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A Statistical Study of Algebraic Vocabularies Found in Eight Ninth-Grade Algebra Textbooks

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A STATISTICAL STUDY OF THE ALGEBRAIC VOCABULARIES FOUND IN EIGHT NINTH-GRADE ALGEBRA TEXTBOOKS

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This thesis, presented by Edwin E. Kval in partial fulfillment of the requirements for the degree of Master of Science in Education, is hereby approved by the committee on Instruction in charge of his work.

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CHAPTER 1

INTRODUCTION

The Importance of Vocabulary Studies

Teachers in elementary grades and in high school who have undertaken an analysis of pupil difficulties in connection with their school work will admit that the major part of those difficulties is produced by the pupils' inability to understand the subject matter of their textbooks. One cannot read a problem effectively unless he understands the words.

The ability to use a large and varied vocabulary is looked upon as a measure of intelligence. Terman[1] has said that vocabulary tests will give an intelligence quotient within ten per cent of that secured by using the entire series of Stanford-Binet intelligence measures. Furthermore, when considering the fact, that the greater share of the school learning is received through the use of written literature, the importance of vocabulary becomes apparent.

Numerous vocabulary investigations have been carried out. The majority of these investigations have attempted to fix a standard of vocabulary attainment for a specific age or grade level. In reviewing some previous studies it was

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1 Terman, L. M., Measurement of Intelligence, p. 230

found there were two kinds of investigations, one whose purpose was developing standardized word lists, and the other which attempted to study the development of the children's understanding of the words. These studies show more investigations have been done on the elementary level than on the secondary level.

Some writers seem to think that teachers have been slow in realizing the need for pupil diagnosis and remedial training in aspects of mathematics other than those which are strictly computational.

The vocabulary of an individual may be divided into the vocabulary of social activity or general, and the vocabulary derived from subject matter, or specific.

It is an indisputable fact, that if a pupil does not understand the vocabulary, he cannot do well in the subject. The vocabulary tests in the various subjects may be used accurately as a standard of achievement for the subject involved. The following quotation from Pressey illustrates this point:

> "A list of the technical terms in any subject is more than a mere list of words; it is a catalogue of the important concepts in that subject... A child's failure to grasp any portion of the subject matter will be indicated by vagueness regarding the meaning of the terms involved in that portion of the subject...The special or technical vocabulary of a school subject thus appears a tool of funda-

> mental importance with which a pupil must become familiar if he is to study that subject with any efficiency. It is the summary of the content of that subject."[1]

Previous Vocabulary Studies in Algebra

According to Cole[2] the first investigations in this field were made by Thrush and Pressey. A later, and a more complete, study was made by Narragon, who went into detailed considerations of the frequency, importance, and social value of each term. The final list, based on all previous work, contained 116 essential concepts; of these, however, 60 were duplicates of words appearing on the arithmetic list. There were thus only 56 new terms. If a year were spent on this subject, the 56 new words would require a mastery of approximately 1.5 words per week; assuming a school year to be 36 weeks. The entire number of words was distributed as follows: 16 were needed for nomenclature, 6 for factoring, 16 for equations, 9 for roots and powers, and 6 for graph making; there were also 6 signs or symbols. The remaining words were borrowed from arithmetic.

In the same study, Cole also published a list of 116 most important algebraic concepts. Of these concepts, 56 were taken from the arithmetic list.

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1 L. C. Pressey, "The Technical Vocabularies of Public School Subjects", School and Society, 20:91-96, 1924.

2 Luella Cole, The Teacher's Handbook of Technical Vocabulary, p. 6.

Among the vocabulary studies on the secondary level, few have dealt with the technical vocabularies of special subjects. Of such vocabulary studies, those made by S. L. Pressey and L. C. Pressey are most comprehensive and best known. Pressey[1] has prepared a list of words common to arithmetic, algebra, and geometry which are basic mathematical terms as well as separate lists of terms peculiar to each of these subjects. These lists are helpful to teachers in discovering what concepts are regarded as fundamental by teachers and writers in the field of high school mathematics. Elementary algebra textbooks require detailed explanation of the procedures to be used and this demands an increased knowledge of the mathematical vocabulary on the part of the pupil.

Humphreys[2] surveyed thirty-two textbooks in junior high school mathematics and found that they contained 4624 different words, forty-two per cent of which were mathematical terms. He concluded that the large vocabulary used in junior high school texts must add greatly to the pupil's difficulty in solving problems.

There has also been added emphasis upon the verbal type of problem. Several authorities in the field have stressed the importance of a suitable vocabulary for the

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1 L. C. Pressey, op. cit., p. 91-96.

2 C. F. Humphreys, The Vocabulary of Math. Material in Jr. High School, (Unpublished M. S. Thesis)

solution of verbal problems in algebra. Breslish[1] asserted that the vocabulary involved in verbal problems is a cause of serious difficulties. Writers of textbooks on mathematics have not given the vocabulary the attention it deserves. He also stated that it was evident that the teacher must take the responsibility for teaching the meaning of the new words that occur in the problem. Proper experiential background preceding the introduction of new words and technical terms is therefore necessary to eliminate the difficulty which arises from too limited a vocabulary.

Schorling states:

> "The chances are high that most of the difficulties of pupils are due to low reading ability or low intelligence or to a combination of these two."[2]

Dresher in a study to determine the effects of extensive and specific vocabulary training in junior high school mathematics says:

> "Considering the gains made by the experimental over the control groups after the vocabulary training, one might draw the conclusion that if one desires to increase the vocabulary of the pupils, it should be by specific training."[3]

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1 E. R. Breslish, Problems in Teaching Secondary School Mathematics, p. 21

2 Raleigh Schorling, The Teaching of Mathematics, p. 113.

3 Richard Dresher, "Training in Mathematics Vocabulary", Educational Research Bulletin, 13:200-4, November, 1934.

Lindquist, writing in the School Review, said:

> "The language of algebra is almost totally incomprehensible to many pupils."[1]

In his chapter on the developing of fundamental concepts, Brink says:

> "One of the basic reading needs of mathematics students is the acquisition of the vocabulary peculiar to the subjects which are being pursued."[2]

Kinney[3] believes that considerable difficulty frequently results from the lack of technical vocabulary.

