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An Investigation to determine if there is a Significant Correlation between Children's Ability to Read and their Ability to do Mathematics

Patricia Duffy Sammler
The College at Brockport

AN INVESTIGATION TO DETERMINE IF THERE IS A SIGNIFICANT CORRELATION BETWEEN CHILDREN'S ABILITY TO READ AND THEIR ABILITY TO DO MATHEMATICS

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Patricia Duffy Sammler

State University College at Brockport
Brockport, New York
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Submitted by:

Patricia Duffy Sammler

Approved by:

George L. Begg 5/29/82
Graduate Adviser Date

George L. Begg 5/29/82
Arthur Smith 5/24/82
Project Advisers Date

Robert B. Rubble 5/27/82
Graduate Director Date

Abstract

This study attempted to determine whether there was a significant correlation between children's reading ability and their ability to grasp mathematical concepts, to perform mathematical computations, and to solve mathematical word problems. To achieve this purpose, the <u>Metropolitan Achievement Tests</u> were administered to students in both reading and mathematics.

One hundred fifteen fourth grade students from an upstate New York suburban community were the subjects for this study. The <u>Metropolitan Achievement Tests</u> were administered to all subjects by their regular classroom teachers during the first week in May. For the purpose of analysis, the raw score for total reading and the raw scores for concepts, computation and problem solving were obtained and evaluated. A Pearson's Product Moment Analysis was used to determine the correlation among reading ability and each of the three areas of mathematics. Correlations were also obtained separately for both boys and girls.

The results of the study found strong, significant relationships between reading ability and mathematical computations, between reading ability and mathematical concepts and between reading ability and mathematical problem solving. The study showed no significant sex variable.

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Chapter I

Purpose

The purpose of this study was to determine whether there was a significant correlation between children's reading ability and their ability to grasp mathematical concepts, to perform mathematical computations, and to solve mathematical word problems. The following questions were examined:

1. Is there a significant correlation between students' reading ability and their ability to grasp mathematical concepts?

2. Is there a significant correlation between students' reading ability and their ability to do mathematical computations?

3. Is there a significant correlation between students' reading ability and their ability to solve mathematical word problems?

4. Is the sex variable significant?

Need for the Study

For years there has been a puzzling phenomenon among teachers as to why certain students who do very well in their reading and language skills have difficulty in doing mathematics. There are also students who do well in mathematics but are poor readers.

Educators vary in their opinions of just what part reading does play in the performance of mathematics. If a significant correlation could be established, techniques could be undertaken by teachers to adequately train students to perform better in the content area of math.

The differences in opinion of many educators have surfaced in recent years indicating that there are disagreements among educators.

On the one hand, Earp and Tanner (1980) have maintained that reading is an important factor in the ability to do mathematics. Knifong and Holton (1976), however, concluded from a study they undertook that 52% of mathematical errors were due to clerical and computational errors.

One of the difficulties that some students have in learning mathematics is poor general reading ability or the specific inability to read and understand mathematics textbooks (Bell 1978). Since many students have little interest in mathematics, they have even less inclination to read mathematics books. Even when these students do read through the assignment, they may do so in a superficial manner which results in little comprehension of the mathematics content. According to Bell, an erroneous assumption exists. This assumption about teaching mathematics is that reading mathematics is not a very important activity in learning the subject. It is the opinion that although most students can learn some facts and skills without ever opening their textbooks, concepts and principles, facts and skills are best understood and mastered when teachers' lectures and students' exercise-solving assignments are supplemented with reading assignments (Bell 1978). Richard Earle (1976) states that "most professionals agree that reading ability in any subject matter field cannot and should not be separated from concept development in that area." (p.5)

An analysis of research reports and journal articles indicates that there is no single best method or combination of methods for teaching students reading and study skills to use in learning mathematics.

However, educators do agree that teaching reading and study skills in mathematics will result in better student attitudes and improved test results. It appears that when students want to improve their study skills, instruction in reading and study methods may result in impressive gains in motivation and mathematics achievement (Brueckner, Grossnickle, Reckzek 1957).

General reading is quite different from mathematical reading. Mathematical reading requires more precision, orderliness, flexibility and concentration. When reading a section of a mathematics textbook, the reader must know the precise meaning of each mathematical term and each mathematical symbol. There is little room for connotation, conjecture, and speculation. When a student attempts to understand a theorem or write a proof, he or she cannot afford to ignore or skim over a word that he or she does not understand. Each mathematical concept has a precise meaning and plays a definite part in comprehending a principle or solving a problem (Bell 1978). When reading mathematics, each word and each sentence should be read carefully. Charts, tables, diagrams and examples should be studied thoughtfully. Steps in the solution of an exercise or problem and each part of a proof should be read and thought about until they are fully understood (Herber 1970).

