READING DIFFICULTY OF SCIENCE TEXTS:
READING DIFFICULTY OF THE CALIFORNIA STATE-ADOPTED
SCIENCE TEXTS, GRADES I TO III, AS
DETERMINED BY THE SPACHE FORMULA

by
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CHAPTER I

THE PROBLEM AND DEFINITIONS OF TERMS USED

Introduction. The selection of books with a difficulty level appropriate for the reading abilities of the child is a recurring problem for parents, teachers, and librarians. The readability of the material, or in other words, the degree of comprehensibility must constantly be matched to the reading abilities of the child. The child should benefit from the consistent and orderly development of reading abilities when he moves toward levels of increasing difficulty in the material he reads.

Inexperienced teachers and parents are prone to depend upon the publisher's grade level designations in determining the probable difficulty of a book. Many textbook commissions and committees despite the wholesale nature of their purchases obviously regard the publishers' statements as unquestionable. Undoubtedly these grade level designations are made in good faith and are as correct as trained opinion will permit. Furthermore, the accuracy of publishers' judgments is reasonable and constantly improving when compared with more objective methods of estimation. However, the fact remains that both elementary and secondary teachers are constantly complaining that the textbooks given them are often obviously misgraded and inappropriate for their particular pupils.

Readability studies of school textbooks have substantiated previous research findings that the reading difficulty levels vary.


Ibid., p. 22.
greatly among books of the same series. In 1947, Gholston concluded that science texts do not conform highly to the grades to which they are assigned.\(^3\) In 1957, Mallinson, Sturm, and Mallinson concluded that recently published science texts were difficult to read.\(^4\) In 1961, Denslow concluded that the author's or publisher's grade designation does not present an accurate picture of the vocabulary and sentence difficulty of a text.\(^5\)

What meaning does this have for the elementary classroom teacher? In Spache's opinion, there are distinct values to be gained from readability studies. Spache stated:

When the teacher is doubtful about the accuracy of the publisher's grade level designations, or the texts seem inappropriate for her pupils, formulas provide a quick basis for reevaluation.\(^6\)

I. THE PROBLEM

Statement of the problem. It was the purpose of this study (1) to measure the reading difficulty of the California state-adopted science texts for grades I to III; (2) to use the Spache readability formula to

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\(^6\)Spache, op. cit., p. 24. This study was limited to applying only the Spache formula to the science texts to determine reading difficulty. The formula estimates the first approximation of the text difficulty.
determine this reading difficulty; (3) and to study the reading difficulty factors of vocabulary and sentence length found in each text.

**Importance of the study.** To secure a consistent development of reading abilities, the elementary-school pupil needs to move through the grade-levels of increasing difficulty in the material he reads. This principle has been understood for a long time and applies to all reading material that the child encounters. Careful efforts have been made to provide graded materials of various levels of difficulty for the child in the field of reading, but there is a lack of graded material in other areas. Too often, one sees all the children in the same primary grade using the same book for science, geography, history, or spelling.

The California state-adopted science texts for grades I to III are all designated for a specific grade level, but not all the texts have a reading difficulty measurement. Do the state-adopted science texts in first grade have a reading difficulty measurement of 1.2, pre-primer level; or 1.5, primer level; or 1.8, first reader level? What reading difficulty levels are to be found in the second and third grade texts? What is the range of difficulty of each text? What is the vocabulary burden and the sentence difficulty in these texts?

At the present time there is no study available to show the reading difficulty of the California state-adopted science texts for grades I to III as measured by the Spache readability formula.

**Limitations of the study.** This study was limited to applying only the Spache formula to the science texts to determine reading difficulty. The formula estimates the first approximation of the text difficulty.
This estimate indicates the average reading ability needed for adequate comprehension of each text. It is assumed that the samples chosen will well represent the difficulty of the vocabulary of each text and will represent the difficulty of the sentence encumbrance of each text. It was assumed that the science tests in grades 1 to 11, that were adopted by the California State Board of Education and were in use in the public schools of each text, but will give only a representation of the difficulty of the science words to be found in that text. No attempt was made to prove that all readers of a certain reading ability would enjoy a science text. No attempt was made to show the difficulty of content or the science concepts in each text. No attempt was made to predict difficulty subjective and objective measurements, the previous studies of science encountered by a child's non-interest in the science material.

