Arithmetical Vocabulary: A Factor In Verbal Problem Solving In Sixth Grade Arithmetic

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ARITHMETICAL VOCABULARY A FACTOR IN VERBAL PROBLEM SOLVING IN SIXTH GRADE ARITHMETIC

being

A thesis presented to the Graduate Faculty of the Fort Hays Kansas State College in partial fulfillment of the requirements for the degree of Master of Science

by

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Date July 26, 1947

Approved

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Major Professor

J. M. Webster
Chairman Graduate Council
ACKNOWLEDGEMENTS

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I wish also to express my appreciation to Dr. Floyd B. Streeter who taught me the principles and techniques of thesis writing and guided me in the writing mechanics of the present volume.

Last but not least I want to thank my wife for her untiring assistance and constant inspiration throughout the study.
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ARITHMETICAL VOCABULARY A FACTOR

IN VERBAL PROBLEM SOLVING IN SIXTH GRADE ARITHMETIC
CHAPTER I

INTRODUCTION

1. The Problem

During the writer's experience of teaching in elementary and junior high schools in Kansas he had excellent opportunity through supervision and classroom teaching to note a more-than-ordinary difficulty experienced by most children in the subject of arithmetic. Not only was the dull student baffled by the subject but many times the average and good students were "lost" when certain problems were presented.

The exceptional troublesomeness of this subject led the writer to ponder on the possible cause or causes of incorrect problem solving. One thing was apparent from observation and this was that many children seemed to lack a readiness to go about a problem when it was presented in a number and word form. A typical question asked by the pupils was, "What does this word mean?". From this observation clues were gathered which pointed strongly at the vocabulary of arithmetic as one of the main obstacles to be overcome.

The verbal or reasoning problem in arithmetic has long been recognized as one of the chief stumbling blocks to most children who fail or at least falter in that particular school subject. With little effort the reader may recall some school mate of bygone years, who may have been an expert at ciphering, but who, when confronted with a
reasoning problem, seemed to have no idea as to whether the numbers should be added, subtracted, multiplied, or divided. In addition, after a final answer had been computed, this same individual did not know whether the answer should be dollars, horses, or tons. It is believed that such cases were and are too numerous to be classed as exceptions.

Reading has been called the key which unlocks all the school subjects, but it is pretty generally believed that arithmetic is one subject which calls for some special reading ability or abilities. Since vocabulary knowledge plays such an important part in general reading ability, the writer believes that one of the special reading abilities required of those who would succeed in arithmetic is a knowledge of the vocabulary peculiar to arithmetic.

The introduction above leads directly to the specific statement of the problem of this thesis, which is, "to discover the extent to which a knowledge of arithmetical vocabulary is a factor in the solution of verbal problems in sixth grade arithmetic".

2. Definition of Terms

The following terms are found frequently throughout this study. No particularly new meaning for them has been chosen by the investigator but an enlargement of their meaning and a presentation here is considered expedient at this point.

Verbal problem - Any problem in arithmetic in which a number and word relationship is involved, such as "If Tom gives away 3 of
his 12 marbles, how many will he have left?" and "What will milk cost the Jones family for a week, if they take a quart each day and milk is priced at 12¢ a quart?".

Problem solving ability - The use of this phrase in the study refers specifically to the child's ability to solve a verbal type problem.

Arithmetical term - Any word or combination of words used in arithmetic which deals with number, value, quantity, magnitude, form, space, buying, selling, units of measure, and operations with numbers. In its larger meaning it includes symbols such as \( \div \), \( \times \), and \( - \), but in this study it is limited to words. Such words as cost, area, sum, divide, acre, and yard are a few of the more common arithmetical terms found in sixth grade textbooks.

Semi-technical term - An arithmetical term which, although used in making up the arithmetic vocabulary, also has a meaning (not different) in the child's out-of-school experience. Such words as pair, buy, hour, and weigh are examples of semi-technical terms.

Technical term - An arithmetical term whose use (for children) is almost wholly confined to arithmetic, and which has no meaning or, if any, a different meaning outside that curriculum. Such words as denominator, quotient, ratio, and decimal are examples.

3. Method of Investigation

An extensive testing program was chosen to be a good means
of investigating the present problem. The investigator examined a copy of the Kansas adopted sixth grade arithmetic textbook, The New Curriculum Arithmetics. Ten verbal problems, typical of those found in the first half of the book, were then prepared. The problems were made up from the first half of the book since it was anticipated that all current sixth grade pupils would have completed that much of the course by the time tests could be prepared and administered. The ten verbal problems were arranged in individual test form as shown in the appendix.

The verbal problems were scanned to discover all terms which might be classified as arithmetical. A list of twenty arithmetical terms was then arranged into a multiple-choice vocabulary test also shown in the appendix.

The verbal problem and vocabulary tests were administered to approximately four hundred sixth grade pupils in Kansas public schools. The four hundred pupils represented fourteen city schools whose sixth grade enrollments ranged from fifteen to seventy pupils. The completed tests were then scored and analyzed by the investigator.

4. Related Studies in Vocabulary of Arithmetic

In the writings on causes of error in arithmetic, attention is drawn time and again to the important part played by vocabulary. Extensive studies which have been made in the past few decades in many schools deal with several phases of the subject. Among these
are included:

1. Studies of the relationship of reading skills to the ability to solve problems in arithmetic.
2. Studies of the vocabulary used in arithmetic textbooks.
3. Studies of techniques and results of teaching the vocabulary of arithmetic.
4. Studies of the nature and development of concepts of technical and semi-technical terms in arithmetic.

Buswell and Judd in summarizing educational investigations relating to arithmetic, covering the period 1892 to 1924, show that general ability in reading has not always proved consistent with ability to solve problems in arithmetic.¹ In concluding their discussion of this phase of studies it is apparent that they lean strongly toward one investigator, Terry, whose study showed that arithmetic calls for some special reading abilities, not the least of which was an understanding of the vocabulary of the subject.

An important view, which deals with the contradiction of correlation between reading ability and problem solving in arithmetic, is believed to have been brought out by Treacy in a study recently made. In his study he attempted to discover if general reading level and specific reading skills were significantly related to ability to solve problems in arithmetic. He states:

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Studies of the relationship of reading to problem solving ability are somewhat contradictory. A possible explanation of these discrepancies is that reading was not interpreted or measured in the same way in the various studies. If different reading skills are not equally important for success in problem solving, and if the reading skills measured varied among the studies, it was to be expected that there would be discrepancies in the findings regarding the relationship of reading to problem solving.