A number of investigations have been made at the University of Minnesota to determine characteristic differences between good and poor achievers in mathematical problem solving (Monroe 1950). The areas in which there was no significant differences include:

A. Differences Highly Significant

1. Psychological factors

a. General reasoning ability
b. Non-verbal mental ability
c. Delayed and immediate memory
d. General language ability
e. General reading ability

2. Computation abilities

a. Skill in fundamental operations
b. Ability to estimate answers of examples
c. Ability to see relations in number series
d. Ability to think abstractly with numbers

3. Problem solving reading skills

a. Steps in problem solving
b. Finding the key-question of the problem
c. Estimating answers to problems
d. Ability to read graphs, charts, tables
e. Range of information about arithmetic users

B. No Significant Differences

1. Range of general information

2. Gates tests in general reading

a. Grasp of central thought
b. Prediction of outcomes
c. Following directions
d. Reading for details

In such psychological factors as general mental ability, delayed and immediate memory, language level, and general reading ability, the differences between good and poor achievers in problem solving are highly significant in favor of the good achievers; that is, the scores for good achievers excel those of poor achievers (Brueckner, Grossnickle and Reckzek 1957).

The differences between good and poor achievers in problem solving, in range of general information, and in the four general reading skills measured by the four Gates Silent Reading Tests are shown not to be significant. (Brueckner, Grossnickle and Reckzek 1957).

These results showed that the ability to solve typical verbal problems such as are found in standard tests of problem solving, depends largely on the general mental maturity of the pupil, his informational background, his ability to perform the necessary computations, and the possession of certain skills in reading peculiar to the solution of such problems. The fact that there are no significant differences between good and poor achievers in problem solving on four tests of ability to read the general types of literary material found in the Gates tests show that there are specialized reading abilities in math that should be developed through systematic instruction. These abilities do not result from general training in reading, and they do not grow out of mere practice in computation. They must be developed through direct teaching. The significant differences also found in range of information about math and in ability to read graphs, charts, and tables suggest that units of experience which enrich and extend meanings and give practice in the interpretation of various forms of representation of quantitative data contribute significantly to the improvement of ability to solve problems (Brueckner, Grossnickle and Reckzek 1957).

Limitations of the Study

This study was limited to fourth grade students from one school in a predominantly middle-income suburban school district.

Summary

Research produced a mixture of results. Some educators contended that reading is important for success in mathematics. Other educators failed to see any direct relationship between reading and the ability to do mathematics. The intent of this study was to examine the specific areas of concepts, computation, and problem solving in order to determine if their relationship to reading would be significant.

Chapter II

Review of the Literature

There are three elements which must be considered relating to reading in mathematics. These are language and mathematics, readability and mathematics materials, and improvements of reading in mathematics.

In reference to language development and mathematics, Knight and Hargis (1977) contend that children's language development is likely to affect their mathematics learning. For example, mastery of the grammar of one-to-one correspondence leads to the concept of "manyness." Another set of patterns occurs in noun phrases that "contain the fundamental language vehicle for presenting arithmetic concepts."
Finally, these researchers point out that an understanding of the syntax of comparative construction is essential to coping with arithmetic reasoning problems.

Hargis (1976) found in a previous study that a significant number of "normal" children do not have adequate language mastery for success in mathematical settings. If many "normal" children do not have proper language structures for mathematics, the inference can be drawn that an even greater number of bilingual and linguistically handicapped children will have similar deficiencies.

In yet another study, Linville (1976) investigated the vocabulary difficulty of word problems. The effects of "hard" versus "easy" vocabulary and "hard" versus "easy" syntax of statements intended to present mathematical situations had significant effect on students' success in solving the problem.

The evidence from these studies strongly indicates that students' success in mathematics is inextricably interwoven with their level of language sophistication (Earp and Tanner 1980).

In regard to the element of reading vocabulary and mathematics, Willmon (1971) analyzed eight series of first-through-third grade mathematics textbooks. She identified 490 words that were used in a mathematical way. In all the texts, less than 200 of these words were repeated as many as 50 times.

Stauffer (1976) found a rather extensive mismatch between the vocabulary of basal reading books and mathematics books at the third-grade level. Some 43% of the words in three third-grade mathematics books were not included in seven current third-grade reading texts.

In a readability study of modern mathematics materials, Heddens and Smith (1964) found mathematics materials to have a reading difficulty level higher than the reading capability of students. They point out that "if educators are to be successful in teaching mathematics, either the reading level of the mathematics material must be lowered or the reading level of the child must be improved, or both." (p. 466)

The third element concerns the improvement of reading the mathematics. Effective reading is based on a well-developed oral language. The process of reading is that of decoding and bringing meaning to symbols that form the vocal communicative system (Knifong and Holton 1976).

Heddens and Smith (1964) contended that mathematical terms are not nearly as likely to be part of children's oral language. The end result is that understanding of mathematical vocabulary is much less sophisticated. Reading in mathematics is likely to be greatly improved when children speak the related oral language. A further observation that the authors make from visiting many elementary mathematics classes is that oral mathematical language is not used extensively. Children spend a great deal of time working independently on assignments, doing "work-sheets," checking work, drilling, and other such activities. Seldom is there extensive discourse in which mathematics is "talked." The suggestion is that much more oral language be used in mathematics classes. More time in the discussion of mathematical ideas is recommended (Earp and Tanner 1980).

Mathematical statements in textbooks often should be rewritten or paraphrased by both teacher and students. This activity, which will expand the meaningful context from which children may develop comprehension, could be done through a language experience approach. Using such statements or statements from the textbooks, the cloze procedure, as described in Earle (1976) can be a very worthwhile procedure.

