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Date May 18, 1988

AN EVALUATION OF THE READABILITY OF FOUR MATHEMATICS SERIES

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Robert A. O'Connor

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Robert A. O'Connor

ABSTRACT

The purpose of this study was to evaluate four mathematics series as to the readability scores and the reinforcement of new vocabulary words. The readability scores were calculated by using the Dale-Chall Readability Formula. The new vocabulary words introduced in the series were listed on the Worksheet for Analysis of Instructional Materials Beyond Readability Scales (Schindler, 1980). The reinforcements of the new vocabulary words were checked on the Schindler worksheet.

From these instruments of comprehensive evaluation, all texts, with the exception of the sixth grade, were seen as being written at a readability level which was more difficult than the proposed grade level. The four mathematics series also did not adequately reinforce the new vocabulary words listed in the introductory lessons. These findings point out the need for publishers as well as teachers to pay attention to the language of mathematics due to the impact which textbooks have upon the mathematics curriculum.

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CHAPTER 1

Introduction

School systems tend to rely on math series to provide their teachers and students with appropriate and adequate materials which will enhance mathematics instruction. This reliance on mathematics series is made with good intentions, but is often not made based on adequate foundations of research. Many of these series include teachers' manuals, students' texts, worksheets, and tests.

The need to use care and insight when selecting a series to appropriately and adequately provide for mathematics instruction is related to the teacher's reliance on such materials. Willoughby (1984) notes the dependence on mathematics series by school systems when he states that the textbook is the most importance influence in determining what mathematics is taught in schools.

A major problem faced by the classroom teacher is whether the text is appropriate for students, based on the reading grade level provided by the publisher. The publisher, like the school systems selecting mathematics series, has good intentions when assigning a specific grade level to a text. But it is in this area that good intentions are not enough and that adequate research is needed in order to insure that a text is appropriate for a specific grade level. Spache (1978) makes this observation:

> Publishers customarily designate their readers and other textbooks as suited for specific grade levels. These grade level designations are undoubtedly made in good faith according to the opinions of the author and the publishing staff. But like other pooled judgements they are frequently erroneous (p. 31).

When writing textbooks for specified grade levels the problem of publishing an appropriate series becomes massive as well as very unclear based upon the size and diversity of the school population. The task seems impractical at the publishing company when considering the areas that must be addressed in this process. Harrison (1980), states that in asking

> "what makes a book difficult for a certain child?" we are reminding ourselves that the reader's response to a book is determined by two groups of factors: one group related to his own knowledge and abilities, and another group related to the text itself (p. 12).

The variables affecting readability involved in the text include: legibility of print, illustration and color, vocabulary, conceptual difficulty, syntax, and organization (Harrison, 1980). These variables may be addressed by the publisher to some degree with some assistance from outside sources such as consultants.

The variables affecting readability involved with the reader include: overall reading ability, familiarity with written language, familiarity with oral language, vocabulary, and motivation (Harrison, 1980). These variables are the factors that cause the greatest concern due to their impact on the success of a program in a particular school.

One of the variables that can override the others is motivation. Unfortunately, in regard to textbooks, research shows that mathematics texts have been rated by students as the most boring reading matter

(Lunzer & Gardner, 1971). In order to better serve the students' needs, the classroom teacher must become involved with the process of evaluating mathematics textbooks. This would involve some cooperation with textbook adoption committees which normally select published series for school systems. This project involved the use of a comprehensive evaluation process which included a readability formula and a worksheet to check new vocabulary word reinforcements.

Background

When a student is in a mathematics program his math ability is measured on (1) mathematical insight and knowledge and (2) acquaintance with language (Thorndike, 1912). While it appears that teachers spend a great deal of time developing a student's mathematical knowledge of basic processes, there also seems to be a lack of instructional time spent acquainting the student with the language involved in mathematics. Many teachers would say that their students do not read well enough to do mathematics, and yet it seems that the language aspect of mathematics is often shied away from or even ignored in the classroom. Many students will not even bother to read the worded context or instructions if they can get by without doing so. This reluctance to read mathematical print seems to be encouraged by mathematics texts writers. Campbell (1979) cites an example of mathematical language taken from the first level text in the Fletcher Math Series (Fletcher, 1971). One random sample taken from the text contained the following terms: set, subset, triangle, square, circle,

and partition. All of these are found in a mathematics workbook when the same child may still have difficulty with the complexities of "the cat sat on the mat" (Campbell, 1979, p. 688).

In modern mathematics materials Heddens and Smith (1964) found the difficulty level of mathematics materials to be higher than the reading abilities of the students. They point out that "if educators are to be successful in teaching mathematics either the reading level of the mathematics materials must be lowered or the reading level of the child must be improved, or both" (Heddens and Smith, 1964, p. 468). The difficulty of the mathematics text must not doom students to dealing with a program that will frustrate them. Therefore, it is up to the textbook adoption committees that select series for school systems to determine, through a comprehensive evaluation, which texts would best serve to motivate and challenge their students.

Statement of the Problem

The purpose of this study was to use comprehensive evaluation to determine the following:

1. Is there a difference between the publishers' stated grade levels of four mathematics series and the actual readability levels according to a readability formula?