The above opinions leave little doubt as to the importance of vocabulary in connection with problem solving in algebra.

Need for Further Study

The importance of vocabulary studies is obvious. Vocabulary difficulties are always present; they hinder the pupils in their understanding of the full import of the problem to be solved. Some writers are of the opinion that teachers of mathematics place too much stress on the learning of definitions. Mere memory of the definition does not insure an understanding of the term. But teachers often

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1 E. F. Lindquist, "The Gap Between Promise and Fulfillment in Ninth Grade Algebra", School Review, Dec., 1934.

2 W. G. Brink, Directing Study Activities, p. 522.

3 L. B. Kinney, "Problem Solving and the Language of Percentage", Journal of Business Education, Jan. 1935, p. 24.

think that because a student can glibly recite a definition for a term, that he has a thorough conception of the term. This is not, however, always the case.

The terms introduced in elementary algebra are the same as those used in higher mathematics. Therefore, in order for the pupils to understand other work in mathematics, they must have a thorough conception of the technical terms employed.

Smith writes:

> "Needs are great in all subject matter fields... Mathematicians, psychologists, teachers and textbook writers still have different ideas concerning the subject of arithmetic, despite the hundreds of investigations in the field...There is disagreement as to what content or subject matter should be taught, and how it should be taught."[1]

While personal experience provides a knowledge of most of the ordinary affairs of life, it is inadequate as a basis for determining educational needs because it is so limited and so easily influenced by personal desires. Because of its subjective nature, knowledge of this type is unreliable for forming judgments and generalizations.

Very few studies were found which dealt with the investigation of the difficulty of algebraic terms found in elementary algebra textbooks.

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1 H. L. Smith, Educational Research Principles and Practices, p. 54,82.

Vocabulary training does help the pupils to understand and work concrete problems. Pupils cannot work problems if they cannot read and understand them. The failure to know a word, or a term, is evidence of failure to comprehend the idea presented by that word or term.

CHAPTER 2

THE PROBLEM

Statement of the Problem

As stated in most of the previous studies, it was implied that many of the difficulties of children in academic areas are due to lack of sufficient and adequate vocabulary. Thus it seems logical to assume that a considerable amount of difficulty in algebra is due to lack of sufficient knowledge of the technical terminology used in high school algebra books. The purpose of this study may be summarized as follows:

1. To study the words having algebraic connotations which are found in eight modern elementary algebra books.
2. To make a frequency count of these words, including the signs commonly used in elementary algebra.
3. To make a comparative word study of the eight elementary algebra textbooks and determine the algebraic words most widely used by the different authors.
4. To compare this list of words with other word studies in order to determine the level of word difficulty.

Delimitations of the Problem

Some difficulty was experienced in determining which words should be included in the algebraic list. There is no criteria for determining which words should be included as algebraic. Cole's[1] list was used as a base from which to work. But, some of the words in that list were also used in the arithmetic and the geometry lists of words.

Since Thorndike and Lorge[2] list only the "root" form of the word in most cases, no comparison can be made with words with different endings. If the assumption is made that the majority of words with different endings may be listed in approximately the same place as the "root" form of the word, then the derivation of the per cent of algebraic words included below the Thorndike-Lorge 8,500 word level could be considered with a fair degree of accuracy. The Thorndike-Lorge word list does not include phrases.

Method of Procedure

A work sheet composed of expressions, words and symbols which are commonly used in elementary algebra textbooks was prepared. In the preparation of this sheet,

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1 Luella Cole, The Teacher's Handbook of Technical Vocabulary, p. 31.

2 E. L. Thorndike and Irving Lorge, The Teacher's Word Book of 30,000 Words.

the word list by Cole[1] was used, together with a brief tabulation of different words found in one textbook. New words were added to this list as they appeared in the different textbooks as they were being checked. The singular includes the plural form of the word. That is, "divide" and "divides" are listed under "divide". All words were arranged alphabetically.

The elementary algebra textbooks selected for the study were the most recent publication date available in each case. The textbooks are listed below and will hereafter be identified by the Roman numerals:

I. Edgerton, Edward I., and Carpenter, Perry A., Elementary Algebra, Allyn and Bacon, 1947.

II. Nyberg, Joseph A., Fundamentals of Algebra, American Book Company, 1944.

III. Betz, William, Everyday Algebra, Ginn and Company, 1946.

IV. Barber, Harry C., First Course in Algebra, Houghton Mifflin Company, 1935.

V. Breslich, E. R., Purposeful Mathematics Algebra, First Course, Laidlaw Brothers, 1943.

VI. Lennes, N. J., A First Course in Algebra, The Macmillan Company, 1947.

VII. Bartoo, C. G., and Osborn, Jesse, Algebra and You, Webster Publishing Company, 1947.

VIII. Engelhardt, Fred, and Haetter, L. D., First Course in Algebra, The John C. Winston Company, 1940.

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1 Luella Cole, The Teacher's Handbook of Technical Vocabulary, p. 31.

The following procedure was used in tabulating the words:

The algebraic terms on the pages of each textbook were tabulated on the work sheet. Each work sheet was marked with the Roman numeral of the textbook which was being checked. Different sets of similar work sheets were used for each book, in order to avoid errors. New expressions, or words, were added to the list as they appeared in the particular book which was being checked.

Each textbook was then rechecked in order to search for the new terms, or words, which had been added to the original list, and also to check possible omissions.

A check for the total number of words was made with the Thorndike-Lorge 30,000 word list. From this comparison, the per cent of words above the 8,500 word level was computed and tabulated for each book. The list was also checked with the algebra list published by Luella Cole in "The Teacher's Handbook of Technical Vocabulary."

A table was constructed, showing which words were most widely used by the different authors.

Two tables were constructed to make a study of the frequencies of different concepts used in each of the eight elementary algebra textbooks.