Davidson (1977) has investigated a language experience approach to working with word problems in which children write word or story problems in their own words. The suggestions made in his article provide a basis for a great deal of verbal interaction in respect to mathematical situations. The use of the technique with young children might be especially useful in developing some of the needed language patterns.

Specific procedures for reading word problems should be taught and practiced. Earle (1976) described a procedure that would be appropriate. Such an effort would require teacher and students to "talk" through numerous examples which produces benefits greater than the simple solution of word problems.

Oral emphasis in mathematics is recommended in that reading skills may thereby be increased. It has been noted that efforts given to improving reading in mathematics tend to be rewarded (Earp 1970). The additional process of making mathematical language a part of children's lives will further enhance these efforts.

It is generally recognized that linguistic abilities affect performance in mathematics and that mathematics itself is a specialized language. Monroe and Englehart (1961) summarized some of the earlier research on the relationship of reading ability to problem solving. Aiken (1971) briefly reviewed research concerned with verbal factors in mathematics learning and teaching conducted during the past four decades. Aiken conducted his own study which showed that reading ability does affect performance on verbal arithmetic problems. In his studies, he determined that various measures of general and specific reading abilities have been found to be correlated positively with scores on arithmetic and mathematics tests. His investigations, the majority of which involved children in the intermediate grades, yielded correlations between reading ability and mathematics achievement ranging between .40 and .86.

A number of studies have been concerned with specific reading skills in mathematics (Henney, 1969; Johnson, 1979). Unfortunately, the results have not consistently demonstrated superior predictive validity for measures of specific reading abilities, either singly or in combination, when compared to measures of general reading ability. For example, Henney reported that specific reading abilities were no more highly correlated than general reading ability with arithmetic problem solving in a large sample on fourth graders.

Perhaps what is required is an extensive cross-sectional study of the relationships of various aspects of verbal (linguistic) ability to performance on a variety of mathematical tasks. Some of the data included in the 1970 Technical Report on the California Tests are representative of findings cited in various sources. These data show that reading vocabulary, reading comprehension, mechanics of English, and spelling have higher correlations with arithmetic reasoning than with arithmetic fundamentals at all elementary grade levels (Aiken 1971). However, the correlations of these four linguistic tests with arithmetic fundamentals are also sizable.

The findings of other investigations (Harwin & Gilchrist, 1970; Martin, 1964; Wallace, 1968) underscore the relationships between mathematical problem solving and reading ability. Martin obtained the following results from administering the Iowa Tests of Basic Skills to fourth and eighth graders. The partial correlation between reading comprehension and problem solving abilities, with computational ability partialed out, was higher at both grade levels than the partial correlation between computational ability and problem solving ability, with reading comprehension partialed out.

Among investigations of the relationships between mathematical abilities and specific aspects of linguistic ability, particular attention has been directed toward vocabulary, and to a lesser extent, syntax. The results of studies conducted (Hansen 1974; Treacy 1974) indicate that knowledge of vocabulary is important in solving mathematics problems and consequently should be a goal of mathematics instruction. A fairly comprehensive correlational study reported by Johnson (1979), involved administering six tests of arithmetic problems and six of the Primary Mental Abilities Tests to several hundred Chicago school children. The following correlations between PMA vocabulary and the standardized achievement tests were obtained. Stanford arithmetic reasoning (.51), Chicago Survey Test in Arithmetic (.50), Stone Reasoning Test (.45). Furthermore, PMA vocabulary correlated more highly with scores on a non-standardized test composed of problems with numbers (.40) than with scores on a test of problems without numbers (.26).

Concerning the difficulty level of vocabulary and syntax, Olander and Ehmer (1971) suggested that the understanding of mathematical terms on the part of elementary school pupils had significantly improved during the past 40 years. However, it is reasonable to assume that difficult vocabulary and syntax continue to interfere with effective problem solving. This hypothesis was confirmed in a study by Linville (1970). Four arithmetic word-problem tests, each consisting of the same problems but varying in difficulty of syntax and vocabulary, were prepared: 1. easy syntax, easy vocabulary; 2. easy syntax, difficult vocabulary; 3. difficult syntax, easy vocabulary; 4. difficult syntax, difficult vocabulary. The four tests were randomly assigned and administered to

408 fourth-grade students in 12 schools. Analysis of variance of the results revealed significant main effects in favor of both the easy syntax and easy vocabulary tests. The authors concluded that both syntactic structure and vocabulary level, with vocabulary level being more crucial, are important variables in solving verbal arithmetic problems. A secondary finding of the study was that regardless of treatment condition, pupils of higher general ability and/or higher reading ability made significantly higher scores on arithmetic problems than pupils of lower ability.

Another approach to studying the relationship of knowledge of vocabulary and/or syntax to achievement in mathematics is to determine whether specific training in vocabulary has any effect on mathematical performance. For example, both Dresher (1964) and Johnson (1979) found gains in problem-solving ability when pupils were given specific training in mathematics vocabulary. In 1967, Lyda and Duncan found that the direct study of quantitative vocabulary contributed to growth in reading, arithmetic computation, and arithmetic reasoning by 25 second graders. Also concerned with arithmetic vocabulary in the early grades was a survey by Wilmon (1971) of selected primary arithmetic books. This survey revealed that children are introduced to approximately 500 new technical words and phrases by the time they reach the fourth grade. These findings led Wilmon to conclude that teachers need to reinforce the textbooks by concentrating more on specific mathematics reading vocabulary in the first three grades.

