects of specialized skill instruction upon the achievement of specially defined ability groups to work mathematics word problems. The results indicated that this special instruction did not significantly raise achievement levels for the students in the High Reading-High Mathematics, Low Reading-Low Mathematics, Medium Reading-High Mathematics, Medium Reading-Low Mathematics, Low Reading-Medium Mathematics groups. A detailed report of these results is presented in Chapter IV.

Interpretation

Although the present study encompassed seven content strands in the developed materials, the results can be interpreted in light of various studies based on more isolated aspects of the total process of word problem solution. The research of the present study indicated that the instructional material was least beneficial for pupils at both extremes of ability level on measures of reading and mathematics. Both Brewer (2) and Burch (3) tested well known problem solving process models. While Brewer (2) determined that teaching a process made no significant difference with fifth graders, Burch (3) found that a process may actually be detrimental to success. Group 7 (Low Reading-Medium Mathematics) of this study was supportive of this conclusion in that the mean difference for the treatment groups was -1.16. The experimental group achieved less than the control after treatment, but not at a significant level.

There were similarities among the findings for Group 3 (Low Reading-Low Mathematics), Group 6 (Medium Reading-Low Mathematics), and Group 7 (Low Reading-Medium Mathematics). In each of these groups, students scored in what was defined as the low range on either or both of the reading or mathematics computation test on the MAT. In light of several studies, the lack of significant achievement after the treatment was predictable. Burns and Yonally (5) cautioned that the students of lower ability need special attention in the area of mathematical reasoning. Glennon and Callahan (13) cited general reading skills as the most important factors in problem solving efficiency. Students in the groups under discussion range from average to low ability in reading. Stretch (20) and Balow (1) both concur with this line of thought. They concluded that reading ability has a high correlation with problem solving success in mathematics. O'Mara (18) did not support the conclusion that reading ability is directly related to problem solving ability. She stated that one cannot expect poor problem solvers to benefit from remedial reading instruction. Much of the material developed for this study dealt with the specialized reading skills of mathematics.

Group 1 (High Reading-High Mathematics) and Group 5 (Medium Reading-High Mathematics) were similar in that both contained those pupils who scored in what was defined as the high ability range on mathematics computation on the MAT, yet reading skills ranged from average to higher. This aspect of the present study is in opposition to the conclusion of Call and Wiggin (6) who found that the teaching of specific reading skills of mathematics was useful to those students who were good in computation. The findings regarding these two groups are, however, consistent with the conclusion of Balow (1) that for a given level of computation ability, problem solving increases as reading ability increases. Group 1, the higher readers, had an adjusted posttest mean of 29.48, while Group 5, the average readers, had an adjusted posttest mean of 26.63.

In light of the interpretations of the present study in regard to those ability groups which did not significantly gain in achievement after receiving the treatment of the specialized skill instruction packets, it can be concluded that this type of instructional material does not benefit students who are (1) at low levels of ability in mathematics or reading or (2) who are in the high level in mathematics computation.

Implications

While this particular specialized skill instruction does not appear to promote a significant gain in achievement for pupils in the lower ranges of ability, it does not mean that specially developed material for pupils at those ranges would not be effective. When the concept and reading levels of instructional material are too high for pupils, frustration develops and the learner does not progress. It may be, in light of O'Mara's (18) conclusion about remedial reading instruction and the lower student, that material for these pupils needs to focus more upon those identified content strands that do not have such a strong reading skills base. Zweng (21) and Burns and Richardson (4) concluded that it is the ability to connect the process to the situation that is crucial. Perhaps more focus upon instruction dealing with choosing the correct operation would be productive. The use of the present type of material, then, must undergo revisions before being used with this particular segment of the population.

The other two groups, High Reading-High Mathematics and Medium Reading-High Mathematics, present an entirely different situation. It appears that if the student is already operating at a high level of ability on computation, the word problem packets developed for this study were not helpful in generating significant achievement. It may be noted, however, that those pupils who were in Group 1 who were also the better readers did show progress to the .145 level. This level could be interpreted as being positive, although not statistically significant. For those pupils who scored higher on computation than at reading, their progress did not approach significance. It appears that the developed material does not produce sufficient reading skills in these average readers to increase achievement in their high level of mathematics functioning. It also does not produce much growth with the High Reading-High Mathematics group in that the levels of achievement were already high, and the existing skills necessary to solve word problems were merely sharpened. The use of this type of skill instruction, then, can be supported with students of High Reading-High Mathematics ability levels, but it is not suggested for students of the lower levels in either reading or mathematics.

Ability Groups Showing Significant Gain

Findings

As hypothesized at the beginning of this study, those students of the experimental group who were classified as being Medium Reading-Medium Mathematics and High Reading-Medium Mathematics achieved significantly higher adjusted posttest scores on the MAT, Test 7 than did their corresponding control groups ($p<.05$). A detailed report of these findings is presented in Chapter IV.

Interpretation

The significant increase in the achievement of these two ability groups is supported by a wide range of research. Englehardt (11) concluded that if teachers are to significantly increase achievement, they will need to use more than normally available classroom materials. The material developed for the present study was in the format of a text extender, and was highly successful with those pupils of average mathematics ability coupled with average to high reading ability. Several important elements of the material included the frequent use of discussion as emphasized by Pace (19), the instruction and practice in dealing with the reading in mathematics skills identified by Hater and others (15), and the use of several problem solving strategies and vocabulary enhancers (see Chapter III for a more detailed discussion). Cohen and Stover (7) found that as little as three hours of instruction focused upon identified sources of difficulty, significantly raised achievement levels on word problem solution. The fifteen hours of instruction of the present study did incorporate work in the areas identified by Cohen and Stover, and were the focal point of more than three of the activities. The highly diversified, multi-directional approach of the instructional material appears to be quite beneficial to this segment of the population.

Parallels can be drawn between this study and others which have preceded it. Glennon and Callahan (13), Stretch (20), and Balow (1) all aver that a high correlation exists between reading and mathematics. In the present study, those two groups that benefited most from the treatment were classified as being average to high level in reading. Call and Wiggin (6) concluded that teaching reading skills was beneficial to students who were good in computation. Without a definition of the term "good" it is not possible to determine whether the present study does indeed support this finding. If Call and Wiggin intended "good" to pertain to only the best students, then this study would not support their findings as described earlier in this chapter. If, however, "good" is defined as being average or better, some agreement between the studies would be possible to ascertain. In this study, those pupils who benefited significantly from the material were all of average ability in computation. Thus, the sharpening of their reading skills in mathematics was effective in raising levels of achievement when working word problems.

Other studies have reached conclusions that pertain to the Medium Reading-Medium Mathematics High Reading-High Mathematics segment of the population. While Earp and Tanner (10) contend that success with word problems is related to the child's level of language sophistication, Hargis (14) stated that "normal" children do not have adequate language mastery for success in the mathematics context. In the present study, the two groups under discussion compose a large part of what are commonly referred to as the average or normal pupils. Englehardt (11), Johnson (16), Earp and

Tanner (10), and Kuzminski (17) all stressed the need of most pupils for material beyond what was available in the typical classroom text. The Medium Reading-Medium Mathematics High Reading-Medium Mathematics groups responded in a substantially positive manner to the added instructional material. One other study, that of Collier and Redmond (8), is of particular interest in the interpretation of the results of Group 4 (High Reading-Medium Mathematics). They found that good readers experienced difficulty in reading mathematics. It appears that these particular good readers sharpened their content reading skills to the degree that their achievement level on word problem solution was sharply raised.

Implications

The results imply that students who are in the middle range in mathematics computation ability and who do not evidence reading problems benefit significantly from the specialized skill instruction on mathematics word problems developed for this study. The fact that both of the groups which responded were in the average range of computation ability implies that the treatment did indeed sharpen their skills in content reading and problem solving to a significant degree. Dunn and Dunn (9) concluded that students with different learning styles need different types of lessons. It is possible that the treatment material met a particular common need found among this specific group of pupils. In light of Collier and Redmond (8), this study confirms that even the very good readers may have difficulty in reading mathematics, yet if those difficulties are overcome, their achievement level in word problem solution sharply increases. Thus, the use of this type of material can prove effective with pupils whose primary reading skills appear adequate in reading classes. Furthermore, this type of material should be an integral part of the mathematics curriculum for all of those students of the average range in computation, unless they have reading problems. It appears that those who have advocated the use of text extensions in conjunction with the topic under consideration were carroborated. The large segment of the population who are average in ability need more than their mathematics texts offer. The specialized skill instruction, based on seven content strands with a highly diversified format is extremely beneficial to these pupils.

Based on the findings of the study, it has been determined that the specialized skill instruction does not significantly increase achievement levels in word problem solution if pupils were categorized as being low in reading, low in mathematics computation, or low in both subject areas. It was also found that the material was not significantly effective in improving word problem skills if pupils were identified as being high in both reading and mathematics computation or high in mathematics computation but average in reading. The materials developed for this study did produce a significant increase in ability to solve word problems if students were of average ability in mathematics computation and average to high in reading ability.

Suggestions for Further Research

In light of the results of this study, the following possibilities for further research are suggested.

1. This study examined the effects of specialized skill instruction with sixth-grade students only. Therefore, further studies should be conducted with younger children to determine whether the effects vary with different stages of cognitive development and language sophistication.

2. In this study, the treatment was not successful with pupils who were classified as being low in either mathematics or reading or both. Specialized skill instruction material should be developed for students of lower ability levels with particular emphasis upon readability levels and concept load in order to accurately assess this form of treatment for this select population.

3. This study was conducted early in the school year. It might be profitable to determine whether placement of the material later in the school's sixth-grade curriculum would increase student achievement. This recommendation is

based upon classroom teacher feedback. The teachers felt that the material might be more effective if used later due to the fact that, at the first of the school year students focus their attention on textbooks, whereas later in the year they are more receptive to material other than the text.

4. The material developed for this study was used daily by the students. It is possible that even greater benefits would be derived if the material were used once or twice per week throughout the entire school year as a text supplement, thus becoming part of the routine of the class while serving to provide an alternative to routine instructional procedures.

5. Zweng (21), Burns and Richardson (4), and others cited the ability to determine the operation as the key to success in word problem solution. It would be desirable to determine if more emphasis upon this concept would prove beneficial to those groups that did not respond significantly to the heavy emphasis upon reading and process skills.

6. The area of teacher training in word problem instruction warrants perhaps the most urgent attention. This study involved no teacher training in word problem solution or in instructional methods other than what was contained in the teaching directions of each activity. Gibney and Meiring (12) recently found that when teachers were trained

intensively for several weeks in word problem solution, they were much more competent and successful in their instruction. Future research should investigate the effects of extensive teacher training prior to the use of the specialized skill instruction developed for this study, in that teacher instruction and teacher directed discussion were key elements of the material.

7. Finally, the effects of the specialized skill instruction upon those students whose scores fell between one-half to one standard deviation both positively and negatively on either the reading or mathematics test should be investigated. They were eliminated from the present study in an effort to construct clearly defined ability groups, however, their performance is important in that those groups who significantly improved after the treatment were in the average range. Future research should be conducted to determine the extent to which these unexplored populations benefit from the instruction.

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APPENDIX

PACKET I

A DECTECTIVE'S KIT

FOR

SOLVING WORD PROBLEMS

Pam Kuzminski

Pictures on my Mind
or
Does Your Verb Have Action?

Purpose: (a) to promote and strengthen ability to visualize problems
(b) to create an awareness of the action verb in word problems

Skills: verb recognition
visualization
word problem generation
computation practice

Content strands: vocabulary, language experience

Materials: pencil and paper

Time: 30 minutes

Class organization: partners

Preparation:

1. The teacher begins the discussion by having students close their eyes. She asks them to "picture" their mother, an apple, the front of the school. Then, she relays the idea that you can put action into your pictures. Students visualize themselves throwing a ball, a friend buying lunch, etc.

2. The teacher then phases into the lesson with the idea that visualization is very useful in math.

3. Read the introduction and the example.

4. Students do Part I. Check orally. Assign Part II.

5. Close the discussion with action words in prepared and original sentences. Elicit student opinion of the value of this visualization technique.

Pictures on my Mind
or
Does Your Verb Have Action?

Every sentence must have a verb. That verb may tell us simply a "state of being." Being verbs include is, are, was, were, have, has, and had. In math word problems, however, many of the verbs used are action words. They give us a mental picture of what is happening. Clever detectives use mental pictures to help them solve problems. How good are your mental motion pictures?

Part I

Underline the action words. Draw your mental image. Solve the problem.

Example: Joe kicked the ball three times. Each time it went ten yards. How far did it go in all?

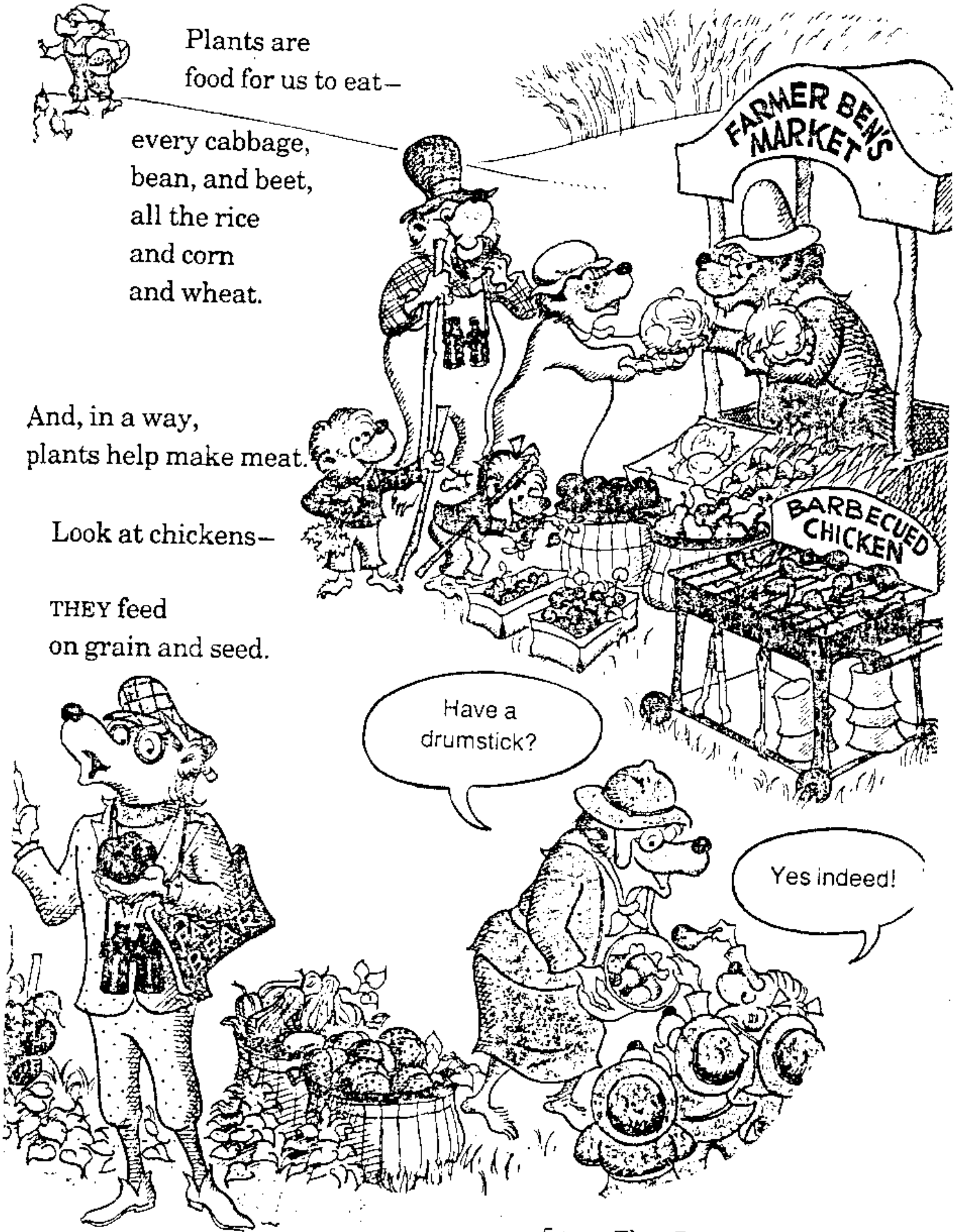
1. John bought a sandwich. It cost $1.20. How much change did he receive from his $5 bill when he paid for the sandwich?

2. Jenny collected 2,386 aluminum cans to take to the recycling center. She paid her brother 1/4 of her profit for flattening those cans. If she received $16, how much did she give her brother?

3. Pac Man ate 37 dots, 6 ghosts, and 4 power capsules. If dots are worth 10 points, ghosts are worth 100 points, and power capsules are worth 25 points each, how many points were scored?

Part II

Now using the picture below, see if you can write two good word problems. Take special care in choosing those action words. Have your partner work your problems without looking at the picture. Did you create a good mental motion picture with your words?



from The Bears Nature Guide

What's Your "P.I." I.Q.?

