



The effect on mathematics achievement of teaching reading in a mathematics class at Casper College
by Allan Geoffrey Skillman

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of
DOCTOR OF EDUCATION

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Abstract:

The problem investigated in this study was the effectiveness of teaching a college mathematics class by a method that stressed instruction in reading and the effect on mathematics achievement of training mathematics teachers to teach reading.

Literature research indicates the existence of reading problems in the reading of mathematical material. Several suggested methods for overcoming these problems are given in the literature. The effectiveness of these methods has not been sufficiently researched.

A mathematics teacher was found who had taken a college course entitled "Teaching of Reading". This teacher and another member of the Casper College, Casper, Wyoming, mathematics faculty agreed to emphasize reading in their classes. Two other Casper College mathematics teachers were chosen to act as a control measure and did not stress reading in their classes.

The reading topics emphasized were technical vocabulary; symbol vocabulary; the purpose for reading; the use of the text including the color codes, author's organization, and structure keys to effective use of the text; reading of text and examples, or graphs, or pictorial aids simultaneously. A statistical analysis of the data derived from six Casper College mathematics classes gave the following results.

(1) The hypothesis that emphasizing reading in the mathematics classroom would improve the mathematical achievement of the students was supported at the 0.05 level of significance in the college algebra class but was not supported in the basic algebra class or the calculus class.

(2) The hypothesis that a mathematics teacher trained to teach reading can more effectively teach reading of mathematical material than can a mathematics teacher not trained to teach reading was not supported at the 0.05 level of significance.

(3) There was a significant interaction between the reading treatment and the course at the 0.05 level.

(4) The correlations found for IQ and ACT mathematics scores, for IQ and ACT reading scores, and for ACT reading scores and gain in mathematics achievement are not significantly different from those reported in the literature at the 0.05 level.

• lx (5) The correlation "between the ACT mathematics scores and gain in mathematics achievement as measured by teacher-made tests was 0.1708.

The following major conclusions were drawn from the statistical results. (1) It is possible to obtain better achievement in mathematics by emphasizing reading techniques. (2) The teacher's attitude or interest has an effect on the effectiveness of emphasizing reading in the mathematics classroom, (3) The ACT mathematics test is not a good predictor of success for Casper College students in mathematics classes where gain in mathematics achievement is used as a grading criterion.

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ABSTRACT

The problem investigated in this study was the effectiveness of teaching a college mathematics class by a method that stressed instruction in reading and the effect on mathematics achievement of training mathematics teachers to teach reading.

Literature research indicates the existence of reading problems in the reading of mathematical material. Several suggested methods for overcoming these problems are given in the literature. The effectiveness of these methods has not been sufficiently researched.

A mathematics teacher was found who had taken a college course entitled "Teaching of Reading". This teacher and another member of the Casper College, Casper, Wyoming, mathematics faculty agreed to emphasize reading in their classes. Two other Casper College mathematics teachers were chosen to act as a control measure and did not stress reading in their classes.

The reading topics emphasized were technical vocabulary; symbol vocabulary; the purpose for reading; the use of the text including the color codes, author's organization, and structure keys to effective use of the text; reading of text and examples, or graphs, or pictorial aids simultaneously.

A statistical analysis of the data derived from six Casper College mathematics classes gave the following results.

(1) The hypothesis that emphasizing reading in the mathematics classroom would improve the mathematical achievement of the students was supported at the 0.05 level of significance in the college algebra class but was not supported in the basic algebra class or the calculus class.

(2) The hypothesis that a mathematics teacher trained to teach reading can more effectively teach reading of mathematical material than can a mathematics teacher not trained to teach reading was not supported at the 0.05 level of significance.

(3) There was a significant interaction between the reading treatment and the course at the 0.05 level.

(4) The correlations found for IQ and ACT mathematics scores, for IQ and ACT reading scores, and for ACT reading scores and gain in mathematics achievement are not significantly different from those reported in the literature at the 0.05 level.

(5) The correlation between the ACT mathematics scores and gain in mathematics achievement as measured by teacher-made tests was 0.1708.