VanderLinde's (1964) experiment with nine fifth-grade classes matched with nine control classes on IQ compared scores on achievement tests in vocabulary reading comprehension, arithmetic concepts, and arithmetic problem-solving. The experimental classes studied a different list of eight quantitative terms each week for 20-24 weeks, after which the achievement tests were administered. Analysis of results revealed significantly greater gains by the experimental than by the control classes on both arithmetic concepts and problem-solving. There were no sex differences in gains on the achievement tests, but students with low IQ's showed smaller gains than students with average or above average IQ's.

Parallel to Linville's (1970) demonstration that the difficulty level of syntax in which verbal problems are phrased affects the ease with which they are solved, Sax and Ottina (1968) found that specific training in syntax can also improve performance. It was shown that training in syntax elevated the mathematics achievement of seventh graders who had no arithmetic training in the early grades, when compared with seventh-graders who had arithmetic in the early grades.

Concerning the relationships of vocabulary and syntax to ease of reading, several types of readability formulas have been applied to mathematics texts and problems. The most popular are the Dale-Chall formula, the Spache formula, and the cloze technique (Aiken 1971). Kane (1968, 1970) has given detailed reasons why readability formulas for ordinary English prose are usually inappropriate for use with mathematics materials. According to Kane, ordinary English and mathematical English differ in that (1) letter, word, and syntactical redundancies are different; (2) in contrast to ordinary English, in mathematical English the names of mathematical objects usually have a simple denotation; (3) adjectives are more important in mathematical English than in ordinary English; (4) the grammar and syntax of mathematical English are less flexible than in ordinary English.

In spite of Kane's disclaimer, the Dale-Chall formula (Dale & Chall 1949), which requires counting the number of unfamiliar words in passages to be rated, has been employed in a number of investigations. For example, Shaw (1967), using both the Dale-Chall and Spache formulas, found a wide range of readability levels in selected California public school mathematics textbooks. Thompson (1968), also applying the Dale-Chall and Spache formulas in California, studied the effects of the readability level of arithmetic problems on the mathematical performance of 368 sixth graders. He found that the readability affected performance at both of the IQ levels studied (above 110 and below 100), but it had a greater effect with pupils whose IQ's were below average.

Although Kane (1970) states that there is no logically defensible approach to assessing the readability of mathematics textbooks, a more recent study by Hater and Kane (1970) of the cloze technique suggests that this procedure can be quite useful. In Hater and Kane's analysis, cloze tests were found to be highly reliable and valid predictors of the comprehensibility of mathematical English passages designed for grades 7-12. But whatever readability formula is employed, Earp (1969) noted in a synthesis of the literature on reading in mathematics, that the vocabulary of arithmetic texts is frequently at a higher readability level than the performance level of students in the grades in which the texts are used. In addition, the vocabulary of arithmetic texts does not greatly overlap that of reading texts. However, in a survey of the readability (as measured by the Dale-Chall formula) of sixth-grade arithmetic textbooks, Smith (1971) reported that the average readability of the problems fell within bounds for the grade level. Although the results indicated wide variation from problem to problem of the same text, the reading levels of the texts were also generally comparable to those of related mathematics achievement tests. Since the readability of the sixth-grade texts and tests were at an average level generally considered appropriate for that grade, Smith concluded that readability may not be the primary cause of low scores on arithmetic problem solving in the sixth grade.

It is difficult to conduct controlled experiments in educational settings, but several experiments or quasi-experiments concerned with the effects of reading instruction on achievement in mathematics have been reported (Earp 1970). Gilmary (1967) compared two groups of elementary school children in a six-weeks summer school program in remedial arithmetic. The experimental group had instruction in both reading and arithmetic, whereas the control group had instruction in arithmetic only. On the arithmetic portion of the Metropolitan Achievement Test, the experimental group gained one-third of a grade more than the controls. Furthermore, when differences in IQ were statistically controlled by covariance analysis, the experimental group gained one-half of a grade more on the test than the control group.

In a study of the effects of special reading instruction, Henney (1969) divided 179 fourth graders into two groups. Over a period of nine weeks, Group I (N=88) received 18 lessons in reading verbal problems. On alternate days during the time period, Group 2 (N=91) studied and solved verbal problems in any way that they chose under the supervision of the same instructor as Group I. Although both groups improved significantly from pre-test to post-test on a verbal problems test, the difference between the mean post-test scores of the groups was not significant. However, the girls in Group I made a higher score on the verbal problems post-test than the boys in that group.