Purpose: to create an awareness of words that signal the correct operation to be used in solving word problems

Skills: operational vocabulary, subtle meanings, problem solving

Content strands: vocabulary, comprehension

Materials: pencil and paper

Class organization: whole class/individual student

Time: 45 minutes

Preparation:

1. Introduce the class with the idea that in some cases directions are very specific. A person knows exactly what to do (ex. to sit, stand, etc.). In word problems some specific directions are common. List the following words on the board and briefly discuss: estimate (about); find (compute); name, tell, write (write on your paper, answer)

2. Other words, however, are not so apparent, yet they may be crucial in knowing what operation to select to solve a word problem. Stress that if you are aware of these words and what they signal, word problems become easier to solve.

3. Illustrate the idea with the following examples:
   Julie scored 1,928 on Pac Man and 3,213 on Donkey Kong.
   (a) What is the difference of her scores?
   (b) What is the total of her scores?
   (c) What is the average of her scores?
   Compute each problem, stressing that the same basic information is used very differently according to the clue word.

Activity:

1. Assign the sheet, Part I. It may be necessary to give a sentence clue for the less obvious terms. Check orally before going on. Note that there is more than one correct answer in several cases. If a question arises, ask the student to generate a sentence which exemplifies his/her answer. Keep in mind that this is an awareness activity.

Do not fail to bring forth in a discussion of the answers that the words may be less specific than the symbol.

2. Assign Part II. Discuss any problems.

What's Your "P.I." I.Q.?

Magnum and Simon and Simon have proven weekly that the most revealing clues to solving any mystery may be so obvious that they are easily overlooked by most mere mortals. Word problems contain clue words that will signal to you exactly what to do if you know what to look for. The following problems test your "Private Investigator" I.Q.

Part I

Put the correct symbol(s) of the operation in the blank by the following clue words. If you are unable to think of the symbol immediately, think of a question in which the word is used. (Symbols +, −, x, ÷)

_____ ago

_____ all together

_____ between

_____ difference

_____ divided

_____ each

_____ equally

_____ evenly

_____ farther

_____ from

_____ get back

_____ in all

_____ later

_____ left

_____ more

_____ product

_____ quotient

_____ sum

_____ than

_____ times

_____ together

_____ total

_____ until

_____ years ago

Part II

Now, search these problems for clue words. Underline the words and then work the problem.

1. Magnum received $6,000 from a client for finding his long lost father. He had agreed to split his fee evenly among Rick, Higgins, and himself because they had helped him. How much did each man get?

2. Rick and A.J. were figuring out the total number of clients that they had helped this year. Rick is 34 and A.J. is 26. The number that they came up with is the sum of their ages divided by 2, plus 3. This number is also the product of 6 times 6 minus 3. What is the number? (Note: The order of the operations is crucial.)

3. Nancy Drew solved her first mystery in March of 1963. She solved her newest case last month.
   (a) How many years has she been solving mysteries?

   (b) How many months are there <u>between</u> her first and last cases?

4. Magnum spent a great deal of his money solving cases. His expenses for five cases were $120, $230, $15, $430, and $125. He made $20,000 on these five cases.
   (a) What were his total expenses?

   (b) What was the greatest difference between two expenses?

   (c) What was the average expense?

   (d) How much did he have left?

Fiddle with a Riddle
or
Is Your Thinking Fine Tuned?

Purpose: to strengthen problem solving skills

Skills: vocabulary--technical, multi-meaning; details, looking beyond the obvious (or for it), and riddle generation

Content strands: vocabulary, comprehension

Materials: riddle and answer sheets, pencil, colored markers or pencils

Class organization: groups of three

Time: 45 minutes

Preparation:

1. Ask pupils to tell a riddle (What is black and white and read all over?).

2. Talk about the importance of not overlooking the obvious (the word "read," not "red") and carefully thinking through a problem.

Activity:

1. Have pupils read the riddles and attempt a solution. Stress that they must come to one consensus answer with the <u>reason</u> that they chose it.

*2. Discuss answers in whole class setting. First, hear their solutions before relaying given ones. Second, in <u>each</u> instance, identify the key (clue) and the process <u>that</u> they used to get the answer.

3. Carefully point out the obvious riddles, riddles that required background information that was not stated, and places where diagrams might have helped.

4. Have each student generate one riddle and put the answer to their riddle on the back of the paper.
Put them in a folder to make a class "Fiddle With a Riddle Book." Allow the students to use it at acceptable times as they desire.

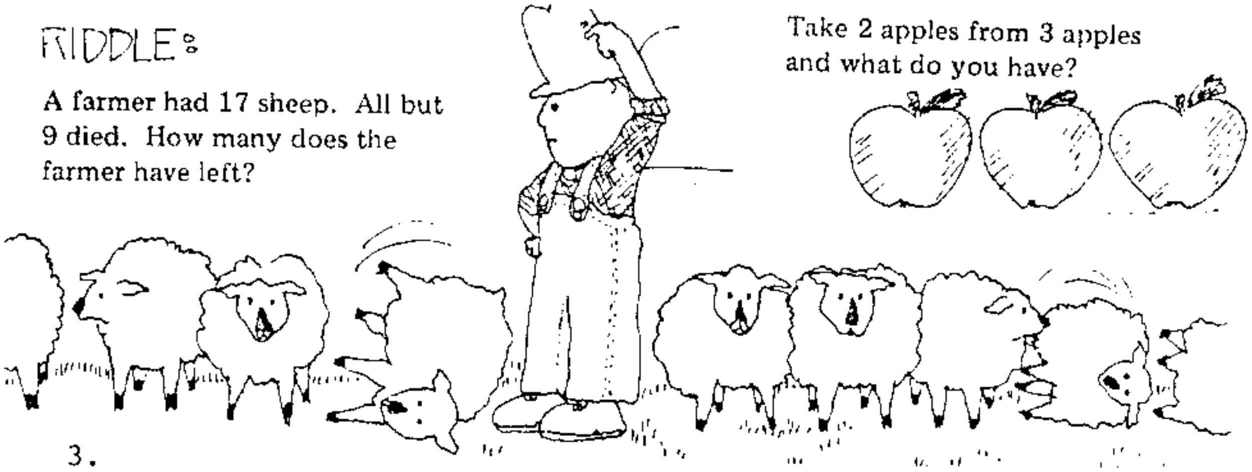
Fiddle with a Riddle
(Riddles used are from The I Hate Mathematics Book)

No great mystery is ever obvious in its solution. The following riddles will help you see just how clever you are. Solve each riddle with your partners using the answer sheet provided. Your group must decide on one answer and the reason why you chose it.

1.

RIDDLE:

A farmer had 17 sheep. All but 9 died. How many does the farmer have left?



2.

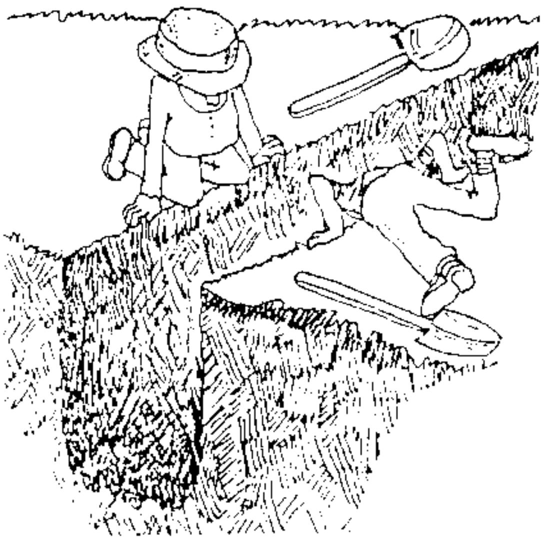
RIDDLE:

Take 2 apples from 3 apples and what do you have?

3.

RIDDLE:

How much dirt may be removed from a hole that is 3 feet deep, 2 feet wide, and 10 feet long?



4.

RIDDLE:

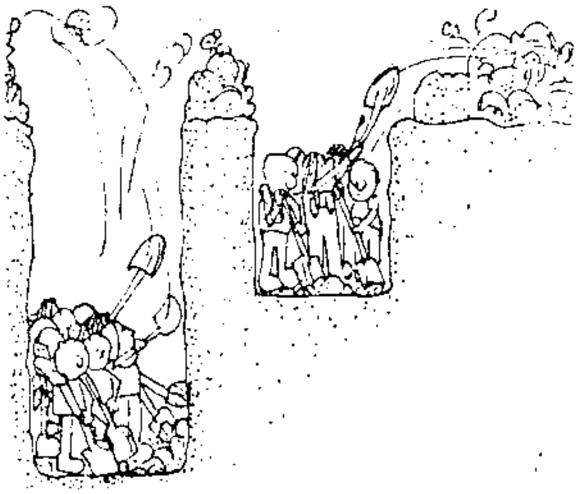
If your bedroom were pitch dark and you needed a pair of matching socks, how many socks would you need to take out of the drawer if there are 10 white socks and 10 blue ones?

5.
RIDDLE:

There are 12 1-cent stamps in a dozen, but how many 2-cent stamps are there in a dozen?

6.
RIDDLE:

If it takes 10 people 10 days to dig a hole, how long will it take 5 people to dig ½ a hole?



7.
RIDDLE:

I've got 2 U.S. coins that total 55 cents. One of the coins is not a nickel. What are the 2 coins?

8.
RIDDLE:

Divide 30 by ½ and add 10. What's the answer?

9.
RIDDLE:

What's the smallest number of birds that could fly in this formation: 2 birds in front of a bird, 2 birds behind a bird, and a bird between 2 birds?

10.
RIDDLE:

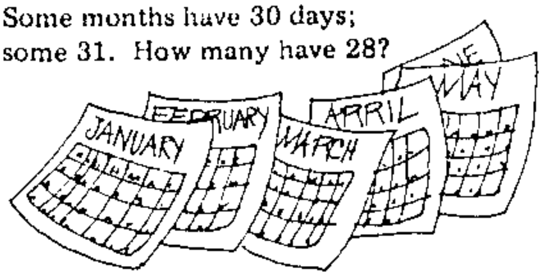
How many birthdays does the average person have?

11.
RIDDLE:

If the doctor gave you 3 pills
and said to take 1 every ½ hour,
how long would they last?

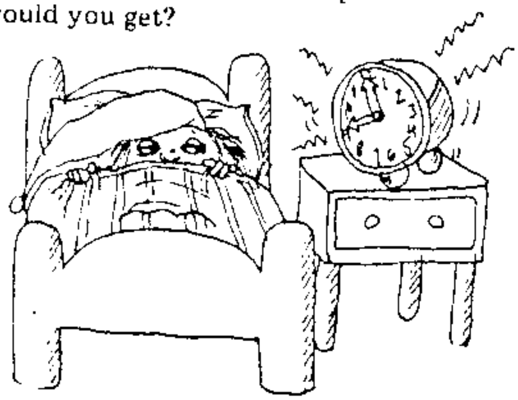
12.
RIDDLE:

Some months have 30 days;
some 31. How many have 28?



13.
RIDDLE:

If you went to bed at 8 p.m. and
set the alarm for 9 in the morn-
ing, how many hours of sleep
would you get?



The Poznick Case

Purpose: (a) to strengthen students' ability to sort through extraneous information
(b) to practice dealing with interrogative words and sentences
(c) to make students aware of the problem of insufficient data

Skills: interrogatives, clue words, extraneous/insufficient data, reading for details, data collection (notes, grouping)

Content strands: vocabulary, sources of difficulty, comprehension, problem solving

Materials: pencil and paper

Class organization: individual seat work

Time: 30 minutes

Preparation:

1. Introduce the activity by discussing the common words and phrases that signal questions. List the following on the board and make a sentence with each: at what time, how, how many, how much, how far, how long, if . . . then, in what year, in which, what, when, which, who.

2. Relate that in many instances, more data are given than can be dealt with by memory. It saves time and energy to take notes, group, or chart the information.

3. Example: A man has ten small red marbles, twenty small blue ones, sixteen small green ones, fifteen large red ones, ten large yellow ones, five medium clear ones, and twelve medium green marbles. Have students help group the data.

	red	blue	green	yellow	clear
small	10	20	16		
large	15			10	
medium			12		5

4. Quickly show how questions would be much easier to handle once data are organized in some way.

Activity:

1. Assign the story and questions.

*2. Discuss answers orally, especially number seven with its lack of sufficient data.

The Poznick Case

The Poznicks were quite an unusual clan. In 1957 Nick and Polly Poznick were married. They moved into a beautiful two bedroom home at 3724 Oak Street. When their third set of twins were born, they moved eight miles away to a larger house. In 1970, when their seventeenth child was born, they moved fifteen miles further out into the country to a very large house with a very large yard. It was a good thing, too, because each of the little Poznicks had three pets, not counting Nick's dog and Polly's parrot. In all they had fifteen dogs, eight cats, thirteen fish, six hamsters, and eleven birds. Ozzie, the oldest boy usually fed all of the pets, but when he was ill, Polly fed them all--family and pets.

Using your knowledge of clue words and questioning words, answer the following questions. Take notes or construct a table in the space provided to help you collect the data. Careful, this case may throw you a curve!

1. In what year did the Poznicks celebrate their tenth anniversary?

2. How many Poznicks lived in the first house?

3. How much farther was their second move to a new house than their first move?

4. How long were Nick and Polly married before they had their seventeenth child?

5. How many pets did the children have?

6. How many meals did Polly serve when Ozzie was ill one morning?

7. If the Poznicks had seventeen children, then how many twins did they have?

King Arthur's Problem

(Story from Math for Smarty Pants)

Purpose: (a) to establish a relationship between math and literature
(b) to practice reading in the language of mathematics
(c) to use diagrams in problem solving process

Skills: narrative reading
details
problem solving
number patterns
use of graphic aids

Content strands: interdisciplinary
problem solving
graphic skills

Materials: story
pencil and paper

Class organization: individual

Time: 30 minutes

Preparation:

1. Relate that in many instances insertion of a diagram can be a great help in solving word problems.

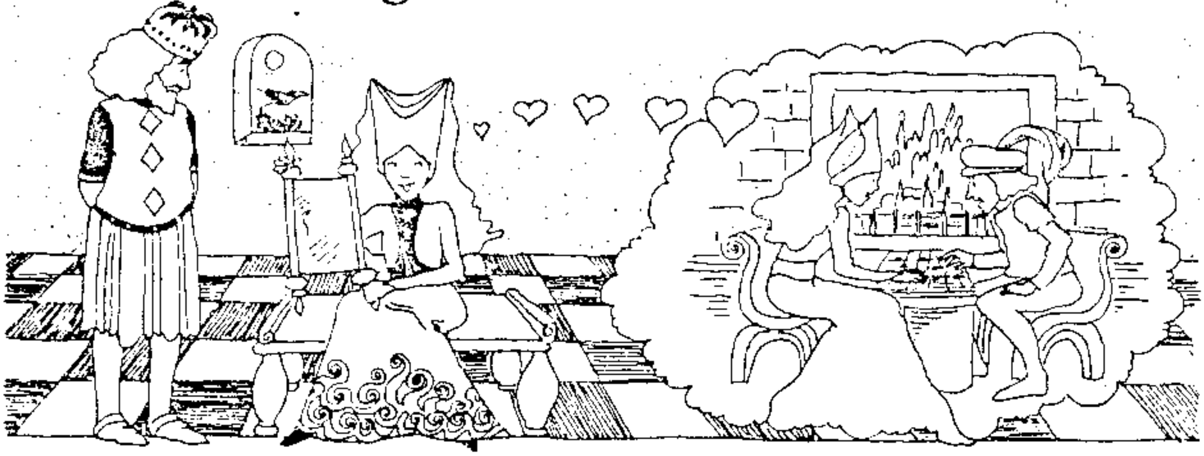
2. Instruct to read, draw a diagram, and solve the problem.

Activity:

1. Discuss both the answer and the pattern.

*2. Stress the process by which the answer was derived. Let a pupil demonstrate his/her process on the board.

King Arthur's Problem



King Arthur had a problem. His daughter, Glissanda, loved mathematics so much that she spent most of her time solving problems, making geometric designs, and playing with numbers. That wasn't King Arthur's problem; he was proud of his daughter and her mathematical interest. Glissanda had reached the age when a young woman was permitted to marry, and she was definitely interested in marrying. In fact, she had one requirement for a husband: he must love mathematics (or at least like it a lot). For her, a life of evenings in front of a warm fire solving mathematical puzzles seemed like a sure way to marital bliss. Finding that mathematics-loving husband was King Arthur's problem.

Now, if this story had taken place in modern times, King Arthur wouldn't have had this problem. Glissanda would probably have met someone in her math classes who would be a fine mate, and that would be that. But in the days of King Arthur and his Knights of the Round Table, women didn't have much freedom; their husbands were chosen by their parents.

Now King Arthur loved Glissanda dearly, and he would do anything for his daughter, but he was confused about how to find a husband to suit Glissanda. After all, the Knights of the Round Table—they were the best men in the land—were outdoor types who spent their time bravely scouting the countryside for dragons to slay. He couldn't remember any of them ever even mentioning mathematics.