2. Are the new vocabulary words which are introduced reinforced at least five times within the context of the lesson?

The comprehensive evaluation technique involves: (a) computing the actual readability of the textbooks and (b) measuring the number of

reinforcements of the new words. These aspects of the comprehensive evaluation have a direct effect on the actual grade level of the books in each mathematics series.

Definitions of Terms

1. Comprehensive evaluation is defined as an evaluation technique for programs encompassing the use of a readability formula and the Worksheet for Analysis of Instruction Materials beyond Readability Scales (Schindler, 1980).

2. Mathematics program is defined as a published sequence of textbooks, teachers' manuals, and student workbooks. Each book is assigned a grade level by the publisher. These programs are designed to teach specific skills that develop mathematical insight and knowledge such as numeration, basic facts, fractions, decimals, etc.

3. Factors are the characteristics of published materials that have an effect on actual readability of that material. The readability factors are: vocabulary words, frequency of the word reinforcement, typography, interest value, style of writing, number of syllables, and sentence length.

4. New words are the vocabulary words introduced before each new lesson in a mathematics series.

5. Readability is defined as the actual grade level calculation derived from a readability formula. The Dale-Chall formula was developed as a tool to calculate the actual grade levels of published text materials. It is the term used for how readable the material is

in printed form: (a) actual readability is the calculated grade level by readability formula, (b) estimated readability is the grade level designation publishers place on the published textbooks, and (c) comprehensive readability is the grade level of books computed by a readability formula and the number of times the new words are reinforced in the published material.

6. Reading can be defined as the act of extracting meaning from the printed page. Some skills involved in reading are: work attack, vocabulary recognition, and comprehension.

7. Reinforcement is the frequency of new vocabulary words in a mathematics text lesson after introduction.

8. Word lists accompany readability formulas to check percentage of hard words in the formula calculations. They were chosen by the authors of readability scales to validate the calculated results.

9. Worksheet for Analysis of Instructional Materials beyond Readability Scales is a form used to list new vocabulary words and to check the number of times these words are reinforced in the lesson of introduction and subsequent lessons. It is also used to record and subjectively evaluate the skills printed in the teachers' manual.

Assumptions

The following is a list of assumptions that are commonly made about mathematics series:

1. The mathematics series is written with the language of students taken into consideration.

2. The publisher's estimates of readability or grade levels for each book in the series are accurate.

3. The new words introduced are reinforced sufficiently in the published lessons according to Kingsley's (1965) recommendation of five repetitions. This recommendation was based on basal reading series but should apply to other content areas such as mathematics.

4. It is not the responsibility of the teacher to evaluate all aspects of reading materials before using them with children. This is typically the responsibility of textbook adoption committees.

5. Grade levels of mathematics texts relate to the mathematics skills taught--not the reading material.

6. The use of the comprehensive evaluation process does not suggest reasons for discrepancies of the publisher's estimated readability and the actual readability scores based on a readability formula.

Null Hypotheses

1. There is no difference between the publisher's estimate of readability and the actual computed readability scores based on a readability formula.

2. There is no difference between the publisher's number of reinforcements of the new vocabulary words and the recommended five times or more than five times within the lesson of introduction.

Limitations

1. Word reinforcements were checked only in the immediate chapter. A search was conducted for three topic related lessons following the initial lesson. In some texts three topic related lessons could not be found in the immediate chapter.

2. Results are only partially conclusive due to sampling of only three chapters per book. The study of additional chapters might provide a clearer insight into the publishers' attention to readability and word reinforcements. The selected chapters may not be representative of the text.

3. The mathematics materials were evaluated with instruments designed for use with reading materials (basal series).

4. The language of mathematics is not widely used in everyday language and is assumed to be more difficult due to this factor. Mathematical terminology is often excluded from many word lists.

Summary

Mathematics series are used extensively in schools today. Due to the popularity of these series, careful considerations must be made when selecting an appropriate series for students. The purpose of the study, definitions of terms, assumptions, and null hypotheses were also presented.

CHAPTER 2

RELATED LITERATURE

Introduction

The purpose of this chapter is to explain the aspects of readability, readability in relation to teaching mathematics and the comprehensive evaluation of readability.

The Aspects of Readability

When looking at mathematics programs in schools, there is a good chance that some type of series will be found. The popularity of these series stresses the need for proper evaluation to insure a degree of appropriateness to serve the students' needs. Effective teachers use a variety of materials but still rely a great deal on the series. The writers of these series are attempting to serve the needs of a very large, diverse population. With these attempts comes the responsibility for writers to consider readability as a major factor in their work.

In order to contend with this problem the writer should have a clear description of the audience. Their reading, educational, and intellectual levels, their previous experience with the topic, interests, and level of motivation should be known. For greatest effectiveness in writing, the writer should also be addressing an audience that is fairly homogeneous.

It is unlikely that a writer of a mathematics series would be able to collect information about the total audience. Since the writer needs to understand the audience as much as possible, a more practical approach is taken. A sample population of the audience is selected and tested. The results of this study are then used to base the levels of the materials which will be the most appropriate for the audience. This method will give the writer an idea about the sample population, but it will not give a clear picture of the audience as a whole.