II. DEFINITIONS OF TERMS USED

Reading difficulty. Reading difficulty was interpreted as the estimate of difficulty of a science text as shown by a grade placement level on Spache's computation table. The Spache readability formula. The complete formula is: the grade placement level of a text equals .141 times the average sentence length per 100 words, plus .086 times the per cent of hard words, plus a constant of .839. In this study a computation table was used which eliminated all of the computations except those determining the average sentence length. The Spache formula was standardized by the analysis

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7 Ibid., p. 118.
8 Ibid., p. 113.
9 Ibid., p. 118.
of primary reading materials and is valid only when used to appraise materials appropriate for primary levels.\textsuperscript{10}

**California state-adopted science texts.** This term was interpreted to mean the science texts in grades I to III, that were adopted by the California State Board of Education and were in use in the public schools of California as of December, 1963.

**III. ORGANIZATION OF THE REMAINDER OF THE THESIS**

Chapter II considers the review of the literature concerned with subjective and objective measurements, the previous studies of science texts, the Spache readability formula, and the California state-adopted science texts for grades I to III. Chapter III is concerned with the application of the Spache formula to the science texts. The results of the study are given in Chapter IV. Chapter V presents the summary and conclusions of the study.

\textsuperscript{10}Ibid., p. 119.
CHAPTER II
REVIEW OF THE LITERATURE

The interested researcher can discover many articles written about the use of readability i.e. reading difficulty formulas in education, about the Spache formula which estimates primary-level reading material, and about the reading level of various science books for children. The material reviewed in this chapter highlights the following points that are related to the study: (1) the teacher’s job of matching the reading difficulty of a text to the level of the child's reading ability; (2) the adequacy of subjective measurement in determining the reading difficulty of a text; (3) the adequacy of objective measurement in determining the reading difficulty of a text; (4) the development of the Spache readability formula; (5) results of other readability studies of science texts; and, (6) the present reading difficulty measurements of the California state-adopted science texts for grades I to III.

The need to determine the reading difficulty of a text. The teacher in the elementary classroom of the sixties faces the problem and the principle of individualized teaching. When the teacher examines the "how" of individualized teaching, then the teacher realizes the need for matching the reading material to the child's reading ability level. This principle of "the right book for each child" is stressed mainly in the area of reading, but concerned teachers know that this principle should be followed in any content area of the elementary classroom.

When the teacher encourages a child to do independent reading in a content area, such as science, too often the teacher finds a lack of
measured material in the school. Upon what basis then, does the teacher match the science material to the reading ability of the child? The teacher has the means to determine the child's ability to read. The teacher has a wide variety of science books from which to choose. Certainly, the teacher can use her good judgment to choose a book for a child. The librarian can help the child choose a book. There are book lists and catalogues which give information regarding the reading level. The teacher's manual often gives information on the difficulty of a text. Are these measurements adequate? The judgments of the teacher and librarian are based on opinion. The book lists and catalogues give un-enlightening statements such as "for the ages six to nine." The teacher's manuals are sometimes limited in their information when a statement similar to "this book may be read by a superior group in the fall." is made. Should the teacher depend upon these methods of measurement to determine the reading difficulty of texts?

LITERATURE ON SUBJECTIVE MEASUREMENT

Adequacy of subjective measurement. Are methods of subjective measurement adequate?