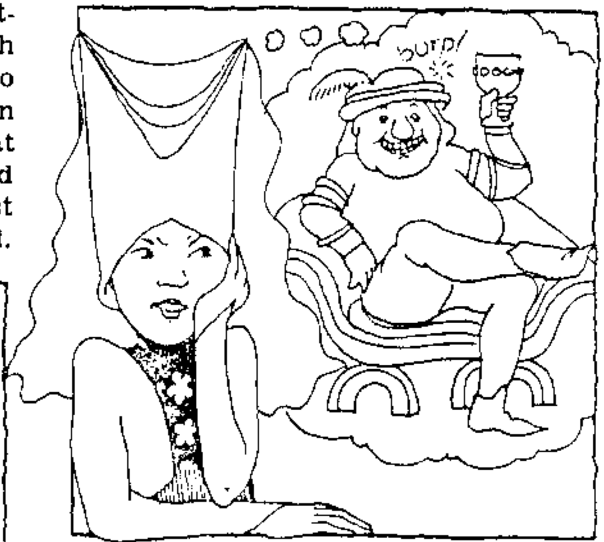
Source: Marilyn Burns, Math for Smarty Pants, Canada and Boston, Little, Brown and Co., 1982, pp. 75-79.

King Arthur was perplexed. He thought about it for days. And days stretched into weeks, but no ideas came to him.

Meanwhile he had his kingly work to do, but he became so distracted by this marriage problem that he couldn't concentrate. King Arthur was definitely not himself. One morning at the meeting he was very short-tempered with his knights. Little things seemed to bother him. At one point he even shouted out, "Can't you control that constant clanking of your armor and sit still?" The knights knew he must have something important on his mind.

That night at dinner King Arthur talked to Glissanda about the situation. "How shall I find out who is the cleverest in mathematics?" he asked her. "Should I just ask?"

"No, no," protested Glissanda. "That wouldn't be a good way. Some would answer yes just to become next in line to be king. I could get stuck with a husband who wants to do nothing at night except drink ale, one with no true interest in mathematical conversation. You must devise a mathematical test."



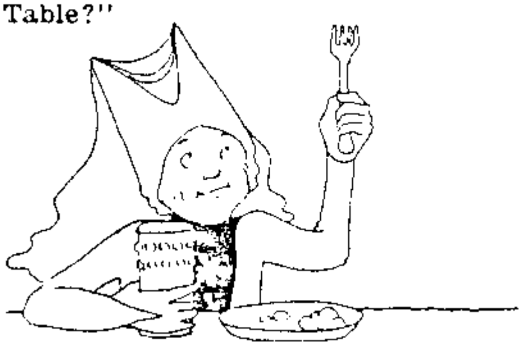
"What sort of test?" King Arthur asked.

"Let me think about it," Glissanda answered, wandering off, already deep in thought.

The next morning at breakfast Glissanda seemed cheerful.

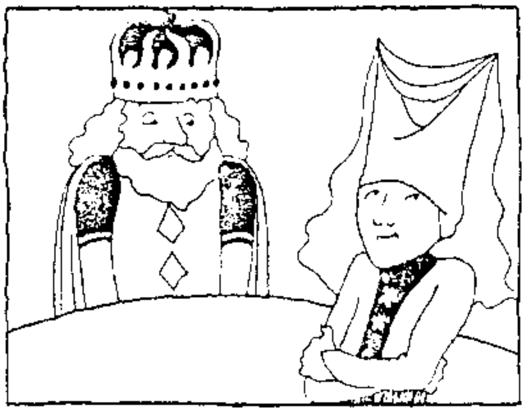
"Do you have the test?" her father asked.

"Not yet," Glissanda answered, "but I'm working on it. Tell me, father, how many knights are there at your Round Table?"



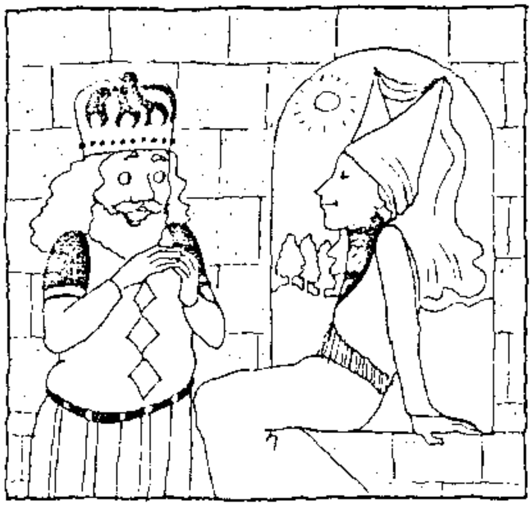
"Well, that varies," he replied. "It depends on how many are back from a journey. Sometimes as many as 50, and sometimes only a handful. Why?"

But Glissanda didn't answer. King Arthur could tell she was lost in thought, with that glaze over her eyes that told him she was thinking about mathematics again. It made him think that her husband would need to be very understanding.



That night at dinner Glissanda made an announcement. "I've got the test," she said. "You can give it at your meeting tomorrow to the Knights of the Round Table."

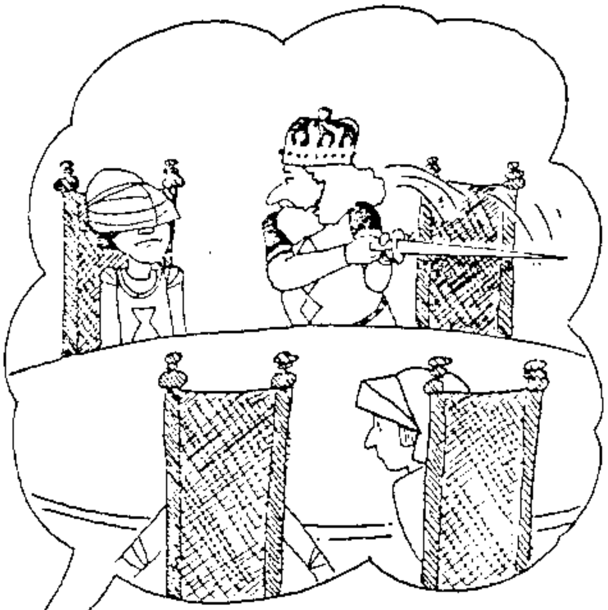
King Arthur's face broke into a relieved smile. "Wonderful, wonderful!" he exclaimed. "But what if all the knights aren't present tomorrow? You know, I never can tell who will come."

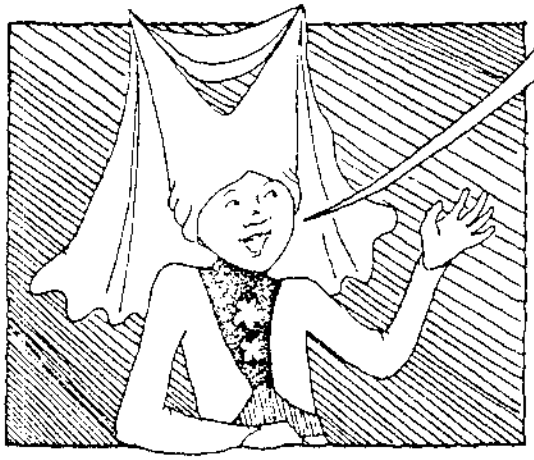


"I've thought of that," Glissanda said. "In this test there is just one problem. Give it tomorrow to the knights who are present and announce that those interested in answering should reappear in one month's time with their solutions. In the meanwhile, they should spread the problem throughout the kingdom, so others who are off doing what knights do can come with solutions as well."

"What is the problem?" King Arthur asked eagerly.

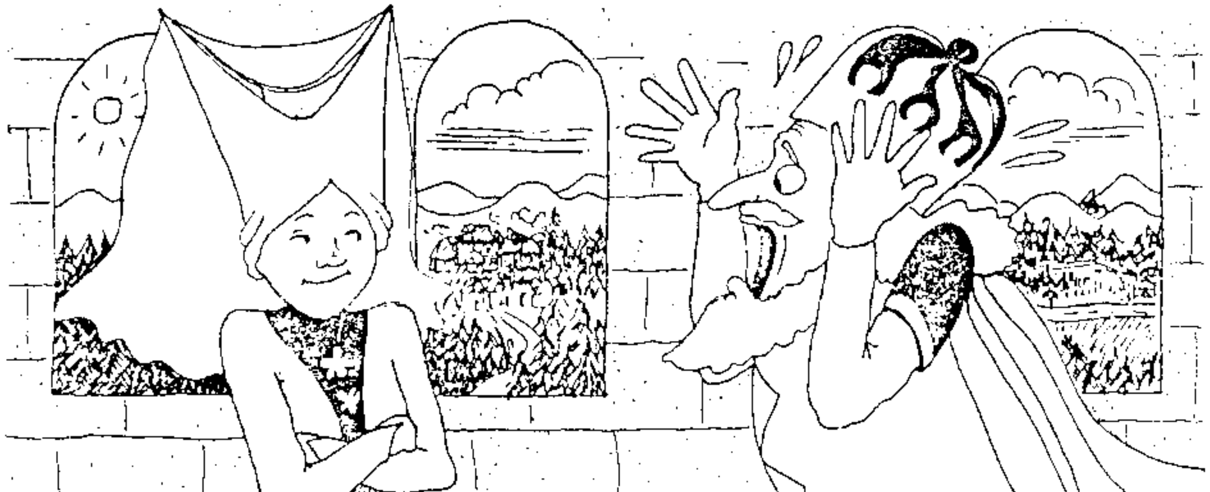
Glissanda explained, "Suppose 24 knights came to a meeting of the Round Table. And suppose the 24 chairs were numbered in order, so that everyone knew which chair was number 1, and in which direction you will count to 24. In order to choose my husband, you draw your sword, point to the knight in the first chair, and say, 'You live.' Then point to the knight in chair number 2, say, 'You die,' and chop off his head. To the third knight you say, 'You live.' And to the fourth, you say, 'You die,' and chop off his head. You continue doing this around and around the circle, chopping off the head of every other living knight until just one is left. That's the one I'll marry.

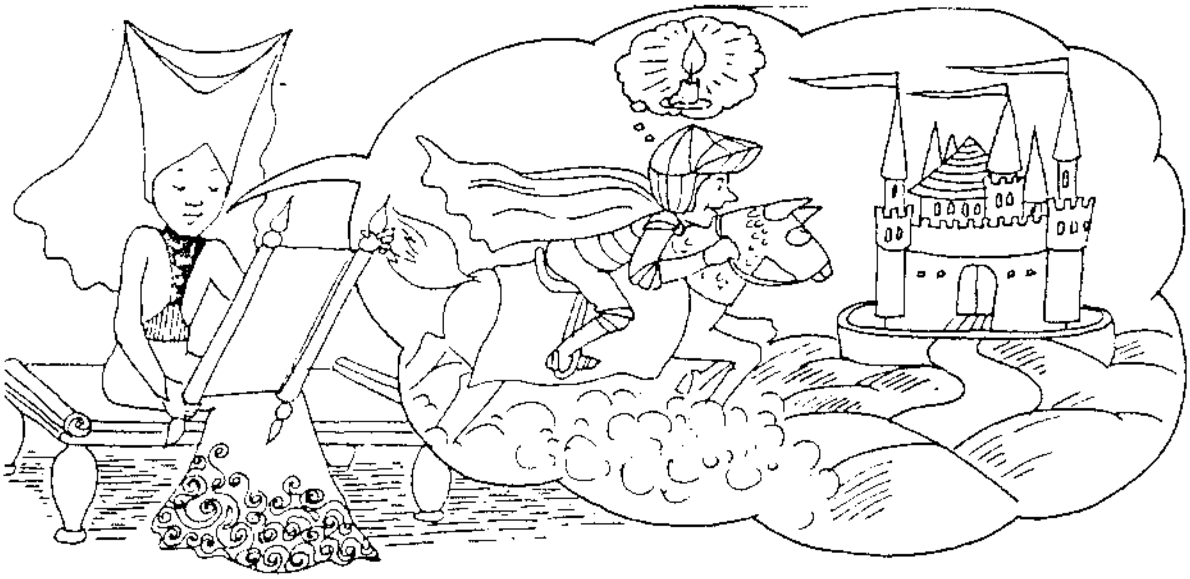




Glissanda stopped talking.

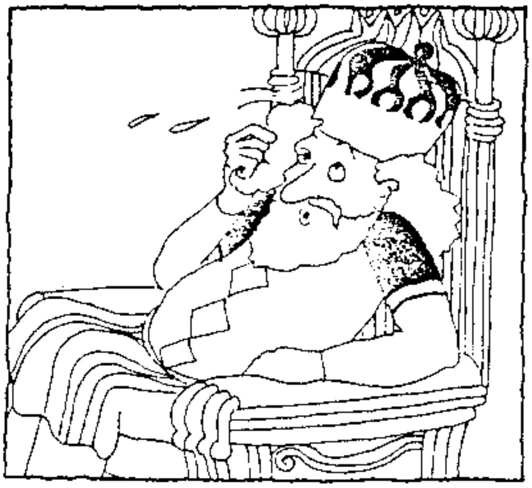
"That's it?" her father asked, horrified. "You expect me to kill all of my knights but one? What kind of kingdom would I have then? There would be just you, your husband, a roomful of dead knights, and the rest of my knights cowering in the countryside for fear of ever returning to the Round Table. Is this what you call mathematics? Have you gone crazy?" King Arthur was shouting now. He couldn't believe his ears. He wanted Glissanda to be happy, but this was ridiculous.



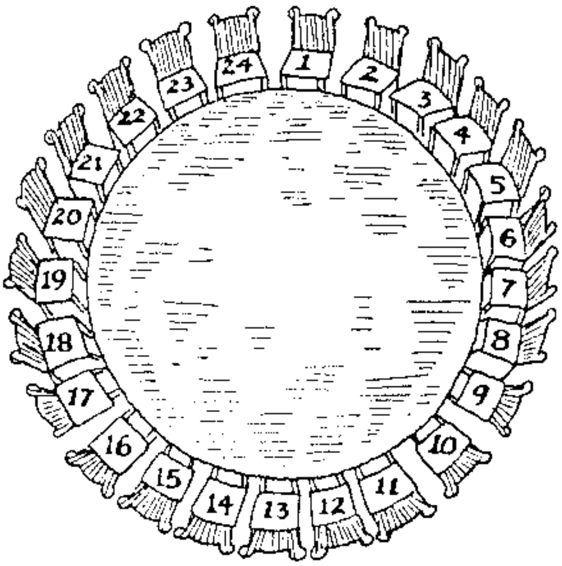


"Oh, father," Glissanda said. "I wouldn't expect you to actually kill anyone. It's just a problem, and it definitely is mathematical. Besides," she went on, giggling a bit, "if you don't tell them you really won't chop heads, then only the brave knights will come. Then I'm sure to have a husband with courage as well as one with mathematical intelligence."

"But Glissanda," King Arthur went on, still rather upset, "I admit it's an unusual problem that is a true test of logical thought. But how do you know 24 knights will return that day to find the solution?"



Glissanda giggled a bit more, feeling even merrier. "That's the real point to the problem," she said. "Don't tell, but the knight of my dreams would know that he has solved the problem only if he knows where to sit for *any* number of chairs. I've been working on this problem, and there's a marvelous pattern for the solution!"



Which seat is the right one when there are 24 knights at the Round Table? Can you find the pattern for predicting which is the right seat for any number of chairs?

Key--Packet 1

Pictures on my Mind

1. cost, receive, paid, $3.80
2. collected, paid, received, give, $4.00
3. ate, scored, 1070 points

"P.I." I.Q.

Part I

- \- ago (as in "how many years ago")
- \+ all together
- \- between
- \- difference
- ÷ divided
- ÷ each (as in "If you have 12 apples and three children, how many apples would each receive if they were divided evenly between them?")
- ÷ evenly
- \- farther
- \- from
- \- get back
- \+ in all
- \+ or - later (as in "How many hours later did they leave?")
- \- left
- \- more
- x product
- ÷ quotient
- \+ sum
- \- than (as in more than)
- x times
- \+ together
- \+ total
- \+ or - until (as in "How many hours until they return?")
- \- years ago

Part II

1. evenly, each, $2,000

2. total, sum, divided, plus, product, times, minus, 33 clients

3. answers depend upon correct date

4. (a) total, $920
   (b) difference, $415
   (c) average, $184
   (d) left, $19,080

Riddle

1. 9
2. 2 apples
3. you can't take dirt from a hole
4. 3
5. 12
6. 10 days
7. a half-dollar and a nickel
8. 70 [$30 \div 1/2 = 30 \times 2/1 = 60$, $60 + 10 = 70$]
9. 3 birds in a row, 1 behind the other
10. one
11. 1 hour
12. all of them
13. 1 hour--the alarm would go off at nine

Poznick Case

1. 1967
2. 8
3. 7 miles
4. 13 years
5. 51 (children only)
6. 53 pets
   17 children
   2 parents
   72 in all
7. not enough information to determine

King Arthur

Seat 17 is the sole survivor.

PACKET II

WHAT'S YOUR SIGN?

Pam Kuzminski

Math is "Symbol-fully Wonderful"

Purpose: (a) to review the common math symbols
(b) to create an awareness of the relationship between a symbol, a word, and any other uses of the symbol

Skills: symbol identification
technical vocabulary
multi-meaning symbols

Content strands: graphic skills
vocabulary
comprehension

Materials: pencil

Time: 15 minutes

Class organization: whole class

Preparation:

1. The teacher opens the discussion with the concept that math has a special symbol language that one must fully understand to work problems. Those symbols, however, are not always as simple as they may first appear.