The following major conclusions were drawn from the statistical results. (1) It is possible to obtain better achievement in mathematics by emphasizing reading techniques. (2) The teacher's attitude or interest has an effect on the effectiveness of emphasizing reading in the mathematics classroom. (3) The ACT mathematics test is not a good predictor of success for Casper College students in mathematics classes where gain in mathematics achievement is used as a grading criterion.

CHAPTER I

INTRODUCTION

The changes in society over the last half century have given the ability to read and the ability to apply mathematics an ever increasing priority. The places in life are few where reading of some kind and mathematics of some kind are not necessities.

The ability to succeed very often depends on the ability to read; therefore the ability to read fluently is given a very high priority. Heilman says that "the failure of large numbers of children to learn to read at a level commensurate with their intellectual ability may well be our number one educational problem."¹

The mathematics teacher should help students learn to read mathematical materials so that they might better learn mathematical concepts. The language of mathematics has vocabulary characteristics and a system of writing structure forms such as exponents and subscripts, which

¹Arthur W. Heilman, Principles and Practices of Teaching Reading, (2nd ed.; Columbus, Ohio: Charles E. Merrill Publishing Company, 1967), p. 452.

complicate the reading problem.¹

The students should be taught to attack and solve problems that will not exist until some future time. The solution of these problems requires the ability to read mathematics and to think mathematically. This seems to require an educational system that teaches not only fundamental mathematical techniques but stresses understanding and original thinking in its mathematics classes. The efficient completion of this task seems to demand the use of every reasonable teaching tool.

The Problem

The specific problem explored by this study was the effectiveness of teaching a college algebra class by a method that stressed instruction in reading. A second problem was to determine whether a mathematics teacher with minimal training in the teaching of reading was better able to provide this instruction than a mathematics teacher without training in the teaching of reading.

¹Harold H. Lerch, "Improving Reading in the Language of Mathematics--Grades 7-12," Improving Reading in Secondary Schools, ed. by Lawrence E. Hafner, (New York: The MacMillan Company, 1967), pp. 344-52.

Purpose of the Study

The purpose of the study was to compare statistically the mathematical achievement of students receiving a reading emphasis in the mathematics class with the achievement of students not receiving a reading emphasis. The achievement was measured by teacher-made tests. A second purpose of the study was to compare the mathematics achievement of students receiving reading instruction from a mathematics teacher trained to teach reading with the mathematics achievement of students receiving reading instruction from a mathematics teacher who had no training in the teaching of reading.

Need for the Study

It has been suggested that the failure of students to solve reasoning problems in arithmetic is in some degree caused by deficiencies in reading ability. It is logical to believe that a pupil who is unable to understand the situation described in a problem will not be able to solve the problem.¹ Balow found that both general reading

¹B. A. Stevens, "Problem Solving in Arithmetic," Journal of Educational Research, 25 (April-May, 1932), pp. 253-60.

ability and computational ability have a significant effect on the ability to solve verbal problems.¹

Mathematics requires special reading skills and the language of mathematics has characteristics which complicate the reading. Technical mathematical terms must convey precise meanings in order to communicate the desired concept to the mind of the reader.²

Students frequently have a lack of prerequisite learnings necessary to read and understand mathematics and they may lack a knowledge of mathematical concepts. They often are easily confused and frustrated by mathematical symbolism.³ It may be incorrectly assumed that students have already learned through previous experience the necessary vocabulary for understanding the topics.⁴

An analysis of materials and learning difficulties

¹I. H. Balow, "Reading and Computation Ability as Determinants of Problem Solving," Arithmetic Teacher, 11 (January, 1964), pp. 18-22.

²J. H. Banks, Learning and Teaching Arithmetic, Boston: Allyn and Bacon, 1959).

³Lerch, "Reading Mathematics," pp. 344-52.