In studies of problem solving, Corle (1964) concerned himself with specific causes of failure in solving arithmetic problems. His findings include: (1) physical and mental defects; (2) difficulties with word recognition; (3) lack of knowledge of vocabulary and technical terms; (4) carelessness in reading the problem; (5) focus upon numbers rather than meaning; (6) confusion caused by numbers larger than those commonly encountered; (7) direction by verbal cues rather than the mathematical relationships within the problems; (8) lack of ability in fundamental operations; (10) lack of knowledge of basic arithmetic facts, rules and formulas; (11) inability to think reflectively; (12) lack of ability to choose the main computational process including inability to recognize the main elements; (13) inaccurate copying of numerals; (14) lack of variety of good problems resulting in adaptation of the pupil to the problems rather than the problem to the pupil; (15) lack of interest and effort; (16) failure to regularly verify results; (17) poor teaching, including failure to help pupils translate problems into their own experiences (Hollander 1978).

Stevenson (1955) investigated four variables thought to be associated with problem solving ability; (1) ability in silent reading; (2) power in the fundamental operations of arithmetic; (3) power in solving reasonable problems in arithmetic; and (4) "general intelligence" test scores. Examination of the findings indicated that ability in fundamental operations was most closely related to ability in problem solving when the effect of general reading ability was held constant.

Goffing (1961) administered a standardized test of paragraph meaning and one of arithmetic reasoning to 335 pupils in grades 4B through 8A in an attempt to study the correlation between ability in silent reading and ability to solve reasoning problems. She concluded that a positive relation existed between the scores made in both areas examined.

In a study designed to determine if level of general reading ability or level of computation was significantly associated with successful problem solving, and if a high level of ability in one of these would compensate for a low level of ability in the other, Balow (1964) obtained scores in reading, arithmetic computation, arithmetic reasoning, and intelligence for 1400 sixth graders. Analysis of variance revealed that general reading ability seemed to have an effect on problem solving, and this was true of all learners when the effect of mental ability was controlled. He also noted that for a given level of computational ability, problem solving ability increased with reading ability.

Eighty high and eighty low achievers in problem solving were studied by Treacy (1974) in an attempt to determine whether general or specific reading skills of seventh graders were significantly related to the ability to solve problems in arithmetic. Eighteen factors were studied in the areas of arithmetic problem solving, mental ability, and reading ability. When mental age was held constant, Treacy found good achievers superior to poor achievers at the .01 level of confidence in the following areas: quantitative relationships, perception of relationships, vocabulary in context, and integration of dispersed ideas. Treacy concluded that reading should be considered a composite of specific skills rather than a generalized ability (Hollander 1978).

In Johnson's (1979) study, a seventh grade experimental group of 316 students was carefully equated with a control group of 282 students in the four areas included in a standardized test of general learnings in arithmetic. The experimental group was provided with practice exercises designed to develop understandings of specific mathematics terms. Tests of problem solving and vocabulary were devised by the researcher and administered to both groups. These tests were based on material included in the textbook and covered in the practice exercises used by the experimental group. Significant differences favoring the experimental group were found. Johnson concluded that the use of instructional materials in mathematical vocabulary leads to growth in the knowledge of the specific terms included in these materials, and in the ability to solve numerical problems involving the use of these terms (Hollander 1978).

In an effort to determine which factors distinguished between groups of sixth grade boys designated as high or low achievers in verbal arithmetic problem solving, Kliebohn (1965) selected as subjects 479 boys and administered a battery of 17 tests in the areas of intelligence, arithmetic skills, and arithmetic-reading abilities. High achievers were significantly superior to low achievers (.01) on all tests with the exception of attitude toward arithmetic. The researcher concluded that problem solving ability appeared to be a composite of a number of specific skills and abilities, and that instructional emphasis must be distributed accordingly and not concentrated primarily upon the development of computational skills. Englehard (1965) tested 496 sixth grade girls from the same population studied by Kliebohn. She concluded that tests of arithmetic and arithmetic-reading factors disclosed more significant differences between groups of high and low achievers than did tests of general reading and vocabulary.

Curry (1955) attempted to determine the effect of two 20-minute periods of reading instruction upon the achievement of 132 students in seventh grade arithmetic. Both an experimental and control group covered the same material in the mathematics text. Members of the experimental group were provided with duplicated sheets which gave the mathematical terms, definitions, and formulas which they were expected to master and with reading instruction focusing on noting details and understanding directions. Curry concluded that the experimental group benefited from reading instruction as evidenced by higher mean scores in both math and reading tests even though the differences in means were not significant at the .05 level (Hollander 1978).

Faulk and Landry (1961) trained teachers of 11 sixth grade classes to present a systematic approach to the solution of arithmetic problems. This approach included emphasis on vocabulary, discussion of the problem, diagramming, and estimation of the answer. A control group of 11 classes was taught through close adherence to the directions in the teacher's guide of a sixth grade arithmetic book. Post-test comparisons favored the experimental group at the .10 level. The investigators recognized that this represented only a slight superiority of the experimental over the control procedure.

Cullen (1962) equated two groups of 21 third graders on the basis of mental age, reading achievement, arithmetic reasoning, and total arithmetic achievement. The experimental group was given instruction in seven specific reading skills and in a variety of computational skills. Post-testing revealed that the experimental group was superior to the control group at the .01 level of confidence. Cullen concluded that training in reading skills specific to arithmetic problems increased achievement in arithmetic reasoning and total reading. No recognition could be given to the additional instruction for the experimental group for the improvements in computational skills.

