Analytical study of reading skills necessary for comprehension of the seventh grade mathematics textbook at Henry Clay School.

William M. Brand

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AN ANALYTICAL STUDY OF READING
SKILLS NECESSARY FOR COMPREHENSION
OF THE SEVENTH GRADE MATHEMATICS TEXTBOOK
AT HENRY CLAY SCHOOL

by
Mr. William M. Brand

A RESEARCH PAPER
SUBMITTED IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF
MASTER OF ARTS IN EDUCATION (READING SPECIALIST)
AT THE CARDINAL STRITCH COLLEGE

MILWAUKEE, WISCONSIN
1970
This research paper has been approved for the Graduate Committee of the Cardinal Stritch College by

[Signature]
(Adviser)

Date: Feb 20, 1976

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CHAPTER I

THE PROBLEM

Introduction

To become a better teacher is a challenge that faces one all through life. With all of the emphasis on space and related fields, mathematics at all levels must be taught with the idea of its necessity to help one fulfill life's needs. Because of this need, the writer has given much attention to reading skills necessary to provide adequate means to understand and attack the mathematics of today. Children need to learn the proper skills so that they can learn to understand and even enjoy mathematics.

The writer has considered in depth the proper approach to the understanding of mathematics at the seventh grade level. Spache says:

It is generally accepted that skill in reading comprehension is directly related to success in arithmetic reasoning or problem solving. This relationship is probably greater at primary levels where reading of problems is almost purely a reading task. However, as arithmetic relationships and processes become more complex, good general reading comprehension becomes increasingly less significant in problem-solving success. Therefore, from upper elementary school levels through
high school and college, more assistance in reading mathematical materials is essential.¹

After much thought, a reading approach designed to understand the textbook² was the result.

It is hoped that because of this analytical study, not only the writer will become a better teacher, but that other teachers of mathematics will benefit by this study.

Statement of the Problem

The purpose of the study is to analyze the reading skills necessary for comprehension of materials in the seventh grade mathematics course at Henry Clay School.

Specifically, this study will include the surveying of the literature in the content areas that relate to mathematics. In addition, the writer will analyze the text to determine which reading skills are needed to comprehend the material presented.

Scope and Limitations of the Study

The study is limited to a compilation of reading skills emphasized by reading specialists, particularly applicable to


reading the mathematics book used in the seventh grade at Henry Clay School where the writer is teaching.

The Plan

To properly evaluate which skills are needed in studying mathematics, it was necessary to arrive at an instrument to do so. The writer did find some instruments suggested by leading authorities but there were differences of opinion. Because of this, the writer decided that the instrument used would be compiled from the various authorities in this field and the writer's objective observation based on his experiences with the teaching of mathematics and background in reading.

The literature in this subject was studied in order to prepare the criteria for analyzing the textbook used in the seventh grade to determine the special reading skills involved.

The reading skills that the writer finally has drawn for the analysis of this paper are:

I. Vocabulary
   A. General
   B. Technical
   C. Symbols

II. Comprehension and Interpretation
   A. Background
   B. Quantitative Sense
   C. Thinking
      1. Selective
      2. Orderly
      3. Logical
III. Specialized Skills
   A. Charts
   B. Graphs
   C. Tables
   D. Diagrams

IV. Selection of Speed
   A. First reading
   B. Second reading
      Reread Specific Areas

V. Problem Solving
   A. Question
   B. Facts needed
   C. Processes required
   D. Computation
   E. Recheck
CHAPTER II

SURVEY OF LITERATURE

Content Fields Emphasizing Mathematics

The writer noted that most books that are written about reading in the Junior High and Secondary levels emphasize what is needed in the content field. Massey and Moore present the section on the content area by saying:

Reading is the most widely used learning procedure for acquiring content at the secondary level. To this extent, every teacher in the content area is a reading teacher. Whenever any teacher instructs the student from printed material, he becomes a reading teacher. Reading is a process for learning, rather than a subject to be taught at any particular school level.¹

The authors presented a suggested outline that the content area teachers attempt to use to teach various skills. These were:

1. Word meaning
2. Comprehension skills
3. Purpose for reading
4. Rate of reading

Also included in the discussion was the necessary physical environment of the classroom where total learning takes place. It seems that most authorities stress the need for guiding principles to teach the content areas with quality and quantity. The teacher needs to have a purpose with students' needs in mind, and the students need specific purposes for reading.

The Kansas Studies in Education, suggests methods and devices a mathematics teacher may use to improve reading. The skills recommended are:

1. Develop vocabulary.
2. Interpret verbal problems.
3. Read and interpret materials showing functional relationships.
4. Proofread to verify solutions and/or to locate errors.
5. Read extensively to make use of quantitative data in newspapers, magazine articles, and books.
6. Acquire meaning from the statements of rules and definitions so they may be used with understanding.

Most authorities agree on the basic skills that are necessary but may present the information in a slightly different manner.

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2Ibid., p. 52.
In a curriculum bulletin published by the New York City Board of Education, a chart was shown, categorizing the reading skills into three basic sections.

1. Word recognition
2. Comprehension
3. Work study

Each category consisted of five to twelve sub-headings. The particular chapter on mathematics listed seven specific reading skills necessary for successful functioning. The skills listed here are:

1. Recognize and understand the different meanings of familiar words when used in mathematics context.
2. Recognize and understand mathematics vocabulary.
3. Recognize and understand operational symbols, variables, etc.
4. Read and interpret tables, graphs, formulas, and equations.
5. Read and understand problems.
6. Distinguish between relevant and irrelevant numerical and verbal details.
7. Read and follow directions correctly.