⁴Ray F. Deck, "Vocabulary Development to Improve Reading and Achievement in Science," Improving Reading in Secondary Schools, ed. by Lawrence Hafner, (New York: The MacMillan Company, 1967), pp. 148-53.

shows that skill in reading is a necessary part of the work in algebra. For example faulty vocabulary or failure to note detail can result in faulty applications. Therefore the mathematics teacher also must be a teacher of reading in that he is concerned with the skills involved in learning.¹

These problems were summarized by Aaron as follows: To read mathematics one needs both basic reading ability and the specialized skills unique to mathematics. Special skills used in mathematical reading are: mathematical vocabulary, both words and symbols; concept background; ability to select skills and rate for the material being read; proficiency in the special reading tasks of mathematics; and skill in the interpretation of mathematical symbols.

The development of these skills is the responsibility of the mathematics teacher. In addition to this the teacher must help the poor readers as well as the excellent readers to find appropriate reading material. These

¹Leo C. Fay, "The Program in the Content Areas," What Research says to the Teacher No. 11 Reading in the High School, Department of Classroom Teachers, American Educational Research Association of the National Education Association, 1956, pp. 23-26.

reading needs grow out of the specialized nature of mathematics.¹ Systematic attention to the development of the specialized reading skills in mathematics will result in better readers and greater achievement in mathematics.

Call and Wiggin performed an experiment using an English teacher to teach a ten day section of algebra II. One of the conclusions of their experiment was; "We also suggest that this experiment has some cogent implications for further testing. . . . It is time we took note of the necessity for studying relationships between disciplines."²

A search of the literature has revealed no listing of the reading skills that should be included in the mathematics course outlines. The teachers' manuals that accompany mathematics texts have few references to methods for teaching vocabulary and no other methods for teaching reading. It has perhaps been incorrectly assumed that the mathematics teacher knows what special reading skills are used to read mathematics. Therefore it seems reasonable to infer that there is a need for study guides in mathematics

¹I. E. Aaron, "Reading in Mathematics," Journal of Reading, 18 (May, 1965), pp 391-95.

²Russell J. Call and Neal A. Wiggin, "Reading and Mathematics," Mathematics Teacher, 59 (February, 1966) p. 57.

which include reading techniques.

General Hypotheses

(1) Presentation of reading techniques in the mathematics classroom will improve the mathematical achievement of the students.

(2) Teachers of mathematics with minimal training in reading can more effectively provide the reading techniques than can mathematics teachers not trained to teach reading.

Definitions of Terms

Basic Algebra, 55-097: a three credit course that meets five hours a week, designed for students who have a deficiency in high school algebra I.

College Algebra, 55-117: a three credit course, "for students in life sciences, business, and liberal arts."¹

Calculus, 55-151: a five credit course covering single variable calculus, using an intuitive approach.

Gain Score: The score found by subtracting the number of items correct on the diagnostic test from the

¹Casper College, Casper College Catalog, (Casper, Wyoming: Casper College, 1971), p. 154.

number of items correct on the final examination for each student.

Basic Assumptions

It was assumed that the assignment of students to the several sections of a mathematics course by the registration procedure used at Casper College, Casper, Wyoming, was done randomly.

Procedures

Two of the Casper College mathematics teachers agreed to emphasize reading in their classes. One of these teachers had completed a two semester hour course entitled "Teaching of Reading." Two other Casper College teachers were carefully chosen to provide a control measure for the experiment. This choice of teachers dictated the choice of four algebra classes and two calculus classes for the study.

Teacher-made tests were revised to make them acceptable for the measurement of student achievement in the college algebra course. Test items were given for diagnostic purposes at the beginning of the semester and were repeated as part of the final examination to yield two measurements for each student included in the study. The

difference of these two measurements was the gain score.

Reading techniques were developed by the investigator and the teacher for the college algebra course. The reading emphasis was given to the experimental sections of each course in the study and statistical methods were used to analyze the resulting data.

Limitations

The size of the sample was determined by the availability of scores for concomitant variables and by the liberal withdrawal policy of Casper College which allows a student to drop a course until one week before the final examination for that course.

The teaching assignment at Casper College severely altered the experimental design. The teacher trained to teach reading was assigned to teach calculus instead of college algebra, which necessitated the inclusion of the calculus course in the study. The teaching assignment change was made between the registration dates and the beginning of classes for the semester.