Corle and Coulter (1964) selected an experimental group consisting of approximately 1000 students in grades four through six. The group received instruction in 10 reading-arithmetic skills as an adjunct to their regular arithmetic instruction while an equal number in a control group followed the usual problem. Mean gain scores from pre-test to post-test indicated that skills appearing to have the greatest influence on the solving of verbal arithmetic problems were closely related to vocabulary development, literal interpretation of the problem statement, and selection of the proper computation process.

VanderLinde (1964) tried to determine the effect of the direct study of technical vocabulary on the ability of fifth graders to solve verbal problems in arithmetic. The experimental group studied mathematical terms selected from grade level arithmetic textbooks while the control group pursued the regular instructional program. Pupils who studied quantitative vocabulary achieved significantly higher scores on tests of arithmetic problem solving and of arithmetic concepts than did the control group.

In regard to the specificity of the problem statement, Mitchell (1962) devised a test in an attempt to determine whether problems with numbers or problems without numbers were more readily understood by pupils. Two lists of problems were prepared. Problems within each list were related, with one list containing problems with definite values expressed in numbers while the other list contained similar problems of a general nature, without specific values. Of 130 students, 125 correctly solved more of the problems containing specific numbers.

Low (1961) devised a series of tests of arithmetic problem solving and administered them to 11 year-olds. The tests were presented in three forms: problems of a general nature with no definitely expressed values; problems of a specific nature with definite values expressed in numerals; problems of a specific nature with values expressed in words. Problems with definitely expressed numerical quantities seemed to be more readily understood and solved than problems expressed in general terms, a finding consonant with that of Mitchell.

Several studies were undertaken showing the significance of language factors. Kramer (1963) studied four factors: (1) sentence form (declarative versus complex-interrogative); (2) style language detail versus concise, compressed language); (3) vocabulary (familiar versus unfamiliar); and (4) problem situation (interesting versus uninteresting). She tested 237 sixth grade children. Regarding sentence form, differences were small but favoring the interrogative-complex form of problem statement. In the matter of style, brief and concise statements produced greater success in problem solving. Familiar vocabulary also was found to be associated with better problem solving performance. The difference in success with interesting and uninteresting material proved negligible. Cue words, rather than the facts and requirements of the problem, were found to be a factor in determining the selection of the fundamental process. The numbers themselves, in particular, relationships and patterns appeared to serve as cues to mathematical operations.

Linville (1970) administered four tests of arithmetic problems differing according to difficulty of both syntax and vocabulary to 408 fourth graders. In the tests of difficult syntax, the sentences which stated the problems (excluding the question) each contained a main clause and a subordinating clause, while in the tests of easy syntax, the sentences stating the problems (excluding the question) were constructed so that each resembled a kernel sentence as nearly as possible. Statistical analysis revealed a significant difference in favor of the easy vocabulary items (.01) and the easy syntax (.05).

Suydam (1967) provided two third grade teachers with a list of cues, or problem types, found to occur most often in widely used textbooks. At the end of an instructional period, pupils were tested using problems containing both unpracticed cues and certain additional vocabulary difficulties. A "marked" amount of transfer was found to occur, even in the case of pupils of low intelligence. As the study included neither pre-testing nor a control group, it is possible that the scores achieved represented the result of 30 days of intensive instruction in problem solving rather than the effect of teaching verbal cues.

Chase (1960) was concerned with the effect of verbal cues and irrelevant details on the solution of verbal problems. Over 600 subjects from grades four through six were presented with four sets of problems in which these two factors were varied. The investigator concluded that choice of computational process was not markedly influenced by the inclusion of cue words or phrases.

Although Talton (1973) concluded in her study of 112 sixth graders that total intelligence was the main individual contributor to high achievement in verbal problem solving ability, she also concluded that activities stressing the following reading skills should improve the ability to solve verbal problems in mathematics: selecting main ideas, making inferences, constructing sequences, following directions of simple and complex choices, and reading maps and graphs.

In a study of two hundred third and fourth grade students conducted by Marzano (1975) in which he administered subtests M-1 and M-2 of the Iowa Test of Basic Skills of mathematical problem solving, he concluded that the ability to read items is a factor in the overall score. When students were aided in reading items, they were able to answer questions they had previously missed. It was also discovered that certain words such as rename, sum, missing factor, pint, true sentence, equivalent, whole number, how much and how many more gave a majority of the selected students trouble. From this, he further concluded that systematic instruction in some vocabulary words prior to the administration of a mathematics achievement test could improve students' scores.

Begle (1975) examined the importance of the ability to read mathematical prose to the learning of fifth graders. Early in the fall, a battery of instruments was administered. These included a computation test of division, four simple geometric questions, some non-routine problems, and an arithmetic reasoning test. A week later, a reading test which utilized the cloze procedure was administered. Near the middle of the school year, a battery parallel to the pre-test was given. Tests were scored and submitted to regression analysis. Results indicated that the best predictor of computation ability at mid-year was computation at the beginning of the year; a similar relationship was observed for problem solving ability. The ability to read mathematical prose contributed substantially to problem solving ability and less so (but significantly) to computation.