There are bound to be students in the audience who will have a great deal of difficulty with the series due to the fact that their abilities and needs were not represented in the sample population. Klare (1963) seems to address this aspect of readability when he uses the term "to indicate ease of understanding or comprehension due to the style of writing" (p. 1). Since the style of writing is suited to the sample population, it will have a great difficulty serving a large, diverse audience such as the total school population. Style of writing is partially determined by the frequency of new word reinforcements which is a factor of comprehensive readability that is discussed in this study.

Readability in Relation to Teaching Mathematics

Mathematics series are at the core of many mathematics programs. School systems put a lot of faith in the fact that the materials in these series are appropriate for their students. It seems unusual then that mathematics textbooks do not match up well with basal reading books in terms of the vocabulary used by the author. This was pointed

out by Stauffer (1966) who found substantial inconsistencies between the vocabulary in basal reading books and mathematics texts at the third grade level, where approximately 43% of the words in three third-grade mathematics books were not included in seven current third-grade reading texts.

In a study done by Earp and Tanner (1980) to gain more information about students' reading and mathematics, a word count was made of a basal mathematics text used in a school. The words were grouped into three categories: basal words, common words, and mathematical words. It was found that the students' abilities to decode the words in the samples was high (above 90%). When the students' comprehension was checked, it was found to be high (98.1%) for common words but was much lower for mathematical words (49.9%). The obvious conclusion of this study was that mathematical words are not frequently used in spoken language as are common words. The exclusion of mathematical terms from oral language restricts a student's opportunities to gain comprehension of these terms. The study also showed that comprehension of the mathematical words was raised when the words were presented in a stronger context. Since the students were able to use contextual clues to gain comprehension, it can be seen that the original mathematical phraseology was not particularly helpful in developing comprehension.

Mathematics materials are not the same as reading materials. The mathematical language found in mathematics texts is not as familiar to students as is the language in their reading materials. Mathematics also differs from reading in that comprehension is very rarely checked

when a student is working in a particular skill area. If students can solve a problem using the required mathematical functions, then they will be allowed to move on in the text. The students will probably not be required to discuss the answers or to explain the process by which the answers were obtained. This lack of oral language makes it possible for students to succeed in mathematics without understanding what they are doing or even why they are doing it.

This lack of comprehension may cause the student to have difficulty with mathematics symbols and their various meanings. The student may also have difficulties with word problems and problem solving activities. According to Hater, Kane, and Bryne (1974), there are approximately 153 symbols in mathematics (excluding English letters) that appear in mathematics texts written for grades 4 through 12. Monroe (1918) estimates that there may be as many as 28 different ways to verbally express a single mathematics problem. These two factors work together to further compound the child's difficulties in trying to understand the task at hand. Word problems and problem solving activities are likely to be the most difficult challenge for the student. This is because the student must deal with the various symbols as well as apply language skills in order to interpret the context in which the problem is presented.

When discussing readability in relation to mathematics materials there are some considerations which need to be made:

1. Good readers are not necessarily good problem solvers and

poor readers are not necessarily poor problem solvers (Harvin & Gilchrist, 1970).

2. There is no linear relationship--good problem solvers are characterized by a variety of reading levels, although poor problem solvers are generally characterized by low reading levels (Cottrell, 1967).

These considerations are significant in that they point out the need to distinguish between the difficulties in presenting a difficult concept and the problems associated with linguistic style.

Comprehensive Evaluation and Readability

The use of a comprehensive evaluation by a teacher can be very beneficial. It can take much of the guesswork out of trying to decide if materials are appropriate. It also may reduce the frustrations of the teacher and student toward the materials. The aspects of the comprehensive evaluation that will be used in this study include: (a) use of a readability formula and (b) use of a worksheet for further analysis. These methods will be used to determine how appropriate the mathematics materials are for their specified grade levels.

Readability Scales

While use of a readability scale may be beneficial to the teacher and student, the final decision of how appropriate a text is should not end at that point. It should be remembered that many factors influence the difficulty of a textbook. Campbell (1979) states that in matching a student with an appropriate text there is much more to do

than just applying a readability formula to the text and a reading test to the student. Even though the use of a readability formula does not constitute the entire evaluation process, it may serve as a starting point for gathering the necessary information.

After surveying a list of readability scales, the Dale-Chall Readability Formula was chosen for this study. It is one of the most accurate formulas used for estimating the difficulty of a text (Dale & Chall, 1948). Studies have shown that the Dale-Chall is the most valid readability formula when used with materials intended for grades 4 and above (Harrison, 1980). Since the texts used in this study were from grades 4, 5, and 6, the Dale-Chall was seen as the most appropriate formula to use. The Dale-Chall formula probably has the best reputation among reading authorities for being accurate and reliable, and there is also evidence that the Dale-Chall formula is somewhat more highly predictive than any of the other formulas available today (Harrison, 1980). This formula has complex but clearly stated instructions for selecting sample passages, computing average sentence length, and determining the percentage of unfamiliar words (those not included in the "Dale List of 3,000 Words") (Harrison, 1980). The average sentence length and percentage of unfamiliar words are multiplied by specifically derived constant factors. They are then added together with another constant factor to arrive at a formula raw score. A correction table is then used to convert the raw score to a corrected grade level score.