A very impressive article on the three main areas usually designating a class was written by Clark. First he presents a situation of three boys attempting their mathema-

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4 Board of Education of the City of New York, Reading in the Subject Areas-Grades 7-8-9, New York, Curriculum Bulletin, 1963-64 Series-No. 6, p. 2.
5 Ibid., p. 51.
tics assignment. The boys each read the particular problem aloud. After the third boy had finished reading (with excellent expression), they realized what the problem was all about. From this, Clark concludes there are three levels of readers in our classrooms today. The one group consists of the "non-readers" who may be able to merely say the words at best with very little comprehension. At the opposite end, we have the child who reads independently and is able to adapt old concepts and come up with the new ones. The third group is the large middle group. They have various kinds of reading problems - mental, physical and emotional.

Clark concludes his article emphasizing the need for the reading specialist to be a resource person to the mathematics teacher to enable her to present the reading techniques in mathematics to the pupils as she would be most qualified to deal with mathematical concepts and language.6

Austin states that comprehension skills must be built, but cites the need for general and specific vocabulary. Once the vocabulary is understood, pupils may begin to practice ways to learn comprehension skills. She suggests practice in reading and solving problems orally in groups. Some specific questions to be considered are:

1. What do we need to find?
2. What facts are given in the problem?

3. What steps are necessary for a solution?

4. What is a reasonable answer?

If the student receives this type of exercise frequently, he will use this approach when answering problem-solving questions. Austin also stated that an approach similar to S, Q 3R, is recommended so the student will begin to do this on his own.7

Henderson states:

Speaking generally, the process of reading is the same whether the student is reading English or mathematics. The symbols, whether they are English words or mathematical signs, serve as cues to the ideas which are to be communicated. As the student reads, he interprets the symbols and uses the ideas they represent to accomplish a certain purpose. As in reading English, so in reading mathematics, the two chief causes of reading difficulty are: (1) not knowing what the symbols mean, and (2) not knowing or being confused about the purpose of reading.8

Concept development appears to be a prime concern of the authors when discussing content reading. Henderson feels that it makes little difference whether the teacher presents the concepts by name to be developed first, or the teacher directs student experiences so that the concept evolves. However, the amount, kind, and organization of the experience the teacher provides, makes the difference.9

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9Ibid., p. 397.
Another important consideration stressed by the content field experts was the need for a purpose when reading. Karlin stressed the fact that students who have a purpose for reading are thinking about the content of the material at hand rather than merely receiving information to digest. He further commented that active readers have a problem to solve, while the passive readers just gather facts.\(^\text{10}\)

Karlin also states, as the other authors previously discussed, that the technical vocabulary of mathematics is like a foreign language and the content teacher must spend time to be sure that the students understand the vocabulary or they will not be able to comprehend the required reading. The required reading, according to Karlin, can be classified into five major stages:

1. Readiness for reading.
2. First reading (silent).
3. Discussion of the material.
4. Rereading (silent and/or oral).
5. Application.\(^\text{11}\)

This is a necessary requirement as many mathematics and other content field teachers know from experience. Every time anyone picks up material about reading in content areas, vocabulary, comprehension, slow reading, rereading, and analyzing verbal problems is always discussed.


\(^{11}\)Karlin, op. cit., p. 236
Two items that impressed the writer when reading material written by Bamman, et al, were that all of the above factors were discussed at length and that there is the need to have adequate general reading abilities to interpret the mathematical language.

They stated:

They (the students) must, for instance, have mastered the essential word-recognition skills, have learned to use contextual clues readily, have proficiency in applying prefixes, suffixes, and roots to new words; have become skillful in following a pattern of ideas, of recognizing main ideas and the required details; and have developed considerable skill in efficient use of the textbook.\(^{12}\)

It was also stated that lack of these skills by students should be reported to a responsible individual, such as the counselor or reading specialist.\(^{13}\)

In the past twenty or so years, schools have realized that teaching of reading in the content areas is necessary. According to Marksheffel, critics claimed that secondary teachers were indifferent to students' reading difficulties. The teachers' answer to this was that they felt some teachers may have been indifferent because they did not know about the reading process to recognize when students needed reading help. Also the teachers stated they realized the need for multilevel texts and reading instruction, but

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\(^{13}\)Ibid., p. 190.
stated five points why this was impossible:

(1) The school administrators insist that teachers use only the one adopted textbook.
(2) The course of study is designed for a single specific textbook.
(3) Less difficult textbooks are unavailable in the particular subject-matter field.
(4) Teachers rarely have had a course in how to teach reading, and therefore, have no idea of what is meant by teaching reading in content areas, or
(5) Teachers would teach reading if they knew how reading should be taught.\textsuperscript{14}

CHAPTER III

A STUDY OF READING SKILLS AND APPLICATION TO READING OF MATHEMATICS

Development of Skills List

The purpose of this study was to devise a method of instruction which would lead to a better comprehension of seventh grade mathematics. A reading skills approach was decided upon because reading seemed basic to the understanding of written problems and involved development of thinking abilities. In order to analyze the text, a skills list was formulated:

I. Vocabulary
   A. General
   B. Technical
   C. Symbols

II. Comprehension and Interpretation
   A. Background
   B. Quantitative Sense
   C. Thinking
      1. Selective
      2. Orderly
      3. Logical

III. Specialized Skills
   A. Charts
   B. Graphs
   C. Tables
   D. Diagrams
IV. Selection of Speed
   A. First reading
   B. Second reading
      Reread specific areas

V. Problem Solving
   A. Question
   B. Facts needed
   C. Processes required
   D. Computation
   E. Recheck

In formulating the list of skills, many types of resources were used, including:

1. Reading of literature referring to reading in mathematics.
2. Discussions with reading specialists.
3. Experiences of content-field teachers
4. Conferences with administrative staff in writer's school district.
5. Interviews with parents and students.
6. Past experience in the educational field.