2. Put a dot (.) on the board and ask what it is. Elicit responses of a period, dot, circle, etc.

3. In math, however that "." has a special meaning. It is a decimal indicating those numbers that are less than one (another way to write a fraction) as in 2.34.

Activity:

1. Read the top section of the sheet aloud.

2. Have students fill in the chart.

*3. Go over the answers together. Discuss differences and shades of meaning.

Math is "Symbol-fully" Wonderful

A symbol represents a concept, idea, expression, operation, or quantity that may be entirely different from your normal reading. One small symbol may contain a great deal of meaning. Complete the chart below to see how "symbol-fully" wonder you are.

Symbol	Word	Other use of Symbol
	plus	cross
$		
1/4		
	question mark	
	one-half	
¢		
	percent	
<		
12		
		dash
	greater than	
=		
		letter X
0		

What's Your Sign

Purpose: to reinforce and extend knowledge of math signs and their various meanings

Skills: symbol identification
context clues
story generation
graphic aids--using a chart

Content strands: graphic skills
comprehension
language experience

Materials: pencil and paper

Class organization: whole class, individuals, partners

Time: 45 minutes

Preparation: Simply remind the class that several words may be appropriate for a symbol. Write the following example on the board:

+ plus, the sum of, increases
- minus, decreased

Activity:

1. Assign Part I, telling pupils to write the best and most appropriate word that they can think of above the symbols in the story.

2. Have several students read their translated paragraphs. Compare and contrast answers and suggest possible better selections if necessary.

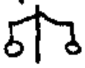
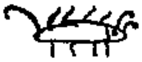
3. Assign Part II.

4. Allow partners time to go over their answers together and discuss any problems.

*5. Close the activity by asking for student comments about the problems that they might have encountered.

What's Your Sign?

For those who believe in astrology, a person's "sign" is extremely important. Theoretically, a zodiac sign is indicative of the type of person one is. Every day in the newspaper, you can find your horoscope--what should happen that day--according to what sign you were born under. Use the chart below and your knowledge of mathematics symbols to translate the following story. *Remember, symbols may have several appropriate corresponding words, but the context of the story should determine which one is best.

Sun Sign	Birth Period	Symbol
Aries, the Ram	March 20-April 20	
Taurus, the Bull	April 20-May 21	
Gemini, the Twins	May 21-June 21	
Cancer, the Crab	June 21-July 22	
Leo, the Lion	July 22-Aug. 23	
Virgo, the Virgin	Aug. 23-Sept. 23	
Libra, the Scales	Sept. 23-Oct. 23	
Scorpio, the Scorpion	Oct. 23-Nov. 22	
Sagittarius, the Archer	Nov. 22-Dec. 21	
Capricorn, the Goat	Dec. 21-Jan. 20	
Aquarius, the Water Bearer	Jan. 20-Feb. 19	
Pices, the Fish	Feb. 19-March 20	

Part I

Peter + Has a Problem

Peter +, a  , has a popularity problem. Lately, his popularity is ≠ to what it was last year; in fact, it has - to 1/2 of what it was. He ? the few friends that he still had. The  and the  said that these bad X would + even more if he did not cut out the large % of X in which he bragged and boasted about how wonderful he was. Diana $, born  15, told him that the < he became more boastful, the number of friends he had would be > ever. Let's hope Peter + comes to his ¢¢¢!

Part II

Now, using each of the following signs, develop your own brief story. Then, trade it with your partner so that it can be decoded.

Signs

+	=	÷	your zodiac sign
-	1/4		
X	%		

Shorthand, Mathematics Style

Purpose: to establish and strengthen the relationship between symbols and prose

Skills: symbol and word transformations
word order vs. symbol order
technical vocabulary
computation
multi-conditional problem solving

Content strands: vocabulary
comprehension
sources of difficulty

Material: pencil

Class organization: individual

Time: 30 minutes

Activity:

1. Read the introduction to the lesson.
2. Assign Part I. Write the answers on the board when students have finished so that both oral and visual reinforcement will be utilized. Elicit student problems and discuss.
3. Assign Parts II and III. Discuss answers.

Shorthand, Mathematics Style

In mathematics, one symbol may be substituted for what otherwise would take many words to write out. Use your knowledge of symbols to rewrite the following expressions in "math shorthand." Also, solve each equation that you write. Remember, the order may be different when translated.

Example: six times three equals ? ______ 6 X 3 = 18 ______

Part I

1. twice twelve is ? ______
2. eighty-four decreased by twenty-three equals ? ______
3. three plus two minus four is ? ______
4. one-fifth of ten is ? ______
5. seven increased by two is ? ______
6. sixteen less five is ? ______
7. the product of six and five is ? ______
8. the quotient of sixty-four divided by eight is ? ______
9. the sum of five and six is ? ______
10. the difference of six from ten is not equal to the product of two times three ______
11. six times two is less than twenty minus two ______
12. three and two and six and four altogether are ? ______
13. fifty-four is greater than the product of six times eight ______

*14. thirty-six shared equally among six groups is ? ______

Part II

Now, translate these statements into words and solve if necessary.

15. $9 \times 9 = ?$ ____________________

16. $56 - 32 = ?$ ____________________

17. $(4 + 3) - 2 = ?$ ____________________

18. $30 > 5 \times 5$ ____________________

19. $3/5 \times 15 = ?$ ____________________

20. $36 \div 6 \neq [(5 \times 5)+(12-6)] \div 6$ ____________________

Part III

Translate the following word problem into the appropriate equation and find the solution.

Dan is twice the age of his little sister Kathy. Kathy's age is the product of four and five minus the difference of 14 from 28. David, their brother, is 11. How old is Dan?

Are You "Cross-Wise" with Math Terms?

Purpose: to review and reinforce frequently used technical vocabulary terms

Skills: technical vocabulary
language of mathematics
reading in different directions

Content strands: vocabulary
graphic skills

Material: pencil

Time: 30 minutes

Class organization: individual

Preparation:

Introduce the idea that in order to be successful in math, one must understand the language.

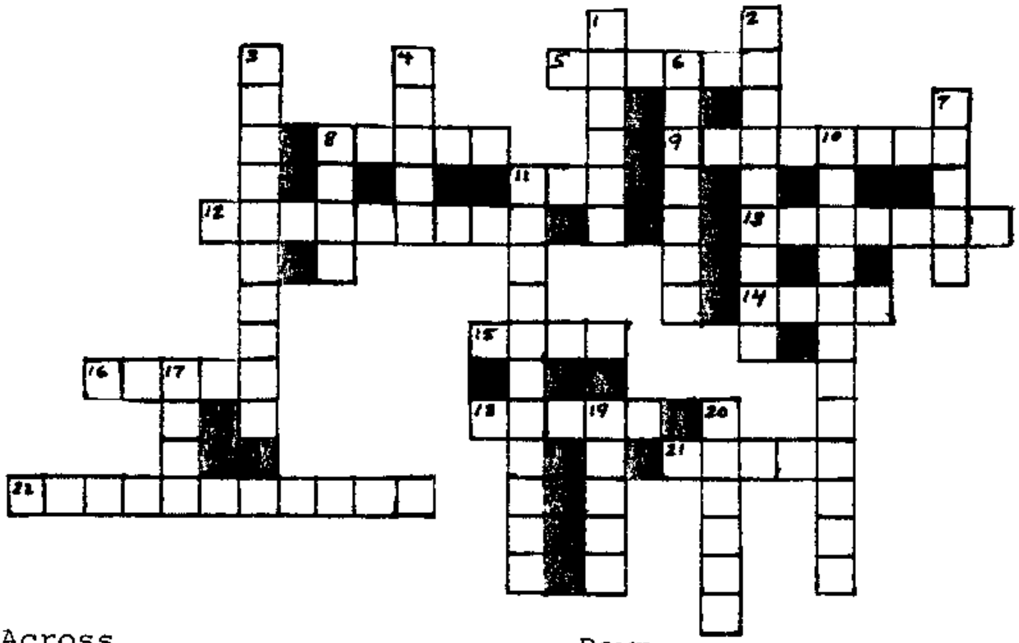
Activity:

1. Assign the puzzle, but do not give out the list of terms. Encourage students to answer every question that they are able to quickly and to save those ones that they find to be more difficult.

2. After 10 minutes, pass out the list of terms and instruct them to use these terms to complete the puzzle.

*3. Go over the answers together by reading both the clue and the appropriate answer.

Are You "Cross-Wise" with Math Terms?



Across

5. 4 equal sides
8. a number divisible only by one and itself
9. guess
11. for every
12. distance around
13. set in which there are no members
14. opposite of more
15. one of 2 equal parts of the whole
16. 12 of something
18. how wide
21. how deep
22. about

Down

1. a number times itself
2. 4 sides with 2 longer segments
3. getting larger
4. 2 times
6. A+B+C=D÷3= the ________
7. 100 centimeters
8. 2 of something
10. unit of speed (3 words)
11. chance
17. none, first whole number
19. sum
20. how long

"Cross-Wise" Terms

Note: This list contains all of the words necessary to solve the puzzle. You must be careful, however, because not all of the words are used, and one term is used twice.

prime	per	one
average	pair	total
approximate	depth	dozen
once	zero	length
probability	meter	kilometer
miles per hour	width	half
square	minutes per hour	rectangle
twice	increasing	less
perimeter	area	null set
estimate	divide	inch

One Picture is Worth 1000 Words

Purpose: to strengthen use of mathematical language

Skills: vocabulary--position, direction; geometric shapes; symbols; spacial relationships; reading in different direction

Content strands: vocabulary, language exp., graphic skills

Materials: pencil, paper, divider   Time: 30 minutes

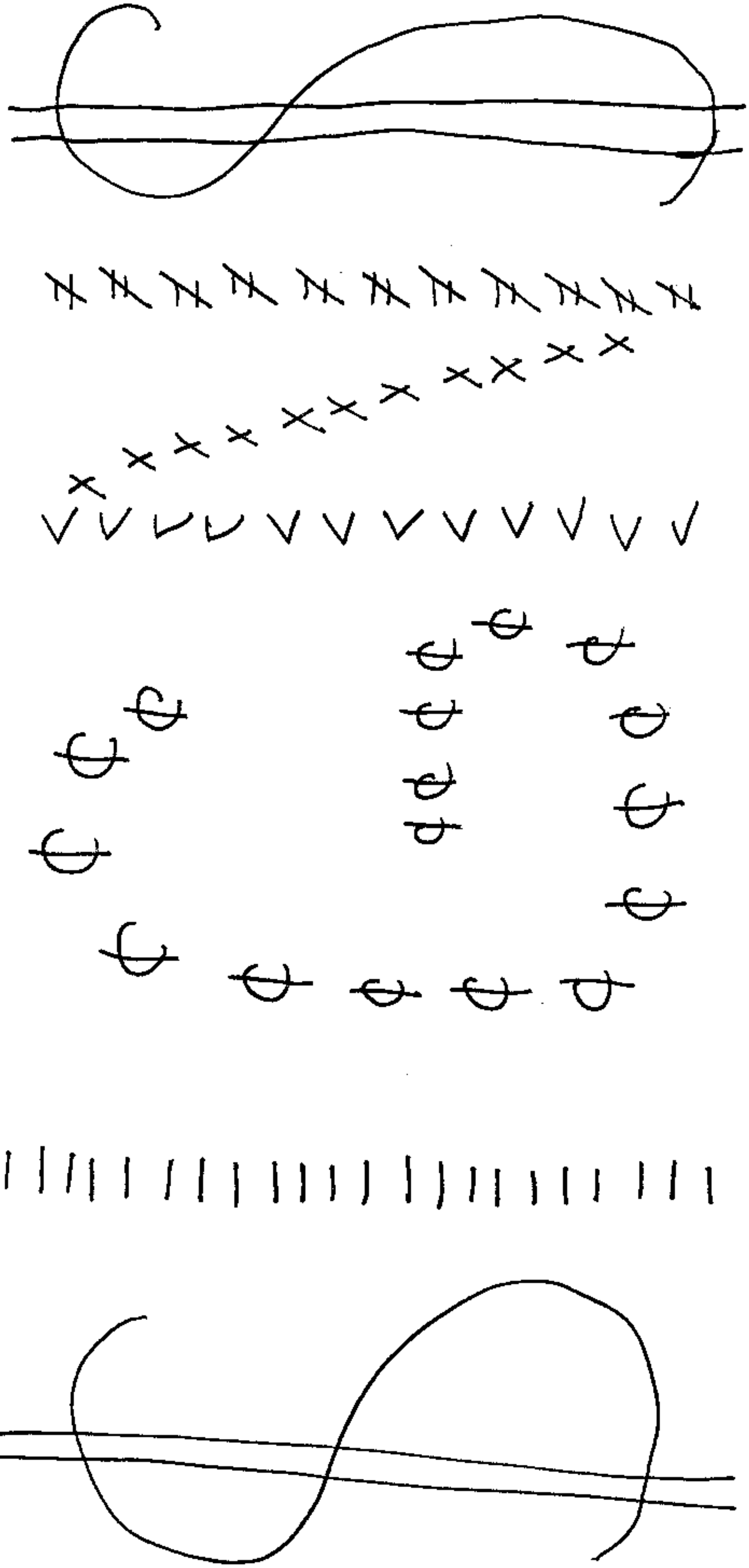
Class organization: groups of three

Preparation:

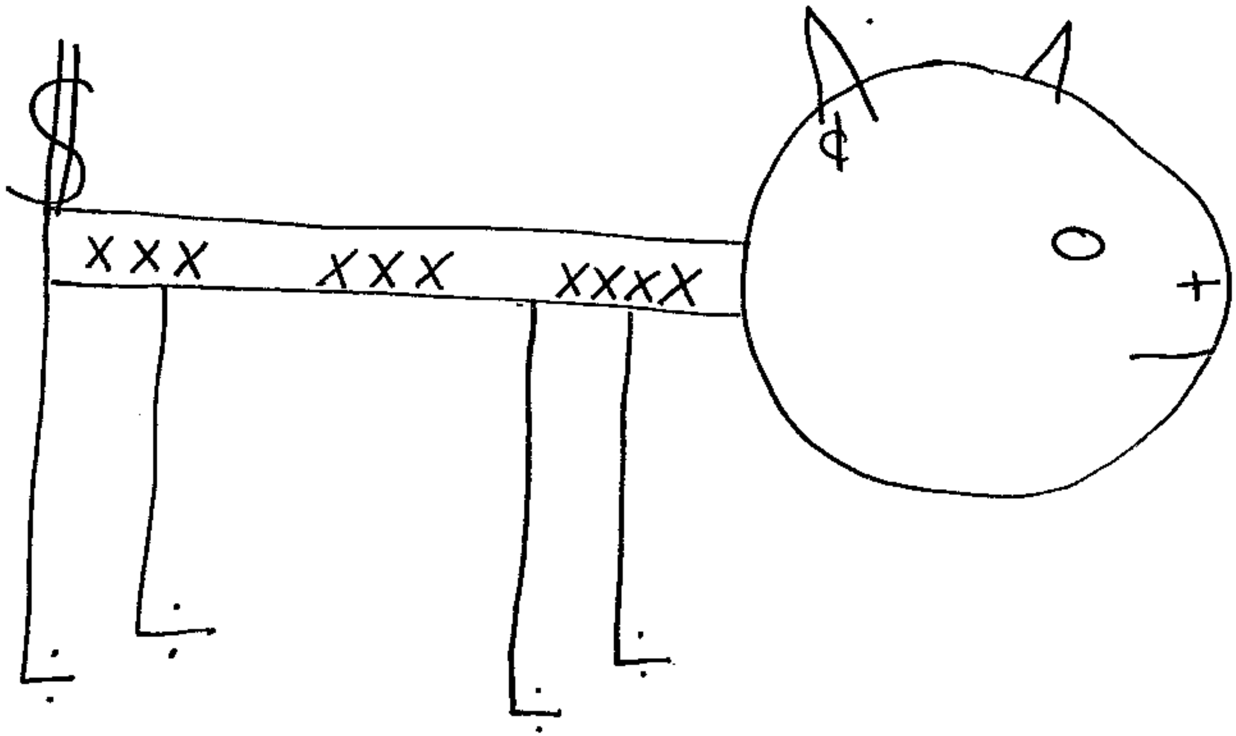
1. Discuss those words that indicate position or direction (above, under, beside).
2. Present students with an arrangement of some sort using items that they all would have (pencil, book, paper, etc.). Ask them to copy your arrangement.
3. Discuss how simple this seemed and why (visual clues).
4. Introduce the idea of reconstructing some sort of arrangement with only word clues.

Activity:

1. Arrange pupils in groups of three. Have each group member face the other two members, placing a barrier (an open notebook stood up vertically will do) between them. Give each group member a different picture to study secretly and two clean sheets of paper.
2. Speaker 1, the pupil who has Picture 1, using only words, must instruct his group members in a recreation of his picture. When completed, the group should compare their drawings to the original. Encourage them to discuss problems and differences.
3. Continue the process with Speakers 2 and 3.
4. Briefly discuss with the entire class the things that helped or confused them. Then, help students to notice that Picture 3 may have been more difficult to reconstruct because of its abstract nature, while the other two formed an animal or familiar letters. This may be why math signs give us so much trouble!