CHAPTER 3

THE INTERPRETATION OF RESULTS

In a vocabulary study of this kind it is necessary to make a frequency count of all the algebraic concepts found in the various textbooks chosen for study. Table I lists the words alphabetically and the number of times the word is found in each book which are listed by Roman numerals.

Each word is also rated according to Thorndike-Lorge's Teacher's Word Book of 30,000 Words. The interpretation of the Thorndike-Lorge code is as follows: In the ninth column after the word is a number stating the occurence per million words. The numeral 1 means at least one occurrence per million and not so many as two per million; 2 means at least two per million and not so many as three per million; and similarly up to 49; A means at least 50 per million and not so many as 100 per million. AA means 100 or over per million. Words occurring less than once per million but more than once per four million, are followed by the Roman numeral II, and by a number (from 5 to 17) reporting the number of occurrences per eighteen million words. Words occurring four times per eighteen million are followed by the Roman numeral III.

Table I shows that there is a wide variation in the number of times different words occur, as well as the fact

that there is a wide variation in the number of different words used by the different authors. For example, one author used the word "evaluate" 174 times, whereas another author used it only three times. Solution was used 291 times by one author but it was used only 41 times by another author.

TABLE I

THE FREQUENCY OF ALGEBRAIC CONCEPTS ACCORDING TO TEXTBOOKS, AND THORNDIKE-LORGE'S RATINGS OF CONCEPTS

CONCEPT	I	II	III	IV	V	VI	VII	VIII	Thorndike Lorge Placement
abscissa		1	3	3	4	6	13		
addition	49	29	98	45	131	42	72	32	A
additional	9	5	8	4	18	13	19	10	25
algebra	70	29	50	59	28	146	77	35	
algebraic	79	21	93	57	199	63	78	30	II 5
altitude	42	34	26	60	52	64	62	15	14
amount	40	46	80	80	69	71	52	62	AA
angle	228	124	221	315	564	204	222	160	30
area	223	140	187	150	192	325	210	112	A
ascending	3		4	2	3		3	1	29
ascending order			1		1		1		
average	62	90	104	53	80	76	45	39	A
axiom	24		1	5	31	5			1
axis	53	30	34	12	25	16	12	8	9
base	64	57	89	100	105	77	146	66	AA
binomial	43	16	38	20	47	40	43	17	II 7
biquadratic	1					3			
braces	1				2	1			17
bracket	2				17	6	3		5
cancel		2	7			30			8
cases	43	6	245	19	45	88	35	5	AA
characteristic								20	35
circle	89	39	47	41	75	77	53	58	AA
circular	5	10	16	8	29	8	4	7	21
circumference	21	37	19	18	28	17	11	24	6
clear of fractions	6	4	10	15	1	7	5		
coefficient	54	7	38	24	65	83	64	37	1
collect	21	3	4	1	5	29	17	2	A
common denominator	8	2	9	3	10	18	2	10	
compass	2			3	13		6	5	28
computation			7	11	6	7	5	2	1
compute	15	1		5	6	5	8	3	5
conditional equation	5			3			16		2
consecutive	36	3	22	36	1	15	38	20	3
constant	35	17	34	16	2	21	9	8	49
contain	1	29	1	3	15	5	4	33	AA

TABLE I (Continued)

THE FREQUENCY OF ALGEBRAIC CONCEPTS ACCORDING TO TEXTBOOKS, AND THORNDIKE-LORGE'S RATINGS OF CONCEPTS

CONCEPTS	I	II	III	IV	V	VI	VII	VIII	Thorndike Lorge Placement
coordinate	8	7	14	10	17	46	31	7	4
cosine	116	10	21	41	33	27	42	38	II5
correction	1								7
cube	39	20	67	29	48	21	34	32	9
cubic	15	21	44	19	50	14	14	29	8
degree	49	11	76	78	191	75	87	24	AA
denominator	109	60	110	48	102	112	92	86	II 12
descending			3	2	3		5	3	49
descending order			2		2		1		
diameter	15	23	47	33	57	8	10	22	17
dimension	30	9	158	32	40	101	19	36	10
distance	116	104	175	99	148	105	107	86	AA
divide	180	109	145	123	263	290	179	165	AA
dividend	16	12	27	9	24	16	12	11	7
division	17	30	125	63	90	62	62	40	A
divisor	26	8	38	13	27	31	18	31	II 17
eliminate	17	9	14	19	18	24	139	11	18
equal	229	112	225	119	310	196	107	179	A
equation	445	441	545	419	574	770	608	461	4
equilateral	9	2	6	13	8	21	17	5	II 5
equivalent			22		4	1	26	9	12
evaluate	7		27	37	17	174	3	12	1
exceed	48	23	10	15	6	14	18	16	26
expand			1			18		9	15
exponent	42	12	34	63	104	33	45	60	2
expression	112	35	157	88	245	163	89	182	A
extract	18			7	11		3	3	16
extremes	4	7	2	1	9		7	1	38
factor	142	72	147	88	239	346	160	91	35
factorable		7	21	1	1				
factoring	30	36	16	20	49	64	40	28	
figure	67	66	602	112	427	166	87	175	AA
formula	319	165	497	381	440	351	244	371	11
fraction	153	128	323	122	192	297	232	177	12
fractional	40	13	33	25	12	10	46	31	1
function	63		1	6		78	5		36
functional	7				7				1
graph	278	153	233	193	240	178	208	200	II 14

TABLE I (Continued)