Treacy's study was carried out by giving tests which measured fifteen separate reading skills and arithmetic reasoning of 244 7-B pupils. "Good achievers" in arithmetic were found to be significantly better than "poor achievers" in nine of the fifteen reading skills measured. An important point for our present study is that four of the fifteen reading skills were either some phase of, or were directly related to, vocabulary. All four vocabulary skills were among the nine skills in which the "good achievers" were significantly better.

J. S. Georges studied the nature of the reading difficulties encountered by a first year junior high school class in mathematics in the University High School of the University of Chicago. Using the interview method when children were stumped by a problem he found that out of 218 cases of difficulty, vocabulary accounted for 23.4 per cent. In fact fully 37.2 per cent of the cases were


accounted for when symbols and notations were counted in as a part of mathematical terminology. Mathematical relationships, which were next in order of difficulty, included only 11 per cent of the total cases.

In attempting to discover the relationship between the mastery of the mathematics vocabulary and achievement in mathematics by university freshmen, A. S. Edwards correlated the results of vocabulary tests and a final examination in mathematics for two groups of students. For one group, numbering one hundred forty-one cases, the correlation was 0.638 with a \( PE_r \) of 0.033. For the second group, numbering one hundred eighteen students, the correlation was 0.59 with a \( PE_r \) of 0.04. These results show a considerable influence of vocabulary upon achievement in mathematics.

Several studies have been made which deal with an analysis of vocabulary make-up of arithmetic textbooks. Almost without exception findings show that too often new technical words are introduced without enough explanation and repetition in succeeding pages to insure their becoming a part of the pupil's vocabulary.

O'Rourke and Mead examined five popular textbooks in third grade arithmetic. One of their discoveries was that of 296 different technical terms used, 71 terms or 24 per cent of the total

appear only once in the books in which they are used. 5

For those who have pondered the wisdom of taking part of the regular arithmetic class time to teach the technical vocabulary of the course, the findings of Harry C. Johnson should prove valuable. 6

In an experiment conducted for 14 weeks involving 898 pupils in 28 seventh grade classes in which the experimental group was given five to eight minutes of specific vocabulary instruction daily (within regular arithmetic time), he found, that although the experimental group failed to show a significant gain over the control group in general mathematical ability, they did make a significant gain in ability to solve problems in which the taught vocabulary was included. Further, he found that gains in vocabulary and problem solving (which included the taught vocabulary) were made at practically all levels of ability.

Techniques of teaching which emphasize starting the teaching of a new term in a child's own thought world and then creating a situation where he can see and feel the meaning of the term are described by Mary Gen Steiss and Bernice Baxter. They report that children, even retarded readers, taught by these techniques showed arithmetic readiness for the next grade at the end of the


In their words:

Arithmetic performance — that is, number manipulation — can be assured if children are guided in their building of an adequate arithmetic vocabulary. The teaching of arithmetic has more in common with the teaching of reading than many teachers realize.\(^7\)

One of the most comprehensive studies of the arithmetic vocabulary of elementary school children to be made thus far was carried out by Buswell and John. Their purpose was to study the nature and development of concepts of technical and semi-technical terms in the arithmetic of the first six grades. Their investigation included the testing of the arithmetic vocabulary of 1,500 school children in twelve city school systems covering a wide area of the United States.

In this same study they examined ten arithmetic textbooks to determine the degree to which textbooks explain technical terms in contrast to simply using them. Also they investigated the possibility of arithmetical words being taught in connection with subjects other than arithmetic by comparing the one hundred arithmetical terms, which were used in the group test, with the principal published vocabularies in reading and spelling. From the results of their complete study they concluded: \(^8\)

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1. Pupils fail to show satisfactory understanding of technical terms which presumably they have studied.

2. Pupils may know a word when it is presented in one situation but fail to know it when it is presented in a different way.

3. Development of concepts of semi-technical words is a very gradual process beginning even in the first grade.

4. Strictly technical words, such as quotient, which do not appear in the out-of-school experience of pupils, have no gradual conceptual development. In these cases learning comes suddenly after a considerable lapse of school time and appears to consist of a rather meaningless definition.

5. Although textbooks include the semi-technical and technical terms of arithmetic the initial explanation is often too meager and the frequency of repetition too little to insure development of adequate concepts for the terms.

6. There are a considerable number of arithmetical terms that are not likely to be encountered by the pupil in his work in reading and spelling.

With respect to the present study a concluding statement by Buswell and John is considered significant:
Until pupils' concepts in arithmetic are as clear as their concepts on the playground there is little reason to expect that the abilities of pupils will go far beyond computational arithmetic.9

9. Ibid., p. 104.
CHAPTER II

THE TESTING

1. Preparation of Tests

In Appendix I will be found the test which was used in the current study. The test was prepared by the investigator after a thorough survey of types of tests used in studies of a similar nature and after an examination of the current arithmetic textbook in use in the sixth grade in the public schools in Kansas.

The test was made up in two forms - Form 1, Arithmetic Problem Test and Form 2, Arithmetic Vocabulary Test. The problem test consists of verbal problems typical of those found in the first half of the sixth grade arithmetic textbook, New Curriculum Arithmetics. Problems were chosen from the several sections so that a sampling of each of the main topics would be included. Since most of the early sixth grade work deals with fractions, the greater part of the test covers various phases of fraction work. Questions on measurement, finding averages, and work in division were also included as these topics are a part of early sixth grade work.

The investigator used Form 1 as a basis for preparing the vocabulary test. A check was made of the verbal problems to discover the arithmetical terms used which might be classed as technical terms. Form 1 yielded twenty such words. These twenty words were then made up into a multiple-choice type definition test of four choices for each word. In the preparation of test Form 2 the
writer made frequent reference to test preparation techniques used by Buswell and John in their study *The Vocabulary of Arithmetic* which has been cited in Chapter I.

2. The Test Group

Invitations were sent to fifteen Kansas public schools asking their willingness to participate in the testing program (see Appendix II). The selected schools were considered to be a representative sampling of elementary schools in the western half of Kansas. Although no rural school was included, schools with a sixth grade enrollment as small as fifteen pupils were included. The largest participating school had a sixth grade enrollment of seventy pupils. The invited schools were Russell, Phillipsburg, Plains, Meade, Scott City, Ness City, Montezuma, Plainville, Lucas, Osborne, Stockton, La Crosse, Ellis, Wakeeney, and Norton.

All schools replied to the invitation letter indicating their willingness to participate in the study. The tests and a letter of directions (see Appendix III), which were reproduced by the Extension Office of Fort Hays Kansas State College, were mailed to the fifteen schools.