The exercises and tests used in this study were made to agree with the texts used in the particular classes at Casper College during the spring semester of 1972. No

claim is made for their use in any other situation.

The method used to obtain the IQ scores for the students at Casper College made it inadvisable to use them for any statistical inference. The method and the reasons for not using the IQ scores are explained in chapter III and chapter IV of this paper.

CHAPTER II

REVIEW OF LITERATURE

In this review three major topics are developed:
(1) reading problems associated with learning mathematics,
(2) recommended methods for teaching reading in mathematics and (3) a brief summary of investigations similar in purpose to that of this study.

Reading Problems Associated With Learning Mathematics

An analysis of materials and learning difficulties shows that skill in reading is very much a part of the work in algebra and geometry. The mathematics teacher is a reading teacher in that he is concerned with the skills involved in learning as well as the mathematical information learned. Students can be helped to learn more if attention is given to the reading and study skills used.¹

Miller says that mathematics requires special reading skills. Much of the difficulty with reading in mathematics stems from the student's lack of awareness of the purpose for the reading. In most instructional reading a

¹Fay, "The Program in the Content Areas," pp. 23-26.

seventy-five per cent comprehension level is acceptable, but in a sequentially structured subject like mathematics comprehension of all the material is necessary.¹ The purpose for reading has an important bearing on the rate at which the reading is done, as well as on the reading skills used for a particular reading task.

The language of mathematics has characteristics which complicate the problem of reading. Technical mathematical terms must convey precise meanings if they are to evoke the desired concept in the mind of the reader. It is too easy to assume that the students have learned through previous experiences the necessary vocabulary for various topics.²

There is a distinct vocabulary of mathematics and about one-fourth of the reading difficulty in mathematics is caused by difficult vocabulary. The technical words are most often the cause of student difficulty.³ Students in

¹Lyle L. Miller, Developing Reading Efficiency, (Laramie, Wyoming: Developmental Reading Distributors, 1962), p. 12.

²Lerch, "Reading Mathematics," pp. 344-52.

³Bernice E. Leary, "Meeting Specific Reading Problems in the Content Fields," Reading in the High School and College, Forty-Seventh Yearbook of the National Society for the Study of Education, Part II (Chicago, Ill.: The University of Chicago Press, 1968), p. 158.

general have a distinct lack of prerequisite learnings necessary to read and understand the mathematical content presented; they lack the necessary understanding or knowledge of mathematical concepts; and they do not have the necessary speaking or reading vocabulary in terms of mathematical reference.¹

Leary summarized the reading problems in mathematics, for the National Society for the Study of Education in the following manner. The vocabulary of mathematics is more specific and more descriptive than vocabulary used in other areas. It consists of many words which have different connotations in common usage. To understand the mathematical usage of these words, they must be related to a specific classification, process, or concept. Another difficulty with words is that the same word is sometimes used to convey different technical meanings. In addition, unfamiliar nontechnical words cause problems for many students. Research shows that students will not grow into an understanding of technical terms.

In addition to English words, some of which have special technical meanings, the language of mathematics

¹Lerch, "Reading Mathematics," pp. 344-52.

uses a large system of signs and symbols. The literal numbers, a , b , c , . . . x , y , z , must convey meanings in sentences exactly as do other nouns. There are exceptions, such as n^a and n_b , where the a is an adverb and b acts as an adjective. The reading of these symbols requires a greater effort than most reading since the size and relative position of the symbol are as important as the symbol itself. If a student reads a as a letter of the alphabet rather than as some number, he is reading with neither meaning nor purpose beyond that of manipulating symbols. The verbs of a mathematical expression are the operational symbols $+$, $-$, $=$, \cdot , $()$, and others. In addition to learning to read all of the symbols, a student must learn to read the arithmetic numerals correctly, including a sense of direction when one is indicated by a plus or minus sign. The same sign is sometimes used for two different technical meanings, as $x - m$ and x^{-m} . Where the first minus sign indicates the operation subtraction, and the second minus sign means take the reciprocal of x^m .