Picture 2



¢

+

900,852,010

$\frac{2}{3}$

(1,2,3,4,5,6)

#

$\neq$

Key-Packet 2

"Symbol-fully" Wonderful

Symbol	Word	Other Use of Symbol
+	plus	cross
$	dollar(s)	*
1/4	one-fourth	1÷4 signal division
?	question mark	*
1/2	one-half	division of 1÷2
¢	cent(s)	*
%	percent	*
<	is less than	angle
12	twelve/dozen	counting nos.
−	minus	dash
>	greater than	angle
=	equal	parallel lines
X	times, multiply	letter X
0	zero	the letter O

*Note--The creative answers in these areas should be examined for validity. Not every one may have an answer!

What's Your Sign?

Peter Plus Has a Problem

plus, Libra, not equal to, diminished, one-half, questioned, Pisces, Aries, times, increase, percent, times, Dollar, June, more, less than, plus, "cents" for senses.

Shorthand

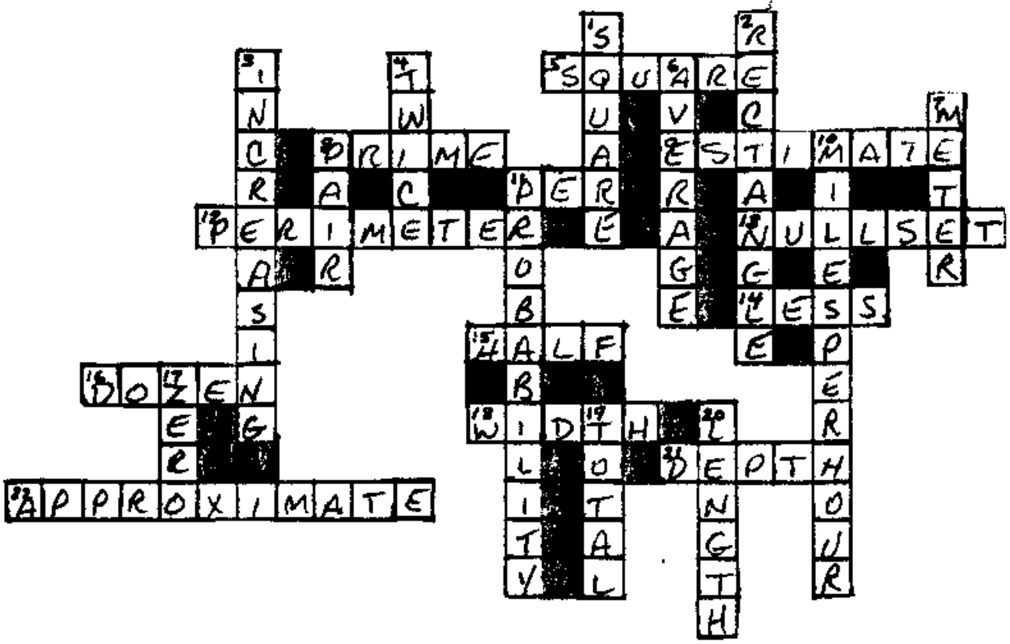
Part I

1. $2 \times 12 = 24$
2. $84 - 23 = 61$
3. $3 + 2 - 4 = 1$
4. $1/5 \times 10 = 2$
5. $7 + 2 = 9$
6. $16 - 5 = 11$
7. $6 \times 5 = 30$
8. $64 \div 8 = 8$
9. $5 + 6 = 11$
10. $10 - 6 \neq 2 \times 3$
    $4 \neq 6$
11. $6 \times 2 < 20 - 2$
    $12 < 18$
12. $3 + 2 + 6 + 4 = 15$
13. $54 > 6 \times 8$
    $54 > 48$
14. $36 \div 6 = 6$

Part II

Dan's age $= [4\times5-(28-14)]$
$= 2[20-14]$
$= 2[6]$
$= 12$

"Cross-Wise"



PACKET III

READ ALL ABOUT IT!

Pam Kuzminski

Extra! Extra!

Purpose: to provide practice in identifying and dealing with problems which contain insufficient and extraneous data

Skills: insufficient data
extraneous information
details

Content strands: sources of difficulty
comprehension

Time: 30 minutes

Material: pencil

Class organization: individual

Preparation:

1. Introduce the idea that in some cases not enough information is supplied to answer a question.

2. Read the introduction to the sheet.

Activity:

1. Assign the activity.

*2. Discuss the answers in detail.
   (a) Bring out the idea that words may not be as exact as numbers and, therefore, it was impossible to answer some questions (few, lower). This brings into focus how important the technical language of mathematics is.
   (b) Detail words (today, yesterday) may be critical to the answer.
   (c) Check to see how many followed the direction of what to write if insufficient data were given. Directions are important!
   (d) Not all reasoning processes have a numerical or a "right" answer. Problem #4 tends to distract a person with the mileage figures on the map. Call attention to the "bridge out" sign. Based on what is known about the "Earls," if they can not go around, they would go down Daisey Drive and simply jump over the stream!

Extra! Extra!

The Haggard County Happening is a newspaper with a few problems. It seems that their star reporters, Sidney Snoop and Sally Scoop, have a tendency to leave out important details in their stories. Without these details, a reader can not find the answers to important questions. In the problems below, answer the questions when you are supplied with the necessary information. If the facts that you need are not given, write "Sidney and Sally goofed."

1. There were 4,236 deaths reported in Haggard County last year. Four hundred twenty of these reported deaths were due to "old age" and 704 were the result of disease. The rest were traffic-related. The Earl boys, however, had been in only 23 accidents, two of which were mid-air collisions.

(a) How many lives were lost in traffic-related accidents?

(b) How many unreported accidents were there?

2. Boss Pig released the latest sales tax figures for the current year. He reported that the present tax of 15¢ on every dollar spent in Haggard County was "not allowing him to live like he would like to . . . oh, uh, provide the county with the community services that it should give the citizens." He has proposed a new 25¢ tax on every dollar spent, except for a lower tax on cigars and white Cadillac convertibles. The City Council passed the measure and it is effective immediately.

(a) How much was the tax increased?

(b) If you bought $17 worth of food yesterday, how much tax would you pay?

(c) How much is the tax on cigars?

(d) If you spent $17 on food today, what was your total bill when the proper tax was added?

(e) What was the vote count when the Council voted on the sales tax measure?

3. Scooter has announced new hours for his garage since his cousin, Hooter, has moved to Haggard to help him. Scooter, who will work from 6 a.m. to 3 p.m., will specialize in fixing transmissions, tires, engine adjustments, and repairing the victims of chase scenes. Hooter will work from noon until midnight on any electrical problems that vehicles might have and keep the financial records. Scooter went on to say that starting next week, he plans to enlarge the garage with a new working area that will be 9 ft. by 12 ft. Make sure y'all stop by to welcome Hooter to our town.

(a) How many hours a day will at least one person be working at the garage?

(b) How many total hours will be spent per day on the General Grant?

(c) How many more hours will Hooter work than Scooter?

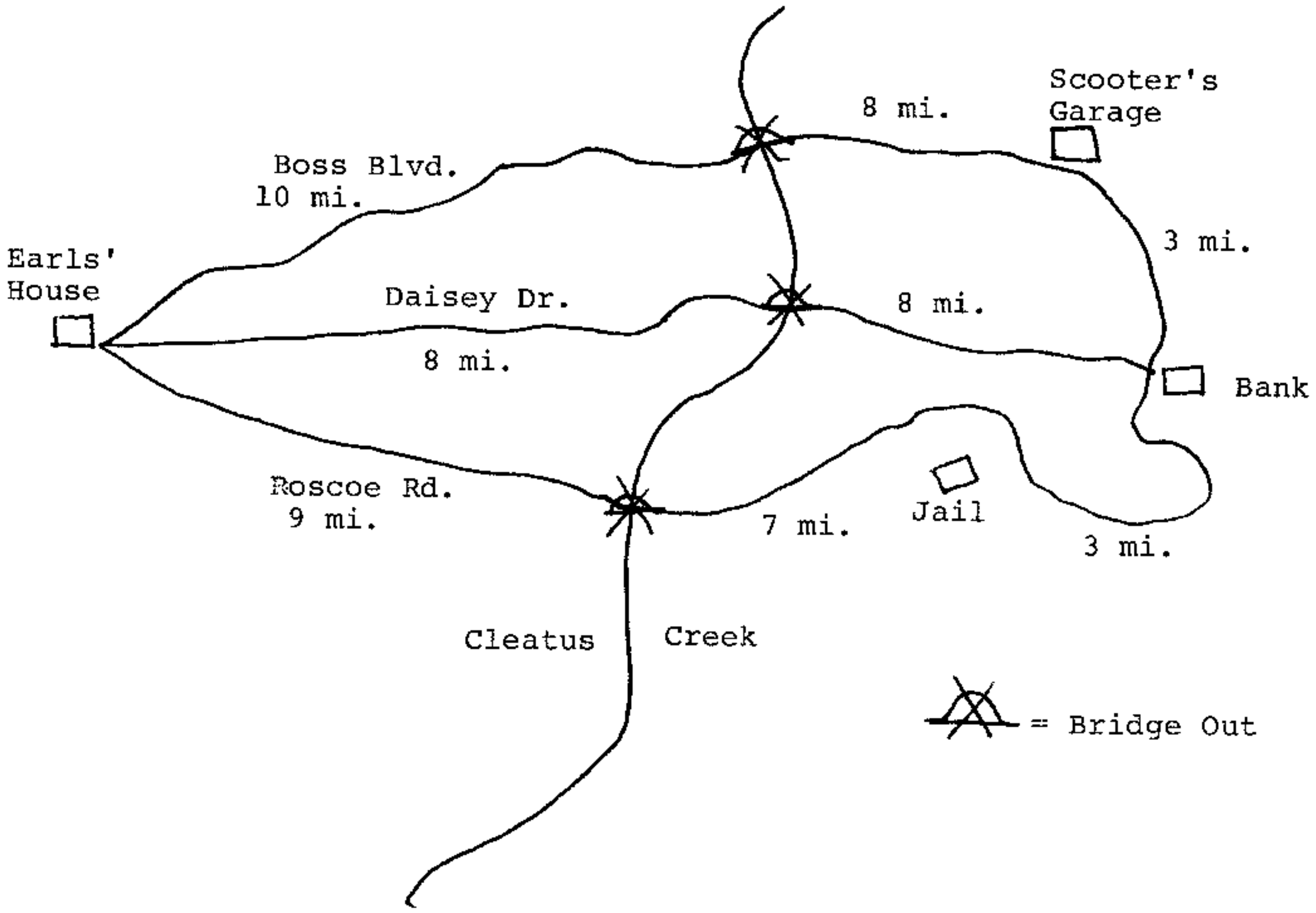
(d) What is the area of the new addition to the garage?

the perimeter?

(e) How many days will it be until work on the garage is started?

4. Mo and Merle Earl are famous for driving over or around any obstacles in their cars, the General Grant. Even though no one ever sees them work, they must always deliver the mortgage money for the Earl farm to the bank. If they are late, Uncle Messie will lose the farm. It is 16 miles from the Earl house to the bank on the most direct route. They usually can make the trip in 20 minutes; however, the bridge on that road was washed away last night in a storm. Using the map below <u>and</u> what you know about the Earls' driving habits, decide which road Mo and Merle will take.

The answer is ______________________________.



This Day in History

Purpose: to create an awareness that math word problems may reflect the time period in which they were written

Skills: problem generation
multi-operational problems
data out of order

Content strands: interdisciplinary
language experience
sources of difficulty

Materials: pencil, paper, history text (optional)

Time: 30 minutes

Class organization: whole/partners

Preparation:

1. Open with a discussion in which you solicit ideas of things that make students think of the past.
   Ex. Boston Tea Party--Revolutionary War
   blacksmiths--Old West where horses were major form of transportation
   steamboats--1800s
   biplane--World War I

2. Then, ask what things might reflect our society today. Mention computers, video games, the space shuttle, high interest rates, jobless people, etc.

Activity:

1. Read the introduction to the activity aloud.

2. Assign Part I. Check immediately.

3. After establishing partners, assign Part II. Allow pupils to check their partners' work.

*4. Briefly solicit comments about especially good original problems. Share several with the class.

This Day in History

Word problems in our math books have some very interesting qualities that many of us have never thought about. They require us to work with both symbols and words and draw relationships between the two. Less obvious is the fact that, in many instances, these problems actually reflect the time in which they were written. The word problems of long ago may deal with different forms of transportation, other types of jobs, wars, major events, and even the strict religious influence of earlier years. In the following problems, read and solve the problem and then see if you can guess the era it refers to. (Note: Some time periods will be more specific than others.)

Part I

1. Five heavily armed wagons full of gold left the California mountains headed for the nearest railroad crossing. The gold would be loaded onto specially secure train cars for shipment to a bank on the east coast. Wagon 1 carried 512 lbs. of gold, Wagon 2 carried 486 lbs. of gold, Wagon 3 carried 382 lbs. of gold, Wagon 4 carried 553 lbs., and Wagon 5 carried 399 lbs. of gold. If one security car could haul only 1 ton of gold, then . . .

   (a) How many pounds of gold would be loaded onto the second car when the first one was full?

   (b) How many pounds would be put on each car if the gold was distributed evenly between the two cars?

(c) What era does this represent?

2. The glorious boys in grey won a stunning victory last week. The Confederate forces, numbering 2,300, decisively drove the 15,000 Yankees back.

(a) By how many men were the Confederates outnumbered?

(b) What era is this?

3. Ration points are necessary in order to buy certain goods. It takes 3 ration points per can of food, 20 points per pair of shoes, 2 points per pound of meat, and 3 points per 5 lb. sack of sugar.

(a) If June wants to buy 10 lbs. of sugar, 1 pair of shoes, 3 lbs. of meat, and 15 cans of food, how many ration points must she have?

(b) Era?

Part II

Now, using this same idea, create 3 word problems of your own, one reflecting the past and two reflecting our present society. Trade them with your partner, solve the problem, and check your answers. You might want to use a history book for ideas.

Best Deal in Town

Purposes: to promote consumer education
to build a student's ability to work with many variables and to graphically arrange the data
to strengthen the ability to use data charts to answer stated problems

Skills: data collection and generation, note-taking, use of charts; percentages; comparison of variables; multi-conditional problems; symbol/word relationships

Content strands: graphic skills, sources of difficulty, problem solving

Material: pencil

Time: 1 hr./two 30-min. periods

Class organization: whole class/partners

First Session

Preparation:

1. Introduce the idea that many people will buy products based on newspaper advertisements. These ads may be misleading if you are not a smart shopper.
2. When buying cars today, most people must pay for a car over a period of months. When doing this, one must pay interest, a certain percentage of the cost added to the total price--or the price you pay for borrowing money. This may drastically affect one's ability to buy a particular automobile.
3. Today the class will take the advertisement information, arrange it in chart form, and generate further data.

Activity:

1. Hand out the activity sheet and the chart.
2. Write the following on the board. 1983 Firebird; List Price: $10,000; Interest Rate: 10%; Payment Period: 48 mos.; Monthly payment: $270; Down Payment: 10% of the list price
3. Have students record the given data on their chart.
4. Then, figure the down payment and total cost.

$$\begin{array}{rr} & 10{,}000 \\ & \underline{.10} \\ \text{down payment} & 1000.00 \end{array}$$

If monthly payments are $270 for 48 mos., what is the total cost of the car?

Down payment	1,000
+(Monthly pay X pay period)	+12,960
Total Cost	13,960 total cost

But what if the payment period is 36 mos.? If the monthly payments are $321, then what is the total cost of the Firebird?

$$\begin{array}{r} 1{,}000 \\ +11{,}556 \\ \hline 12{,}556 \end{array} \text{ total cost}$$

Then, determine . . .

(a) the difference per month

$$\begin{array}{r} 321 \\ -270 \\ \hline \$51 \end{array} \text{ per month}$$

(b) the total cost difference

$$\begin{array}{r} 13{,}960 \\ -12{,}556 \\ \hline \$1{,}404 \end{array}$$

(c) the reason the total price may vary
the longer the payment period, the more interest one must pay

Note: During this process, remind students of the following.
(a) 10% = .10, 15% = .15
(b) Put decimals in answers after multiplying by a decimal number (200 X .10 - 20.00).

5. Instruct students to work as partners and to complete the chart.

Second Session

Activity:

1. Complete the charts if necessary.
2. Review the idea that "1/n of something" means to multiply. Example: 1/4 of 2000 = 1/4 X 2000 = 500
3. Hand out questions to be answered. Partners may work together and encourage them to discuss answers.
4. Go over answers orally as a class. Discuss variables that may have caused difficulty.

Note: Scenarios may have more than one answer that is reasonable.

Best Deal in Town

The following information was posted in a local newspaper's advertisement section in regard to the cars that a local dealer was featuring for the week. You are extremely interested in buying a car, but you must do some comparative shopping. Use the advertisement information below to see if you can afford the car of your dreams. Remember, interest rates do make a difference and you <u>must</u> consider income and other factors when necessary!