A Worksheet for Further Analysis

In addition to the Dale-Chall Readability Formula, another tool can be beneficial in the comprehensive evaluation process. In order to record the number of new words introduced in a story as well as the number of times the new words are reinforced, the Worksheet for Analysis of Instructional Materials beyond Readability Scales (Schindler, 1980) was used in this study. Repetitions of new vocabulary words are used to help students learn the words and to be able to recognize them rapidly. Kingsley (1965) stated that there should be five repeated citations of a word within the lesson of introduction. This recommendation was based on basal reading books but should also apply to mathematics texts. These repetitions should be provided by the publisher as well as the classroom teacher in a variety of ways. Harris (1970) states that "to be effective, this repetition should not be monotonous drill, but should be presented in such a way as to maintain the child's interest at a high level and encourage accuracy of perception" (p. 319).

In contrast, research has also shown that repetitions of new words in mathematics series have been neglected. Horodezky and Weinstein (1981) state that,

> Whereas in basal readers, vocabulary is generally carefully controlled and words are deliberately repeated many times, the data contained in this study revealed that at least 75 percent of the different words were repeated fewer than ten times in each of the texts. Teachers should therefore be alerted to the fact that this lack of repetition might present a potential problem for the unskilled and beginning reader (p. 128).

This problem can be further compounded when it is realized that mathematical terms may have totally different meanings when used in everyday spoken language. Examples of words that appear in mathematics and everyday language would include: factor, closed, half, ring, and base. Word frequency can be seen as a critical factor to be considered when determining the difficulty of a text. Klare (1963) notes that increased word frequency allows the reader to have a larger number of words within his memory span. He goes on to say that increased memory span is related to comprehension as well as learning and retention, and that frequently used words have more familiar dictionary meanings.

Gates (1930) made an investigation of vocabulary loads for various intelligence levels and found that some students have difficulty learning new words which are not adequately reinforced. Gates' findings on the number of reasonable repetitions for new vocabulary words at different intelligence levels are reported below. The number of repetitions listed at each level are seen as being necessary in order for the students to retain the new vocabulary words and to recognize them rapidly.

120 -	I.Q.	-	20 repetitions
110 - 119	I.Q.	-	30 repetitions
90 - 109	I.Q.	-	35 repetitions
80 - 89	I.Q.	-	40 repetitions
70 - 79	I.Q.	-	45 repetitions
60 - 69	I.Q.	-	55 repetitions

(Gates, 1930, p. 35).

The importance of reinforcements of new vocabulary words for students at all ability levels can be seen from this data.

Summary

Mathematics series have become widely used in elementary education today. The mathematics terms used in these texts are not common in our spoken language. Successful students in mathematics may not necessarily comprehend the material due to this lack of spoken language in mathematics. In order to better serve the students who will be using a mathematics series, a comprehensive evaluation process is needed. This process includes: (a) a readability formula to calculate grade levels and (b) a worksheet to record new words with a frequency of reinforcements in the text materials. An appropriate series can be selected by the teacher with the aid of these techniques. It should be noted that research into this area has diminished in recent years. Nevertheless, publishers have continued to develop and publish mathematics series with designated levels on them. It is time to challenge the assumptions made by users of the series that they are, in fact, written with an appropriate readability level for the intended grade level.

CHAPTER 3

DESIGN FOR EVALUATION OF MATHEMATICS SERIES

Introduction

The purpose of this chapter is to present the purposes of the study, procedures for data collection, the instruments used to collect data, and the statistical procedures used in the analysis of data.

Purpose

The purposes of this study were as follows:

1. To determine if there exists a difference between the publishers' estimated grade levels of four mathematics series and their actual readability according to a readability formula.

2. To determine if there exists a difference between the number of times the new words are reinforced and the recommended five times.

Data Collection Procedures

For this study the researcher chose four mathematics series which are used by various school systems. The series chosen were:
(a) Mathematics Unlimited (1987), Holt, Rinehart & Winston (HRW);
(b) Houghton Mifflin Mathematics (1987), Houghton Mifflin Company (HM);
(c) Heath Mathematics (1987), D. C. Heath & Company (DCH); and
(d) Mathematics Today (1987), Harcourt Brace Jovanovich (HBJ). In this study the data were collected solely by the researcher. These texts

were available through the Curriculum Lab at The University of Tennessee, Knoxville. Data were collected over a 9-month period.

Instrumentation

The following instruments were used to collect data for this study: (a) the Dale-Chall Readability Formula (see Appendix A) and (b) the Worksheet for Analysis of Instructional Materials beyond Readability Scales (Schindler, 1980) (see Appendix B). These instruments were chosen for use in this study due to validity and ease of administration.

The Dale-Chall uses three 100 word samplings from a selected text. In these samplings the following are checked: (a) number of sentences, (b) number of words not on the Dale list and (c) average sentence length. A formula raw score is given and then converted to a corrected grade level.