The most common and the earliest method of determining the reading difficulty of a text was by the method of subjectiveness that was based on trained opinion and experienced judgment. Hildreth observed that, "The idea of gradation in a series of texts for school

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reading instruction was first introduced in the McGuffey readers. The selections were assigned to lower or higher levels largely on the basis of the author's judgment.\textsuperscript{2}

Spache pointed out the inadequacy of subjective measurement when he stated:

> When the pooled judgments of experts are compared, as in various book lists and catalogs, we find wide variations in estimates from the average opinion. Experts are not highly successful in identifying the exact importance of literary factors to the adult or child reader. These subjective means of estimating readability have been and will continue to be extremely useful. But they lack a known point of reference against which intuition and judgment can be compared. Their estimates must be approximate and lacking in fine discriminations, as between successive ages of readers. For these reasons, many will continue to seek methods of estimation that are apparently more exact and objective.\textsuperscript{3}

Chall observed that, "The failure of expert judgment to predict difficulty gave rise in the early 1920's to the search for effective means of grading materials."\textsuperscript{4}

It has often been assumed that "a good teacher" can evaluate the reading difficulty level of a text.\textsuperscript{5} Harrington and Mallinson conducted a study to determine if the measurements made with readability formulas were


\textsuperscript{4}Jeanne S. Chall, "The Measurement of Readability," Education Digest, XXI (November, 1955), 44.

of the reading difficulty of certain elementary science texts' passages were more consistent than estimates made by reading experts on the reading difficulty of these same passages.

The data obtained by the study indicated that:

1. In none of the one hundred and ninety-nine samples did the reading experts agree completely with respect to the grade level of difficulty. However, in twenty of the samples the readability formulas gave the same measurement of reading difficulty.

2. In forty-nine of the sample passages the formulas measurements differed by only .5 of a grade level. In none of the samples did the estimates of the reading experts differ with a range as close as only .5 of a grade level.

3. The measurements by formulas differed by four grade levels in one sample analyzed as compared with thirty-seven samples in which the estimates of reading experts differed by four grade levels.

4. There was no great difference in the consistency of measurement by formulas at various grade levels.

5. There is a great extent of difference between the consistency with which the reading experts evaluated the grade level of reading difficulty of the samples and the consistency with which the reading experts evaluated the grade level of these same samples.

Mallinson and Harrington concluded that: "the readability formulas do measure grade levels of reading difficulty of science materials more consistently than the estimates of reading experts."

Mallinson and Harrington recommended that:

In view of the need which has been expressed for evaluation of reading materials as to grade level of difficulty, and in view of the lack of consistency in the estimates of grade level of difficulty of reading materials by experts, it seems desirable that

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7. Ibid., p. 390.
a more reliable technique should be used to evaluate materials as to their suitability with respect to this criterion. It must be remembered that the estimates of grade level of difficulty used in this study were the estimates by reading experts in large school systems, not the estimates of average classroom teachers. Teachers might not do as well. It appears therefore, that all teachers should have some method of evaluating materials as to reading difficulty which is more objective than their estimates.8

Hunnicutt and Iverson emphasized the inadequacy of subjective measurement and stated:

Until recently, individual opinion has been the only appraisal mechanism available. Authors made estimates, librarians made estimates, teachers made estimates and readers made estimates, and, of course, all were different.9

There is no research available at the present time which indicates that a teacher, trained over a period of years, could be consistently objective and accurate in estimating the grade level or reading difficulty of any reading materials.

The literature reviewed up to this point supports the view that subjective measurement of reading materials is inadequate for measuring the reading difficulty of texts because it falls short of the refinement that is needed for determining fine levels of reading difficulty. Subjective measurement is too variable. Subjective measurement lacks a known point of reference against which judgment can be compared. Subjective measurement can be considered only as the opinion of a person.

But much progress has been made in improving the readability formulas and in adjusting them to the abilities of the children. My studies of readability and those of my students show that books are somewhat easier in spots than in the 10

8Ibid.


LITERATURE ON OBJECTIVE MEASUREMENT

The need for objective measurement of texts. The inadequacy of subjective measurement shows the need for objective measurement for determining the levels of reading difficulty of a text. Inaccurate reading difficulty predictions support the view that subjective measurement is inadequate. Spache reviewed this and observed that:

On the other hand, false predictions of the readability of books are available everywhere. We see children's books which fail to sell, school textbooks which cannot be read at the grade levels for which they are designated, materials offered for public information that only the specialist could read, and efforts at communication such as letters, announcements and bulletins that, literally speaking, no one can understand.¹⁰

The need for use of objective measurement in determining the reading difficulty of texts is strengthened by Dolch when he stated:

We must also emphasize that children of any certain grade vary within the particular room, grades vary between schools in the same city, and grades vary between cities in different parts of the country. . . .

