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READING PROBLEMS IN MATHEMATICS TEXTS.

BY- SHAW, JUDITH A.

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CALIFORNIA STATE-ADOPTED MATHEMATICS TEXTBOOKS FOR GRADES 1 THROUGH 8 WERE ANALYZED TO DETERMINE THE READABILITY LEVELS, THE AMOUNT OF EXPOSITORY AND STORY-PROBLEM READING REQUIRED, AND THE FREQUENCY OF MATHEMATICS VOCABULARY USED. READABILITY WAS DETERMINED THROUGH THE DALE-CHALL FORMULA AND THE FINDINGS OF AN EARLIER STUDY USING SPACHE'S FORMULA. CHAPTERS RANDOMLY CHOSEN FROM THE INTERMEDIATE AND JUNIOR HIGH TEXTBOOKS AND ALL THE PRIMARY TEXTBOOKS WERE STUDIED TO INVESTIGATE THE AMOUNT OF READING REQUIRED. WORD LISTS WERE CONSTRUCTED FOR EACH LEVEL AND COMPARED WITH THORNDIKE'S WORD LIST FOR VOCABULARY LOAD. RESULTS INDICATE THAT THERE WAS A WIDE RANGE OF READABILITY LEVELS WITHIN EACH TEXTBOOK. ONLY THE FOURTH, FIFTH, AND SIXTH GRADE TEXTBOOKS FELL WITHIN THE INTENDED RANGE. THE INTERMEDIATE AND JUNIOR HIGH TEXTBOOKS REQUIRED A CONSIDERABLE AMOUNT OF EXPOSITORY AND STORY-PROBLEM READING, BUT THERE WAS NO ORDERLY PROGRESSION IN THE AMOUNT OF READING REQUIRED. THERE WAS A SIGNIFICANT GAP BETWEEN THE THIRD AND FOURTH GRADES. THE VOCABULARY LOAD WAS THE LOWEST AT THE PRIMARY LEVEL AND GREATEST AT THE JUNIOR HIGH LEVEL, WITH A GRADUAL INCREASE AT THE INTERMEDIATE LEVEL. TABULATED RESULTS ACCOMPANY THE FINDINGS, AND AN EXTENSIVE BIBLIOGRAPHY IS PROVIDED. (NS)

READING PROBLEMS IN MATHEMATICS TEXTS

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by

Judith A. Shaw

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Mrs. Judy Shaw
5844 Kantor Ct.
San Diego, Calif. 92122

READING PROBLEMS IN MATHEMATICS TEXTS

The importance of reading as a basic educational tool is an accepted fact; the performance of the below-average reader is impaired in most areas of the curriculum. In recently published mathematics materials, there is evidence of a trend toward an increased amount of reading in textbooks. What reading problems may be encountered in the course of mathematics instruction? More specifically, what are some of the reading problems observed in selected mathematics textbooks?

Smith and Heddens (3,4) applied the Spache and Dale-Chall readability formulas to elementary mathematics experimental materials and textbooks. They concluded that the readability of these materials was generally above the level of the students for whom the materials were intended. They also noted considerable variation of readability levels within the materials.

The purpose of this study was to determine the reading difficulty of the California state-adopted basic mathematics textbooks (Grades 1-8), employing other criteria in addition to the readability formula measures. These other criteria involved determining (1) the amount of expository and "story" problem reading actually required in each book and (2) the percent of the specialized mathematical vocabulary occurring above the 6,000 word level in Thorndike's word list of 20,000

words (6).

Procedure

The books reviewed for this study were the twelve basic textbooks used in California for mathematics instruction in grades one through eight: Greater Cleveland Mathematics Program, Science Research Associates, grades one through three; Modern Arithmetic through Discovery, Silver Burdett, grades four through six; Growth in Arithmetic, Harcourt, Brace, and World, grades seven and eight (low ability); Mathematics, Laidlaw Brothers, grades seven and eight (middle ability); and Exploring Modern Mathematics, Holt, Rinehart, and Winston, grades seven and eight (high ability). Three separate texts are provided for each of the junior high grades in order to implement a three-track approach to individual differences.