THE FREQUENCY OF ALGEBRAIC CONCEPTS ACCORDING TO TEXTBOOKS, AND THORNDIKE-LORGE'S RATINGS OF CONCEPTS

CONCEPTS	I	II	III	IV	V	VI	VII	VIII	Thorndike Lorge Placement
graphing				7					
height	39	54	140	76	77	17	80	84	AA
horizontal	35	20	39	22	32	13	26	26	9
hyperbola	2							1	III
hypotenuse	21	21	36	18	17	18	32	21	II 6
identity	6		10	12	1		13	3	6
imaginary	4	1	1	4	1	5		1	11
inconsistent			1	2	4			1	3
independent	3	2	2	2	1		9	4	A
indeterminate	3		6		2		3	1	1
index	6		3		2	1	13	9	14
interpolate	2	1	1	3	2		1	1	II 10
interpolation	3	6		3	1		3	1	II 11
interpret	11	1	3	4	3	6	1	3	15
interpretation	9		1	1	1			2	10
intersect			3	2	9	8	2	2	2
invert	7	4	5		7	3	1	2	7
irrational	15	1	7	6	3	3	9		1
length	192	130	268	103	176	197	120	155	AA
less	36	35	36	64	54	123	62	37	AA
linear	28	8	35	31	137	21	71	45	1
literal	21	13	26	24	52	25	19	12	2
logarithm	1	1		22	6			131	II 13
mantissa								44	
means	27	21	22	27	61	15	49	47	AA
measure	23	27	146	29	187	71	48	25	AA
median	12	9	7	19				5	2
members	80	52	64	42	39	164	69	87	AA
minuend	8	5	11	1	8	14	4		
minus	26	22	9	16	37	15	30	36	5
modal or mode	6	5		8	4			2	23
monomial	35	17	59	23	81	62	45	20	
multiplicand	2		10	3	1		4		
multiplication	55	50	107	94	101	66	66	38	5
multiplier	1	9	9	3	1	10	4		II 7
multiply	143	167	145	147	214	442	151	180	24
negative	71	19	57	59	50	150	56	35	10
numerator	78	82	42	34	54	55	46	58	III
numerical	27	3	80	8	29	13	31	19	2
ordinate		1	2	2	4	7	12		II 12

TABLE I (Continued)

THE FREQUENCY OF ALGEBRAIC CONCEPTS ACCORDING TO TEXTBOOKS, AND THORNDIKE-LORGE'S RATINGS OF CONCEPTS

CONCEPTS	I	II	III	IV	V	VI	VII	VIII	Thorndike Lorge Placement
origin	13	5	1	2	5	22	6	2	28
parabola	4	3	6		1	5		4	1
parenthesis	73	32	33	26	29	88	95	18	II 6
per cent	15	60	77	20	55	19	57	16	A
perimeter	83	18	91	64	92	79	97	38	II 8
plot	18	7	18	8	56	10	11	15	36
plus	39	29	19	15	13	80	49	50	10
polynomial	33	14	81	20	124	25	39	38	
positive	74	19	61	33	56	123	54	39	15
power	51	11	93	8	92	10	24	50	AA
prime	4	13	3	1	5	6	3		17
prime factor	9	7	8	19	7	19	19	12	
product	138	66	179	84	199	330	175	72	A
proportion	25	40	48	27	20	27	47	15	A
proportional	12	69	11	16	1		11	10	3
protractor	8	7	14	2	17	4	13	12	II 12
quadratic	32	4	7	22	38	24	37	5	II 5
quadratic equation	38	29	45	25	36	14	38	43	
quantity	150	117	47	22	4	32	33	54	A
quotient	59	29	84	56	46	66	63	53	1
radical	68	11	71	43	45	55	48	53	16
radicand	26	7	8				6	5	
radius	28	14	46	34	48	65	25	19	6
rate	174	102	195	88	118	80	122	130	AA
ratio	88	51	134	107	80	44	93	77	11
rational	7		7	6	4	6	5		6
rationalizing	7		3	4		28	1	1	II 7
reciprocal	7	2	6	6	2	4	11	3	3
reduce	45	6	48	7	57	98	27	31	A
reduction	2			1	1	5	1	1	20
remainder	38	15	48	34	25	51	58	21	17
respective	2				2			1	8
respectively	17	7	15	7	12	17	13	12	8
resultant	4								2
root	156	19	99	59	28	54	82	107	A
sign	139	58	105	92	115	130	140	107	AA
signed	15	12	91	28	115	93	38	2	
similar	8		9	4	39	40	27	28	A
simple (equation)	10	2	1			2		1	AA

TABLE I (Continued)

THE FREQUENCY OF ALGEBRAIC CONCEPTS ACCORDING TO TEXTBOOKS, AND THORNDIKE-LORGE'S RATINGS OF CONCEPTS

CONCEPTS	I	II	III	IV	V	VI	VII	VIII	Thorndike Lorge Placement
simplify	44	34	42	38	54	59	36	42	5
simultaneous equation	4	2	10	3	11	12	2	1	1
sine	61	31	29	63	60	48	43	47	1
solution	160	41	286	66	201	291	86	230	31
square	352	181	460	163	316	354	326	232	AA
squaring	4	5	5		4	1	1	2	
square root	66	74	84	55	134	109	87	105	
statistical	3	1	9	1	1				3
statistics	3	4	5	5	4	2	1		11
(sub)subscript		3	4		2			2	
substitute	54	39	55	42	92	87	56	22	29
substitution	13	7	31	15	31	16	13	21	4
subtract	172	41	94	105	152	221	134	97	4
subtraction	38	19	88	39	107	52	57	13	1
subtrahend	9	9	7	1	16	18	5		
sum	206	112	119	198	246	448	247	144	A
surd	6							1	
symbol	31	8	31	36	154	43	25	51	17
tabular difference					3				1
tabulate	3		2		8				2
tangent	88	32	33	59	44	34	47	115	1
term	232	156	324	150	351	452	244	188	A
times	267	156	94	170	208	229	120	107	AA
total	48	57	151	82	28	42	46	58	A
transform	13		13	7		2			17
transformation	11		4	2					7
transpose	11	8	2		1	45	10		1
transposition	6	2					16	2	II 7
triangle	138	79	200	142	183	196	226	112	8
trinomial	31	17	30	8	63	55	60	13	
unit	40	15	97	49	92	83	159	18	29
unknown	63	39	87	60	167	117	79	42	A
variable	28	18	16	29	23	19	24	27	5
variation	13	6	9	9		43	10	44	14
vector	11								III
vertical	34	19	58	15	61	8	17	18	10
vinculum	1			1					
volume	24	39	108	31	70	24	20	40	A
weight	47	109	104	52	56	103	43	34	AA