The reading department in the Whitefish Bay School District developed a reading curriculum guide for the elementary school and also one for the junior high school. It consisted of general content area essentials as well as specific essentials for each field. The curriculum plans for the teacher to provide instruction for vocabulary skills, comprehension skills, study skills, flexibility or rate, and oral expression.

The guide for the teaching of reading in the field of mathematics suggests six main areas. These are:
1) Introduce textbook to the students.
2) Guide students in the difficult, technical vocabulary.
3) Point out to students that the style in which mathematical problems is written calls for a different type of reading.
4) Encourage some type of problem analysis approach.
5) Promote slow and careful reading of problems.
6) Encourage thinking that is selective, orderly and logical.

As these are broad areas, the writer felt a need for a more specific program.

Bond and Wagner, in discussing the mathematics text-
book, say:

It can readily be seen that this reading task is entirely different from that of reading the basal reading test. There is no running context in the problems that the child can use for help in recognizing words. The book contains a technical vocabulary that must be learned. The reading material calls for careful and exact reading, which must be done at a relatively slow rate. Each step in the process must be fully understood before the next step is taken. Much more time is used in reflecting upon the material presented than in recognizing the words with the reading techniques that are suitable and effective in reading the basal reading material he is in difficulty almost immediately. In reading the materials of mathematics, even the habit of continuous reading must be laid aside, for much of the time the child reads a short problem, thinks about it, goes back to reread, and then takes pencil in hand and works for a time. He may then be ready to go to the next problem. The nature of the material and the purpose for reading cause marked adjustment of reading abilities, habits, and attitudes.

Spache lists eight needs of pupils for training in reading in mathematics:

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1Whitefish Bay Public Schools, Reading Curriculum (Junior High), Whitefish Bay, Wisconsin, August 1963.

1. organizing details into working ideas
2. recognizing relationships
3. organizing processes to find solutions
4. adjusting rate to slow speed to secure a high degree of comprehension
5. understanding technical vocabulary and symbols
6. understanding common words with mathematical connotations or more precise mathematical usage
7. locating and selecting related readings
8. evolving procedures for problem-solving.

In their discussion about improvement of reading in the mathematics area, Strang, et al, discuss difficulty with terms, comprehension and speed, directives for developing reading skills and aids in reading difficult texts. In this discussion the authors consider methods and ways to teach mathematics.

When the writer was reading through the material on the content-field reading, the comments by McKee made quite an impression. He states that there are three important matters that pertain to the process of reading and are necessary to interpret the printed material. The first comment is that there are no meanings on any printed page, but that the words and symbols merely stand for meanings intended by the writer. The second point stresses that the quality of the meaning a reader gives the printed material depends upon the quality of the concept which his experiences have enabled him to build and what he has attached to that symbol. Thus, if the con-

3Spache, Toward Better Reading, p. 287.

cept is vague or erroneous, it can lead to misunderstanding. The third point says that if the concept built and attached to the given symbol is clear and correct, the thinking he has to do is quite simple; but if the concept is vague and an incorrect idea of the symbol is present, the thinking required is rather complicated. This causes much confusion and frustration to the youngster, and each new concept may then be erroneously made and the problem increased. This is one of the problems the teacher faces and must try to eliminate.

As has been said earlier, most of the reading authorities are in agreement, stressing one area a little more than another, but they seem to agree on the necessity of the content-field teacher to realize her role in teaching reading to the child so that the subject will be understood.

One of the headings the writer found to be of much value was, "What Can the Teacher Do To Help His Students Read Better?" Marksheffel, in this article dispels the fallacy that children above the elementary level know how to use their textbooks to the utmost. The results of a questionnaire given to 3,000 juniors, seniors, and graduate students revealed the following:


1) From 60 to 70 per cent of the students never look at charts, graphs, or tables;
2) ten to 20 per cent look briefly at the charts, graphs, and tables but do not study them;
3) about 95 per cent use context clues to derive meanings of words;
4) less than half the students use a dictionary skillfully;
5) ninety-nine to 100 per cent feel that the way to improve their reading is to increase their speed.7

These results certainly cause one to wonder what kind of teaching is being done.

As one reads the literature, vocabulary, slow reading, rereading, comprehension, careful thinking, and following directions are discussed. Baumman, et al, says:

Mathematical materials require that students think in an orderly and logical way as they read. They must see clearly that conditions one and two must necessarily lead to condition three; that angles and arcs are, or are not, equivalent; that the conditions in one problem are actually quite different from those in another that are stated somewhat similarly. In addition, the students must think selectively as they try to identify the data and details essential to the solution and must disregard any that can and should be ignored. Selective thinking is also necessary as they decide on exactly what they are to find as an answer to the problem.8

Vocabulary

In the readings, the primary need seemed to be that of vocabulary. Strang, et al,9 puts vocabulary into three major categories of difficulty. First, the same term is not always used to mean a particular operation. Secondly, several

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7Ibid, p. 161.
8Baumman, et al, Reading Instruction in the Secondary Schools, pp. 191-92
9Strang, et al, The Improvement of Reading, pp. 159-60.
technical terms in mathematics have their uses in general conversation with quite a different meaning. The third problem is that mathematics requires understanding of many terms which remind the student of absolutely nothing and must be learned the long, hard way.

Bond and Wagner\(^\text{10}\) also stress the need for the teacher to plan for the vocabulary difficulties that the students probably would encounter. They remind the reader that general and technical terms cause the average child much confusion and frustration. Symbols are also included in this area because the writer has experienced through the years that symbols are part of the basic vocabulary that one needs to handle mathematical problems.