Skrypa (1979) conducted a study to determine the effectiveness of mathematical vocabulary training on the problem solving ability to third and fourth grade students. Sixty-six students were placed into either an experimental or a control group. All were pre-tested and post-tested with an experimental mathematics vocabulary test and with a standardized mathematics test. Mathematical vocabulary was then taught to the experimental group for eight weeks. The results favored the experimental group. There were significant differences between the gain scores of the two groups on both the vocabulary test and on the standardized test. The findings suggest that systematic mathematical vocabulary training increased the problem solving ability of third and fourth grade students.

The results of these studies indicate that although in many instances, reading is not the primary key to success in math, it is significantly important. For this reason, emphasis should be placed on training teachers in the content area of math to play an active role in helping students improve their reading skills. Levy (1978) conducted a study in which fifteen secondary level teachers representing the fields of mathematics, science, social studies and technology received instruction on the nature, measurement, and treatment of students with reading skills problems. These teachers then integrated desired teaching strategies and procedures with their on-going instruction of subject content. The reading skill levels of their students were tested prior to the application of project-related teaching procedures and then were retested after 18 weeks. Test results and evaluations by project teachers indicated that content area teachers can make a significant contribution to helping students improve their reading skills.

Chapter III

The Research Design

The relationships among children's reading ability and their ability to grasp mathematical concepts, to perform mathematical computations, and to solve mathematical word problems were examined in this study. Four null hypotheses were formulated:

1. There is no significant correlation between students' reading ability and their ability to grasp mathematical concepts.

2. There is no significant correlation between students' reading ability and their ability to do mathematical computations.

3. There is no significant correlation between students' reading ability and their ability to solve mathematical word problems.

4. There is no significant sex variable.

Methodology

Subjects

The sample for this study consisted of one hundred-fifteen fourth grade students from one school in a predominantly middle-income suburban school district in Western New York State. Fifty-nine female students and fifty-six male students from four separate classrooms participated in the study. This constituted approximately thirty-three and one third percent of the entire population of fourth grade students in this particular school. Those students who have an IQ score of 130 and were judged by the school to be gifted were excluded from the sample.

Instruments

The 1971 edition, Form F, of the Metropolitan Achievement Tests was used to measure reading and math achievement. The Elementary battery designed for grades 3.5-4.9 was administered. The raw score was used for comparison. The test yields scores for word knowledge, reading, and total reading (a combination of the word knowledge score and the reading score). The test also yields scores for math concepts, math computation and math problem solving as well as a total math (a combination of the three aforementioned areas). For the purpose of this study, the total reading score was used and the raw scores for concepts, computation and problem solving were also obtained and evaluated. A Pearson's Product Moment Analysis was used to determine the correlation between reading ability and each of the three areas of mathematics. In addition, correlations were obtained separately for both boys and girls.

Procedure and Statistical Analysis

The Metropolitan Achievement Tests were administered to all subjects by their regular classroom teachers during the first week in May. A period was set aside on three consecutive days for the administration of these tests. A computer program was used on the data collected and the results were analyzed to determine correlation coefficients among the variables.

Summary

The sample for this study consisted of one-hundred fifteen fourth grade students from one school in a predominantly middle-income school district. Reading achievement and math achievement were measured by the Metropolitan Achievement Tests. These tests were administered on three consecutive days during the first week in May. A Pearson's Product Moment Analysis was used to determine correlation and the degree of correlation. Data obtained were computer programmed and analyzed.

Chapter IV

Analysis of the Data

Purpose

This study was designed to determine if there was a relationship between children's ability to read and their ability to grasp mathematical concepts, to perform mathematical computations and to solve mathematical word problems.

Findings and Interpretation of Data

The following null hypotheses were tested:

1. There is no significant relationship between students' reading ability and their ability to grasp mathematical concepts.

2. There is no significant relationship between students' reading ability and their ability to do mathematical computations.

3. There is no significant relationship between students' reading ability and their ability to solve mathematical word problems.

4. There is no significant sex variable.

Findings and Interpretations

The data collected from the scores of the three areas of math and the score of the total reading were analyzed utilizing a computer program specially designed for this study. The program was written particularly to do the three separate Pearson's correlations. The computer system utilized was a Digital Equipment PDP 11/55. The correlation coefficients are presented in table 1.

Fisher's Z function was used to convert the correlation coefficients and the Student-t was employed to examine the sex variable involved in this study. The Student-t coefficients are shown in table 2.

Table 1

Correlation Coefficients Determined between Mathematical Computations, Mathematical Concepts, Mathematical Problem Solving and Reading Ability

		Mathematical Computations	Mathematical Concepts	Mathematical Problem Solving
Reading Ability	Male $r_{crit} = .261$	0.415	0.623	0.498
	Female $r_{crit} = .253$	0.383	0.703	0.639
	Combined $r_{crit} = .185$	0.359	0.668	0.576

$\alpha = .05$

1. The correlation between reading ability and mathematical computations was 0.415 for males, 0.383 for females, and 0.359 for the combined group. All correlations were statistically significant.

2. The correlation between reading ability and mathematical concepts was 0.623 for males, 0.703 for females, and 0.668 for the combined group. All correlations were statistically significant.

3. The correlation between reading ability and mathematical problem solving was 0.498 for males, 0.639 for females and 0.576 for the combined group. All correlations were statistically significant.