TABLE I (Continued)

THE FREQUENCY OF ALGEBRAIC CONCEPTS ACCORDING TO TEXTBOOKS, AND THORNDIKE-LORGE'S RATINGS OF CONCEPTS

CONCEPTS	I	II	III	IV	V	VI	VII	VIII	Thorndike Lorge Placement
width	103	63	99	78	71	145	71	63	28
X-axis	5	3	10	3	4	9	16	15	
Y-axis	3	3	4	2	4	11	16	11	
zero	21	24	38	22	50	67	33	50	11
=	4417	5954	4533	3156	3490	5637	4560	4226	
+	5055	3869	3973	3092	5175	10013	4227	3293	
±	26	46	39	12	33	27	37	55	
√	7581	5025	3752	4929	4818	8538	5792	5266	
.	998	611	558	621	545	1199	528	851	
≡	369	117	214	51	140	560	189	502	
	1			344	2				

In Table II the words marked with c in the first column are also found in Cole's list of algebraic concepts.

In the other four columns are numbers giving the number of occurrences in approximately 4½ millions of words of (T) the Thorndike general count of 1931, (L) the Lorge magazine count, (J) the Thorndike count of 120 juvenile books, and (S) the Lorge-Thorndike semantic count. The numbers under T are computations from the Thorndike 1931 data. An M in the T column means that the word was one of the 500 commonest by the Thorndike count, and occurred 800 to 100,000 or more times per 4½ million words. An M in the L column means that the word occurred 1,000 times or more in the Lorge magazine

count. An M in the J column means that the word occurred 1,000 times or more in the count of 120 juvenile books. An M* in the J column means that the word probably occurred 1,000 times or more in the count of 120 juvenile books. M and M* in the S column mean that the word had 1,000 or more occurrences in the semantic count, surely (M) or by estimate (M*).

The starred numbers in the J column are estimates. Other starred numbers are also estimates. A question mark in the T, L, J, or S column means that for some special reason no reliable estimate could be made for the count in question.

Regular plurals, comparatives and superlatives, verb forms in s, d, ed, and ing, past participles formed by adding n, are ordinarily counted in under the main word.

TABLE II

THORNDIKE AND LORGE'S RATINGS OF THE ALGEBRAIC CONCEPTS, AND A COMPARISON WITH COLE'S LIST

CONCEPTS	Cole's	T	L	J	S
abscissa	c				
addition	c	240	245	240*	405
additional		88*	106	27	239
algebra					
algebraic	c				
altitude	c	57	53	20	106
amount	c	700	662	700*	996
angle	c	113	158	94	189
area	c	220	215	220*	635
ascending		210	21	210	90
ascending order	c				
average	c	210	519	210*	720
axiom		8	4	0	8
axis		57	4	31	85
base	c	430	337	430*	627
binomial	c				
biquadratic					
braces		100	98	77	39
bracket	c	28	41	8	28
cancel	c	50	43	1	50
cases	c	M	912	M*	M
characteristic		90	151	97	305
circle	c	700	388	379*	369
circular		130	71	66	120
circumference	c	50	8	17	37
clear of fractions	c				
coefficient	c	5	0	0	13
collect	c	260	233	260*	363
common denominator	c				
compass		245	35	129*	107
computation		14	3	0	16
compute		50	18	7	23
conditional (equation)		16	3	2	17
consecutive	c	18	15	2	31
constant	c	190*	212	190*	301
contain	c	700	373	700*	M
coordinate		28	19	0	35
cosine					
correction		57	32	10	38
cube	c	90	58	13	10
cubic		57	19	11	71
degree	c	380	391	380*	834
denominator	c				

TABLE II (Continued)

THORNDIKE AND LORGE'S RATINGS OF THE ALGEBRAIC CONCEPTS, AND A COMPARISON WITH COLE'S LIST

CONCEPTS	COLE'S	T	L	J	S
descending		280	166	223*	224
descending order	c				
diameter	c	50	36	92	135
dimension	c	57	30	28	77
distance	c	700	370	700*	753
divide	c	700	194	468*	509
dividend		57	0	3	75
division		230	141	230*	460
divisor					
eliminate	c	57	117	5	147
equal	c	494	300	494*	504
equation		50	7	2	26
equilateral					
equivalent		57	59	6	98
evaluate		4	6	0	8
exceed	c	110*	59	110*	190
expand	c	57	80	61	82
exponent	c	12	4	1	24
expression	c	90	412	157	363
extract	c	90	68	44	97
extremes	c	135	143	135*	276
factor	c	57	99	19	470
factorable	c				
factoring	c				
figure	c	700	M	700*	M
formula	c	50	59	5	92
fraction	c	90	36	30	70
fractional		10	3	3	3
function		90	165	27	368
functional		6	4	0	11
graph	c				
graphing					
height	c	700	284	550*	407
horizontal		42	38	35	61
hyperbola					
hypotenuse	c				
identity		14	40	7	53
imaginary	c	57	65	42	46
inconsistent		28	8	4	27
independent		204	134	204*	585
indeterminate		18	6	1	2
index		57	58	10	130
interpolate					

TABLE II (Continued)

THORNDIKE AND LORGE'S RATINGS OF THE ALGEBRAIC CONCEPTS, AND A COMPARISON WITH COLE'S LIST

CONCEPTS	COLE'S	T	L	J	S
interpolation					
interpret		90	50	32	110
interpretation		57	44	10	78
intersect		14	3	10	23
invert	c	57	20	13	49
irrational		16	9	2	2
length	c	M	328	?	620
less	c	M	M	M	M
linear	c	6	0	4	16
literal		10	10	5	13
logarithm					
mantissa					
means	c	M	M	M	M
measure	c	M	184	530*	876
median		12	2	1	26
members	c	700	666	700*	M
minuend					
minus	c	18	14	3	9
(modal or) mode		160	83	33	132
monomial	c				
multiplicand					
multiplication	c	57	9	10	18
multiplier					
multiply		200	45	108*	80
negative	c	57	28	5	98
numerator	c				
numerical	c	14	8	2	12
ordinate	c				
origin	c	90	62	75	278
parabola		10	1	5	3
parenthesis	c				
per cent	c	57	315	19	M
perimeter	c				
plot	c	220	128	164*	145
plus	c	50	70	2	63
polynomial	c				
positive	c	52	92	18	111
power	c	M*	911	M*	M
prime		130	65	51	74
prime factor	c				
product	c	280	353	280*	709
proportion	c	200	197	200*	387