To determine the amount of expository and "story" problem reading required in each intermediate or junior high textbook, one-half the learning stages or chapters, chosen at random, were analyzed. At the primary level, the books were studied in their entirety. For all texts, the total pages in each section containing one hundred words or more were recorded. One hundred words was chosen as an arbitrary criterion because the readability analysis required samples of this size.

The Dale-Chall readability formula (2) was used to test the readability level of the intermediate and junior high textbooks. A hundred word sample was taken at random from each

chapter or learning stage. The range of readability as well as the average difficulty level was computed for each book. The raw scores were then adjusted using the Dale-Chall Correction Table (2:8) in order to determine the corrected grade-level scores.

The results of Smith and Heddens (4:392) were used for the readability comparison at the primary level. However, it must be noted that to obtain one hundred word samples, they used numerous consecutive pages. They also used the Spache readability formula to rate the primary material because the Dale-Chall technique does not apply to books below grade four. The Spache formula (5:125-35), while similar to the Dale-Chall formula, was specifically developed for use with primary reading materials.

To determine the frequency of the mathematics vocabulary used in the textbooks, the words were compared to Thorndike's word list of the 20,000 words that occur most frequently in general reading for children and young people. The vocabulary lists published in Implementing Mathematics Programs in California (1:37-54) were used as the source of the mathematics words used in the textbooks. At the primary level, the words listed were those used in the text, while the intermediate vocabulary list also included words used in the teacher's commentary. At the junior high level, the words rated were just those introduced in the text as new words.

The frequency of six thousand was arbitrarily chosen as a cut-off point. All words from the vocabulary lists above the first sixth thousand words in Thorndike's list were recorded. The proportion of these more difficult words to the total vocabulary list, expressed as a percentage, was computed for each book.

Results

The percentage of pages in which there is exposition in excess of one hundred words is given in Table I. At the primary level, a gradual increase in the amount of reading occurred. In the third grade text, the maximum amount (less than 20 percent) was reached. While there is still a gradual increase in expository material at the intermediate level, it was noted that the percentage of pages containing one hundred words or more was greatly increased. At no time is there less than 85 percent, while at the sixth grade level the figure approaches 100 percent. There is also a marked increase in expository and "story" problem material from the third to fourth grade texts.

The seventh and eighth grade textbooks are supplied for three ability levels. It was noted that the books intended for use with both the seventh and eighth grade students of high ability required less reading than either of the books intended for use with the middle and low tracks.

With the exception of the primary books, there appeared to be no orderly progression of reading amounts; instead, the amount of exposition seemed closely related to the particular topic under discussion. In one seventh grade book, for example, six of the nine chapters analyzed had no pages with fewer than one hundred words. (See Appendix, Table 4.) This analysis was rather subjective; yet, the results indicated that consideration of the amount of reading required during a mathematics assignment is a reasonable point of concern.

TABLE I

CALIFORNIA ADOPTED BASIC MATHEMATICS TEXTS (GRADES 1-8)
PERCENT OF PAGES USING EXPOSITION IN EXCESS
OF ONE HUNDRED WORDS

Book*	%	Total pages reviewed**
1	0	332
2	7	368
3	19	329
4	87	145
5	88	147
6	96	154
7(HBW)	95	150
7(L)	93	183
7(HRW)	77	237
8(HBW)	95	168
8(L)	95	178
8(HRW)	74	232

* Grades 1-3, Science Research Associates, Greater Cleveland Mathematics Program; Grades 4-6, Silver Burdett, Modern Arithmetic through Discovery; Grades 7 and 8, three tracks, Harcourt Brace and World, (HBW), Growth in Arithmetic, low; Laidlaw Brothers, (L), Mathematics, middle; Holt, Rinehart and Winston, (HRW), Exploring Modern Mathematics, high.

** Books 1-3 were analyzed in their entirety, while books 4-8 were sampled at random.

The results of the application of the Dale-Chall readability formula to the textbooks are given in Table II. In the evaluation of these figures, it should be recognized that the Dale-Chall formula, like other readability techniques, is not specifically intended for use with mathematics materials. While it is entirely possible that the specialized nature of mathematics vocabulary may have affected the scores, none of the ratings appeared unduly high. The results of readability formulas are not infallible; rather, they provide an estimate of a book's difficulty level. These data are also based on a relatively small number of samples.

In the fourth through sixth grade texts, the average readability fell within the range of intended usage. In all cases the child of average reading ability should be able to read and comprehend the expository and "story" problem material.