Certain fourth grade children may need a book that conforms to third grade standards and other fourth grade children may need a book that conforms to fifth grade standards. This problem of adaption of material is entirely apart from the tendencies in published readers.¹¹

Yoakum referred to a need for objective measurement of texts in this manner:

Not much progress has been made in improving the readability of textbooks and in adjusting them to the abilities of the children. My studies of readability and those of my students show that textbooks are somewhat easier in spots than in the 1930's but that many books are still over-graded and are bound to be very difficult for average or slow-learning children. And,

¹⁰Spache, op. cit., p. 21.
sad to say, we have not made notable progress in teaching children how to read and use school textbooks in the days since reading dominated the scene. There still remains to be solved the problem of how to select, organize and use books with children so that the individual child may find meaning in the study of subjects in the content fields.12

From the observations of these authors, the interested educator will realize that there is a definite need for objective measurement to be used in determining the reading difficulty of school textbooks.

Using formulas. Why use formulas as the objective measurement for determining the reading difficulty of a text? There are distinct values in the formula approach. Spache observed that:

Readability formulas are needed when finer discriminations of the probable reading difficulty are sought, as in providing reading materials for young children and for poor readers particularly. Teachers need and want materials which apparently differ by small degrees of difficulty when dealing with pupils of lesser reading skill.

When books have not been evaluated by expert opinion or other methods, as in the case of new trade books, or when a variety of books lists is not available to the teacher, then readability formulas are of immediate, practical service. When the teacher is doubtful about the accuracy of the publisher's grade level designations, or the tests seem inappropriate for her pupils, formulas provide a quick basis for re-evaluation. For the estimation of reading difficulty of such publications as bulletins, pamphlets, newspapers, and other magazines for which estimates are not commonly available from other sources, the appropriate formulas are essential.13

Chall, in her report on research in the field of readability, noted that readability studies began as early as 1923.14 Lively

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and Pressey conducted one of the earliest studies on textbook vocabulary.\textsuperscript{15}

Evidence is present to show that formulas are being used and to good advantage. In 1958, Chall reviewed the research on readability and the various applications of readability measurements.\textsuperscript{16} She described how measurements of readability have been applied to subject-matter texts, reading texts, juvenile and adult literature, encyclopedias, pamphlets of various kinds including the government publications, newspapers, publications of health and welfare organizations such as the National Tuberculosis Association, industry and public relations communications, tests and questionnaires and comic books.

There is an indication that formulas are being used to make texts more readable for children. Yoakum observed that:

While the readability formulas are far from perfect, they are able to measure sequences of materials of increasing difficulty with considerable reliability. The use of these measures to improve the readability for materials for children of different reading levels promised to work more changes in the development of instructional materials for children. Already books of high interest to slow learners, but of easy readability levels, are available to make the task of teaching the retarded learner easier.\textsuperscript{17}

The concept of readability can be utilized by the teacher in the elementary classroom. Hildreth summarized the uses of basic principles of readability and stated that:

\begin{itemize}
\item \textsuperscript{15}Bertha A. Lively and S. L. Pressey, "A Method for Measuring 'Vocabulary Burden' of Textbooks," \textit{Educational Administration and Supervision}, IX (October, 1925), 589-593.
\item \textsuperscript{16}Chall, \textit{op. cit.}, pp. 113-52.
\item \textsuperscript{17}Yoakum, \textit{op. cit.}, p. 429.
\end{itemize}
The teacher who has the basic principles in mind is in a better position to make informal judgments of the suitability of materials for a particular grade or an individual pupil, and to construct readable materials for them.

Another use of the readability principles is found in choosing materials to be read aloud to children and in preparing talks for children. Teachers find knowledge of readability principles useful in editing charts and experience records at all grade levels and in modifying and re-writing reading materials for slower learners.

The observations of these authors support the view that readability formulas are extremely useful.