3. Response of the Test Group

No definite date was set for the administration of the tests by the participating schools. That the tests did receive early attention by most of the schools is evidenced by the fact that completed tests were received by the investigator from three schools within a
week of mailing date. All but three schools had returned completed tests within the month — all this with an influenza epidemic closing down several schools in Western Kansas at the time. A follow up letter was sent at the end of a month to the three unreported schools and within a short time two of these had returned their completed tests. In all, fourteen of the schools made returns, yielding a total of four hundred eleven paired (Forms 1 and 2) tests. These four hundred eleven tests provided the material from which the analysis to follow was made.
CHAPTER III

ANALYSIS OF DATA

1. Scoring of Tests and Tabulation of Test Scores

Both test forms were scored on a total point basis, allowing one point for each example that was correctly answered. Form 2 was strictly an objective type test and therefore calls for no further explanation on its scoring.

An element of subjectivity of necessity entered into the scoring of Form 1. The investigator wishes to draw attention to the following general rules which were observed in scoring all of the Form 1 tests.

1. Full credit was either given or withheld for each of the ten examples; i.e., a problem was counted either all right or all wrong.
2. Applying Rule 1, both parts of Example 1 in the test had to be correct to receive credit.
3. In Example 2 both six (or 6) and sixths were counted correct.
4. In Example 6 the answer was not counted complete and correct unless the full \( \frac{3}{8} \) square miles was written in.
5. Example 9 was not counted correct unless at least two numbers were given in the answer.
Table I shows the frequency distribution of the scores made on both test forms by the four hundred eleven pupils participating in the testing program.

Table I

Frequency Distribution of Test Scores

<table>
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<tr>
<th>Form 1 Arithmetic Problem Test</th>
<th>Form 2 Arithmetic Vocabulary Test</th>
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</table>
The mean score of the group on Form 1 was 6.33 with a standard deviation of 2.38. In other words approximately two-thirds of the scores fell between $6.33 \pm 2.38$ or between 3.95 and 8.71. Also it will be noted that scores ranged from the lowest possible score to the highest possible score. All in all, the scores of the problem test indicate a great variability among sixth grade pupils to solve verbal problems.

On Form 2 the mean score for the group was 15.48 with a standard deviation of 3.20. Hence, approximately two-thirds of the scores on the vocabulary test fell between 12.28 and 18.68. Variability among the pupils was much less pronounced than that shown on Form 1.

2. Comparison of Verbal Problem Scores
with Vocabulary Scores

It is generally accepted that one of the best ways of determining whether an individual's success or failure in one line of endeavor will ordinarily be accompanied by corresponding success or failure in a second line of endeavor, is to correlate the results of tests which separately measure the individual's ability to achieve in each line. This correlation should be made from an adequate sampling of individuals. The subject test group of four hundred eleven pupils is thought to meet the requirement of an adequate sampling. The two test forms used are believed to be fair measures of a sixth grade pupil's ability to solve verbal problems and his knowledge of
the technical vocabulary of arithmetic.

In determining the coefficient of correlation for the present study the "product-moment" method described by Garrett has been used.  

This method is recommended by the author as being the advisable one when \( N \) (the sampling) is large.

Table II shows the arrangement of the paired scores by which the coefficient of correlation was determined. The tabulation shown in Table II gives the group frequency of all the paired scores. For example (at the top right) 16 pupils made scores of 10 on the Arithmetic Problem Test and the same 16 pupils had scores of 19 or 20 on the Arithmetic Vocabulary Test.

Without further reference to statistical data it will be seen from Table II that a fairly high positive correlation exists between the two tests. This means that a pupil who made a high score on one test was likely to have made a high score on the other test. Likewise medium and low scores tended to be paired together. The application of the "product-moment" method to the given test pairs resulted in a correlation coefficient \( (r) \) of 0.67.

Garrett states that an "\( r \) from 0.40 to 0.70 denotes substantial or marked relationship".  

However he goes on to warn that correlation

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2. Ibid., p. 342.
**Table II**

**Correlation of Test Results**

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<td>57</td>
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<td>6</td>
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<td>57</td>
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<td>5</td>
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<td>57</td>
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<tr>
<td>0</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6</td>
</tr>
</tbody>
</table>

coefficients must be viewed in the light of coefficients that are usually obtained in studies of a similar nature. The only figures available to the writer at the time of this study were the results of Edwards' study.
described in the first chapter. In an investigation similar to the present one he found correlation coefficients of 0.638 and 0.59 in two groups respectively. These findings appear to lend additional weight toward placing the present correlation near the upper limit of the "substantial or marked relationship" rating.

The reliability of any correlation coefficient depends upon its size and upon N, the size of the sample. The probable error ($PE_r$) formula given by Garrett was applied to determine the probable error of the coefficient of correlation of the present study. The formula $$PE_r = \frac{.6745 \sqrt{1 - r^2}}{\sqrt{N}}$$ resulted in a $PE_r$ of 0.0183, which means in general that the true $r$ lies somewhere between $0.67 \pm 0.0183$ or between 0.6517 and 0.6883.

The probable error computation corrects the correlation coefficient where chance error may have entered in the original computation, such as an abnormal arrangement within frequency distributions. It assumes that an adequate sampling has been made. Garrett brings out that an obtained $r$ to be significant should be at least five or six times its $PE_r$. In the present study the obtained $r$ exceeds the $PE_r$ by much more.

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3. See page 7.
5. Ibid., p. 281.
3. Analysis of Principal Errors

The results of test Form 2 were used in drawing up Table III which gives the frequency of total error on each of the twenty technical terms used in the test. To a limited degree the results shown at Table III may be considered indicative of the relative difficulty of the various terms. However Dolch issues a warning which should be heeded in interpreting results of a vocabulary test of an objective type, such as that used herein. According to his study, purely objective testing for word difficulty often

... fails very decidedly in showing us the true relative difficulty of words. ... With some words they [the test statements] aid the pupil and with others they hinder him, doing each in unequal amounts for different words.

Dolch goes on to recommend the administering of subsequent tests using new choices for each word as a more accurate check on relative word difficulty. The writer believes that subsequent testing after the manner described by Dolch would yield some very informative data on the present list of technical words. Such an investigation is recommended for further study.