TABLE II (Continued)

THORNDIKE AND LORGE'S RATINGS OF THE ALGEBRAIC CONCEPTS AND A COMPARISON WITH COLE'S LIST

CONCEPTS	COLE'S	T	L	J	S
proportional		8	10	2	36
protractor					
quadratic					
quadric equation	c				
quantity	c	360	184	360*	394
quotient	c	28	2	0	4
radical	c	53	51	3	193
radicand					
radius	c	50	17	11	32
rate	c	410	388	410*	686
ratio	c	57	14	4	133
rational		28	33	9	50
rationalizing					
reciprocal		28	6	4	29
reduce	c	240	285	240*	502
reduction		90	56	6	214
remainder	c	160	42	42	73
respective		44	19	23	60
respectively	c	46	12	12	89
resultant		10	15	2	23
root	c	410	227	410*	306
sign	c	700	865	700*	765
signed					
similar		142	264	183	681
simple (equation)	c	700	906	700*	721
simplify	c	28	51	8	19
simultaneous (equation)	c	8	7	6	13
sine		6	2	0	13
solution		90	166	51	258
square	c	700	573	626*	552
squaring					
squarw root	c				
statistical		10	30	0	24
statistics		28	56	8	116
(sub) subscript					
substitute	c	130	155	49	201
substitution		8	17	3	50
subtract	c	57	6	1	14
subtraction		14	2	1	6
subtrahend					
sum	c	400	289	400*	462
surd					

TABLE II (Continued)

THORNDIKE AND LORGE'S RATINGS OF THE ALGEBRAIC CONCEPTS AND A COMPARISON WITH COLE'S LIST

CONCEPTS	COLE'S	T	L	J	S
symbol	c	115	94	27	85
tabular (difference)		11	0	1	10
tabulate		18	12	2	17
tangent		8	4	2	21
term	c	340	442	340*	948
times	c	M	M	M	M
total	c	290	277	290*	782
transform		90	77	54	91
transformation		50	23	28	40
transpose	c	16	1	0	6
transposition					
triangle	c	57	38	30	26
trinomial	c				
unit	c	57	165	4	304
unknown	c	245	207	228*	232
variable	c	50	8	6	42
variation		18	84	30	129
vector					
vertical	c	47	24	29	95
vinculum					
volume	c	240	211	240*	773
weight	c	700	357	517*	494
width	c	235	65	129*	86
X-axis	c				
Y-axis	c				
zero	c	90	50	16	49
=	c				
+	c				
±	c				
−	c				
√	c				
.	c				

The most important use of Table II by a teacher is in guiding his or her treatment of the words that occur in the readers, supplementary readers, textbooks, and other material to be read by a class. A teacher should decide, concerning

many words which occur in books or articles to be read by the class, whether to have the class learn the word well enough so that the ability to know the sound and the important meaning or meanings of the word when they see it will be a permanent part of their stock of word knowledge, or merely to inform them of its meaning temporarily so that they can understand and enjoy the reading matter in which it occurs. The list tells anyone who wishes to know whether to use a word in writing, speaking, or teaching how common the word is in standard English reading matter.

The Level of Difficulty of the Concepts

The following table shows the number of words which are rated in the vocabulary study by Thorndike-Lorge. It also gives the number of words rated below the 8500 word level and from this data it is possible to find the per cent of words that Thorndike would list as too difficult for the ninth-grade.

TABLE III

THE PERCENT OF ALGEBRAIC CONCEPTS WHICH APPEAR ABOVE THE THORNDIKE-LORGE 8500 WORD LEVEL

	Textbooks							
	I	II	III	IV	V	VI	VII	VIII
Number of concepts	184	165	177	175	183	165	169	170
Concepts rated	155	132	146	146	153	137	151	145
Below 8500 word level	109	89	96	95	97	92	103	97
Per cent above 8500 word level	29.7	32.6	34.2	34.9	36.6	32.8	31.8	33.1

The per cent of concepts above the 8500 word level varies from 29.7 to 36.6 in the textbooks studied. Although this variation is not great, the fact that from 29 to 37 per cent of the algebraic concepts used in an average elementary textbook are too difficult for the grade may prove quite serious. Certain technical words must be introduced in order to acquaint the pupil with the terminology used in the fundamental processes of algebra. According to this survey these words constitute about one-third of the technical vocabulary.

The Frequencies of the Different Concepts

The number of times which a word must be used before it will become a part of the pupil's permanent vocabulary has not been scientifically determined. A great deal depends on the individual differences of the pupils. Some pupils acquire a new word the first time they come in contact with it; while other pupils need to come in contact with the same word countless times before they acquire the correct use of it. Then too, the place the word appears in the textbook, and the frequency make a great deal of difference. A word may appear quite frequently in one chapter and from then on it may be seldom, if ever, used again. Then too, it makes a difference how the word is used in the textbook and whether or not the teacher explains it.

In Table IV, the concepts occurring only once, two to five times, six to nine times, ten to nineteen times, and those occurring more than twenty times, have been tabulated. The percentages for each of the above frequencies have been calculated and are given in Table V.