**Limitations of readability formulas.** Spache discussed the limitations of formulas and stated:

They do not reflect conceptual difficulties caused by varied contextual meanings of words, idiomatic expressions or the ratio of abstract and concrete terms. No formula in current use accomplishes this type of distinction although several have attempted it. Secondly, the formulas do not evaluate the organizational character of materials, the manner of presentation or the degree of explanation. This is an important element in readability as many of those who have attempted to simplify reading materials have discovered. Mechanically shortening sentences or eliminating hard words because these elements are present in most readability formulas does not produce the desired effect. Unless organization is also improved and explanation increased, the simplified material is not more widely read or better understood. But this element does not lend itself to mathematical evaluation and cannot be evaluated by current techniques.

Readability formulas do not reflect the difficulty of the content of the reading material. Nor, obviously, can the formula predict the reader's interest in the content. But neither can any other method of estimating readability guess what the individual reader's reactions will be, except in very general terms. There is no substitute for the trial of various types of content with the prospective reader, and first-hand observations of his apparent reactions. The format of reading materials is not considered in common formulas chiefly because materials is not considered in common formulas chiefly because the influence of these factors is relatively slight and obscure.

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Readability formulas are valid and justified for specific purposes. As many studies show they do arrange reading materials in order of their difficulty for the reader. Of course, they do not indicate the exact degree of difficulty for all readers since reading difficulty is basically a reaction of the reader, rather than entirely inherent in the reading material. The formulas indicate the average reading ability needed for adequate comprehension of a certain book.

Formulas cannot be a "cure-all" for overcoming the problems of reading difficulties that each child encounters. The formulas do allow the interested teacher to take that objective first step in determining the reading difficulty of a certain text. The formulas should be used cautiously. A review of Chall's limitations on readability formulas showed that:

1. A formula can give an estimate of relative difficulty.

2. This estimate of difficulty cannot tell whether the book is suitable for children of a given grade or reading ability since other factors such as format and illustrations, difficulty of ideas, and the reader's interest must be considered in concluding that a book is suitable for a particular child.

3. A formula cannot be turned into a set of rules for writing.

The Spache formula. In March, 1953, Spache published a readability formula for evaluating primary-grade reading materials. Since the time of the first publication, several modifications have been made in the procedures of applying the formula. This study

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used the recent modifications so that the application of the formula would be in its most up-to-date form.

How the formula was made. Spache studied the percentage of hard words outside the Dale list of 769 words and the average sentence length of primary-level materials as the internal factors of difficulty that influence readability. The selection of these two factors as the two elements that best predicted readability was based on many earlier research studies.

Selection of texts were made from the schoolbooks in common use in the United States at that time. Spache selected 224 samples of approximately 100 words each from 152 schoolbooks. The number of 100 word samples taken from each text ranged from one or two samples in pre-primers to five or more samples in longer books. All of the books were basal readers except for 23 books drawn from social science, health, and science. Each book was assigned the grade level designation of the publisher i.e. preprimers 1.2, primers 1.5, first readers 1.8 and 1.9, second readers 2.1 and 2.4 and third readers 3.3 and 3.7.

The elements of reading difficulty were then intercorrelated with each other and with the grade level designations. The multiple correlation coefficient obtained by combining sentence length and per cent of hard words in predicting the grade level of books is .818.

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22 Spache, Good Reading for Poor Readers, p. 111.
23 Ibid., p. 11.
The complete formula is: \[ \text{Grade Level Placement} = 0.141 \times \text{average sentence length per 100 words} + 0.086 \times \text{the per cent of hard words} + 0.839. \]

**Accuracy of the Spache formula.** Spache reported on the accuracy of the formula and stated:

The accuracy of this formula compares very favorably with that obtained from other readability formulas. The probable error of estimate in predicting the grade level of a book by this method is 3.3 months. In other words, in half the predictions the error in estimating the grade level will be less than this amount. In the remaining predictions the error will probably be greater than three months. At the primary levels, where relatively fine degrees of discrimination are most desirable, this formula evidences a high degree of accuracy and should be distinctly useful.