**Comprehension, Interpretation and Speed Selection**

Bond and Wagner stated the need for careful scrutiny of the text when they say,

Mathematical reading material used in elementary school lacks the continuity the child has become accustomed to in other reading experiences. One paragraph of material often bears little or no relationship to the paragraph immediately preceding or following it. Arithmetic problems are generally short and compact statements with very little descriptive material. Often, there is no contextual relationship between the problems on a page. Even the names of the people of the problems are not the same from problem to problem. In most other fields where reading is employed, the child is taught to continue the meaning from paragraph to paragraph. To transfer a generalized attack to reading mathematics is confusing. Many of the newer textbooks attempt to overcome this difficulty by presenting a series of problems on a theme common to all.\(^\text{11}\)

\(^\text{10}\) Bond and Wagner, *Teaching the Child to Read*, pp. 270-72.

\(^\text{11}\) Bond and Wagner, *op cit.*, pp. 272-73.
Also a necessary ingredient in comprehension is background. That is, the child must be able to draw from past experiences so that he can develop new and old concepts. The child must be given material in proper sequence so that he can build new concepts. Basic number understandings must be continually presented.

Everyday experiences used in developing mathematical concepts help solidify the idea presented. Gray states:

The use of concrete experiences to give meaning and add interest to arithmetical concepts also is advocated. This might include having children divide possessions equally, plan what to buy with a given amount of money, plan refreshments for a party, time classmates to see who runs fastest, go on errands to the store. These experiences will help them to read meaning into the problems.\textsuperscript{12}

This type of background material and previous concepts must be reviewed over and over. Almost every authority stresses this need.

McKee describes certain ways of building background:

1. Much can be contributed by the teacher's oral explanations. Many of these will necessarily be composed by the teacher from his fund of knowledge on the topic and the pupils' experiences and will be used by her in talking to the pupils. Each oral explanation must contain considerable detail, and, in composing any explanation, it is imperative that the teacher plan carefully just what is to be said so that vague expressions and ambiguous sentences are avoided and clear organization of ideas is guaranteed.

2. Some concepts, particularly those pertaining to objects and activities, can be developed by having the pupils observe critically pictures of all types, including illustrations in books, loose prints, film strips, and sound films.

3. One of the most fruitful ways of developing concepts of objects, activities, and conditions is critical observations of those items themselves. Often direct observation requires excursions to places where the objects, activities, or conditions are to be seen.

4. Probably the most effective means of helping the pupil construct concepts of activities and of objects inherent in them is to make it possible for him to engage in those activities himself. Each activity must be authentic in the sense that the pupil can get from it a correct or truthful concept.13

Another part of comprehension is the child's use of quantitative sense. Taken from the dictionary and as used in this study, quantitative is:

(a) an entity, subject to treatment in accordance with a set of consistent rules and, (b) the property of magnitude involving comparability with other magnitudes and, (c) magnitude, size, volume, area, or length.14

Therefore, it is expected that the child can comprehend or visualize sizes, etc. For this to be accomplished, a spiral type of text helps to review this concept.

Another category of comprehension that the writer deemed necessary was the process of thinking. Under this category, three sub-headings were decided upon:

1) Selective
2) Orderly
3) Logical

All of the skills are interwoven as a unit and are hard to separate when writing the criteria in this study.

13McKee, Reading/A Program of Instruction for the Elementary School, pp. 417-18.

Another factor, the selection of speed, will be dis­
cussed here. Most authors, one being Bond and Wagner, sug­
gest a general and fast reading the first time through. They say:

Much of the material of mathematics must be reread reflec­
tively several times. The child rarely reads more than
two pages of arithmetical material per day, as contrasted with many pages per day in the social studies. All math­
ematical material must be read slowly, and most of the
facts will never be referred to again.  

This shows the necessity of reading the entire mater­
ial so one may select the important points and put them in
their proper order so that the resulting understanding will
be logical or reasonable.

Specialized Skills

When one browses through a mathematics book, many
charts, graphs, tables, and diagrams are seen. Because of
the questionnaire mentioned in the introduction, and from
past experience, the writer believes these parts are skipped
mainly because readers do not understand them. These skills
are needed in almost every subject encountered by a student.
In fact, people use and read charts the rest of their lives.

Problem Solving

This is probably one of the most important phases of
the skills because children do not know what they are reading,
therefore, they are not able to compute. Every author that
the writer read had something to say about problem-solving.

15Bond and Wagner, p. 273.
As was written earlier in this paper, some sort of method must be taught. I must involve sensing the problem revolving the aspects of the problem to determine possible method of solution, and completing the solution. In fine, children need to develop the type of thinking involved in problem solving.

Application of Skills List to the Textbook

The writer taught four seventh grade mathematics classes using the following procedure in applying the reading skills list to the text. The results were very satisfying.

The text was introduced by listing the title, authors, publisher and copyright date on the chalkboard as suggested and emphasized by most critics. A short resume about the author was given. Before the children were exposed to the text the writer pointed out in the table of contents some of the areas to be covered. Through the use of humor and a positive approach by the instructor, the class was exposed to comments for challenge.

One such comment was concerned with the many uses of mathematics. Page 31 in *Modern School Mathematics* has two pictures with the title, "Who Uses Mathematics?" (Figure 1) This brought comments from many youngsters. A page showing the symbols to be encountered was discussed. A short discussion ensued because the students noted that some of the symbols were different from past experiences. (Figure 2)
A civil engineer designs and supervises the construction of such public works as highways, dams, and bridges. The photographs show a crew on a working platform for the Verrazano-Narrows Bridge at the entrance to New York Harbor (above) and the completed bridge (below). A civil engineer uses algebra, geometry, trigonometry, and advanced mathematics in solving the wide variety of problems that arise in his work.