The Worksheet for Analysis of Instructional Materials beyond Readability Scales developed by Schindler (1980) also takes samplings of three sections (beginning, middle, and end). In this worksheet the new words introduced in these samplings were recorded and checked for number of reinforcements. The reinforcements of these new words were also checked in the next three lessons. Also recorded were the skills listed in the teachers' manual. These were then checked as to whether or not they are taught.

Data Analysis

The data were analyzed by charting each series according to readability scores and frequency of new word reinforcements.

To compare the results, an index number for each book was computed using a ratio that placed the publishers' estimated grade level over the readability level computed by the researcher using the Dale-Chall Readability Formula. The result was then subtracted from 1. A 20% confidence interval was used as the allowable tolerance for the index numbers closest to 0, +.1, and -1. In this process a positive index number shows that the actual readability level is higher than the publishers' estimated readability level. Likewise, a negative index number shows that the actual readability level is lower than the publishers' estimated readability level.

Each new word presented in a specified lesson or unit was listed on the Worksheet for Analysis of Instructional Materials beyond Readability Scales. The number of reinforcements for each new word was then checked and categorized into three columns: less than 5, 5, and more than 5. Percentages were then calculated by placing the number of reinforcements over the total number of new words presented in each book.

Summary

This chapter discussed the design by which the mathematics series were evaluated. The four series selected were listed. The instruments used to evaluate the series were also listed and described. Finally,

the process for the analysis of data was discussed. The results of this study are discussed in Chapter IV.

CHAPTER 4

RESULTS

Introduction

The purpose of this study was to comprehensively evaluate four mathematics series. In this chapter the null hypotheses and the actual results of the study are analyzed in two separate sections. The first section contains the null hypotheses and is labeled Individual Analysis of Each Mathematics Series. The second section contains information about each program and is labeled Comparative Analysis of the Four Mathematics Series.

The four mathematics series are dealt with in this order: (a) Mathematics Unlimited (Holt, Rinehart, & Winston, 1987); (b) Houghton-Mifflin Mathematics (Houghton-Mifflin, 1987); (c) Heath Mathematics (D. C. Heath & Company, 1987); and (d) Mathematics Today (Harcourt Brace Jovanovich, 1987).

All four series were analyzed according to the null hypotheses, by applying the Dale-Chall Readability Formula and the Worksheet for Analysis of Instructional Materials Beyond Readability Scales. The worksheet was adapted to fit the format of the mathematics texts. New vocabulary word reinforcements were checked in three topic related lessons in the immediate chapter following the introductory lesson. This approach was taken due to a lack of topic-related lessons in subsequent chapters. The adaptations made on the worksheet are shown in Appendix B.

Individual Analysis of Each Mathematics Program

The observations of the Holt, Rinehart & Winston series, according to the null hypotheses, are as follows:

Holt, Rinehart & Winston

Hyo:1. There is no difference between the publisher's estimate of readability and the actual computed readability scores based on a readability formula.

The fourth grade text has an actual readability (5.1) which may be far too difficult for this grade level. The index number for this text (.22) is the farthest away from the publisher's estimated garde level according to the calculated index numbers. The fifth grade text has an actual readability (5.8) which may also be too difficult for students at this grade level. The index number for this text (.14) is close to the confidence interval (+.1 through -.1) which is tolerable for this study. The sixth grade text has an actual readability (5.7) which is below the publisher's estimated grade level. The index number for this text (-.05) is within the confidence interval tolerable for this study. The scores for the sixth grade text seem appropriate for this grade level and may possibly encourage students at this grade level to become more competent readers of mathematics (see Table 1).

Table 1. Estimated and actual readability, index, percentage new words reinforced for Holt, Rinehart & Winston text series (1987)

Text	Estimated	Actual	Index	Percentage reinforced Less	5	More
Mathematics Unlimited	4	5.1	.22	67	0	33
	5	5.8	.14	67	33	0
	6	5.7	-.05	50	0	50
Means			.10	61	11	28

Hyo:2. There is no difference between the publisher's number of reinforcements of the new vocabulary words and the recommended five times or more than five times within the lesson of introduction.

In this series only the sixth grade text has at least 50% of the new vocabulary words reinforced a minimum of five times. The texts for the fourth and fifth grades each reinforced only 33% of the new vocabulary words five times or more than five times. All the texts studied in this series fall far below the recommended five or more times reinforcements (see Table 1).

The observations of the Houghton-Mifflin series, according to the null hypotheses, are as follows:

Houghton-Mifflin

Hyo:1. There is no difference between the publisher's estimate of readability and the actual computed readability scores based on a readability formula.

The fifth grade text has an actual readability (6.6) which may be far too difficult for the intended grade level. The index number for this text (.24) is the farthest away from the publisher's estimated grade level according to the calculated index numbers. It is interesting to note that the actual readability score for the fifth grade text (6.6) is higher than the actual readability score for the sixth grade text (6.0). The fourth grade text may also be too difficult for this grade level with an actual readability of 4.9. The index number for this text (.18) seems to indicate that even the more able students may be frustrated by the printed material in this text. The sixth grade text has an actual readability (6.0) which matches the publisher's estimated grade level. This finding results in the text having an index number of 0. The scores suggest that the sixth grade text may be very appropriate for use with this grade level (see Table 2).