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Table III

Frequency of Error on Technical Terms

<table>
<thead>
<tr>
<th>Technical Term</th>
<th>Frequency of Error</th>
<th>Error as Per Cent of Total Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Numerator</td>
<td>23</td>
<td>5.6</td>
</tr>
<tr>
<td>2. Average</td>
<td>23</td>
<td>5.6</td>
</tr>
<tr>
<td>3. Remainder</td>
<td>31</td>
<td>7.5</td>
</tr>
<tr>
<td>4. Dimensions</td>
<td>32</td>
<td>7.8</td>
</tr>
<tr>
<td>5. Reduce</td>
<td>36</td>
<td>8.8</td>
</tr>
<tr>
<td>6. Quotient</td>
<td>49</td>
<td>11.1</td>
</tr>
<tr>
<td>7. Lowest common denominator</td>
<td>70</td>
<td>17.0</td>
</tr>
<tr>
<td>8. Dividend</td>
<td>72</td>
<td>17.5</td>
</tr>
<tr>
<td>9. Product</td>
<td>74</td>
<td>18.0</td>
</tr>
<tr>
<td>10. Divisor</td>
<td>76</td>
<td>18.5</td>
</tr>
<tr>
<td>11. Lowest terms</td>
<td>90</td>
<td>21.9</td>
</tr>
<tr>
<td>12. Cancel</td>
<td>94</td>
<td>22.9</td>
</tr>
<tr>
<td>13. Sum</td>
<td>96</td>
<td>23.4</td>
</tr>
<tr>
<td>14. Fraction</td>
<td>113</td>
<td>27.5</td>
</tr>
<tr>
<td>15. Area</td>
<td>124</td>
<td>30.2</td>
</tr>
<tr>
<td>16. Proper fraction</td>
<td>130</td>
<td>31.6</td>
</tr>
<tr>
<td>17. Difference</td>
<td>130</td>
<td>31.6</td>
</tr>
<tr>
<td>18. Perimeter</td>
<td>136</td>
<td>33.1</td>
</tr>
<tr>
<td>19. Rectangle</td>
<td>198</td>
<td>48.2</td>
</tr>
<tr>
<td>20. Terms of a fraction</td>
<td>262</td>
<td>63.7</td>
</tr>
</tbody>
</table>

Table III reveals a wide range of difficulty among the twenty technical terms even if we allow for inaccuracies pointed out by Dolch.

In the study of Buswell and John previously referred to, they tested five hundred sixth grade pupils on one hundred arithmetical terms and included in their results a ranking of the terms according to difficulty, based on the per cent of correct responses made by the
pupils.\textsuperscript{7} Fifteen of the terms used in the present study were included in the study of Buswell and John. Table IV shows a comparison of the relative difficulty of the fifteen terms as revealed by the separate studies.

Table IV

Comparison of Relative Difficulty of Arithmetical Terms as Revealed in Two Separate Studies

<table>
<thead>
<tr>
<th>Buswell and John Study (500 sixth grade pupils)</th>
<th>Present Study (411 sixth grade pupils)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-rank from easy to difficult -</td>
<td></td>
</tr>
<tr>
<td>1. remainder</td>
<td>1.5 numerator</td>
</tr>
<tr>
<td>2. divisor</td>
<td>1.5 average</td>
</tr>
<tr>
<td>3. difference</td>
<td>3. remainder</td>
</tr>
<tr>
<td>4. sum</td>
<td>4. dimensions</td>
</tr>
<tr>
<td>5. reduce</td>
<td>5. reduce</td>
</tr>
<tr>
<td>6. quotient</td>
<td>6. quotient</td>
</tr>
<tr>
<td>7. fraction</td>
<td>7. dividend</td>
</tr>
<tr>
<td>8. average</td>
<td>8. product</td>
</tr>
<tr>
<td>9. numerator</td>
<td>9. divisor</td>
</tr>
<tr>
<td>10. dividend</td>
<td>10. sum</td>
</tr>
<tr>
<td>11. dimensions</td>
<td>11. fraction</td>
</tr>
<tr>
<td>12. product</td>
<td>12. area</td>
</tr>
<tr>
<td>13. rectangle</td>
<td>13. difference</td>
</tr>
<tr>
<td>14. area</td>
<td>14. perimeter</td>
</tr>
<tr>
<td>15. perimeter</td>
<td>15. rectangle</td>
</tr>
</tbody>
</table>

Examination of Table IV shows that a fairly equal ranking exists for the majority of the words. Six words, "divisor, difference, sum, average, numerator, dimensions" appear as exceptions to a positive correlation between the two rankings. Accepting Dolch's thesis, the

\textsuperscript{7} Buswell and John, \textit{The Vocabulary of Arithmetic}, pp. 20–22.
two separate studies then give considerable weight toward an accurate relative difficulty ranking for nine of the words. Using the rank of the present study, those nine words in order from easy to difficult are:

1. remainder  
2. reduce  
3. quotient  
4. dividend  
5. product  
6. fraction  
7. area  
8. perimeter  
9. rectangle

It is significant that in both studies the words "area, perimeter and rectangle" are among the most difficult terms. These three words fall into a class of terms which describe measurement and spatial figures. One might conclude that the newness of these words for sixth grade pupils would account for this difficulty. However the numerous studies examined do not bear this out. In fact often the opposite situation obtains. Many words are found to be best known by pupils in the first grades in which the words are introduced. A logical conclusion then in the present case is that technical words relating to measurement and spatial figures are more difficult than technical words in other categories.

Table V is a tabulation of the various choices made by the test group on each of the twenty technical terms contained in test Form 2.
The information in Table V yields an abundance of data pertaining to the concepts which sixth grade pupils have of certain technical
words. The discussion in the next paragraphs applies to those words that were missed by a large number of pupils.

"Product" was correctly identified by 82.0 per cent of the pupils. The chief error by those who missed the word was to confuse it with "quotient" in division (9.2 per cent), followed closely by a confusion with "sum" in addition (7.5 per cent). Only 3 pupils made the least wise choice, "Count the number of feet around a plot of land".

The chief error for those missing "fraction" was to confuse it with elements of a multiplication problem (15.8 per cent). A second error was to call it "Any number of things", (7.3 per cent).

"Difference" although not well known was associated with the subtraction process in that 25.5 per cent said, "A number that is subtracted from another number."

The chief error on "divisor" was to confuse it with "dividend". (13.1 per cent).

"Rectangle", one of the least known terms, was called "A three sided figure" by 43.6 per cent of the pupils. It is significant that only 4 pupils omitted the example; as they were instructed to do so in case they had no idea of the right answer.

Of the pupils missing "lowest terms" 15.6 per cent said "A fraction is in lowest terms when the top number is very small compared to the bottom number".