**Figure 1**
### SYMBOLS

<table>
<thead>
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<th>Symbol</th>
<th>Description</th>
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<td>set</td>
<td>6</td>
</tr>
<tr>
<td>=</td>
<td>equals or is equal to</td>
<td>7, 35</td>
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<tr>
<td>≠</td>
<td>is not equal to</td>
<td>7, 35</td>
</tr>
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<td>∈</td>
<td>is a member of</td>
<td>7</td>
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<tr>
<td>∉</td>
<td>is not a member of</td>
<td>7</td>
</tr>
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<td>⊂</td>
<td>is a subset of</td>
<td>11</td>
</tr>
<tr>
<td>⊄</td>
<td>is not a subset of</td>
<td>11</td>
</tr>
<tr>
<td>Ø</td>
<td>empty set or null set</td>
<td>12</td>
</tr>
<tr>
<td>N</td>
<td>set of natural numbers</td>
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<tr>
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<td>for at least one whole number n</td>
<td>66</td>
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<td>81-82</td>
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<td>x, x²</td>
<td>powers of x</td>
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<td>x̅, etc.</td>
<td>line</td>
<td>176</td>
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<td>greatest common factor</td>
<td>236</td>
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<td>LCM</td>
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<td>ray</td>
<td>253</td>
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<td>AB</td>
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<td>angle</td>
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<td>≅</td>
<td>is congruent to 274, 276</td>
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<td>≃</td>
<td>is not congruent to</td>
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<td>a · b</td>
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<td>⋯</td>
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<td>...</td>
<td>arc</td>
<td>483</td>
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<td>m° ASB</td>
<td>degree measure of arc</td>
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<td>sector</td>
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<td>500</td>
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<td>J</td>
<td>set of integers</td>
<td>501</td>
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<tr>
<td>+1, 2, etc.</td>
<td>positive numbers</td>
<td>501</td>
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</table>

**Figure 2**
In order to use a reading approach to the text, the writer studied the structure and content of the textbook. Each chapter consists of four to eight sections. Each section consists of several pages of reading interspersed with charts, tables, designs, graphs, and pictures. Following the reading, the authors have oral exercises which help digest the material and prepare the students for the written exercises that follow. This pattern was discussed with the students.

A reading approach was presented to the students. Emphasizing the concern to do well, the writer proposed the skills list to the students advising them that utilizing past experiences would help them to improve.

For each chapter the writer introduced an outline, a copy of which was given to each child. This copy was called a contract and the children signed up to do A, B, or C level work. The contract listed objectives, special vocabulary, points of emphasis, and written assignments. In the latter, the three levels of difficulty were used. The reason that levels were used was two-fold. First, the student having difficulty should do problems that will help him understand the basic concept. Secondly, the student who would profit from challenging problems should be required to do only the more difficult exercises. The aim was not to punish students by making them do more problems. The favorable response to this method has been most gratifying.
Some of the reading skills of this study were presented in the contract without the students realizing it. Most of the technical vocabulary was noted in the comments and was discussed when the assignment was given. Here, general vocabulary and symbols were discussed.

In order to show how the skill list was used in teaching mathematics, the writer chose Chapter 6 of the Modern Mathematics text. The contract written for this chapter and several others are reproduced in the appendix.\textsuperscript{16}

The chapter was introduced by handing out the contracts and discussing the objectives. Vocabulary was the focal point when the class looked over the objectives. General and technical vocabulary were discussed in detail. While discussing the objectives, it was suggested that the chapter should be looked at carefully. Each member of the class opened the text and the writer pointed out the pictures and diagrams on pages 168-69, (Figure 3). The children noted the bold faced printed words, realizing the need for careful reading. The class noted the intricate diagrams and special positioning of important interpretations as on the bottom of page 182 and top of page 183, (Figure 4). Several of the class members noted the many pink and gray rectangles containing important principles to be learned.

In examining Section 6, "Extending Your Vocabulary," the writer felt it necessary to remind the class that addi-

\textsuperscript{16}See Appendix page.
6-1 Points and Space

Pictures and Diagrams. Can you recognize an object when you see a picture of it? On the left below you see a photograph of a box. On the right you see a diagram of the same box. Notice that in the diagram dashes are used to show edges that are not visible in the view shown.

Below are photographs and diagrams of several other objects. Match the numeral labeling each photograph on the left with the letter for the diagram which matches the object.

Figure 3
Imagine a speck of dust in mid-air in your classroom. Can you describe its exact location? As the picture below suggests, you might locate the position \( A \) of the dust-speck by telling how far \( A \) is from the floor and from each of the two walls shown. Now suppose that the speck were to drift out of sight. Would its old position \( A \) still exist? Of course it would! You can talk about the position \( A \) without having to think of a material object in that position.

The physical idea of location, or position, suggests the mathematical idea of point. Thus, the positions of such physical objects as a pin-prick in a wall, the corner of a box, the center of the earth, and the North Pole, all suggest the notion "point."

The diagram on page 170 and the picture below use small dots to mark positions. In the same way, diagrams picturing mathematical ideas use dots to represent points. Below you see representations of three points, named by the letters \( B \), \( N \), and \( T \).

![Diagram of points](image)

Figure 3
Chapter 6

6-3 Planes

Painting Blocks. Ed had several blocks, all like the one in the picture. He painted them and gave each block three completely red faces and three completely white faces. After being painted, all but one of the blocks could be turned so that the top, bottom, and front faces were completely red. How had Ed painted the last block?