Car 1: Magnum Special
1983 Red Ferrari
List Price: $45,000
Interest Rate: 10%
Payment Period: 48 mos.
Monthly Payment: $1245
Down Payment: 10% of list price

Car 2: Family Dream
1983 Monte Carlo (loaded)
List Price: $15,000
Interest Rate: 11%
Payment Period: 48 mos.
Monthly Payment: $465
Down Payment: 10% of list price

Car 3: Sporty and Practical
1983 Thunderbird
List Price: $9,400
Interest Rate: 9%
Payment Period: 48 mos.
Monthly Payment: $224
Down Payment: 10% of list price

Car 4: Economy Plus
1983 Nissan Sentra
List Price: $8,000
Interest Rate: 11%
Payment Period: 48 mos.
Monthly Payment: $186
Down Payment: 10% of list price

Car 5: Gas Miser
1983 Nissan Sentra
List Price: $8,000
Interest Rate: 11%
Payment Period: 36 mos.
Monthly Payment: $272
Down Payment: 10% of list price

DATA SHEET

Car	List Price	Interest Rate	Down Payment	Monthly Payment	Payment Period in Mos.	Total Cost

Questions

1. Which is the most expensive car if you pay the list price?

   the least expensive?

2. If you could afford a monthly payment of less than $200, which car should you buy?

3. If you could afford monthly payments of less than $350, what cars could you consider?

4. If a car payment should consist of 1/6 of your monthly budget, and your monthly income is $2,000, what car(s) might you consider?

5. If a car payment should consist of 1/6 of your monthly budget, and your monthly income is $6,500, what car(s) might you consider?

6. If a car payment should consist of 1/6 of your monthly budget, and your monthly income is $1,400, what car(s) might you consider?

7. Which installment plan would be the most economical in regard to total cost, Car 4 or Car 5?

   How much could you save?

Scenarios

1. You are a 35 year-old lawyer. You are single, and your yearly income is $36,000. What car might you buy and why?

2. You are a college professor with a yearly salary of $28,000. You have a family of four, and you need an all purpose car for the whole family. What might you select? Why?

3. A married couple with one child has a combined income of $43,000 per year. They already make payments on one mid-size car of $325 per month. What car(s) might they consider buying to serve as a second car to use mainly for going to and from work? Why?

Sports Surplus

Purpose: to strengthen basic comprehension skill when reading word problems

Skills: question generation
deduction reasoning
data out of order
multi-conditional problems
extraneous information
using a simple chart

Content strands: comprehension
language experience
sources of difficulty

Material: pencil

Time: 30 minutes

Class organization: individual

Preparation:

1. Tell the students that there are 30 pupils in a class. Forty percent of the class is female, while 60% is male. If the answer is 12, what is the question? You may wish to write the numbers on the board. Figure the answer for each variable (30 X .40 / 30 X .60) and then generate the question. Question: How many girls are in that class?

2. Quickly review the main interrogative words by writing them on the board and leave them up during the activity.

what	at what time	if . . . then
when	how many	in what year
which	how much	in which
who	how far	
how	how long	

Activity:

1. Assign activity.

2. Go over the questions orally. Note the best ways to word question as well as their suitability.

Sports Surplus

Scott Scurry has been having some difficulty in writing his sports news for this edition. He knows what he wants to say, he just does not know how to word his script correctly. Can you supply the appropriate question to go with his answer?

1. The New York Marathon was run today with 2,341 participants starting the race. Of the runners, 835 were women. During the race, 782 participants were forced to drop out. If the answer is 1506, then what is the question?

2. The National Hot Air Balloon Association held its annual race across the U.S. this week. Foul weather has played havoc with the contest. Of the 45 balloons that began the race, only 38 were sighted at the first check point. However, 44 were noted at Checkpoint Two. By the time the balloonists reached the Rocky Mountains, 37 were still in the race. Bobby Blast, in his balloon "Follow the Rainbow," reached Los Angeles first. Twenty-nine other contestants also completed the race.

(a) If the answer is 15, then what is the question?

(b) If the answer is 7, what are <u>two</u> possible questions?

3. The Texas Strangers are having a bad baseball season. Their batting average as a team has gone down considerably in each of the past ten games. Let's take a look at those figures.

Date	Team Batting Average
July 10	282
11	270
12	270
15	232
16	183
18	180
19	165
20	161
26	181
27	126

You can see the problems they are having. Let's study the data.

(a) If the answer is 156, what is the question?

(b) If the answer is 99, what is the question?

(c) If the answer is July 11th and 12th, what is the question?

(d) If the answer is 205, what is the question? Hint: This is no "average" question!

4. The Girls' Association of Swimmers, GAS, has released the results of their latest private meet. Of the 200 members, 45% are eligible to attend the Olympic trials, and 15% are considered serious contenders for the Olympic teams. Only 22 of the serious contenders and 53 of the others that are eligible, however, plan to attend.

(a) If the answer is 120, what is the question?

(b) If the answer is 8, what is the question?

*(c) If the answer is 15, what is the question?

Packet Key #3

Extra! Extra!

1. (a) 3,112 lives
   (b) Sidney and Sally goofed
2. (a) 10¢ on every dollar
   (b) $2.55
   (c) Sidney and Sally goofed
   (d) $21.25
   (e) Sidney and Sally goofed
3. (a) 18 hrs.
   (b) Sidney and Sally goofed
   (c) 3 hrs. per day more
   (d) A = 108 sq. ft., P = 42 ft.
   (e) Sidney and Sally goofed
4. Since all bridge are out, they would use Daisey Dr. and jump the creek.

This Day in History

1. (a) 332 lbs.
   (b) 1,116 lbs.
   (c) gold rush days
2. (a) 12,700 men
   (b) Civil War
3. (a) 77
   (b) World War II

Best Deal in Town

Car	List Price	Int. Rate	Down Paymt.	Monthly Payment	Number of Mos.	Total Cost
1. Ferrari	45000	10%	4500	1245	48	64260
2. Monte Carlo	15000	11%	1500	465	48	23820
3. Thunderbird	9400	9%	940	224	48	11692
4. Sentra	8000	11%	800	223	48	10713
5. Sentra	8000	11%	800	272	36	10592

Questions

1. Ferrari/Sentra
2. None
3. Thunderbird, Sentra 4, Sentra 5
4. Thunderbird, Sentra 4, Sentra 5
5. Thunderbird, Sentra 4, Sentra 5, Monte Carlo
6. Sentra at 48 mos. (#4)
7. Car 5, $121

Scenarios

1. all but the Ferrari
2. Thunderbird or Sentra
3. Sentra or Thunderbird

<u>Sports Surplus</u>

Note: Answers may vary, these are one way.

1. How many of the participants who started the race were men?
2. (a) How many of the balloons did not finish the race?
   (b) How many balloons were not sighted at the first checkpoint?
   How many balloons were lost between checkpoints 2 and 3?
3. (a) What is the difference between their best and worst average?
   (b) What is the difference between the batting average of July 10 and July 16?
   (c) When was the only time that the batting average remained the same?
   (d) What is the average team batting average in July?
4. (a) How many GAS members can go to the trials if they wish?
   (b) How many of the serious contenders will not attend the trials?
   (c) If half of the serious contenders make the team, how many will that be?

PACKET IV

WHAT'S COOKING?

Pam Kuzminski

Zoo Stew

Purposes: to reinforce the ability to work with common units of weight, to increase student awareness of the relationship of math word problems to everyday situations, to introduce a problem solving process that pupils may find useful in problem solution

Skills: problem solving process
equivalent measures

Content strands: problem solving
interdisciplinary

Material: pencil

Time: 30 minutes

Class organization: individual

Preparation:

1. Write the following on the board. 16 oz. = 1 lb.
   2,000 lbs. = 1 ton
2. Briefly review.
   If I have 32 oz. of meat, how many pounds is that?
   If a truck weighs 4 tons, how many pounds is that? ounces?

Activity:

1. Inform pupils that they are about to do some very "wild" cooking. Assign the activity.

2. Discuss the answers, especially on #4. Take special care to note how pupils state processes and operations. If they are unable to work in this verbal realm, they may be lacking an important language base in mathematics.

Zoo Stew

1 elephant (2 tons)

2 medium giraffes (750 lbs. each)

1 lion (800 lbs.)

2 tigers (500 lbs. total)

2 rabbits, optional (6 lbs. each)

Salt and pepper (1 lb. each)

Cut the elephant, giraffes, lion, and tigers into bite-size pieces. This may take up to two months. Add 1,600 ozs. brown gravy. Cook over an extremely large kerosene fire for about four weeks at 450 degrees. This will serve 3,451 people generously. However, if more are expected, two rabbits may be added, but do this only if necessary because most people do not like to find a hare in their soup.

Circle the correct answer in each column.

Problem	What Should I Find?	What Should I Do To Get the Answer?	The Answer Is?
What is the total weight of the stew without the 2 rabbits?	(a) the average of the weights listed (b) the sum of the weights (c) the product of the weights	(a) convert the weights to ozs. and add them (b) convert the weights to lbs. and add them (c) add the weights as they are (d) convert to tons and add	(a) 6,802 (b) 6,814 (c) 6,902 (d) 6,914
What is the weight of the stew with rabbits before the gravy is added?	(a) the average of the weights listed (b) the sum of the weights (c) the product of the weights	(a) the total of #1 plus the weight of the rabbits minus the gravy weight (b) add all of the ingredients at the top part of the receipe	(a) 6,802 (b) 6,814 (c) 6,902 (d) 6,914
If all of the expected 3,451 people come to dinner, about what (give or take a hare) will be the size of each one's serving if the stew is divided evenly among them?	(a) the oz. per person (b) the lbs. per person (c) the size of the bowls	(a) divide (b) multiply (c) subtract (d) add	(a) 8 oz. (b) 15 oz. (c) 2 lbs. (d) 4 lbs.

Given the problem as stated below, you fill in the rest of the chart.

Problem	What Should I Find?	What Should I Do To Get the Answer?	The Answer Is?
If an 8 oz. serving is the average serving size per meal, then for how many meals can the guests eat zoo stew?			

Numbers to Eat By

Purpose: to apply the problem solving skills to real-life situations

Skills: computation
comparison
consumer
multi-conditional problems

Content strands: interdisciplinary
problem solving
sources of difficulty

Materials: pencil

Time: 30 minutes

Class organization: partners

Activity:

1. Begin by asking "Which is a better buy, a case of 24 soft drinks at $7.75 or a six-pack of soft drinks at $2.29?"

2. Hand out the activity and inform pupils that they are about to do something that many people must do each day--be a wise consumer who must plan and stay within a budget. Assign.

3. Go over answers orally. If there is variation in response, check for the reasoning behind it. In this type of activity interpretations may differ slightly, and the idea of being right is not as important as the problem solving process, as long as that process is valid.

Numbers to Eat By

You and your friend are preparing a dinner for four for very special company. You want the meal to be of top quality, yet your budget requires that you be especially careful of costs. The following is your menu.

Baked Chicken
Green Beans Oriental   Rice
Dinner Rolls
Pineapple Sherbet
Tea or Coffee

Your budget will only allow you to spend $14.00 at the most on this meal. The chicken that you purchased cost $5.12. The sherbet was $2.80, and the rolls were $1.10. You already have rice, coffee, and tea at home. Now you must decide if you can afford to make the Green Beans Oriental, a favorite of your company. This is the receipe.

2 16-oz. cans French-style
1 16-oz. can bean sprouts, drained
1 5-oz. can water chestnuts, drained and sliced
Salt and pepper to taste
1 4-oz. can mushrooms, drained
1 10-oz. can cream of mushroom soup
1 3 1/2-oz. can French-fried onions

In a buttered 2-quart casserole, combine all ingredients except onions. Top with onions. Bake about 15 minutes at 325°.

Now you head to the grocery store to price the items. You must be careful to look at the measurements (ounces per can) of the receipe and the amount per can of a product. You may need more cans that it first appears, and you may end up with a surplus of some products. You discover the following information.

green beans

Del Monte 16 oz. 2/$1.00
Safeway 16 oz. 47¢
Del Monte Fancy 16 oz. 57¢
Scotch Buy 16 oz. 35¢
Green Giant 16 oz. 53¢
Del Monte 8 oz. 37¢
Safeway 8 oz. 33¢

mushrooms

Safeway 4 oz (stems & pieces) 65¢
B in B 3 oz. (sliced) 95¢
B in B 3 oz. (stems & pieces) 83¢
Safeway 4 oz. (sliced) 89¢
Green Giant 4 1/2 oz. (sliced) $1.33

bean sprouts

La Choy 14 oz. 57¢
only brand available

water chestnuts

La Choy 8 oz. 95¢
only brand available

cream of mushroom soup

Town House 10 3/4 oz. 29¢
Campbells 10 3/4 oz. 33¢

French-fried onions

Durkee 2.8 oz. 75¢
Durkee 6 oz. $1.55

Answer the questions in light of the dish you are making.

1. Which is the best buy?
   (a) green beans?
   (b) bean sprouts?
   (c) water chestnuts?
   (d) mushrooms?
   (e) soup?
   (f) onions?

2. Which is the most expensive product?
   (a) green beans?
   (b) mushrooms?
   (c) soup?
   (d) can size of onions?

3. What is the total cost of the dish if all of the
   (a) best buys are used?
   (b) most expensive products are used?

4. How much money did you spend before you left to price the receipe items?

5. How much could you spend in order to stay within your budget?

6. Can you make the dish?
   If no, how much over your budget of $14.00 would you go?

   If yes, how much money less than the $14.00 did you spend?

Do Your Measures "Measure UP"?

Purpose: to strengthen and review units of measurement, their equivalencies, their abbreviations, and their relationships

Skills: technical vocabulary
abbreviations
equivalent measures
relationships

Content strands: vocabulary
comprehension

Time: 15 minutes

Material: pencil

Class organization: individual

Activity:

1. Hand out the sheet and assign both parts.

2. Check activity orally, stating the measure and its equivalence in addition to the correct letter choice. This has a strong reinforcing effect upon many learners.

3. Discuss Part II, especially the "why" part.

Do Your Measures "Measure Up"?

No matter what you're "cooking," whether it be a receipe or a trip, you may not be successful unless you know your equivalent measures. Match the following. Be careful, abbreviations can be tricky!

Part I

___ 1. liter	(a) 100 yrs.
___ 2. foot	(b) 8 oz.
___ 3. cup	(c) once every 365 days
___ 4. meter	(d) 2c
___ 5. minute	(e) 24 hrs.
___ 6. pint	(f) 3 tsp.
___ 7. centimeter	(g) 1000 ml.
___ 8. pound	(h) 12 in.
___ 9. tablespoon	(i) a little over 1 yd.
___10. gallon	(j) 2000 lbs.
___11. century	(k) 1/100 m.
___12. mile	(l) 7 days
___13. kilometer	(m) 60 sec.
___14. quart	(n) 12 oz.
___15. decade	(o) about 1 mi.
___16. ton	(p) 16 oz.
___17. day	(q) 2 pts.
___18. hour	(r) 4 qts.
___19. week	(s) 100 m.
___20. yard	(t) 5280 ft.
___21. yearly	(u) 1000 g.
___22. kilogram	(v) 36 in.
	(w) 60 min.
	(x) 1000 yds.
	(y) 3 tbsp.
	(z) 10 years

Part II

Circle the member that does not belong in each group and state why.

23. meter
centimeter
yard
ounce
kilometer
foot

Why?

24. hours
days
centuries
tons
seconds
decades

Why?

25. millimeter
inch
ounce
second
gram
mile
teaspoon

Why?

Cooking in a Fraction of the Time

Purpose: to strengthen the ability to correctly use context and operational clue words when dealing with fractional numbers

Skills: context clues, operational clue words, technical vocabulary, fractions, problem solving process

Content strands: vocabulary, comprehension, problem solving processes

Material: pencil

Time: 45 minutes

Class organization: whole/individual

Preparation:

1. Open the lesson with a brief review of fractions. Include the concepts that you can not add or subtract fractional numbers until the denominators are the same. When multiplying fractional numbers, you multiply the numerators and then the denominators, while when dividing them one must invert the second fraction and then multiply.

*2. Then introduce the idea that the way a problem is stated should give you more than enough clues as to how to work the problem. Write and discuss the following steps on the board.

    1. READ THE PROBLEM--for a general understanding
    2. REREAD--for details
    3. LOCATE OPERATIONAL CLUE WORDS--may vary slightly when dealing with fractions. ex. sum, total = add; difference = subtract/if know difference then add; 1/nth of the time = multiply
    4. APPROXIMATE THE ANSWER--size, more or less than one, mixed number
    5. WORK THE PROBLEM
    6. REREAD--to see if you have a reasonable answer in light of the context

Activity:

1. Hand out the sheet and read the introduction.
2. Work #1-4 together as a teacher-guided activity. Go through the prescribed steps <u>carefully</u>, paying close attention to steps 3 and 4. Show all work on the board.
3. Assign the rest of the problems as seat work.
4. Check the answers.
5. Have pupils correct mistakes, especially if the errors are operational in nature. Make them look at the context to discern why their answer was not "reasonable."

Microwave Cooking--Cooking in a Fraction of Time

These days many Americans have discovered the ease and speed of cooking in a microwave oven. In fact, one could truthfully say that when compared to cooking in a conventional oven or on a stove top, microwave cooking takes only a fraction of the time.