"Sum" is a word which pupils first meet in grades below the sixth. However only 76.6 per cent made the correct response. Among the errors 20.6 per cent associated it with the addition process.
"Lowest common denominator", although a long term and fairly new for sixth grade pupils, was known by 83 per cent of the group. The main error (8.8 per cent) was to call it "The number found by adding all the fractions and dividing by the number of fractions".

"Quotient" was better known than "divisor" or "dividend". The chief error in this case (6.3 per cent) was to place it in the subtraction process.

The main error on "cancel" (12.2 per cent) was "To subtract the same number from the numerator and the denominator of a fraction".

Of those missing "area", 28.5 per cent confused it with perimeter.

"Dividend" like "divisor" was identified with the process of division even when errors were made. 11.2 per cent of the pupils called it "The answer to a problem in division".

"Terms of a fraction" was the least known of the twenty terms (36.2 per cent). It was omitted by the most pupils (7.1 per cent). The chief error was to make Choice 1 (35.0 per cent). All evidence points to this choice as simply a guess for most pupils.

Of those missing "perimeter" 23.8 per cent made what might be termed a close answer "length and width".

The principal error on "proper fraction" was to call it "A whole number and a fraction" (18.8 per cent). The next highest error was "A fraction that is easily reduced".

An examination of similar studies shows that a greater
percentage of omissions occur in tests of the type used. To conserve paper the investigator included in the teachers' directions the request for the pupils to make omissions rather than make pure guesses. It is believed that more omissions would have occurred had the directions been printed on each pupil's test paper. The elimination of more pure guesses would no doubt have increased the value of the vocabulary test and consequently the entire study.

An analysis of each pupil's test forms to discover cases of consistency and inconsistency with respect to vocabulary knowledge yielded some interesting results. In other words, does a pupil reveal knowledge of a certain word under one circumstance, say in response to a vocabulary test, and then fail to show knowledge of the same word when it appears in a problem situation? Table VI has been prepared to show the results of a thoroughgoing analysis of the pupils' test forms to arrive at an answer to the preceding question.

A few examples should suffice to show how this analysis was conducted. The word "product" appears as Example 3 on Test Form 2 and the word is also contained as a part of the problem in Example 7 of Test Form 1. If the pupil made the correct response for "product" on Form 2 and also showed by his work (i.e., using the multiplication sign and carrying through to a final answer) on Form 1
<table>
<thead>
<tr>
<th></th>
<th>Correct Form 1</th>
<th>Incorrect Form 1</th>
<th>Incorrect Form 1</th>
<th>Correct Form 1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Correct Form 2</td>
<td>Incorrect Form 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>reduce</td>
<td>349</td>
<td>10</td>
<td>26</td>
<td>25</td>
</tr>
<tr>
<td>numerator</td>
<td>212</td>
<td>22</td>
<td>175</td>
<td>2</td>
</tr>
<tr>
<td>product</td>
<td>301</td>
<td>34</td>
<td>39</td>
<td>38</td>
</tr>
<tr>
<td>dimensions</td>
<td>320</td>
<td>21</td>
<td>60</td>
<td>10</td>
</tr>
<tr>
<td>average</td>
<td>278</td>
<td>18</td>
<td>109</td>
<td>6</td>
</tr>
<tr>
<td>fraction</td>
<td>242</td>
<td>51</td>
<td>57</td>
<td>61</td>
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<tr>
<td>difference</td>
<td>267</td>
<td>13</td>
<td>13</td>
<td>118</td>
</tr>
<tr>
<td>divisor</td>
<td>310</td>
<td>12</td>
<td>25</td>
<td>64</td>
</tr>
<tr>
<td>rectangle</td>
<td>172</td>
<td>146</td>
<td>40</td>
<td>53</td>
</tr>
<tr>
<td>lowest terms</td>
<td>303</td>
<td>18</td>
<td>19</td>
<td>71</td>
</tr>
<tr>
<td>sum</td>
<td>282</td>
<td>30</td>
<td>34</td>
<td>65</td>
</tr>
<tr>
<td>l.c. denominator</td>
<td>242</td>
<td>32</td>
<td>100</td>
<td>37</td>
</tr>
<tr>
<td>quotient</td>
<td>344</td>
<td>11</td>
<td>18</td>
<td>38</td>
</tr>
<tr>
<td>cancel</td>
<td>275</td>
<td>36</td>
<td>41</td>
<td>59</td>
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<td>area</td>
<td>57</td>
<td>117</td>
<td>231</td>
<td>6</td>
</tr>
<tr>
<td>dividend</td>
<td>313</td>
<td>15</td>
<td>25</td>
<td>58</td>
</tr>
<tr>
<td>terms of fract.</td>
<td>147</td>
<td>14</td>
<td>3</td>
<td>247</td>
</tr>
<tr>
<td>perimeter</td>
<td>133</td>
<td>101</td>
<td>142</td>
<td>34</td>
</tr>
<tr>
<td>remainder</td>
<td>352</td>
<td>12</td>
<td>28</td>
<td>19</td>
</tr>
<tr>
<td>proper fraction</td>
<td>149</td>
<td>95</td>
<td>131</td>
<td>36</td>
</tr>
</tbody>
</table>
that he understood what a product was, he was credited as being consistent. His final answer on Form 1 may not have been correct due to an error in multiplying or in copying or for some other reason, yet at the same time his consistency is indicated by his method of work. Take the word "sum" which appears in Example 11 on Form 2 and is found in Example 8 on Form 1. Consistency again would be indicated for this particular word by a correct response on Form 2 and an arrangement of any of the numbers in Example 8, Form 1 in addition order and carrying through to a final answer. Likewise consistency would be indicated by an incorrect response on Form 2 and an arrangement of any of the numbers in Example 8, Form 1 for performing multiplication, division or any other incorrect act.

Table VI shows that for eleven words, "reduce, product, dimensions, divisor, rectangle, lowest terms, sum, quotient, cancel, dividend, and remainder" responses on both tests were at least 75 per cent consistent. For practically all of these words the pupils showed that they knew the word in both situations.

Cases of inconsistency, which were rather marked (more than 25 per cent of responses) on the other nine words "numerator, average, fraction, difference, lowest common denominator, area, terms of a fraction, perimeter, and proper fraction" with a few striking exceptions, indicated that the word was generally known in the vocabulary test but was not known when it appeared in a problem situation.