The formula is a universal tool. It is a combination of algebraic symbols used in sequence. The ability to understand and translate formulas is the heart of applied mathematics. Since the formula is more often a design

rather than a line of print, or a series of words, it presents special reading problems. The perception involved in reading formulas and graphs makes a greater demand on the eye than reading algebraic prose.

Reading mathematics, like reading other subject materials, demands that the student recognize the vocabulary and symbols, not only when they are isolated, but also when they are in combination. The student must be able to draw on the implied meanings of the context to get the ideas intended by the author. The extent to which the student has clear referents for the words and symbols determines the extent to which he can read them.¹

In addition to the reading problems caused by the nature of mathematical material, there are poor reading habits that add to the reading problem in mathematics. In the following quotation is a list of poor reading habits which are likely to be crucial in reading mathematical material.

Number attraction. Some readers come to a complete stop every time they reach a number. They seem to want to study it carefully as if it were a completely different idea in communication. . . .

Word analysis. Stopping to think slowly and carefully about a strange word as to its origin, structure,

¹Leary, "Meeting Problems," pp. 150-62.

prefixes, and suffixes may be a sound vocabulary building exercise, but it destroys the general direction of your thought in reading. . . .

Monotonous plodding. Keeping the same pace of reading in all materials, from light fiction to heavy study is tiresome. One needs to develop his ability to change habits of reading to adjust to different needs.

. . . .

Clue blindness. Like the driver who is too busy watching the road to see the sign posts that direct him to his destination, many readers become too involved in word reading to notice such things as headings, titles, styles of type, listings, illustrations, introductions, and summaries. . . .

Back tracking. Going back to reread words or phrases is an indication that you doubt your own ability to pick out the important material. . . .

Rereading. . . . If you concentrate on doing a good job of reading in the first place, a few minutes of thinking about what you have read will be far more valuable than rereading.

Daydreaming. Allowing your attention to wander to other things while you are reading leaves you with the feeling of having covered pages but having no knowledge of what you have read.¹

All of these habits can be overcome unless the student has a serious mental or physical handicap. An individual will overcome the poor habits much more quickly with guidance and controlled practice than he will if he is expected to learn to read on his own.²

¹Miller, Developing Reading, pp. 7-8.

²Vernon Troxel, "Effects of Purpose on the Reading of Expository Mathematical Materials in Grade Eight," Journal of Educational Research, 55 (February, 1962), pp. 221-27.

One of the marks of a good reader is his ability to adjust his reading skills to his purpose and to the type of material which he is reading. The kinds of reading skills, as defined by Dr. Vandiver, most used in reading mathematics are described briefly here.

Study reading is a type in which the reader should get seventy to eighty per cent understanding of the ideas presented and how they fit together.

Critical reading requires that the reader understand all of the ideas presented. At the same time it requires that he must consider what is known of the source of the material; he must watch for faulty logic and false comparisons; and he must be aware of what the author is trying to make him believe. Some errors in mathematical material cause the noncritical reader wasted study time while the critical reader recognizes them as obvious errors.

Analytical reading uses a questioning approach seeking complete understanding and requires careful and intense concentration.¹

When reading skills are graded by the amount of

¹Dr. Willis C. Vandiver, Lecture given to his Teaching of Reading class, Montana State University, Winter Quarter, 1968.

concentration needed it is observed that the three skills previously listed demand more concentration than any of the other reading skills. Generally this need for more intense concentration makes the kinds of reading skills used in mathematics harder to learn and more difficult to apply than other kinds of reading skills. The successful solution of a story problem or the completion of a mathematical proof requires the student to combine parts of these three reading skills with good reading habits, with an understanding of the vocabulary, concepts, and symbols of mathematics, and with the necessary computational skills.

Recommended Methods for Teaching Reading in Mathematics

Two basic assumptions concerning the teaching of reading in mathematics were held by the writers who were surveyed in this section. They were that students need specific classroom instruction in reading techniques and that teachers need a periodic reminder of this fact. Two of the emphases were teaching of vocabulary and teaching the student to read with a predetermined purpose.