This study found a strong, positive relationship between reading ability and mathematical computations with all groups. Higher reading ability scores were significantly related to higher mathematical computations scores. Lower reading ability scores were significantly related to lower mathematical computations scores. Consequently, hypothesis 1 was rejected.

This study also found a strong, positive relationship between reading ability and mathematical concepts with female, male, and combined. Higher reading ability scores were significantly related to higher mathematical concept scores. Lower reading ability scores were significantly related to lower mathematical concept scores. Consequently, hypothesis 2 was rejected.

A strong, positive relationship between reading ability and mathematical problem solving was also found in this study. Here, too, the higher reading ability scores were significantly related to higher mathematical problem solving. Lower reading ability scores were significantly related to lower mathematical problem solving. Hypothesis 3, therefore, was rejected.

With respect to the fourth null hypothesis regarding sex difference, the Student-t comparisons between male and female showed no significance at the .05 level for any of the three comparisons. Based on these results, hypothesis 4 failed to be rejected.

Table 2

Student-t Coefficients between Male and Female for Mathematical Computations, Mathematical Concepts, and Mathematical Problem Solving

Mathematical Computations	Mathematical Concepts	Mathematical Problem Solving
0.219	0.719	1.044

$\alpha = .05$

$t_{crit} = 1.98$

Summary

Correlation coefficients between the independent variables reading ability and mathematical computations/mathematical concepts/mathematical problem solving were computed. This study found strong, significant relationships between reading ability and mathematical computation, between reading ability and mathematical concepts and between reading ability and mathematical problem solving. The first three hypotheses were rejected. However, because the differences in the data between the males and females were not significant, any difference can be attributed to chance. There appears to be no significant sex variable. Therefore, the fourth hypothesis must be accepted.

Chapter V

Conclusions and Implications

Purpose

This study investigated the relationship between reading ability and mathematical computation/mathematical concepts/mathematical problem solving. Specifically, four questions were addressed:

1. Does a significant relationship exist between reading ability and mathematical computation?

2. Does a significant relationship exist between reading ability and mathematical concepts?

3. Does a significant relationship exist between reading ability and mathematical problem solving?

4. Is there a significant sex variable?

Conclusions

This study found significant relationships between reading ability and the other three independent mathematical variables. High reading ability scores were significantly related to high scores in mathematical computations, mathematical concepts, and mathematical problem solving. Correspondingly low scores in reading ability were significantly related to low scores in mathematical computations, mathematical concepts and mathematical problem solving. All of these relationships reached significance at the 5% level of confidence. Data analysis also revealed that differences between the male and female groups tested were small enough to be attributed to chance and therefore not significant.

Implications for Classroom Practice

Students would definitely benefit from being taught how to read in the content area of mathematics. From this study and other literature researched by this author, it can be stated that mathematical performance and reading ability are closely related.

Mathematics teachers should be aware of the reading problems that should be given specialized attention in the mathematics class by the mathematics teachers.

Specialized classes could be set up which would incorporate both reading and math vocabulary and skills. These classes could be set up for slow learners, average learners and even some bright youngsters.

Mathematics teachers should avoid assigning youngsters who have general reading difficulties those mathematical problems that contain too many technical or difficult words. Teachers have many options of choosing problems that would meet the needs of the members of a specific class.

It would be useful if teachers would determine specific readability for a particular narrative mathematic selection. Examination of words used in an arithmetic text and checking the words against the cumulative word list of a basal reader would be an excellent tool. If the words have essentially the same meaning as those on the reading list, count these words familiar. Those different from the ones normally used in reading books should be counted unfamiliar.

Each unfamiliar word should be tabulated. If a given problem averages more than one unfamiliar word per twenty running words of print (5 percent unfamiliar; 95 percent familiar), it may be difficult for average students to attack the problem (Barney 1972).

Word length and sentence length are two factors that affect general readability of narrative mathematics problems. Mathematics teachers should avoid assigning problems that are long to a child who is already having difficulties with reading. However, if the mathematics problem is highly significant, mathematics teachers might consider rewriting the problem (Barney 1972).

Before reviewing the problems to be assigned, teachers should clarify vocabulary words. Teachers should be aware of problems that contain words having one meaning in literature and another in arithmetic. Narrative problems containing unnecessary or insufficient data should be used with discretion to determine how well the child is able to use his reading skills at the interpretive or analytical level.

Students should be taught how to orally restate mathematics problems that are difficult to read. Many typical mathematics texts are written in a literary style that is especially difficult for children with reading difficulties.

Mathematics teachers and reading teachers should be encouraged to combine their efforts toward helping students read better. Decoding words can be closely related to analyzing the wording of a problem.

Efficiency of a mathematics student can be increased if he is given assistance in learning to read problems. Teachers should be encouraged to work together to develop techniques or methods that will remove deficiencies in reading problems.

Implications for Further Research

This study could be replicated at other grade levels and other populations to determine if the same relationships exist.

A larger population would be required to determine if there is a handedness variable.

A more detailed study might be conducted over a period of years using an experimental group.

These students could be tested and then given special reading instruction in "mathematical reading" for a period of three years and then retested against a controlled group.

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