An analysis of the nine words just mentioned and the inconsistent responses that were made reveals some important points.
**Numerator** was given the correct response on Form 2 (Vocabulary test) by 175 pupils who at the same time made an incorrect response to it on Form 1. The large percentage of total correct responses on this word on Form 2 (94.4 per cent — see Table III) leads one to conclude that the word is well known by sixth grade pupils but that carelessness has occurred in the reading of the problem on Form 1.

**Average** like numerator shows many correct responses on Form 2 (109) by pupils who at the same time failed to respond correctly to the word on Form 1. The usual point of failure on Form 1 was to carry through only the addition part of the problem.

**Fraction** inconsistencies were about evenly divided. Fifty-seven pupils knew the word on the vocabulary test but did not know it in a problem situation, while 61 pupils knew it in a problem situation but did not know it in the vocabulary test. On the whole, consistencies for this word were fairly high, approaching the 75 per cent mark (see Table VI).

**Difference** was a word which was known in a problem situation by 118 pupils who did not know it in the vocabulary test. For some words such as this it appears that other elements of the problem aid in its recognition.

**Lowest common denominator** was more generally known in the vocabulary test and unknown in the problem situation (100 such cases). Here, like in "average", the chief failure appeared to be in manipulation of the given data to show complete knowledge of the word.
Area showed a large number of cases (231) where the pupil knew the word in the vocabulary test but did not know it in a problem situation. Many of these cases consisted of failure by pupils to add the term "square miles" to their number answer in the problem test.

Terms of a fraction, like "difference", appeared to lend itself to recognition in a problem situation but was not known by definition (247 such cases).

Perimeter in general was known in the vocabulary test but unknown in a problem set-up (142 cases). In a problem set-up the pupils were often confused with methods of finding area.

Proper fraction was known in the vocabulary test but unknown in the problem test in 131 cases. The common error was to treat it as if it included fractions.

From the preceding analysis it is apparent that pupil's concepts of technical terms employ a wide range of thought patterns. For some words like "difference" and "terms of a fraction" their concept is not clear-cut and depends much on other problem elements being present. For words like "average, lowest common denominator, area, perimeter, and proper fraction" their ideas are fairly accurately formed but pupils falter when relating these ideas to other elements of the problem.

4. Interpretation of Results

The marked positive correlation of $0.67 \pm 0.02$ between problem solving test scores and technical vocabulary test scores
revealed by this study indicates that a positive relationship does exist between a pupil's ability to solve verbal problems in arithmetic and his mastery of the technical vocabulary used to state the problems.

The problem solving ability of pupils tends to show greater variability than their mastery of the technical vocabulary. This indicates to some degree the greater complexity of the problem solving situation. In other words elements other than vocabulary enter into the problem solving process.

The results of the study are believed to show that most pupils have some, but not always a clear-cut, conception of a technical word. Sometimes it appears that the problem situation is not the end product but a means by which a word is recognized.

For the most part, pupils show consistency in vocabulary knowledge whether the technical words are simply defined or whether they appear in verbal problems. In many cases where pupils are inconsistent they show evidence of careless reading.

Many technical words are often confused with other technical words which are used to describe a closely related process or part.

The study bears out the findings of former studies that technical words learned early in school years are not always the best known words.

For the age group with which this study is concerned, words dealing with measurement and spatial figures are not generally as
well known as technical words that fall in other classes. This also has been brought out in previous studies.
CHAPTER IV

SUMMARY AND CONCLUSIONS

1. Review of the Problem

While serving as teacher and principal in Kansas elementary schools over a period of years the writer's interest was aroused over the great amount of difficulty experienced by most pupils with verbal problems in the subject of arithmetic. Clues were gathered during his teaching career which appeared to indicate that the vocabulary, particularly the technical vocabulary, in which the problems were couched was a primary source of trouble.

An investigation of related studies covering the past twenty years showed that although a child's reading ability did not always show positive correlation with his problem solving ability, there apparently were elements of his reading ability which did correlate positively.

The present study was an effort to determine the relationship of the child's knowledge of the technical vocabulary to his ability to solve verbal problems. The method used was an analysis of the responses made on a double form test by four hundred eleven sixth grade pupils from the public schools of Western Kansas. The double form test was arranged to test the verbal problem solving ability and the arithmetical vocabulary of each child participating. The test group represented fourteen public school systems whose sixth grade
enrollments ranged from fifteen to seventy pupils.

2. Review of the Results

An analysis of the test results showed that a mean score of 6.33 out of a possible score of 10 was made on the problem solving test and a mean score of 15.48 out of a possible score of 20 was made on the vocabulary test. On the problem solving test scores ranged from 0 to 10 with a standard deviation of 2.38; on the vocabulary test scores ranged from 3 to 20 with a standard deviation of 3.20.

The correlation of the paired scores on the double form test yielded a correlation coefficient of 0.67 with a probable error of 0.0183.

The results of the vocabulary test showed that words best known by sixth graders were "numerator, average, remainder, dimensions, and reduce" and words least known were "proper fraction, difference, perimeter, rectangle, and terms of a fraction". The results of the vocabulary test agreed with the findings of previous studies concerning the relative difficulty of certain technical words, especially "remainder, reduce, quotient, dividend, product, fraction, area, perimeter, and rectangle".

A comparison was made of the pupils' interpretations of each of the technical words when used in the two distinct situations, (1) as an element of the verbal problem and (2) as a term unrelated to other words. Generally interpretations were consistent
(75 per cent or more of the pupils showed consistent answers on eleven words). In cases of inconsistency the pupils usually made a correct interpretation of the word as it stood alone but did not show correct interpretation as it appeared in the problem.

3. Conclusions

From the evidence presented the investigator draws the following conclusions:

1. There is a close positive relationship between a pupil's knowledge of the technical vocabulary of arithmetic and his ability to solve verbal problems in the subject.

2. Children show more variation in problem solving ability than they exhibit in vocabulary knowledge.

3. Pupils carelessly read some verbal problems and fail to know how to go about them even when they know the technical words contained therein.

4. In general, interpretations given to technical words are the same whether these words stand alone or are an element of a verbal problem.

5. For certain words like "difference" and "terms of a fraction", the problem situation offers clues to their recognition.

6. Words like "sum" and "difference", which are first met in the early years of a child's arithmetic experience, are not as well known as some words which are met later.

7. For sixth grade pupils, concepts of the technical words
dealing with measurement and spatial figures like "area, perimeter, and rectangle" are not well developed.

8. When pupils do not know the exact meaning of a technical word, they usually show a partial concept by identifying it with a closely related term.

4. Recommendations

The writer believes this study should prove of value primarily to the classroom teacher of elementary school arithmetic. Although the study was conducted on the sixth grade level, much of the findings should be applicable to all grades, especially to the other intermediate grades of the elementary school.