Table 2. Estimated and actual readability, index, and percentage new words reinforced for Houghton-Mifflin text series (1987)

Text	Estimated	Actual	Index	Percentage reinforced Less	5	More
Houghton-Mifflin Mathematics	4	4.9	.18	80	0	20
	5	6.6	.24	70	10	20
	6	6.0	0	75	8	17
Means			.14	75	6	19

Hyo:2. There is no difference between the publisher's number of reinforcements of the new vocabulary words and the recommended five times or more than five times within the lesson of introduction.

The texts in this series all fall far below the recommended five times or more than five times reinforcements for the new vocabulary words. The fourth grade text has only 20% of the new vocabulary words reinforced at the recommended number of times. The sixth grade text is a little better in this area with a finding of 25%. The fifth grade text is the best in this series at 30% but still falls far below the recommended five times or more than five times (see Table 2).

The observations of the D. C. Heath series, according to the null hypotheses, are as follows:

D. C. Heath

Hyo:1. There is no difference between the publisher's estimate of readability and the actual computed readability scores based on a readability formula.

The fourth grade text may be far too difficult for this grade level due to an actual readability of 5.3. The index number for this text (.25) is farthest away from the publisher's estimated grade level. The fifth grade text may be somewhat difficult for students at this grade level with an actual readability of 5.6. The index number for this text (.11) is very close to the tolerable confidence interval. The sixth grade text has an index number of 0 due to an actual readability of 6.0 (see Table 3).

Hyo:2. There is no difference between the publisher's number of reinforcements of the new vocabulary words and the recommended five times or more than five times within the lesson of introduction.

None of the texts in this series came close to the recommended number of reinforcements. The fourth grade text has only 18% of the new vocabulary words adequately reinforced. The sixth grade text is next in this area at 22%. The fifth grade text has the highest percentage in this series at 40% (see Table 3).

Table 3. Estimated and actual readability, index, and percentage new words reinforced for D. C. Heath text series (1987)

Text	Estimated	Actual	Index	Percentage reinforced Less	5	More
Heath Mathematics	4	5.3	.25	82	9	9
	5	5.6	.11	60	0	40
	6	6.0	0	78	0	22
Means			.12	73	3	24

The observations of the Harcourt Brace Jovanovich series, according to the null hypotheses, are as follows:

Harcourt Brace Jovanovich

Hyo:1. There is no difference between the publisher's estimate of readability and the actual computed readability scores based on a readability formula.

The fourth and fifth grade texts may both be far too difficult for these grade levels due to actual readability scores of 5.4 and 6.4, respectively. The index numbers for the fourth grade (.26) and the fifth grade (.22) are far away from the publisher's estimated grade level. The sixth grade text has an actual readability (5.5) that is below the publisher's estimated grade level. The index number for this

text (-.09) is within the tolerable confidence interval for this study. It is interesting to note that the actual readability for the fifth grade text (6.4) is higher than the actual readability of the sixth grade text (5.5) (see Table 4).

Hyo:2. There is no difference between the publisher's number of reinforcements of the new vocabulary words and the recommended five times or more than five times within the lesson of introduction.

The sixth grade text has 67% of the new vocabulary words reinforced at the recommended five times or more than five times. The fifth grade text has the next best percentage in this area at 50%. The fourth grade text has 46% of the new vocabulary words reinforced at the recommended five times or more than five times (see Table 4).

Table 4. Estimated and actual readability, index, and percentage new words for Harcourt Brace Jovanovich text series (1987)

Text	Estimated	Actual	Index	Percentage reinforced Less	5	More
Mathematics Today	4	5.4	.26	54	23	23
	5	6.4	.22	50	0	50
	6	5.5	-.09	33	11	56
Means			.13	46	11	43

Comparative Analysis of the Four Mathematics Programs

The four mathematics programs were analyzed across text in order to evaluate the mean values for the series. Table 5 shows the mean index numbers and the mean percentages of reinforcements. These means were used to compare the four series to one another.

The Holt, Rinehart & Winston mean scores are some of the most appropriate among the series. The mean index number (.10) is within the tolerable confidence interval for this study. It is the only series which met this criterion. The index numbers of the D. C. Heath series (.12), Harcourt Brace Jovanovich series (.13), and Houghton-Mifflin series (.14) indicate that the actual readability is higher than the publishers' estimated grade level. None of the series' mean index numbers seem to indicate major discrepancies between the publishers' estimated grade level and the actual readability. This was due to the effect of the sixth grade texts' actual readability scores which were either on or below the publisher's estimated grade level scores in all four series. The averaging of the index numbers (see Table 5) washes out the inconsistencies of the scores which can be seen in Table 6.