Wide variations in readability levels were observed in the seventh grade textbooks. The book intended for use with the high ability group received a fifth to sixth grade rating, while the text intended for the low ability group was at grade level readability. The book intended for use with the middle group received a ninth to tenth grade rating. Both books intended for the eighth grade low and middle students were at grade level, while the readability level of the book for more able students was ninth to tenth grade.

Of greater consequence than the average readability levels of the textbooks, however, was the wide internal variation noted in all the books regardless of grade level. Samples taken from one eighth grade book, for example, ranged from fifth grade to grade fifteen (college). (See Table II and Appendix, Table V.)

TABLE II

CALIFORNIA ADOPTED BASIC MATHEMATICS TEXTS (GRADES 1-8)
READABILITY BY FORMULA

Book*	Range of samples by readability grade level**	Average readability grade level
1***	2.1-2.8	2.5
2***	2.9-3.2	3.1
3***	3.1-4.3	3.7
4	4-6	4 and below
5	4-8	5-6
6	5-8	5-6
7(HBW)	4-10	7-8
7(L)	5-12	9-10
7(HRW)	4-8	5-6
8(HBW)	4-12	7-8
8(L)	5-15(college)	7-8
8(HRW)	5-12	9-10

* Grades 1-3, Science Research Associates, Greater Cleveland Mathematics Program; Grades 4-6, Silver Burdett, Modern Arithmetic through Discovery; Grades 7 and 8, three tracks, Harcourt, Brace and World, (HBW), Growth in Arithmetic, low; Laidlaw Brothers, (L), Mathematics, middle; Holt, Rinehart and Winston, (HRW), Exploring Modern Mathematics, high.

** The Dale-Chall readability formula was used for all but books 1-3. The scores recorded for grades 4-8 have been adjusted with the Dale-Chall Correction Table (Appendix, Table VI). The data from Smith and Heddens (see below) was used to complete the table.

*** The data for these books were obtained from the study of K.J. Smith and J.W. Heddens, "The Readability of Experimental Mathematics Material," The Arithmetic Teacher, XI (October, 1964), 392. These authors used the Spache formula.

The data regarding the frequency of the mathematics vocabulary used in conjunction with the textbooks are given in Table III.

TABLE III

CALIFORNIA ADOPTED BASIC MATHEMATICS TEXTS (GRADES 1-8) MATHEMATICS VOCABULARY FREQUENCY ACCORDING TO THORNDIKE'S WORD LIST *

Book**	Total Vocabulary***	Words above 6,000 word level	
		Number	Percentage
1	118	10	8
2	46	9	20
3	32	4	12
4	62	24	39
5	84	36	43
6	67	35	52
7(HBW)	81	55	68
7(L)	79	35	44
7(HRW)	94	71	76
8(HBW)	84	59	[illegible]
8(L)	75	45	60
8(HRW)	68	39	51

* E.L. Thorndike, A Teacher's Word Book of the Twenty Thousand Words Found Most Frequently and Widely in General Reading for Children and Young People. (New York City: Bureau of Publications-Columbia University, 1932).

** Grades 1-3, Science Research Associates, Greater Cleveland Mathematics Program; Grades 4-6, Silver Burdett, Modern Arithmetic through Discovery; Grades 7 and 8, three tracks, Harcourt, Brace and World, (HBW), Growth in Arithmetic, low; Laidlaw Brothers, (L), Mathematics, middle; Holt, Rinehart and Winston, (HRW), Exploring Modern Mathematics, high.

*** Obtained from Janet Briggs, et al, Implementing Mathematics Instruction in California: A Guide K-8 (Menlo Park, California: Pacific Coast Publishers, 1965), pp. 149-73.

At the primary level, the vocabulary load was the lowest; however, the greatest percent of words in the primary texts above the sixth thousand word level on Thorndike's list occurred in the second grade text. In a developmental program, this would be expected to occur instead in the third grade text. It was noted that the greatest number of words were introduced at the first grade level; yet, these words were at a relatively low frequency.

While there appeared to be little continuity in vocabulary development at the primary level, the vocabulary load at the intermediate grade level showed a gradual increase. In the fourth grade text and teacher commentary, 39 percent of the words were above the 6,000 word level, while 52 percent of the sixth grade vocabulary surpassed this mark.