Students must be taught to read for a specific purpose. Smith suggests four readings of a story problem

with the following reasons for each. (1) Read the problem to grasp the whole situation. (2) Read it a second time to concentrate on the question. (3) Use the third reading to decide on the process or the formula. (4) Last, pull out and use the given number facts.¹

Spache claims that the approach stated in the preceding paragraph is not the same as the steps: "(1) what is given, (2) what is to be found, (3) what steps should I take (4) about what is the answer?"² He says also that research has shown these four steps to be unprofitable as a method for teaching problem solving.

Rereading in some situations is called a reading problem, but Maribeth Henry, says, "Rereading is often unnecessary with narrative materials, but is essential for successful reading of verbal problems."³

Vocabulary development is an important part of

¹Nila Banton Smith, "Reading in Subject Matter Fields: Reading in Mathematics," Educational Leadership, 22 (March, 1965), p. 384.

²George D. Spache and Evelyn B. Spache, Reading in the Elementary School, (2nd ed.; Boston: Allyn and Bacon Inc., 1969), pp. 305-307.

³Maribeth Henry, "Improving Mathematics Verbal Problem-solving Ability Through Reading Instruction," Arithmetic Teacher, 18 (April, 1971), p. 224.

teaching reading in mathematics. First, the teacher must identify the technical words for each lesson, use a word list and teach the technical vocabulary. Second, the teacher must teach unfamiliar words which occasionally give the key to understanding a specific topic. Third, words with multiple meanings should be explained to the student, with their mathematical meaning clearly separated from the other usages. Jo Phillips points out that we should "clarify the meaning of each term by pointing out what it does not mean."¹

If the practice problems given to the students are to effectively aid the learning process, the teacher should adjust the problem length to the student ability. Problems with unnecessary data or with insufficient data should be used carefully and the students should be reminded to read all problems critically, looking for the useless information and expecting to find some problems that cannot be completed.²

Vocabulary instruction in mathematics should include an explanation of signs and symbols. The word exponent,

¹Leroy Barney, "Problems Associated with the Reading of Arithmetic," Arithmetic Teacher, 19 (February, 1972), p. 384.

²Jo McKeeby Phillips, "Reading Math Content," Instructor, 81 (November, 1971), p. 64.

for example, is not a part of the student's vocabulary until he identifies the x in 3^x with both the word and its corresponding meaning. The teaching error occurs when the student reads exponent as the little number above the line and omits the mathematical operation which the author used as his referent for the symbol.

Children need to write and to tell number stories the same way they write and tell experience stories.¹ For example the student should practice statements such as: During the past thirty-two years a man's age has increased by 2^5 while his net worth has increased by 10^6 and he is now called a millionaire. Practice of this type needs to be both written and oral.

The need for vocabulary emphasis is repeated by Shepherd. He also states the need for teaching the use of the text. Students should be shown the significance of typographical differences and vocabulary aids, such as color, underlining, and shaded areas. The use of the glossary, table of contents and the index should be explained by the mathematics teacher. The use of the introductions and summaries given in the text should be

¹Frayda F. Cooper, "Math as a Second Language," Instructor, 81 (October, 1971), p. 76.

taught as review techniques.¹

"An absolutely essential skill that everyone needs if he is to read a math book with understanding is that of referring to an example, or a diagram, or a graph, or a picture, that goes with an explanatory paragraph."² It is sometimes a help to use both hands as well as the eyes to read this kind of explanatory material, one hand to keep the place in the paragraph and the other to keep the place in the pictorial aid or example.³

The effectiveness of these teaching techniques and methods is determined by whether or not they are an integral part of the mathematics teacher's unit plans. If the reading is taught as a separate item the students will usually keep reading and mathematics separated and therefore will not profit from the teaching effort.

The Arithmetic Teacher, The Mathematics Teacher and The Reading Teacher contain some articles that give, in detail, specific lesson plans designed to treat items that

¹David L. Shepherd, "Teaching Science and Mathematics to Retarded Readers in High School," Reading Teacher, 17 (September, 1963), pp. 25-30.

²Phillips, "Reading Math Content," p. 65.

³Ibid.