All four series fall far below the recommended five times or more than five times reinforcements of new vocabulary words within the lesson of introduction. The Harcourt Brace Jovanovich series ranks first with 54% of the new vocabulary words adequately reinforced. The Holt, Rinehart & Winston series ranks second with 39%. The D. C. Heath

Table 5. Mean index, percentage new words reinforced

Series	Mean index	Mean percentage reinforced		
		Less	5	More
Mathematics Unlimited Holt, Rinehart & Winston (1987)	.10	61	11	28
Houghton-Mifflin Mathematics Houghton-Mifflin (1987)	.14	75	6	19
Heath Mathematics D. C. Heath & Company (1987)	.12	73	3	24
Mathematics Today Harcourt Brace Jovanovich	.13	46	11	43

Table 6. Estimated and actual readability, index, and percentage new words reinforced for all series

Text	Estimated	Actual	Index	Percentage reinforced Less	5	More
Mathematics Unlimited (HRW, 1987)	4	5.1	.22	67	0	33
	5	5.8	.14	67	33	0
	6	5.7	-.05	50	0	50
Means			.10	61	11	28
Houghton-Mifflin Mathematics (HM, 1987)	4	4.9	.18	80	0	20
	5	6.6	.24	70	10	20
	6	6.0	0	75	8	17
Means			.14	75	6	19
Heath Mathematics (DCH, 1987)	4	5.3	.25	82	9	9
	5	5.6	.11	60	0	40
	6	6.0	0	78	0	22
Means			.12	73	3	24
Mathematics Today (HBJ, 1987)	4	5.4	.26	54	23	23
	5	6.4	.22	50	0	50
	6	5.5	-.09	33	11	56
Means			.13	46	11	43

series ranks third at 27%. The Houghton-Mifflin series is the least adequate among the series in this area at 25%.

These percentages indicate a lack of attention to the reinforcements of new vocabulary words by the publishers. This lack of attention in addition to the average sentence length and number of unfamiliar words in the texts contribute to the overall difficulty of the series.

CHAPTER 5

CONCLUSIONS

Discussion and Conclusions

The purpose of this chapter is to discuss the results of the comprehensive evaluation process in relation to the four mathematics series. The information gathered in Chapter IV indicates that all four series were analyzed adequately through the data available in the comprehensive evaluation.

The methods used in this study enabled the researcher to evaluate the series in order to determine their appropriateness in the mathematics curriculum. The comparative analysis showed that the four series were all higher in actual readability than the publishers' estimated grade levels. It is interesting to note that only one series, Holt, Rinehart & Winston, was within the confidence interval tolerable for this study according to the mean index number for that series. The other three series did not appear to be far away from the confidence interval when the mean index numbers were presented. The actual readability scores of the sixth grade texts caused the true inconsistencies in the series to be washed out when they were averaged with the scores from the other texts.

Each series had one text (sixth grade) with an actual readability which was either on or below the publishers' estimated grade level. The Harcourt Brace Jovanovich sixth grade text (5.5) and the Holt, Rinehart & Winston sixth grade text (5.7) were below the estimated

grade level. The Houghton-Mifflin and D. C. Heath sixth grade texts were at the estimated grade level with an actual readability of 6.0.

The fourth grade texts, with the exception of the Houghton-Mifflin text, showed the greatest discrepancies between actual readability and the publishers' estimated grade level. All the fourth grade texts were substantially more difficult than the publishers' estimated grade level. The Houghton-Mifflin text was the only fourth grade text with an actual readability (4.9) within the grade level range. The other fourth grade texts all had actual readabilities at the fifth grade level.

Fifty percent of the fifth grade texts did not have actual readabilities which were within the fifth grade level. The two most difficult texts were the Harcourt Brace Jovanovich text (6.4) and the Houghton-Mifflin text (6.6). The fifth grade texts, among the series, were evaluated as ranging from somewhat difficult to very difficult for this grade level. These findings placed the fifth grade texts between the extremes of most appropriate (sixth grade texts) and least appropriate (fourth grade texts) texts for a specified grade level.

The Houghton-Mifflin mean scores are the least appropriate among the series. The mean index number (.14) is the farthest away from the publisher's estimated grade level. The mean percentage of reinforcements of five times or more than five times (25%) falls far below the criterion in null hypothesis number 2 and ranks last among the series.

According to the Worksheet for Analysis of Instructional Materials beyond Readability Scales, none of the texts in the series did an adequate job of reinforcing the new vocabulary words within the lesson of introduction. The series which did the most adequate job of reinforcing the new vocabulary words was Mathematics Today (Harcourt Brace Jovanovich). This series had the highest percentage of new vocabulary words reinforced at the recommended five times or more than five times at all three grade levels. The sixth grade text in this series had the highest percentage (67%) for all texts at any grade level. Even though this score was the highest among the series, it still points out the lack of attention to the reinforcement of new vocabulary words by all the publishers in this study.

The lack of reinforcements is at least partially due to the format of the mathematics texts. The new vocabulary words are introduced in a brief lesson (usually two pages) and are usually not presented again just as the topic or skill is not repeated within the text. This, in addition to inadequate reinforcements in the initial lesson, can cause students to have great difficulty retaining and comprehending the new vocabulary words. The series studied also seem to put a stronger emphasis on student practice (math skills) than in reinforcing directions or explanations concerning a particular topic or skill (reading skills). This emphasis supports the statement from Chapter II that students may go through the mathematics curriculum without understanding what they are doing or why they are doing it. To this researcher this approach would be comparable to using a reading

program, which only required students to recognize new vocabulary sight words and then move on to the next reader in the series without any need to comprehend or analyze the material.