Can you imagine extending the top of the table shown in the picture to form a flat surface without boundaries in any direction? Such a surface suggests an infinite set of points called a plane.

In your classroom are any flat surfaces, each suggesting a plane. Here are a few:

- the face of the chalkboard
- a sheet of paper
- the ceiling
- the front cover of your textbook

Of course, each of these objects suggests only a part of a plane because the object has boundaries whereas a plane does not.

In diagrams, planes are usually suggested by drawings like the ones below, which actually represent only parts of planes. Notice the use of script capital letters to name the planes.

One of the points of the plane $Z$ pictured above has been named “$R$.” The fact that $R$ is a point of $Z$ can be said in any of the following ways:

- $R \in Z$
- $Z$ contains $R$
- $R$ lies on or lies in $Z$
- $Z$ passes through $R$
- $R$ is contained in $Z$

Figure 4
The diagram at the right shows a plane \( \pi \) containing all the points of line \( l \). Thus, \( l \) is a subset of \( \pi \), and we may write:

\[ l \subset \pi \]

\( \pi \) includes \( l \).

\( l \) lies in or lies on \( \pi \). \( \pi \) passes through \( l \).

Note that to say "\( \pi \) passes through \( l \)" means "\( \pi \) contains all points of \( l \)."

By considering the corners, edges, and faces of a box, you can discover some properties of points, lines, and planes.

(a) Points \( A \) and \( B \) shown at the right both lie in the plane partly suggested by the top face of the box. Call that plane \( z \). Does every point of \( AB \) belong to \( z \)? The answer "yes" suggests the following property of space.

The boy in the photograph is using this "flatness" property of a plane to decide whether the top of the counter is a good representation of (part of) a plane. The boy holds a straight edge against the counter-top. Moving the edge across the surface, he checks to see if everywhere the counter-top touches the edge, all along the edge.

\[ \text{Figure 4} \]
tional new words would be found throughout the book. From this, a class member brought up the need for slow reading. The writer then took time and suggested a reading of the section first so that a general idea could be established in their minds. Moving to the assignment area, the writer emphasized some of the important areas so they could be reread. Section 1 pointed out the difference between the object and the picture of the object which was discussed on pages 168-69, (refer to Figure 3). The oral exercises were stressed.

Section 2 of the contract, a note suggested that the oral exercises be written out for class discussion.

Each section noted some emphasis on rereading. Section 2 made a special note about pages 175 and 176 (Figure 5), discussing 'lines' and 'object.' Without really mentioning speed, the writer advised the class to read sentence by sentence, or paragraph by paragraph, whichever one suited the situation the second time they read the section.

Indirectly, comprehension and interpretation were involved in the rereading because the students had to use their past experiences along with their quantitative sense in order to select, orderly and logically, the material presented. By using the oral exercise and other questions the comprehension understandings were tied together.

The problem solving in Chapter 6 was different because this chapter involved geometry. The emphasis was on points, lines, and plans. But, the problem-solving techniques still

17Sukra, p. 28-29.
Can you imagine a single ray of light shining on dust-specks in the air? These dust-specks would mark a set of positions that suggests the set of points or mathematical figure called a straight line, or simply a line.

The straight red streak in the diagram on page 174 and in the picture on page 169 show how we picture lines. Of course, each streak has color, width, and thickness, while a line has no such properties. Also, each streak has a beginning and an end, whereas a line is endless. To emphasize that a line has no beginning and no end, the diagram picturing it is sometimes drawn with arrowheads like this:

\[ \rightarrow \]

One of the points of the line pictured at the right above has been labeled "P." The line itself has been named by the letter "L." The fact that \( P \) is a point of \( L \) can be stated in any of the following ways:

- \( P \in L \)
- \( P \) is contained in \( L \)
- \( P \) lies on \( L \)
- \( P \) lies in \( L \)
- \( L \) passes through \( P \)

Given any line, there are points of space which do not lie on the line. The diagram below pictures a point \( S \) which does not lie on the line shown.

\[ \rightarrow \]

Now look at the photograph at the right. It shows a carpenter's plumb line stretching from a particular location on the ceiling of a room to a particular location on the floor. Is there more than one position for the plumb line joining those locations? Of course not; and this physical fact suggests a property we assume to be true of lines in space. (See page 176.)

**Figure 5**
Through any two different points in space there is exactly one (one and only one) line.

Another way of stating this property is: "Two different points in space determine a line." Notice that the statement uses the words "two different points" to emphasize the fact that two points are needed to determine a line. Hereafter, when we speak of two objects, we will always mean two different objects.

As the diagram at the right suggests, a single point \( A \) lies on many lines. In fact, the lines through any one point form an infinite set.

We assume that every line contains at least two points. Therefore, since there is one and only one line containing two given points, you can identify a line by naming any two of its points. For example, suppose the line \( m \) pictured at the right contains points \( A, B, \) and \( T \). One symbol for this line is \( AB \), read "line \( A, B \)." The order in which you name the two points does not matter, so that \( BA \), read "line \( B, A \)," is another symbol for line \( m \). Why does \( AT \) also name the line? Still other names of line \( m \) are \( TA, FB, \) and \( BF \).

Look carefully at the following photographs. The string stretched from position \( S \) to position \( F \) represents part of \( SF \). The boys hold another string to suggest a different line.

(a) The lines meet at \( M \).

(b) The lines do not meet anywhere.

Figure 5
could be used. The children still had to read the problems to determine the question asked, decide on needed facts, assimilate the information, and reach a conclusion. Rechecking, no matter what kind of problem, was needed.