There is an indication that the greatest vocabulary load occurs at the junior high level. In all but one of the six junior high texts (Laidlaw, Grade 7) over 50 percent of the mathematical vocabulary exceeded the 6,000 word level. There was also considerable variation from text to text.

Because various series are used through the grades, it was not possible to determine whether these percentages were cumulative; that is, were some words re-introduced as new words at a different level in another series?

Conclusions

Prediction of reading problems to be encountered during

mathematics instruction is a difficult process. Because there are numerous factors that affect reading difficulty, pinpointing a single factor or group of factors is impossible and at best, subjective. However, the results of this study indicate several corclusions in regard to the reading difficulty of the California state-adopted basic mathematics textbooks for grades one through eight.

1. Considerable reading is required in the intermediate and junior high textbooks. Because so much reading is required in these grades during the course of mathematics instruction, the classroom teacher must be prepared to cope with reading problems which may arise. While the amount of reading required does not indicate the difficulty level of the concepts included, it could be assumed that capable students would adjust more readily to an increased reading load than less able pupils, especially if the reading requires considerable independent interpretation.

2. Fourth grade teachers, in particular, must help their students make the transition from the third grade text, which requires little reading, to the fourth grade book which contains a great deal of expository and "story" problem material.

3. All of the textbooks seem to be aimed at the average and above-average reader. Special provisions must be made for the below-average reader in the area of mathematics instruction.

4. There is a wide range of readability levels within each textbook. To partially compensate for this factor, mathematics lessons should include provisions for vocabulary development.

5. The vocabulary load at the primary and junior high levels appears to lack continuity. This factor, complicated by the usage of relatively uncommon words at all levels, makes the conscious instruction in mathematical vocabulary skills an extremely important part of the elementary mathematics program.

6. The advisability of a three track program at the junior high level should be re-examined. These books must be carefully used because they may not be suitable for the group for whom they were intended.

Reading skills form an important basis for instruction in mathematics as well as other curricular areas. For successful arithmetic teaching, educators must be cognizant of the reading problems encountered in their mathematics textbooks. Steps may then be taken to alleviate these problems through improved teaching techniques and/or critical evaluation and revision of instructional materials.

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APPENDIX

TABLE IV

CALIFORNIA ADOPTED BASIC MATHEMATICS TEXTS (GRADES 1-8) PERCENT OF PAGES USING EXPOSITION IN EXCESS OF ONE HUNDRED WORDS

Book	Section or Chapter	%	Average	Total pages reviewed
1	entire book	0		332
2	entire book	7		368
3	entire book	19		329
4	2	89	87	28
	4	81		31
	5	84		35
	6	90		31
	9	90		30
5	2	83	88	30
	4	91		46
	6	88		24
	8	96		25
	9	82		22
6	1	97	96	39
	3	98		44
	5	91		22
	6	92		26
	8	100		23
7(HBW)	3	89	95	28
	4	90		41
	5	100		24
	7	100		33
	9	100		24
7(L)	4	100	93	16
	5	94		18
	7	100		20
	8	100		16
	9	100		30
	10	100		16
	14	100		20
	17	91		22
	18*	56		25

* This chapter is devoted to practice and review.

TABLE IV (continued)

Book	Section or Chapter	%	Total pages reviewed
		Average	
7(HRW)	1	83	35
	2	72	59
	6	53	55
	7	82	59
	9	93	29
8(HBW)	1	96	27
	3	100	32
	6	88	25
	7	100	30
	8	100	34
	9	95	20
8(L)	1	100	17
	2	94	20
	6	100	19
	7	100	30
	8	100	18
	10	100	20
	12	100	16
	14	85	20
	15	94	18
8(HRW)	1	86	57
	3	65	49
	4	77	47
	7	77	31
	9	63	48