TABLE IV

NUMBER AND FREQUENCY OF DIFFERENT CONCEPTS USED IN EACH OF THE EIGHT ELEMENTARY ALGEBRA TEXTBOOKS

Text-book	Frequency 1	2-5	6-9	10-19	20 or more	Number of different concepts
I	5	21	16	21	121	184
II	8	22	18	22	105	165
III	11	20	15	17	114	177
IV	7	27	18	21	102	175
V	13	30	11	17	112	183
VI	4	15	13	27	106	165
VII	8	19	8	26	108	169
VIII	12	21	6	25	106	170

TABLE V

THE PERCENTAGE FOR EACH FREQUENCY OF DIFFERENT CONCEPTS USED IN EACH OF THE EIGHT ELEMENTARY ALGEBRA BOOKS

Text-book	Frequency 1	2-5	6-9	10-19	20 or more
I	2.7	11.4	8.7	11.4	65.8
II	4.8	13.3	10.9	13.3	57.7
III	6.2	11.3	8.5	9.6	64.4
IV	4.0	15.4	10.3	12.0	58.3
V	7.1	16.4	6.0	9.3	61.2
VI	2.4	9.1	7.9	16.4	64.2
VII	4.8	11.2	4.8	15.4	63.8
VIII	7.1	12.4	3.5	14.7	62.3

Words used less than twenty times account for 34.2 per cent to 42.3 per cent, and words used only once account for 2.4 per cent to 7.1 per cent of the total algebraic concepts used by the eight books.

The Distribution of Concepts Used By the Different Textbooks

Table VI indicates how widely the various algebraic concepts are used by the different authors. It also gives the total number of times each concept is used by the eight textbooks.

TABLE VI

THE NUMBER OF BOOKS IN WHICH THE ALGEBRAIC CONCEPTS APPEARS AND THE TOTAL NUMBER OF TIMES EACH CONCEPT IS USED BY THE EIGHT TEXTBOOKS

CONCEPT	Number of Books	Total Frequency
abscissa	6	30
addition	8	498
additional	8	86
algebra	8	494
algebraic	8	520
altitude	8	355
amount	8	500
angle	8	2038
area	8	1539
ascending	6	16
ascending order	3	3
average	8	549
axiom	5	76
axis	8	190

TABLE VI (COntinued)

THE NUMBER OF BOOKS IN WHICH THE ALGEBRAIC CONCEPTS APPEARS AND THE TOTAL NUMBER OF TIMES EACH CONCEPT IS USED BY THE EIGHT TEXTBOOKS

CONCEPT	Number of Books	Total Frequency
base	8	704
binomial	8	264
biquadratic	2	4
braces	3	39
bracket	4	28
cancel	3	39
cases	8	486
characteristic	1	20
circle	8	479
circular	8	87
circumference	8	175
clear of fractions	7	48
coefficient	8	372
collect	8	82
common denominator	8	62
compass	5	29
computation	6	38
compute	7	43
conditional equation	3	24
consecutive	8	171
constant	8	142
contain	8	91
coordinate	8	140
cosine	8	328
correction	1	1
cube	8	290
cubic	8	206
degree	8	591
denominator	8	719
descending	5	16
descending order	3	5
diameter	8	212
dimension	8	425
distance	8	940
divide	8	1454
dividend	8	127
division	8	489
divisor	8	1922
eliminate	8	251
equal	8	1477
equation	8	4263

TABLE VI (Continued)

THE NUMBER OF BOOKS IN WHICH THE ALGEBRAIC CONCEPTS APPEARS AND THE TOTAL NUMBER OF TIMES EACH CONCEPT IS USED BY THE EIGHT TEXTBOOKS

CONCEPT	Number of Books	Total Frequency
equilateral	8	81
equivalent	5	62
evaluate	7	277
exceed	8	150
expand	3	28
exponent	8	393
expression	8	1071
extract	5	42
extremes	7	31
factor	8	1285
factorable	4	30
factoring	8	283
figure	8	1702
formula	8	2768
fraction	8	1624
fractional	8	210
function	5	153
functional	2	14
graph	8	1683
graphing	1	7
height	8	567
horizontal	8	213
hyperbola	2	3
hypotenuse	8	184
identity	6	45
imaginary	7	17
inconsistent	4	8
independent	7	23
indeterminate	5	15
index	6	34
interpolate	7	11
interpolation	6	17
interpret	8	32
interpretation	5	14
intersect	6	26
invert	7	29
irrational	7	44
length	8	1341
less	8	447
linear	8	376
literal	8	292
logarithm	5	161

TABLE VI (Continued)

THE NUMBER OF BOOKS IN WHICH THE ALGEBRAIC CONCEPTS APPEARS AND THE TOTAL NUMBER OF TIMES EACH CONCEPT IS USED BY THE EIGHT TEXTBOOKS

CONCEPTS	Number of Books	Total Frequency
mantissa	1	44
means	8	269
measure	8	556
median	5	52
members	8	597
minuend	7	51
minus	8	181
modal or mode	5	25
monomial	8	342
multiplicand	5	20
multiplication	8	577
multiplier	7	37
multiply	8	1589
negative	8	497
numerator	8	449
numerical	8	200
ordinate	6	28
origin	8	56
parabola	6	23
parenthesis	8	394
per cent	8	319
perimeter	8	562
plot	8	143
plus	8	294
polynomial	8	374
positive	8	459
power	8	339
prime	7	35
prime factor	8	100
product	8	1243
proportion	8	249
proportional	7	130
protractor	8	77
quadratic	8	169
quadratic equation	8	268
quantity	8	459
quotient	8	456
radical	8	394
radicand	5	52
radius	8	279
rate	8	1009

TABLE VI (Continued)

THE NUMBER OF BOOKS IN WHICH THE ALGEBRAIC CONCEPTS APPEARS AND THE TOTAL NUMBER OF TIMES EACH CONCEPT IS USED BY THE EIGHT TEXTBOOKS

CONCEPTS	Number of Books	Total Frequency
ratio	8	674
rational	6	35
rationalizing	5	37
reciprocal	8	41
reduce	8	319
reduction	6	11
remainder	8	290
respective	3	5
respectively	8	100
resultant	1	4
root	8	604
sign	8	886
signed	8	394
similar	7	155
simple equation	5	16
simplify	8	349
simultaneous equation	8	45
sine	8	382
solution	8	1361
square	8	2384
squaring	7	22
square root	8	714
statistical	5	15
statistics	7	24
(sub) subscript	4	11
substitute	8	447
substitution	8	147
subtract	8	1026
subtraction	8	413
subtrahend	7	65
sum	8	1720
surd	2	7
symbol	8	379
tabular difference	1	3
tabulate	3	13
tangent	8	452
term	8	2097
times	8	1351
total	8	512
transform	4	35
transformation	3	17