The comprehensive evaluation process of the four mathematics series proved to broaden the analysis beyond simply calculating a readability formula. The most notable result of the comprehensive evaluation process was evident in the results concerning the fourth grade reading texts. All of these texts were substantially more difficult than the estimated grade level. The results showed that these texts may serve to only frustrate many students at this grade level. Students are usually taught at the instructional or frustration level but should be taught at the independent level in order to encourage them in their academic work. Students make more word recognition errors at the instructional level than at the independent level and comprehension is not as high. Betts (1946) defined the instructional level as the one at which a student misses 5 words out of 100 running words, and comprehension should be at 75 to 90%. These texts were developed on the frustration level, which would cause great difficulty in mathematics for most students at this grade level. At the frustration level students make too many errors in word recognition and their comprehension is not adequate enough in order to be successful with the text. Students' attitudes towards mathematics are at least partially shaped through their experiences with the mathematics text. If their experiences are negative, then their reluctance to read mathematics will only be reinforced even more.

The attitude of this researcher towards mathematics has changed dramatically due to this thesis. While researching this project an awareness developed that many of the teaching practices which were criticized in this study were common in this researcher's classroom. The language of mathematics became an important part of the lessons in the classroom and brought much more meaning to these lessons. The students' attitudes towards mathematics changed when the language was reinforced and discussed regularly. The students became more able to explain how they managed to solve problems and were more confident and eager to solve these problems. The most dramatic change occurred during the most recent chapter which covered multiplication and division. A girl in the class had correctly answered only 1 out of 25 problems on the chapter pretest and was convinced that she would be unable to learn how to multiply and divide. The emphasis of the lessons changed to include the language of multiplication and division and her attitude changed dramatically. She was much more attentive in class and volunteered to discuss the concepts which were covered. The results of her posttest (100%) would have been surprising if only the pretest and posttest had been compared and her development in the classroom had not been observed. This researcher feels that results such as these could become commonplace if other teachers would attempt to teach mathematics as a language as well as a skill.

Suggestions for Further Research

Observations of this study reveal additional possibilities for expanded research. The first option would be to study additional lessons in the mathematics texts in order to evaluate more closely the consistency of the readability scores already found in the texts. A second option would be to evaluate the texts according to additional readability formulas and/or graded word lists. A third option would be to assume that there are no valid and reliable formulas for estimating the readability of written mathematics. This option would involve the investigation of three variables: the percentage of vocabulary particular to mathematics, the percentage of mathematical symbols, and average sentence length (Kulm, 1973).

Additional studies for further research would be beneficial for students as well as teachers. This study served to raise many more questions than those tentatively answered for this researcher. Publishers should be familiar with expanded research in order to develop a more appropriate mathematics series. Educators should also be familiar with expanded research in order to make appropriate decisions concerning the use of these series in their classrooms. In the end, it is these series which determine the mathematics skills or concepts our students are taught.

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APPENDICES

APPENDIX A

DALE-CHALL READABILITY FORMULA-II

Article:_____ No.____	Page No. ____	Page No. ____	
Author:_____	From_____	From_____	
Publisher:_____	To _____	To _____	
1. Number of words in the sample	_____	_____	_____
2. Number of sentences in the sample.	_____	_____	_____
3. Number of words not on Dale list.	_____	_____	_____
4. Average sentence length (divide 1 by 2) . . .	_____	_____	_____
5. Dale score (divide 3 by 1, multiply by 100) .	_____	_____	_____
6. Multiply average sentence length (4) by .0496	_____	_____	_____
7. Multiply Dale score (5) by .1579.	_____	_____	_____
8. Constant.	3.6365	3.6365	3.6365
9. Formula raw score (add 6, 7, and 8)	_____	_____	_____

Average raw score of _____ samples. . . . . ____ Analyzed by_____ Date_____

Average corrected grade level . . . . . ____ Checked by _____ Date_____

APPENDIX B

WORKSHEET FOR ANALYSIS OF INSTRUCTIONAL MATERIALS BEYOND READABILITY SCALES

Name of Book _____

Workbook _____

Publisher _____

Proposed Grade Level _____

Other Information _____

Pick a story at the beginning, middle and end of each level and analyze according to information requested below:

List New Words	Number of times reinforced	Reinforcements in next 3 stories

List New Words	Number of times reinforced	Reinforcements in next 3 stories

Looking at teachers manual, list skills to be taught in this lesson:

Skills	Are they taught

Skills to be taught or reinforced in workbook	Check appropriate observation taught	reinforced	neither

WORKSHEET FOR ANALYSIS OF INSTRUCTIONAL MATERIALS BEYOND READABILITY SCALES (ADAPTED)

Name of Book_____

Workbook_____

Publisher_____ Proposed Grade Level _____

Other Information_____

Pick a story at the beginning, middle, and end of each level and analyze according to information requested below:

List new words	No. of times reinforced	Reinforcements in 3 topic-related lesson in chapter of introduction

List new words	No. of times reinforced	Reinforcements in 3 topic-related lesson in chapter of introduction

Looking at the teacher's manual, list skills to be taught in this lesson:

Skills	Are they taught?

Skills to be taught or reinforced in workbook	Check appropriate observation Taught	Reinforced	Neither

VITA

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