The writer feels that verbal problem difficulty is not peculiar to the elementary school alone. For junior and senior high schools similar studies carried on in the subjects of algebra, geometry and trigonometry should yield results which might form the basis for recommending textbook and teaching revisions.

The importance of giving time and effort to the development of a child's technical vocabulary was brought out in several studies referred to in the first chapter. The results of the present study add further weight to those recommendations. The recommendations apply to all who have a part in arranging the child's arithmetic environment - teachers, supervisors, and textbook writers.

It is especially recommended that this "extra instruction"
in technical vocabulary include the development of better concepts of words which are used to express measurement and spatial figures if the pupil is expected to solve problems which contain these words. It is also deemed important that frequent checking be made of children's concepts of technical terms which were first introduced in preceding grades to insure that original concepts were accurately formed and have not been forgotten.

In conclusion the writer is wholeheartedly in agreement with Steiss and Baxter when they say, "Arithmetic performance — that is, number manipulation — can be assured if children are guided in their building of an adequate arithmetic vocabulary." ¹

¹. see page 9.
APPENDIX I

Form 1

ARITHMETIC PROBLEM TEST
for the sixth grade

Prepared by Ernest A. Hoopes - Ft. Hays Kansas State College

NAME ___________________ BOY OR GIRL ____ AGE LAST BIRTHDAY ___

SCHOOL _______________ CITY _______________ DATE __________

---

Sample: Problem - How many $\frac{3}{4}$ inches are there in 1 foot?

Answer - 1 foot = 12 inches, $\frac{12}{3/4} = \ ?$

$\frac{12}{\frac{3}{4}} = \frac{16}{1}$ or 16

---

1. Reduce the following fractions to lowest terms:

$\frac{6}{9}$

$\frac{12}{16}$

2. Find the lowest common denominator for:

$\frac{1}{2}$, $\frac{1}{3}$, and $\frac{1}{6}$

3. In one year Henry's height increased from 54 1/2 inches to 57 3/4 inches. What was the difference in height?

4. The weights of three boys in the sixth grade are 76, 80, and 66 pounds. What is their average weight?
5. Find the perimeter of a rectangle whose dimensions are 6 inches and 3 1/2 inches.

6. What is the area of a field 3/4 mile long and 1/2 mile wide?

7. Find the product of the following fractions. Cancel if you can.

\[
\frac{3}{4} \times \frac{2}{9}
\]

8. From the following numbers pick out the proper fractions and find their sum.

\[
2, \quad \frac{3}{4}, \quad \frac{1}{2}, \quad 4, \quad \frac{9}{8}
\]

9. The numerator of 15/16 can be divided evenly by what numbers?

10. Using 6 as a divisor find the quotient when 15 is the dividend.

* * * * *
Do you remember the grade you received in arithmetic last year? Yes ____ No _____. If you answered yes (X), then write that number or letter grade here _____.

Sample: A quart is:

1. A piece of money equal to 25 cents. ( )
2. A unit of measure for milk, berries, and other things. (X)
3. A unit of measure for land. ( )
4. A measure of weight. ( )

1. To reduce a fraction, you:
   ( ) 1. Multiply it by another fraction.
   ( ) 2. Turn it upside down.
   ( ) 3. Divide the top and bottom part by the same number.
   ( ) 4. Make it larger.

2. A numerator is:
   ( ) 1. The answer to a division problem.
   ( ) 2. A unit used to measure area.
   ( ) 3. A number that is added to another number.
   ( ) 4. The top number in a fraction.

3. You find a product when you:
   ( ) 1. Add several numbers together.
   ( ) 2. Count the number of feet around a plot of land.
   ( ) 3. Multiply numbers together.
   ( ) 4. Divide a large number by a small number.

4. The dimensions of fields and gardens are:
   ( ) 1. The length and width in feet, yards, etc.
   ( ) 2. The colors of the plants growing in them.
   ( ) 3. The numbers of quarts, pecks or bushels of food produced.
   ( ) 4. The amounts of money earned from them.

5. An average weight for 4 boys is found by:
   ( ) 1. Multiplying the weight of one by 4.
   ( ) 2. Guessing the weights of the 4 boys.
   ( ) 3. Finding the weight of the largest and smallest, then dividing by 2.
   ( ) 4. Adding the weights of the 4 boys, then dividing by 4.
6. A fraction is:
   ( ) 1. A part of a thing or a part of a group of things.
   ( ) 2. A number that is multiplied by another number.
   ( ) 3. The answer to a multiplication problem.
   ( ) 4. Any number of things.

7. Difference in arithmetic means:
   ( ) 1. The answer to a subtraction problem.
   ( ) 2. The number below the line in a fraction.
   ( ) 3. The amount of money you put in a bank.
   ( ) 4. A number that is subtracted from another number.

8. Divisor is:
   ( ) 1. The answer to a fraction problem.
   ( ) 2. A number used in dividing another number.
   ( ) 3. A number made up of a whole number and a fraction.
   ( ) 4. A number which is divided by another number.

9. A rectangle is:
   ( ) 1. The shortest side of a garden.
   ( ) 2. What you use to measure the length of anything.
   ( ) 3. A three sided figure.
   ( ) 4. A four sided figure with square corners.

10. A fraction is in lowest terms when:
    ( ) 1. The top number is very small compared to the bottom number.
    ( ) 2. Both the top and bottom numbers cannot be divided evenly by any other whole number except 1.
    ( ) 3. The bottom number is very small compared to the top number.
    ( ) 4. The top and bottom numbers multiplied together equal 8.

11. A sum is:
    ( ) 1. A number that is added to another number.
    ( ) 2. A unit used to measure length.
    ( ) 3. The answer obtained when numbers are added together.
    ( ) 4. A number you divide by.

12. The lowest common denominator for several fractions is:
    ( ) 1. The answer when all are added.
    ( ) 2. A number with several figures.
    ( ) 3. The smallest number into which the denominator of each fraction will divide evenly.
    ( ) 4. A number found by adding all the fractions and dividing by the number of fractions.
13. A **quotient** is:
   - 1. The answer to a division problem.
   - 2. The measure of surface in a garden or field.
   - 3. A number that is subtracted from another number.
   - 4. A written paper given when money is received.

14. To **cancel** means:
   - 1. To check your answer.
   - 2. To divide the numerator and denominator of one or more fractions by the same number.
   - 3. To turn a fraction upside down.
   - 4. To subtract the same number from the numerator and denominator of a fraction.