**Analysis of Textbook**

Noting the relative importance of skills drawn up, the text was studied well in relation to the list. The results of this analysis are given in Table 1.

Vocabulary, comprehension and selection of speed were required in every chapter. The problem-solving skills were used in almost all of the chapters.

In the section of specialized skills, charts were the least of the skills used, with graphs being used about half the time and tables about three-fourths of the time. Diagrams were used in all but one chapter of the text.

When one looks at the Table, it is quite evident that the teacher in mathematics must also understand reading skills and guide pupils in utilizing the skills. Looking back on the last semester and the grades made by the students, the writer was pleased with the results of this approach. It is felt that any teacher who teaches in the content field can gain some insight on approaches to their subject matter by browsing through this paper.

**Conclusions and Implications**

The intensive study of the literature and the mathematics text while working with the students, yielded the following findings:
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1. In the reading of mathematics, four aspects of reading are stressed by reading specialists, namely: vocabulary, comprehension, selection of speed, and problem solving.

2. Skills most needed in reading mathematics at seventh grade level are vocabulary, comprehension, and problem solving.

3. Skills required, but of lesser frequency, are special skills which include diagrams, tables, graphs, and charts.

4. After applying the reading skills to the teaching of mathematics for one semester, it was observed that the greatest benefit was to the low achievers.

5. Students seemed to become more aware of the need for analytical study of the more difficult mathematical concepts.

Certain implications resulting from this study are:

1. Teachers of mathematics should have sufficient background in reading skills and the ability to analyze lessons for reading skills as well as ability to guide students in the functional applications of reading skills to mathematics.

2. A reading approach to teaching mathematics apparently improves the comprehension of mathematical reading and problem solving, general and technical
vocabulary development, and symbol recognition.

3. Further research should be carried out in the form of an experimental study of the comparative effectiveness of emphasizing reading skills in a functional application to mathematics versus stress on the mathematics concept only.
BIBLIOGRAPHY

Books


Reports


Yearbooks

APPENDIX
I, ________________________________, hereby agree to complete the following contract A, B, C.

Teacher __________________________

READ CAREFULLY THE ENTIRE CONTRACT BEFORE SIGNING OR BEGINNING WORK.

Behavioral Objectives

The student will:

... distinguish different methods for counting.

... know the basic Roman Numerals.

... know how to read and find the power of a numeral.

... be able to determine a base-two numeral naming a base-ten numeral.

... know the place value system of the decimal system.

... be able to use the expanded notation for the decimal system.

... be able to distinguish other base systems.

Assignments

Section 4-1  Read Section 4-1 in text on Primitive Numerals.

Define: hieroglyphic numeral (all levels)

Be able to intelligently discuss how primitive people counted.

Be able to discuss "tallies" and "one-to-one" correspondence.

Be able to discuss the oral exercises on p. 106.

You will not be liable for the Ancient Egyptian Numerals.
If there are any problems on this system these symbols would be given to you.

Written exercises:
Exercises on p. 107 will be done together in class.

Section 4-2
Read Section 4-2, pp. 107-110 on Roman Numerals.

Know the basic Roman Numerals - I, V, X, L, C, D, M.

We will simplify the "Principles" on pp. 108-110.

Be able to work the oral exercises on p. 110.

Written exercises:
C level - p. 111 odd ex. 1-23.
B level - p. 111 odd ex. 1-29
A level - p. 111 even ex. 10-30, and 31-34.

Section 4-3
Read this section on exponents and powers, pp. 112-113.

Observe carefully what the beginning introduction is telling you.

Analyze carefully the table on p. 113.

Be prepared to discuss the oral exercises on p. 114.

Written exercises:
C level - even numbered problems, 2-22
B level - even numbered problems, 16-26
A level - problems 20-28

Section 4-4
Read about Base-two, pp. 115-119.

Read carefully about the pair wrapper, pp. 115-16.

Study the tally numeral on pp. 116-117. Be able to show an example using more or fewer tallies than shown on pp. 116-117.

Express the diagram in notation form.

Be able to define:
place value and place value system
base-two system

Be able to determine a base-two numeral that names a base-ten numeral. Ex. $\_2 = 128_{10}$
CONTRACT, Chapter 4, page 3

Study the chart on p. 119

Be able to do the oral exercises on pp. 119-20.

Written exercises:
- C level - do problems 1, 6, 10, 15, 20
- B level - do problems 10, 12, 18, 20, 22, 23, 25 and 26
- A level - do problems 12, 17, 19, 22, 24, 25 and 26

Section 4-5 Read pp. 120-122 about decimal numerals.

Be able to take a base-ten numeral and express it in expanded notation.

Be able to discuss the oral exercises on p. 123.

Written exercises:
- C level - do problems 1, 4, 8, 11, 15, 16, 17, 18 and 21
- B level - do problems 4, 10, 12, 15, 18, 20, 22, 23, 25, 27
- A level - do problems 12, 18, 20-28

Section 4-6 Read about numerals in Other Place-Value Systems, pp. 124-127.

We will do selected oral and written problems from pp. 128-129 in class.

A level students will be assigned problems to present to class.

A level students are to hand in the work for problems 1-8 on page 134 after reading carefully pp. 133-134.

Take Chapter Test pp. 130-131, and 7 problems made up by Mr. Brand.

(Please do not look ahead at the Chapter Test.

THIS IS THE COMPLETION OF ALL WORK REQUIRED FOR THIS CHAPTER.
I, ____________________________, hereby agree to complete
the following contract A, B, C.

Teacher ______________________

READ CAREFULLY THE ENTIRE CONTRACT BEFORE SIGNING CONTRACT OR
BEGINNING WORK.