TABLE VI (Continued)

THE NUMBER OF BOOKS IN WHICH THE ALGEBRAIC CONCEPTS APPEARS AND THE TOTAL NUMBER OF TIMES EACH CONCEPT IS USED BY THE EIGHT TEXTBOOKS

CONCEPTS	Number of Books	Total Frequency
transpose	6	77
transposition	4	26
triangle	8	1276
trinomial	8	277
unit	8	553
unknown	8	654
variable	8	184
variation	7	134
vector	1	11
vertical	8	230
vinculum	2	2
volume	8	356
weight	8	541
width	8	693
X-axis	8	65
Y-axis	8	54
zero	8	305
=	8	35,973
+	8	38,697
±	8	275
−	8	45,701
√	8	5,911
·	8	2,142
≡	3	347

This table shows that there is a wide variation in the different concepts used by the different authors. Of the total 203 concepts, 128, or 63.1 per cent, are common to all eight textbooks.

The ten words used the greatest number of times by the eight authors rank as follows: equation (4263); formula(2768); square (2384); term (2097); angle (2038); sum (1720);

figure (1702); graph (1683); fraction (1624); and multiply (1589). Of the signs checked, the minus sign occurred the greatest number of times, occuring 45,701 times in the eight textbooks.

It is sometimes desirable to compare one textbook with another in order to determine the algebraic concepts common to both books. Table VII gives this information for the eight textbooks studied.

TABLE VII

NUMBER OF WORDS COMMON TO ANY TWO TEXTBOOKS

Textbook	I	II	III	IV	V	VI	VII	VIII
I	...	155	157	170	169	155	161	156
II	...	...	154	151	155	147	149	147
III	...	...	...	162	167	158	159	155
IV	...	...	...	...	166	151	158	153
V	...	...	...	...	...	154	165	159
VI	...	...	...	...	...	...	154	145
VII	...	...	...	...	...	...	...	154
VIII	...	...	...	...	...	...	...	...
Number of different concepts	184	165	177	175	183	165	169	170

CHAPTER 4

CONCLUSIONS

The following conclusions may be drawn:

The algebraic vocabularies used in the average elementary algebra textbook are rather difficult for the attainment of the grade. The findings show that 29.7 per cent to 36.6 per cent of the algebraic concepts used are above the 8500 word level, or the ninth grade level of attainment as rated by Thorndike-Lorge.

It is also questionable if the different algebraic concepts are used a sufficient number of times to become a permanent part of the pupil's vocabulary. Words used only once constitute from 2 per cent to 7 per cent of the total number of concepts studied. This is not bad. Words used less than twenty times account for 34.2 to 42.3 per cent of the total. It is known that the learning process could be facilitated if the words occurred a greater number of times, although the exact number of times a word should be repeated to assure meaning is unknown. Since some words are used hundreds of times, and other words are used only a few times, it would be reasonable to assume that an algebra book would become a more efficient tool of learning if all the words used were more evenly distributed as far as frequency is concerned.

There is also a wide variation in the different words used by the different authors. Of the total of 202 algebraic concepts used in this study, only 129, or 63.8 per cent, were used by all the textbooks. These are shown in Appendix A. The concepts appearing the greatest number of times in the eight textbooks were "equation", "formula", "square", "term", "angle", "sum", "figure", "graph", "fraction", and "multiply".

The teaching of algebra is difficult. The pupil must be taught not only words, but also combinations of words, and terms. The learning process becomes still more complex when one considers the technical vocabulary which has to be introduced in algebra. It would be logical to assume that the algebraic vocabularies should be more scientifically constructed in order to facilitate the learning process. A scientific vocabulary construction is principally a vocabulary which would be made up of words occurring a sufficient number of times to become a permanent part of the pupil's vocabulary. Difficult words that must be used should be thoroughly mastered before the pupil attempts to solve the problems.

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APPENDIX A

THE ALGEBRAIC CONCEPTS COMMON TO THE TEXTBOOKS

addition
additional
algebra
algebraic
altitude
amount
angle
area
average
axis
base
binomial
cases
circle
circular
circumference
coefficient
collect
common denominator
consecutive
constant
contain
coordinate
cosine
cube
cubic
degree
denominator
diameter
dimension
distance
divide
dividend
division
divisor
eliminate
equal
equation
equilateral
exceed
exponent
expression
factor
factoring
figure
formula
fraction
fractional
graph
height
horizontal
hypotenuse
interpret
length
less
linear
literal
means
measure
members
minus
monomial
multiplication
multiply
negative
numerator
numerical
origin
parenthesis
per cent
perimeter
plot
plus
polynomial
positive
power
prime factor
product
proportion
protractor
quadratic
quadratic equation
quantity
quotient
radical
radius
rate
ratio
reciprocal
reduce
remainder
respectively
root
sign
signed
simplify
simultaneous equation
sine
solution
square
square root
substitute
substitution
subtract
subtraction
sum
symbol
tangent
term
times
total
triangle
trinomial
unit
unknown
variable
vertical
volume
weight
width
X-axis
Y-axis
zero

Signs

$=$ (equal)
$+$ (plus)
$\pm$ (plus or minus)
$-$ (minus)
$\sqrt{\ }$ (radical sign)
$\cdot$ (times)

LIST OF WORDS ABOVE THE THORNDIKE-LORGE 8500 WORD LEVEL

algebraic
binomial
cosine
denominator
divisor
equilateral
graph
hyperbola
hypotenuse
interpolate
interpolation
logarithm
multiplier
numerator
ordinate
parenthesis
perimeter
protractor
quadratic
rationalizing
transportation
vector