TABLE V

CALIFORNIA ADOPTED BASIC MATHEMATICS TEXTS (GRADES 1-8) READABILITY BY FORMULA

Book	Section	Page	Readability*	Range**	Average**
	1	20	5.3957		
	2	49	4.7550		
	3	68	4.1416		
	4	92	5.0210		
4	5	127	4.0333	4.0-5.6*	4.3*
	6	152	4.5070		
	7	193	4.7550		
	8	206	5.5627		
	9	247	5.0303		
	10	275	3.9837		
	1	15	4.9625		
	2	49	5.9281		
	3	86	4.8815		
	4	99	4.9807		
5	5	148	4.9131	4.9-6.1*	5.5*
	6	179	5.9777		
	7	233	5.6619		
	8	259	6.1761		
	9	278	6.0182		
	1	22	5.2965		
	2	56	5.2287		
	3	72	5.4271		
	4	121	5.7520		
6	5	154	6.5101	5.2-6.8*	5.9*
	6	190	6.5010		
	7	198	5.4166		
	8	251	6.0182		
	9	264	6.7986		
	1	36	5.9099		
	2	87	4.4392		
	3	96	7.5972		
	4	142	7.4889		
7(HBW)	5	166	7.0739	4.4-7.6*	6.6*
	6	187	5.7511		
	7	237	7.4393		
	8	282	7.0739		
	9	292	6.9251		
	10	319	6.4828		

* These are raw scores computed using the Dale-Chall formula. See Table VI for the Dale-Chall Correction Table.

** These figures are rounded off to the nearest tenth.

TABLE V (continued)

Book	Section	Page	Readability*	Range**	Average**
	1	9	6.4332		
	2	24	6.7672		
	3	50	6.7581		
	4	78	6.6093		
	5	82	6.2844		
	6	98	5.4676		
	7	132	7.9626		
	8	155	7.9626		
7(L)	9	188	7.0800	5.4-8.4*	7.0*
	10	195	5.5445		
	11	215	6.1761		
	12	231	7.0611		
	13	246	8.3280		
	14	267	6.5233		
	15	294	8.1023		
	16	303	8.3776		
	17	319	6.8664		
	18	339	7.1913		
	1	2	4.8228		
	2	67	4.9761		
	3	97	6.0707		
	4	154	4.8724		
7(HRW)	5	197	5.7520	4.8-6.7*	5.7*
	6	253	6.7176		
	7	295	5.8594		
	8	359	5.9686		
	9	399	6.5911		
	1	6	6.2257		
	2	35	8.2784		
	3	90	7.5294		
	4	118	4.7641		
	5	166	5.2874		
8(HBW)	6	191	7.4302	4.4-8.2*	6.0*
	7	217	6.3927		
	8	251	4.4979		
	9	277	4.4719		
	10	299	5.7024		
	11	330	4.5384		
	12	349	6.7085		

* These are raw scores computed using the Dale-Chall formula. See Table VI for the Dale-Chall Correction Table.

** These figures are rounded off to the nearest tenth.

TABLE V (continued)

Book	Section	Page	Readability*	Range**	Average**
	1	7	6.9788		
	2	29	6.5506		
	3	44	5.8512		
	4	63	5.5040		
	5	87	5.6437		
	6	104	6.2844		
	7	133	7.5790		
	8	156	7.4798		
8(L)	9	168	5.5354	5.5-9.0	6.8
	10	189	6.4332		
	11	209	9.0274		
	12	236	7.5881		
	13	247	7.7551		
	14	267	5.9686		
	15	290	8.6256		
	16	302	6.7804		
	17	328	7.8452		
	18	339	5.8694		
	1	4	6.2348		
	2	69	6.5597		
	3	137	7.9808		
	4	194	5.8603		
8(HRW)	5	227	6.9160	5.8-8.2	7.1
	6	277	6.8077		
	7	295	7.1144		
	8	341	8.2470		
	9	402	8.0819		

* These are raw scores computed using the Dale-Chall formula. See Table VI for the Dale-Chall Correction Table.

** These figures are rounded off to the nearest tenth.

TABLE VI

DALE-CHALL CORRECTION TABLE*

Formula raw score	Corrected grade-levels
4.9 and below	4th grade and below
5.0 to 5.9	5-6th grade
6.0 to 6.9	7-8th grade
7.0 to 7.9	9-10th grade
8.0 to 8.9	11-12th grade
9.0 to 9.9	13-15th grade (college)
10.0 and above	16/ (college graduate)

* Edgar Dale and Jeanne S. Chall, A Formula for Predicting Readability Reprinted from the Educational Research Bulletin, XXVII (January 21 and February 17, 1948), p. 8.