Read the problems below to determine just how much time will be saved. Write the appropriate problem and the answer. (Hint: Answers should be fractional in nature.)

1. A T.V. Dinner must cook 30 minutes in a conventional oven, yet it only takes 6 1/2 minutes in a microwave. What is the difference of cooking time between the two methods?

2. It takes 10 minutes to bake frozen chicken fillets in the oven, but it takes only 1/4 of that time to prepare them in a microwave. How many minutes will the microwave method take?

3. It takes 2 minutes in the microwave and 3 minutes on the stove in a pan for 1 cup of water to boil. The microwave method can be done in __?__ of the time.

4. Frozen lasagna requires a cooking time of 16 3/4 minutes in the microwave. The difference between preparing this dish in the conventional oven and the microwave is 18 3/4 minutes. What is the cooking time in the conventional oven?

5. One medium baked potato has a microwave cooking time of 4 1/2 minutes, while 8 medium potatoes require 25 minutes in the microwave. A conventional oven takes 45 minutes whether you are cooking one potato or eight potatoes.
   (a) What is the difference between the cooking time for
   (1) one potato? (2) eight potatoes?

   (b) The microwave method takes what fraction of time when compared to the conventional method for
   (1) one potato? (2) eight potatoes?

6. Six slices of bacon take 6 minutes to cook when fried in a skillet. They could be prepared in 2/3's of the time in a microwave. How many minutes will the microwave method take?

7. A refrigerated 8 oz. baby bottle of formula takes 55 seconds to heat in the microwave. The method of heating in a pan of boiling water takes 5 1/2 minutes. If your baby is screaming, what fraction of time does the microwave method take?

8. A 4 lb. pot roast regularly takes 37 1/2 minutes per pound to cook. The same roast takes 1 hr. 50 min. less to cook in the microwave. How many minutes was it cooked per pound?

9. It takes one pound of fresh spinach 6 to 7 minutes to cook in a microwave. How many 3 1/3 ounce servings will that make?

10. It takes ten minutes to cook frozen corn on the cob in a pan of boiling water. In the microwave, two ears of corn may be cooked in 1/2 of the time, four ears in 4/5 of the time, and six ears in 10/10 of the time. How many minutes does it take to cook in the microwave

    (a) two ears?

    (b) four ears?

    (c) six ears?

    (d) Which takes longer, cooking 6 ears of corn two at a time in the microwave, or cooking them all at once in a pan of boiling water?

Toothpicking

(adapted from _The I Hate Mathematics Book_)

Purpose: to practice reading in the language of mathematics in order to follow directions, to reinforce and expand knowledge of geometric shapes, and to develop problem solving skills

Skills: following directions
spacial relationships
technical vocabulary
fine motor skills
graphic

Content strands: problem solving
comprehension
vocabulary
graphic

Materials: toothpicks--24 per group
clay
pencil

Time: 30-45 minutes

Class organization: groups of three

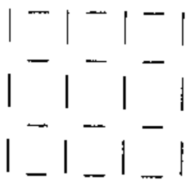
Activity:

1. Hand out the materials and the activity sheet.

2. Instruct students to follow the directions carefully. Each student is to fill in the sheet, even though they are working in groups.

Toothpicking

Many people enjoy a toothpick at the end of every good meal. If you, however, are one of those people who is too refined to do as the name implies, you may discover a whole new dimension to these slivers of wood. Follow the directions below.



1. Arrange 24 toothpicks like this →→→

2. How many squares do these make? (the answer is between 10 and 15, and it's even)

3. Take away 8 toothpicks so that you have two squares left. Draw a picture of this arrangement. →→→→→

4. Four is the smallest number of toothpicks needed to build 1 square. What is the smallest number needed for 2 squares?

5. Fill in the Data Chart below. Record the number of squares which can be made from a given number of toothpicks until a total of 24 toothpicks has been used.

Toothpicking Data Chart

Number of Toothpicks	Number of Squares
4	1
7	2

6. What type of pattern began to emerge on your data chart?

7. Predict the next three entries to the chart based on that pattern.

Toothpicks	Squares

8. Now use the same process and 15 toothpicks with triangles.

Toothpicks	Squares

9. Is there a pattern?

10. Predict the next three chart entries.

Toothpicks	Squares

*11. This is a toothtickler. Give your group only 5 minutes in which to do this. Can you arrange 6 toothpicks so that <u>each</u> one touches all the others? If so, draw your design here. Time:

12. Using small balls of clay, construct a 3 dimensional toothpick structure using a repeating pattern. Name your structure. (Note: Many of these will have a formal mathematical name. You may wish to do some research!)

Key-Packet 4

Zoo Stew

1. b, b, c
2. b, b, b
3. b, a, c
4. no. of 8 oz. in 2 lbs., convert 2 lbs. to oz. and divide by 8, 4

Numbers to Eat By

1. (a) Scotch Buy (b) La Choy (c) La Choy (d) Safeway (s&p) (e) Town House (f) Durkee 2.8 oz.
2. (a) Del Monte Fancy (b) Green Giant (c) Campbells (d) Durkee 6 oz.
3. $5.23 (b) $6.44
4. $8.42
5. $5.58
6. Yes, 35¢

Measure Up

1g, 2h, 3b, 4i, 5m, 6d, 7k, 8p, 9f, 10r, 11a, 12t, 13o, 14q, 15z, 16j, 17e, 18w, 19l, 20v, 21c, 22u

23. ounce, it's a weight, not length
24. tons, it's a weight, not time
25. mile, it's a large unit, not a small one

Cooking

1. 23 1/2 min.
2. 2 1/2 min.
3. 2/3
4. 35 min.
5. (a) 40 1/2 min., 20 min. (b) 1/10 of the time, 5/9 of the time
6. 4 min.
7. 1/6
8. 10 min. per lb.
9. 4 4/5
10. (a) 5 min. (b) 8 min. (c) 10 min. (d) 2 at a time in microwave

Toothpicking

2. 14
4. 7

THE SCIENCE OF MATHEMATICS

PACKET V

Pam Kuzminski

The Study of the Extremely Technical Vocabulary Found When Communicating in the Vernacular of Mathematics
(adapted from Math for Smarty Pants)

Purpose: to provide pupils with an opportunity to use the language of mathematics

Skills: technical vocabulary
context clues
glossary/dictionary
problem generation

Content strands: vocabulary
language experience
interdisciplinary
comprehension

Material: pencil, paper, math book or dictionary

Time: 30 minutes

Class organization: partners

Activity:

1. Divide class into partners. Have them read the activity and identify the description (Part A & B).

2. Now, have each person create an original description of an object written in the language of mathematics. Instruct pupils to refer to their math books, the glossary if there is one, or a dictionary for ideas.

3. Have the partners trade their descriptions and try to identify them.

4. Collect all samples and compile a booklet consisting of student examples. Have all pupils work through it during the week. Number the samples. Have pupils keep an answer sheet of their guesses. The teacher must keep the key and the completed answer sheets. (Note: This activity is continued at the end of the week.)

The Study of the Extremely Technical Vocabulary Found When Communicating in the Vernacular of Mathematics

In science and mathematics, some words that appear to be easy may represent ideas that are much more difficult. In fact, they may have one meaning in normal English usage and a much different meaning in math and science contexts. You do not "set" the table, you work with "sets." Numbers are not "perfect" if they behave themselves, and being "odd" is no reason for the neighbors to talk about them. You do not buy a "product" as the result of your work. These are only a few examples of this dilemma. People cannot successfully deal with a subject unless they understand the special words and their appropriate meanings.

Part I

Choose the right meaning in the context of the statement.

1. A housewife wants a cut of meat that is of <u>prime</u> quality.
   (a) divisible by 1 and itself
   (b) main
   (c) the best

2. The number is even. (a) of equal length
   (b) divisible by 2
   (c) level

Part II

Now, read the following description of an object commonly found in school.

> A long, cylindrical multi-faceted object, containing a mineral core, bordered on one end by a small unit of solid polymer of isoprene and on the other end by a cone-shaped exposure of the mineral core.

What is the object? ______________________________

Do you and your partner agree? ___________________

Part III

Use the following steps to develop your own version of technical "math talk."

1. Pick an object with a describable geometric shape.
2. Describe the object in everyday terms.
3. Using your math text or a dictionary, convert your description into the more difficult vernacular (that's an example meaning "the language of a particular trade or profession").
4. Copy your final draft onto a fresh piece of paper. Do not include the answer.
5. Trade with your partner and decode the description. Discuss any suggestions. Revise if necessary.
6. Give your teacher your final draft and your answer on another sheet. A booklet will be made with the examples, and you will work through them during the week.
7. When doing the booklet, record your answers on a numbered sheet of paper and give it to the teacher when complete.
8. Later in the week, your class will see who is the best "technical talker."

Word Problems are Comparatively Easy

Purpose: to focus upon a pupil's knowledge of the most common comparatives used in the language of mathematics while dealing with totally abstract data

Skills: technical vocabulary
serial computation
conditional problem solving

Content strands: vocabulary
graphic

Material: pencil

Time: 30 minutes

Class organization: individual

Activity:

1. Simply introduce the idea of comparatives in everyday language as words that compare some quality such as height, distance, etc.

ex.	tall	taller	tallest
	good	better	best
	long	longer	longest

2. Assign the activity. When going over the answers, help pupils determine whether their errors were in vocabulary or computation.

Word Problems are Comparatively Easy

In many math and science problems or experiments, you are asked to deal with words or phrases that are critical to the solution to a problem in that they compare certain data (greatest, smallest, larger, heaviest, etc.). These are logically called "comparatives." You may be well aware of these in your normal reading, yet when used in a scientific or mathematical sense, they take on very specific meanings. In fact, they may be so specific that you can derive a number using them (twice, five times, etc.). Use the data chart below to compute the answers to the problems. Give it your best effort, which should be better than what you were capable of last year, but which was still quite good!

Data Chart

Rows	Columns				Row Total	Row Average
	A	B	C	D		
1	5	10	15	20		
2	25	30	35	40		
3	45	50	55	60		
4	65	70	75	80		
Column Total						
Column Average						

1. Which column has the largest total? _____ smallest? _____
2. Which row has the smallest average total? _____ largest? _____
3. Which is larger A1+B2+C3+D4 or A4+B3+C2+D1? ____________

4. If these numbers pertained to weight, what row would have the heaviest total weight listed? _____ lightest? _____

5. If these numbers pertained to distances, does B or C have the longer average distances listed? _____

6. How much more is the total of D than the total of B? _____

7. How much less is the average of A than C? _____

8. What row has a total about four times that of row 1? _____

9. What number is twice the number in B3, minus the smallest number in column A, plus the greater number found in C1 or D2, less the total of row 1, plus the largest number in row 4, minus five times the number in A2? _____

10. What number is more than five times B2
    less than three times D3
    more than twice D4
    a multiple of 10

_____

Dr. Flunkinmath is Approximately Mad

Purpose: to strengthen the problem solving process through approximation, data collection, and reading for details

Skills: approximation; data collection; vocabulary--technical, operational, use of per; details

Content strands: problem-solving, comprehension, vocabulary

Material: pencil

Time: 30 minutes

Class organization: individual

Preparation:

1. Introduce the word approximate. Define as a "knowledgeable or educated guess" for this purpose.
2. Write the sign for approximation on the board (≈).
3. Some problems use the word "about" to signal approximation. It helps you determine if your computation is reasonable.
4. Do the following orally. Approximate the sum of 47+38+19.

$$\begin{array}{r} 47 \approx 50 \\ 38 \approx 40 \\ 19 \approx \underline{20} \\ 110 \end{array}$$

   The sum is approximately 110. If you computed the exact answer as 154, would this be reasonable?

   Compute the correct answer. This problem is used because the approximation does not appear extremely close, yet if pupils realize that this answer will be larger than the exact one because numbers were rounded up, there should be no difficulty.

5. Remind pupils that per means "for each."
   ex. 3 apples, 5¢ per apple, total cost = 15¢

Activity:

1. Stress that approximations will not be right or wrong and to make them before computation is done. Use it as a guide. Assign the activity.
2. Discuss answers. Elicit opinions on the value of approximation. Take a few minutes to discuss how pupils chose to set up the data chart, what seemed to help them the most, and whether they did the required computations before or after their entry on their chart.

Dr. Flunkinmath is Approximately Mad

Dr. Flunkinmath began his work in 1831. His dream was to create human life. To do this, he had to go about the countryside robbing graves to find the choicest human parts (a comparison shopper!). Because the average daily temperature in the summer was 95°, he stored the parts in a cool, damp dungeon that remained at 33° at all times. It would take him several years to locate a donor for the heart for his creation, especially since it must still be beating! But finally, on December 13, 1837, he was ready to begin construction of his monster. He assembled all of the parts and began to work. He chose the torso of an extremely well-built blacksmith. The arms of a local wrestler were best suited to the torso, so Dr. Flunkinmath used 1,230 stitches per arm to make the connection complete. The legs, donated by Gregor, took 3,821 stitches per leg to connect to the body. Being a shrewd scientist, Dr. Flunkinmath located the feet of the fastest known runner residing at Gloom and Doom Cemetery, and the hands of the renowned pianist, Freachi. It took Dr. Flunkinmath a total of 2,223 stitches to connect the hands and feet. Also, Dr. Flunkinmath decided to use the head of Freachi since he had been quite handsome. It took only 387 stitches to join it to the body.

Dr. Flunkinmath then waited for a night in which there would be a tremendous electrical storm. It was February 3, 1838 before the weather conditions were perfectly suited for his purposes. Dr. Breinstein, local genius, reluctantly donated both the brain and heart for the monster at this time. The connection of these organs took extensive work, the brain requiring 1,390 stitches and the heart needing 400 less than the brain.

Once the body construction was complete, Dr. Flunkinmath opened the dome of his laboratory. Immediately, the lightning struck the protruding metal rods. Machines began to buzz and pop. The monster jerked violently as the volts shot through his body. Suddenly, in the early hours of February 4, 1838, the monster sat up.

After seeing that things were going well, Dr. Flunkinmath did as all doctors do--gave the monster the bill! There was a slight problem, however, because Dr. Flunkinmath's math skills were not as sharp as were his sewing skills. He did do something that helped him a great deal. He found that if he would approximate (guess) the answer to a problem, he then could judge if his computation was reasonably correct. Below are the questions that Dr. Flunkinmath had to answer. Approximate the answer <u>before</u> you work the problem. Then compute the exact answer. On a problem requiring a lot of information, set up a data chart to collect what you will need before you perform the operation(s).

1. How many years did it take Dr. Flunkinmath to realize his dream from the time he first began his work?
   Approximation: Answer:

2. How much cooler was the temperature of the dungeon than an average summer day? Approximation: Answer:

3. How many months and days from the time construction was begun did Dr. Flunkinmath have to wait for the perfect stormy night? Approximation: Answer:

4. How many people contributed their body parts? Approximation: Answer:

5. To compute the bill, Dr. Flunkinmath had to know the following items.

   (a) At 2¢ per stitch, what was the "sewing" fee? (Use a data chart to set up your information, then make an approximation before you compute the answer.)

   Data Chart

   Approximation: Answer:

   (b) At $2.00 per day of construction, what was the labor fee for the time from the beginning of the construction until the monster sat up? Approximation: Answer:

   (c) At $15 per body, what was the "parts" fee? Approximation: Answer:

6. What was the total bill? Approximation: Answer:

Math is a Precise Science

Purpose: to strengthen comprehension skills through the correct use of multi-meaning and technical words, and practice in dealing with the special structure of the language of mathematics

Skills: technical vocabulary
multi-meaning words
potentially confusing words
modified cloze technique

Content strands: comprehension
vocabulary

Materials: pencil, dictionary if needed

Time: 30 minutes

Class organization: individual

1. Assign the activity.

2. Go over the answers orally. Use this as a screening activity for pupils with potential deficiencies in content language skills.

Math is a Precise Science

When reading mathematics, words with several different meanings may cause confusion. Words that appear to be the most simple may, in fact, be the most confusing if the precise mathematical definitions are not understood.

Part I

For each term listed, write a <u>short</u>, <u>informal</u> mathematical definition as well as a nonmathematical definition for that same word. If you can not think of one, use the dictionary.

ex. yard (a) 36 inches or 3 feet
(b) the grassy area around a house

1. pound (a)

   (b)

2. cup (a)

   (b)

3. times (a)

   (b)

4. inch (a)

   (b)

5. left (a)

   (b)

6. average (a)

   (b)

7. meter (a)

   (b)

8. set (a)

(b)

9. area (a)

(b)

10. square (two mathematical and one other meaning)

(a)

(b)

(c)

Part II

Dr. Forgetoword, unlike Dr. Flunkinmath, is great when it comes to math calculations, but he, being the typical absent-minded professor, can never remember what technical word to use. You, his trusted lab assistant, must fill in the blanks for him with the most appropriate word that you can think of. Be sure to take special care to see what the sentences are saying. Then solve the problem.

1. Dr. Forgetoword wants to carpet the lab and he must figure how many square _______ of carpet to buy. What is the _______ of the lab if it is 13 ft. by 20 ft.?