Behavioral Objectives
The student will:

... Know the 100 addition facts.

... Be able to use the algorithm system for addition.

... Know the "difference sum property" in relation to sub-
traction.

... Know the 81 subtraction facts.

... Know the multiplication algorithm system.

... Know the basic multiplication facts.

... Know the division algorithm.

... Know the basic division facts.

Assignments
Section 5-1 Read over very carefully step by step the differ-
ent examples presented in showing the addition
algorithm pp. 138-142. Reread several times!

Review the basic addition facts.

Be able to discuss the oral exercises.

Written exercises:
C level - p. 143 ex. 3, 6, 8, 9, 10, 13, 14,
17, 19, 20, 23.
B level - p. 143/4, ex. 6, 8, 10, 13, 14, 18,
19, 20, 22, 24, 28, 30.
A level - p. 143 ex. 10, 14, 17, 19, 20,
21, 22, 23, 24, 25, 28, 30, 32.
Section 5-2 Read very carefully pp. 144-47 about the subtraction algorithm.

Study the "The Difference - Sum Property" carefully and be able to use it with examples.

Know the oral exercises for class discussion.

Review the basic subtraction facts.

Written exercises:
- C level - p. 148-49, ex. 2, 3, 8, 10, 13, 14, 15, 16, 17, 18, 19, 20.
- B level - p. 148-49, ex. 9, 10, 14, 15, 16, 17, 18, 19, 20, 22, 24.

Take Test 12, Form a, Ch. 5-1 and 5-2.

If you do poorly, use Independent Study to use the practice books.

Section 5-3 Pp. 149-152 covers the multiplication algorithm.

Study this section carefully.

Study the basic multiplication facts on p. 151.

The oral exercises provide an excellent opportunity for class discussion provided we study it ahead of time.

Written exercises:
- C level - p. 154, ex. 1, 21
- B level - p. 154, ex. 5, 23
- A level - p. 154, ex. 10, 12, 14, 16, 17, 18, 19, 20, 21, 23, 24, 25, 26.

Section 5-4 Read pp. 155-157 covering the division algorithm.

Study the oral exercises.

Written exercises:
- C level - p. 158, odd ex. 1, 33
- B level - p. 159, odd ex. 11, 29, 31, 32, 33, 34, 35, 36.
- A level - p. 158-9, ex. 22, 24, 26, 27, 31, 32, 33, 34, 35, 36, 37, 40.
CONTRACT

I, ____________________________, hereby agree to complete
the following contract A, B, C.

Teacher _____________________

READ CAREFULLY THE ENTIRE CONTRACT BEFORE SIGNING CONTRACT OR
BEGINNING WORK.

Behavioral Objectives

The student will be able to illustrate and/or define:

- point
- coplanar
- space
- coincident
- line
- parallel
- intersecting line
- skew lines
- intersection point
- figure
- plane
- geometry
- collinear
- equivalent

Assignments

Section 6-1 Read pp. 168-70 in text on points and space.

Keep in mind the discussion to know the difference between the object and the picture of the object.

Words for definition:

space figure geometry point

Study carefully the 18 oral discussion questions. They are tricky.

Written exercises:

C level - pp. 171-73 problems 1-7
B level - pp. 171-73 problems 3-10
A level - pp. 171-74 problems 4-12
Section 6-2 Read pp. 174-178 on lines.

Copy the diagram on p. 174 and locate the intersections.

Notice the important emphasis on p. 175 about "line and straight line" and on p. 176 about "objects and different objects."

Words for definition:
- line p. 176
- two lines p. 177
- intersecting lines p. 178

Be able to answer the oral questions in class. (Write out any answers that are difficult for you)

Written Exercises:
- C level - pp. 179-80 problems 1-12, 14, 15, 17
- B level - pp. 179-81 problems 2, 4, 5, 7-12, 14, 17, 20.
- A level - pp. 179-81 problems 2, 6, 7-12, 14, 15, 20, 22, 23-26.

Section 6-3 Read pp. 182-84 on planes

Words for definition:
- plane

Notice on p. 182 the bottom paragraph for saying "a point in a plane."

Oral exercises on p. 184-85 help us understand planes.

Written exercises:
- C level - pp. 185 problems 1-16
- B level - pp. 185 odd problems 1-20
- A level - pp. 185 even problems 2-16, 17-25

Section 6-4 Read pp. 186-188 to gather information on determining planes.

Reread carefully:
- p. 187 - points determine a plane
- p. 188 - the five boxes should be studied carefully
- p. 189 - oral exercises should be written out for class discussion.
Section 6-4 (Continued)

Written exercises:
- C level - pp. 189-91 problems 1-12, 17-18
- B level - pp. 189-91 problems 1-12, 18, 20, 22, 24, 25, 26
- A level - pp. 189-91, problems 9-30
  (13-16 will be demonstrated by A level students)

Progress test (6-1 through 6-4) - Those who do not pass this test will work on the practice books.

Section 6-5
Read pp. 192-195 about intersections of lines and planes.

Reread carefully:
- p. 193 - the three boxes discussing lines
- p. 195 - the two boxes discussing planes

Oral exercises p. 195 for class discussion

Written exercises:
- C level - p. 196, problems 1-12
- B level - p. 196, odd problems 1-18
- A level - p. 196 even problems 1-22

Section 6-6
Read pp. 197-201 on extending vocabulary

Words for definition:
- collinear
- coplanar
- noncoplanar
- concurrent
- parallel
- skew lines

Study examples on p. 201.

Oral exercises will be done together in class.

Written exercises:
- All levels - pp. 201-03, problems 1-26.