15. Area refers to:
   - 1. A very large number.
   - 2. The distance around the edge of a playground.
   - 3. A measure like a quart or pint.
   - 4. The measure of surface of a yard, floor, etc.

16. A **dividend** in arithmetic is:
   - 1. The number to be divided by another number.
   - 2. The answer to a problem in division.
   - 3. A fraction with a larger number above than below the line.
   - 4. Either one of two numbers to be multiplied.

17. The **terms** of a fraction are:
   - 1. The numbers which will divide evenly into the top and bottom numbers.
   - 2. The lines used to separate the numbers.
   - 3. The numbers above and below the line.
   - 4. The answers obtained by dividing the top by the bottom number.

18. The **perimeter** of a triangle is:
   - 1. The height of it.
   - 2. The distance around it.
   - 3. The length and width of it.
   - 4. About one-half of it.

19. A **remainder** is found:
   - 1. In division problems that do not divide evenly.
   - 2. When we multiply one number by another number.
   - 3. In all addition problems.
   - 4. When an amount of money is given regularly to a certain person.
20. A proper fraction is:
   ( ) 1. A whole number and a fraction.
   ( ) 2. A fraction that is easily reduced.
   ( ) 3. A fraction that is made up of small numbers only.
   ( ) 4. A fraction in which the number above the line is smaller than the number below the line.

* * * * * * *
APPENDIX II

Lewis Field
Hays, Kansas
January 18, 1947

Mr. Thomas L. Iden
Superintendent of Schools
Russell, Kansas

Dear Mr. Iden:

A research study is being carried on in the subject of arithmetic by the undersigned, a graduate student at Fort Hays Kansas State College and a former instructor in grade and junior high schools of Kansas. The specific problem under investigation is the extent to which technical vocabulary is a contributing factor in the solution of verbal problems in arithmetic.

To collect data for the research, the investigator proposes to have tests administered to 200 or more sixth grade children in the public schools of Kansas within the next six weeks. The test will be in two forms:

1. Verbal problems typical of those contained in the first half of the current sixth grade arithmetic textbook.

2. A vocabulary test (objective type), testing the pupil's mastery of the technical words contained in the problems in form 1.

The test will be arranged so that it can be administered with a minimum of inconvenience to the participating schools. Directions will be included so that it can be given by the regular classroom teacher. Each pupil will be provided with a test sheet. The only equipment the pupils will need is a pencil. Administration time will require about one hour for the whole test. The tests will be scored by the investigator.

The plan of the research is to keep all test results anonymous. However, if any participant desires a pupil-by-pupil score report of its own school, such information will be furnished upon request.

Naturally the research cannot be carried on without the assistance of the administrators, teachers and pupils of
the schools of Kansas. Your co-operation will be greatly appreci- ed. Your help is requested in that you have the tests administered to the sixth grade pupils of your school. All mailing charges will be paid both ways.

A self-addressed card is enclosed for your convenience in replying. Thanking you in advance, I am

Yours very truly,

Ernest A. Hoopes
To the teacher:

Enclosed are the tests in arithmetic problem solving (Form 1) and vocabulary (Form 2) for sixth grade pupils. Since you previously agreed to co-operate in this study in arithmetic by administering the tests, will you read carefully and observe the directions in giving each test because this is of particular importance.

1. Give the problem solving test (Form 1) first. Neither test form is timed, so allow enough time for the slower pupils to finish. It is anticipated that 30 to 40 minutes for each test form will be sufficient time for all pupils to finish as many as they can work.

2. Please allow an interval of time between the giving of Form 1 and Form 2. It is suggested that a recess, class, or play period be spaced between them.

3. As vocabulary is one of the principal parts in these tests, please limit your assistance of the pupils to such activities as: seeing that they have the beginning blanks filled, re-reading any of the directions below, and other impartial acts.

4. To conserve paper, the pupils' directions are listed here for you to read as soon as they have their test sheets.

Directions – Form 1.

a. Fill in the blanks at the top of the page. Be sure to write plainly there and in the other parts of the test as well.

b. This is a test to see how well you can read, understand, and work problems. Enough space has been provided for you to do all of your work under each problem. It is important that you show the steps of your work as well as your answer. The sample problem at the top of the test should help you to see how to arrange your work.

c. Of course not all of the problems will look like the sample, but remember to show you steps and the final answer to each problem. Try to work every problem. Your teacher will take your paper when you finish.

Directions – Form 2.

a. Fill in the blanks at the top of the page. Be sure to write plainly.
b. This is a test to determine whether or not you know the meaning of certain words. Following each word four meanings of the word are given. Only one of these meanings is correct. Choose the correct meaning and place an (X) in the space before it to indicate your choice. A sample of the type of statements is found at the top of your test. An (X) has already been made to indicate the correct answer in the sample.

c. The statements in the test are to be answered like the sample. Start at the beginning and answer the statements in order. Be sure to try every one. If you find some words and statements of which you do not know the meaning, just omit them. Do not guess. However, if you have an idea that you know the meaning, but are not sure, go ahead and mark it. Your teacher will take your paper when you finish.

5. Place all completed tests in the enclosed addressed envelope and mail at your earliest convenience.

6. If you desire a pupil-by-pupil score report of your own school please indicate on this sheet and return with the tests. Yes _____ No ______. Every effort will be made to comply with your request as soon as possible. The investigator however is working without secretarial assistance so it may be some weeks before such a report if forthcoming.

The co-operation of the administrators, teachers and pupils of your school in this testing program has been most heartily appreciated.

Yours very truly,

Ernest A. Hoopes

   Current adopted arithmetic textbook for the Sixth grade in public schools of Kansas.


   An exhaustive study of vocabulary of elementary school arithmetic including the phases of general concepts, development of those concepts, and textbook use of terms. Indispensable for this study.


   Excellent source of research in arithmetic from 1895 to 1925.


   Source of important principles for preparation of vocabulary tests.

An attempt to discover relationship of vocabulary knowledge to achievement in mathematics. Two groups, totaling 259 cases, were used.


An ideal reference for the worker in educational statistics.


Using 218 cases author makes first hand study of reading difficulties in mathematics.


Report of an extensive experiment in the specific teaching of technical vocabulary as a part of the arithmetic class. Should prove of value to every arithmetic teacher.

Authors develop an excellent case against current practices of arithmetic textbook writers.


A thought provoking article which appears to get to the bottom of vocabulary teaching.


One of the first attempts to find which of the reading skills are related to arithmetic problem solving ability. Valuable for this study.