**Revisions in the formula.** In the first publication of the Spache formula in 1953, Spache employed a word list devised by Edgar Dale. This list contained the 769 words found in the spoken vocabulary of children was noted in the International Kindergarten Union List and in the first 1000 words of the reading vocabulary of Thorndike's Teacher's Word Book of 10,000 Words. In 1956, Stone suggested a revision of this list in his constructive criticism of Spache's formula. Stone's revision involved changes in 173 words. Spache adopted this revised list by Stone and comments on this revision:

We have adopted this list and find that estimates based upon it do not vary materially from those found in using Dale's list. We compared the estimates by either word list for 25 books ranging in reading difficulty from low first to high third grade in levels. There were no consistent differences in the estimates at any

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24 Ibid., p. 113.

25 Ibid., p. 113.
particular level. Differences in the estimates of reading difficulty average less than two months and in no case were greater than four months. For these reasons, we believe that the Stone Revised Word List can now be used in the application of the formula. 26

A short method for computation of the Spache formula. Spache has a computation table which eliminates some of the mathematical procedures when applying the Spache readability formula. Daniel E. Safier, Research Director for the Webster Publishing Company, offers a short method for applying the formula and using the table of computation. In this short method, all samples are kept to exactly 100 words by ceasing to count words at that point. If the last word included half or more of the last sentence, that sentence is counted in determining the number of sentences. The researcher determines the number of hard words in the sample by comparing the words in the sample to the Stone Word List. Then the researcher enters the table horizontally with the number of hard words. Again the researcher enters the table vertically from the number of sentences. Where these two meet, the estimate of reading difficulty of the selection is found. 27

How to interpret the formula. Spache gives his view on interpreting his formula:

It should be obvious that the Spache formula was standardized by the analysis of primary reading materials. It is applicable only to materials which are appropriate for those levels. Although estimates of reading difficulty greater than 3.9 can be found by the formula, it is doubtful that these have any real meaning. In our own use of the formula, we re-evaluate any materials testing higher than this by the Dale-Chall formula which is more appropriate for material of higher reading levels than third

26 Ibid., p. 114.
27 Ibid., p. 115.
grade. The formula can certainly be used to evaluate trade books, school textbooks, readers of all types and reference books offered for primary children. Even picture books with a relatively small number of sentences can be analyzed in this fashion. In effect, the teacher is determining the reading levels of these books in comparison with the common readers used in the classroom. She is also evaluating these various books in terms of the reading ability needed to comprehend them.

In addition to a final estimate of the reading difficulty of a book or story, there are other kinds of information which may be derived from the application of the formula. The teacher will observe that the estimates based on various samples vary somewhat. In some books, we have found differences of more than a year in grade level between successive 100 word samples from a book. While the average estimate of readability is significant, the range of difficulty within the book and the difficulty of the hardest sample are also important. Books with a wide range of difficulty and relatively hard passages are not appealing to reluctant readers.28

LITERATURE ON SCIENCE TEXTS

**Importance of reading in science.** Reading ranks high in the list of ways in which children learn science. Thoughtful classroom planning should include planning for accurate science material on the reading level of the various children's reading abilities in the classroom. This need for science books of varied and measured reading difficulty is shown by Frank's remarks on individual needs:

> While books may meet an average level of reading ability and interest, no list which requires all the children in a class to read the same book can possibly suit each individual child. One child finds the book too easy—not challenging enough, or too babyish in content. Another finds it too hard. And for a third, the book just does not touch him at any point of his own interests.29

Reading and science are related and should go hand-in-hand in the elementary classroom. The importance of appropriate reading for children is emphasized in the following excerpt from a bulletin published by the National Association for the Education of Young Children:

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28 *Ibid.*, p. 120.

Selection of appropriate reading material is pre-requisite to success in reading activity. This is largely the responsibility of the teacher, but the help of the children is also desirable. Material which is too difficult, or which is too easy, or which is inappropriate, because it does not answer the children's questions, is discouraging when offered to slow-learning pupils or pupils with reading difficulties who need special attention in selection of their reading materials.\textsuperscript{30}

Zim also emphasized the importance of reading in science when he stated:

Texts can be used effectively in the classroom when the class is not limited to one of them. While most of the texts do tend to cover the same areas of science content, there is enough variation to provide a real advantage when two, three or more, different texts are used. The wide range of reading ability in the average classroom also makes the use of a variety of texts desirable.\textsuperscript{31}

The words of these authors emphasize that many science texts are needed in the elementary classroom. The measured reading difficulty of these texts should be available to the teacher to enable her to meet the demands of each child's reading ability. This information will help the teacher perform the job of individualized teaching in a more objective, technical and professional manner.