2. Dr. Forgetoword is looking for the best air conditioner for his newly redone laboratory. One unit cools 3000 cubic _______ and costs five-hundred _______. Another cools 2000 _______ ft. and _______ four _______ dollars. The third one cools 2100 _______ _______ and _______ four _______ thirty-five _______. His lab is 13 ft. _______, 20 _______ wide, and 8 ft. tall. To figure what air conditioner best suits

his needs, he must compute the _______ of his lab. What unit should he buy?

3. Dr. Forgetoword's remodeled lab offers him _______ the floor space of his old lab which was 10 ft. by 13 ft. His new work table which is _______ _______ by _______ _______ is three _______ the size of his old one, which was 18 in. by 21 _______. Dr. Forgetoword needs to know the _______ between the size of the new table and the old one in order to plan how much more table-top space he will have to work on. What is this _______?

4. Dr. Forgetoword had to pay his bills for the renovation work. It _______ him 500 _______ for material and 300 _______ for labor. He had 2030 _______ in his bank account. _______ much did he have _______ in his account after he _______ the bill? If this job took ten _______ to complete, what is the _______ daily cost?

5. Dr. Forgetoword is planning a reception to show his colleagues his new environment. The _______ of scientists invited was ten. He planned one _______ of pie _______ person to eat. For the punch, he used two of the two-_______ mixes, giving him one _______ of punch. He bought two _______ mints, allotting a little over two per person. When this was done, he _______ the table. He found, however, that his new table cover was too _______ for his new work table. If the new cover is 2 ft. by 3 _______, how many _______ will he have to cut off?

The Continuation of the Study of the Extremely Technical Vocabulary Found When Communicating in the Vernacular of Mathematics

Time: 30 minutes

Activity:

1. Return the answer sheets. Read each example in the booklet. Elicit student response, then convey the object that the author intended to describe.

2. Based on the number of correct guesses found on pupil answer sheets, recognize the best "Technical Talker."

3. At the end of the process, analyze as a group the strengths and weaknesses of the samples. Rewrite those samples that drastically need revision.

Key-Packet 5

The Study . . .

Part I: 1. c, 2. b
Part II: a pencil

Comparatively Easy

Chart	A	B	C	D	TOT	AVE (rounded off)
1	5	10	15	20	50	13
2	25	30	35	40	130	33
3	45	50	55	60	210	53
4	65	70	75	80	290	73
Total	140	160	180	200		
Ave.	35	40	40	50		

1. D, A
2. 1, 4
3. the same
4. 4, 1
5. C
6. 40
7. 10
8. 3
9. 0
10. 170

Flunkinmath

1. 7 yrs.
2. 62 degrees
3. 1 month
4. 6 bodies
5. (a) 15,092 stitches X 2¢ = $301.84
   (b) 31 + 22 = 53 days X $2 = $106
   (c) 6 X $15 = $90
6. $497.84

Precise Science

Part I--accept any definitions that are reasonable, stress brief and simple and in own words

Part II

1. feet, area, 260 sq. ft.
2. feet, dollars, cubic, costs, hundred, cubic, feet, costs, hundred, dollars, long, feet, volume, the third one
3. twice, 54, inches, 63, inches, times, inches, difference, difference, 3402 - 378 = 3024 sq. in. or 252 sq. ft.
4. cost, dollars, dollars, dollars, How, left, paid, days, average, $1,230, $123 per day
5. number, piece, per, quart, gallon, dozen, set, feet, inches, none--it's too small!

PACKET VI

THE FORCE BE WITH YOU

Pam Kuzminski

Visions of Meaning
(adapted from Math for Smarty Pants)

Purpose: to develop the ability to express word meaning in a graphic manner, and to enhance meaning through visualization

Skills: vocabulary
graphic representation

Content strands: vocabulary
graphic
interdisciplinary

Materials: paper (3 pieces per pair), colors, text and/or dictionary

Time: 30 minutes

Class organization: partners

Activity:

1. Have students study the idea sheet and then, with their partner, create three pictures that depict the mathematical meaning of each word chosen. Remind them that their text or a dictionary might be of help, and that they need to make the illustration as artistically attractive as possible.

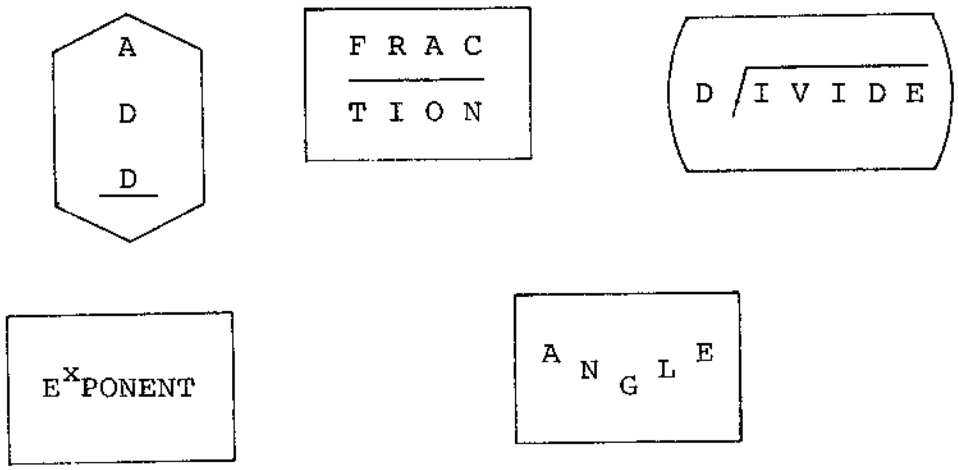
2. Have pupils write the definition of the word in small letters at the bottom of each picture.

3. Create a display of student work. Comment on several of the pictures in which the meaning was clearly or creatively illustrated.

Visions of Meaning

Great artists have the ability to convey a great deal of emotion and detail on a flat surface with assorted colored paints. Mathematicians may also convey, as we have seen before, the meaning of concepts that might take numerous words to express with a simple symbol or small group of symbols. You are, however, to function today as a combination of the two--a Mathmartist! Your assignment is to, with your partner, graphically depict (draw) the meaning of three math terms, using the term itself in the illustration. Your math text or a dictionary may help you. Write the definition in small letters at the bottom of the picture. Remember to make the pictures as attractive as possible for display, and that the purpose is to convey meaning through a simple picture!

Examples:



Are Your Word Problems in Condition?

Purpose: to strengthen the ability to deal with multi-conditional problems and to reinforce the ability to utilize word/symbol translations

Skills: technical vocabulary, multi-conditional problems, word/symbol translations, deductive reasoning, formula generation

Content strands: graphic, vocabulary, sources of difficulty

Material: pencil

Time: 30 minutes

Class organization: individual

Preparation:

1. Introduce the idea that sometimes one must consider several factors in order to solve a problem. However, if you carefully arrange the data or take notes of some kind, the problem may not be so hard after all.
2. On the board, work through the following.

   The number is

an even number	(0, 2, 4, 6, 8, . . .)
less than 5x11	(less than 55)
more than 1/2x100	(more than 50)(so 52 & 54 left)
divisible by 13	(52, because 53/13 = 4)
<u>52</u>	

3. Go over the conditions to check that the number is correct.

Activity:

1. Assign Part I. Check immediately, discussing any problems, especially on #6 in which several sequences are possible.
2. Before assigning Part II, do the following on the board.

   two plus six times four

   translate to: 2 + 6 X 4 = 32 (stress to do in order if no parentheses are present)

   then say: "Jane is 15 years older than Bill. Bill is 30. How old is she?"

   write the formula: 30 - 15 = 45 45 years old (use the word with the answer)

3. Assign Part II. Check the formula as well as the answer.

4. Then, have one partner, <u>using only words</u>, instruct his partner in a recreation of his picture. Unlike the earlier version of this activity, students are able to use the technical vocabulary of rectangular coordinates to add precision to their descriptions. <u>Encourage</u> them to be as technical as possible.
5. Compare results.
6. Have pairs decide which words were helpful words, what confused them, and what words were used most often.
7. Continue the process with the other partner describing his or her design.
8. Gather for an overall discussion. Research has shown the value of this. This may be very brief, but the ideas that should be brought out are that
   (a) word selection is crucial;
   (b) technical vocabulary is extremely precise and helpful when used correctly;
   (c) the sequence of directions is important; and
   (d) in textbooks, like in this activity, one is not given the verbal and nonverbal clues that enhance meaning when communicating with another person.

   Thus, an understanding of the language of mathematics is paramount to effectively dealing with word problems.

Are Your Word Problems in Condition?

Part I

Write the number which satisfies all of the conditions stated.

Remember that taking notes may help you.

1. What number is ______
   an odd number
   a multiple of 5
   less than 30
   not divisible by 3
   contains 2 digits

2. What number ______
   is a prime number
   is between 10 and 20
   contains digits that do not add up to 2, 4, or 10

3. What number is ______
   the square of a number
   an even number
   not less than 40
   contains 2 digits

4. What number ______
   contains 4 digits
   is between 5,200 and 5,300
   has an 8 and a 0 in the last 2 digits
   is equivalent to feet per mile

5. What number is ______
   less than 12 X 12
   more than 11 X 12
   an even number
   a multiple of 4
   divisible by 34

6. The number is 28. Write the conditions necessary to arrive at that number.

   What number is ______

Part II

Now work the following problem. First, translate the words to the proper numbers and operational signs. Then, set up the formulas to derive the answers to the questions.

* * * *

Paul and Patsy decided to undergo a rigorous conditioning program to get in shape. They planned to take (the square of five plus ten minus four) days to accomplish their goal. They both ran (four plus sixteen divided by four) miles each day. Paul, however, ran an additional (eighty-one divided by nine minus three) miles per day. They both also rode their bicycles for (more than 4 X 5, less than 5 X 5, a multiple of 7) miles per week. Three times a week, Paul would swim laps in the local pool for (an odd number, more than 10% of 400, less than 17% of 400, a multiple of 15) minutes, while Patsy swam only (a multiple of 3, divisible by ten, less than 50) minutes.

1. How many more miles did Paul run per day than did Patsy?

   Formula: Answer: (a number and a word)

2. How many miles did Patsy run during their allotted time?

   Formula: Answer:

3. How many minutes per week did Paul swim?

   Formula: Answer

4. How many more miles did Paul run and ride per week than did Patsy?

   Formula: Answer:

1000 Words Revisited

Purpose: to strengthen use of mathematical language, to review use of rectangular coordinates, and to practice following directions

Skills: vocabulary--position, direction; spacial relationships; color relationships; graphic coordinates; following directions--sequences

Content strands: language experience, graphic, vocabulary

Materials: 3 colored pencils, each set of partners need the same 3 colors graphing paper, 2 sheets per person, ruler

Time: 45 minutes

Class organization: partners

Preparation:

1. Briefly review words that indicate position or direction (north, above, below, right, etc.), and how to work with rectangular coordinates.
   ex. "Place a dot on coordinate (3,2)" would mean to go horizontally on the graph along the bottom line to 3, and then follow that line vertically up to the point at which the lines intersect.
2. Remind pupils that this is a variation of an earlier activity. Elicit a few comments as to those things that helped students be successful last time (specific words used, directions in a logical order, etc.).

Activity:

1. Have each pair sit back-to-back. This is important so that the emphasis is upon the language, and nonverbal clues are minimized.
2. Make sure that each person has 2 pieces of graphing paper and the same 3 colors as his/her partner.
3. Instruct each pupil to design a picture on one piece of the graphing paper. The picture must use all 3 of the colors and must contain a minimum of 5 distinct shapes. The shapes may, however, intersect. Caution pupils not to make pictures too complex, yet they should still represent a challenge!

Symbolic Review

Purpose: to review word/symbol relationships

Skills: technical vocabulary
word/symbol relationships

Content strands: vocabulary
graphic

Material: pencil

Time: 15 minutes

Class organization: individual

Activity:

1. Introduce the idea that even in mathematics, there may be several ways to say something.

   ex. 2 X 5 = 10 Two times five is ten.
   or
   The product of two and five is ten.

2. Assign the activity.

Symbolic Review

Part I

Put the correct symbol by the word it represents.

_____ difference	_____ plus	_____ dollar
_____ percent	_____ equivalent	_____ decreased
_____ in all	_____ less	_____ question
_____ times	_____ not equivalent	_____ equal
_____ from	_____ quotient	_____ minus
_____ product	_____ cents	_____ and
_____ total	_____ sum	_____ shared equally
_____ less than	_____ greater than	_____ one-half
_____ left	_____ altogether	

Part II

Express each equation in <u>two</u> different ways. Solve the equation.

1. 238 + 42 = _____
2. 19 X 20 = _____
3. 120 ÷ 12 = _____
4. 4,203 - 211 = _____
5. .50 X $5.00 = _____

The Force Be With You

Purpose: to serve as a culminating activity in which a variety of skills are used

Skills: extraneous data
insufficient data
multi-operational problems
data collection
question generation
conditional problem solving
conversions

Content strands: vocabulary
sources of difficulty
problem solving
comprehension
interdisciplinary

Materials: pencil, dictionary

Time: 30-45 minutes

Class organization: partners or individually, as preferred by pupils

Activity:

1. Introduce this as the culminating activity in which pupils will have to put to the test all of the skills worked on in earlier packets.

2. Assign the activity, allowing them to work alone or in partners. Note: These questions have a higher difficulty level than most. Encourage students to work in the best situation for them.

3. If time permits, check the work as a group. Discuss necessary steps for data generation. Demonstrate the solutions process if necessary.

The Force Be With You

You have spent the last six weeks as a member of the Rebel Alliance, fighting the ominious Deathstar of Word Problems. During your training, you have effectively conquered special vocabulary and language skills, word/symbol relationships, operational clues, and comprehension skills. From your droid, you were trained in various alternatives and steps to use when faced with a problem. Your Jedi trained you in the art of visualization and thinking skills. Your combat training enabled you to zap those problems you faced containing extraneous or insufficient data, and you developed the ability to arrive at the right answer under some most trying conditions. Now, you are prepared to face the ultimate "deathstars" of word problems. Beware! Darth Vader will try to stop you at all costs. You must, however, never forget your training, both at this present conflict and in the future, for the force of your knowledge is with you!

Answer the following questions. Fill in missing information when necessary.

1. It is the very last year of the third millennium A.D. on the planet of Earth. Earth has been ravaged by war since 2,400 A.D. In 2,800, all but a few of the human race were destroyed in a massive assault by the Creonite warriors. These survivors, however, banned together a century later to form the Rebel Alliance.

   (a) How long had Earth been ravaged by war?

   (b) How long had the Rebel Alliance been in existence?

2. The main Rebel base was located one light year from Earth. It was twice that distance from the Earth to the major enemy base, yet that base was in a different direction. An auxiliary Rebel base was located directly one-half of the way between Earth and the main Rebel base. (Answer in terms of miles.)

   (a) How far away was the enemy base from earth?

   (b) How far was the auxiliary station from the main Rebel station?

   (c) How far was the Rebel base from the enemy base?

3. The rebels were planning a major offensive to begin on Earth's summer solstice. They hoped to have completed the mission by the vernal equinox of the next year. To complete their mission, they must visit each planet in our solar system for an equal amount of time.

   (a) How many months did they plan for this mission to take?

   (b) If they hoped to land on each planet in our solar system, and travel between the planets would take 60 days, how many days were they allotting per planet?

4. Darth Vader led his ominious forces in a vain attempt to destroy the Rebel Alliance. His forces, consisting of 13 starships and _______ fighters met the Rebel forces near the moons of Saturn. The Rebels, having only (2 X 3 + 4 - 3 + 0) starships and 100 fighters, one-half the number of the enemy forces, were greatly outnumbered. The battle rages for days. After one _______, the fighting was almost over. The enemy lost 4 of their starships and (more than 50, less than 100, a multiple of 25) fighters. The Rebels sustained lighter losses. They lost only (an even number, more than 0, less than 3) starships and 10% of their fighters. On the seventh and final day of fighting, one last skirmish occurred in which Vader's Deathstar was destroyed. The Rebel Alliance was safe, for the force was with them.

   (a) If the answer is 125, what is the question?

   (b) If the number is 4, what is the question?

   (c) If the answer is 35, what is the question?

Key--Packet 6

Condition

Part I

1. 25
2. 17
3. 64
4. 5,280
5. 136
6. students generate

Part II

1. 6 more per day
2. 155 miles
3. 135 minutes
4. 42 miles

Symbolic

−	+	$
%	≃	−
+	−	?
X	≠	=
−	÷	−
X	¢	+
+	+	÷
<	>	½
−	+	

Force

1. (a) 600 years, third millennium A.D. is the year 3000
   (b) 100 years
2. (a) 11.756 trillion miles
   (b) 2.939 trillion miles
   (c) insufficient data
3. solstice--June 22, vernal equinox--March 21
   Note: These dates were located in the dictionary definition of the term. Make pupils locate them on their own, yet make sure to suggest a dictionary.
   (a) 9 months
   (b) about 23 days if 1 mon. = 30 days--accept reasonable variation.
4. 200, 7, week, 75, 2, 10
   (a) How many enemy fighters were left?
   (b) How many more starships did the enemy still have after the battle/
   (c) How many more fighters did the enemy still have after the battle?

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