Results of previous studies. Mallinson observed, "There is great disagreement among authors and publishers concerning the level of reading difficulty of their books.\textsuperscript{32}

\begin{itemize}
\item \textsuperscript{31} Herbert Zim, Science for Children and Teachers, Association for Childhood Education International, Bulletin 91 (Washington: Association for Childhood Education International, 1953), p. 27.
\end{itemize}
reading difficulty with which science books should be written.\textsuperscript{32}

Mallinson discussed this further and stated:

Some espouse the viewpoint that the development of sequential reading skills with these materials should be congruent with growth in science knowledge and in the understanding of science concepts. Thus a textbook designed for science courses at the ninth grade level should have a ninth grade level of reading difficulty.

Others believe that the efforts of a student in using science materials should be devoted to "learning the science" and not dissipated in struggling with the problems of developing reading skills. The lack of resolution of these conflicting viewpoints is evidenced by analyses of the reading difficulty of different science textbooks. The findings indicated that competing textbooks are written with levels of reading difficulty, below, at, and above grade levels of the student for whom the books are produced.\textsuperscript{33}

There is disagreement concerning, not only the level of reading difficulty of science texts, but also how this reading difficulty is to be measured.\textsuperscript{34} Subjective measurement is often used to measure reading difficulty of science texts. Mallinson discussed this and stated:

Several studies also cast doubt on the ability of reading experts or classroom teachers to evaluate the levels of reading difficulty of textbooks in science. It has been generally assumed that "a good teacher" can do so. The research findings, however, suggest that the estimates of "reading experts" concerning the reading difficulty of a science textbook may be expected to vary as much as two grade levels from the measurements made with formulas.


\textsuperscript{33}Ibid.

\textsuperscript{34}Robert B. Mills and Jean R. Richardson, "What do Publishers Mean by 'Grade Level'?," Reading Teacher, XVI (March, 1963), 359-62.
It is therefore recommended that evaluations of the levels of reading difficulty of textbooks should be accomplished with reading formula rather than by inspection. This would seem to be particularly desirable in view of the fact that many textbooks of science are too difficult for the students for whom they are designed.  

Mallinson and his co-workers conducted a series of studies and used similar techniques to determine the levels of reading difficulty of texts for the areas of elementary science, junior high-school science, high-school science, biology, general physical and earth science, chemistry and physics: The data obtained from these studies showed that:

1. Textbooks in elementary science were, in a number of cases, likely to cause difficulty for the students for whom they were designed.  

2. The unit-type texts are generally too difficult for use at the grade level that publishers suggest.  

3. There is a great deal of variation among the levels of reading difficulty of texts assigned for the same field of science. In the area of physics, Mallinson found the easiest text to be on level VIII and the most difficult to be on level XIV or equal to college sophomore level.

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Recent texts (1953-4) do not seem to be easy. Many have grade levels of reading difficulty higher than the grade levels of the students for whom they are designated.  

One general conclusion that can be drawn from these studies is that the reading difficulty and the grade level designations of science texts as determined by authors and publishers are not accurate in many cases. If this inaccuracy is caused by subjective measurement, then there is a definite need for these texts to be measured objectively.

California state-adopted science texts for grades I to III. The reading difficulty level of the present state-adopted science texts was investigated. The information was obtained from three sources: (1) the California State Department of Education (2) the publishers and (3) the teacher's manual for each book or series.

The California State Department of Education informed this writer that no formula was used by the textbook commission to determine the level of reading difficulty for the texts in grades I to III. The State Curriculum Commission considered that "books for each grade as submitted by the publisher were satisfactory for the grade."  

The publishers’ information on the California state-adopted science texts for grades I to III indicated that thirteen books had been submitted. A letter dated November 13, 1963 and received December 11, 1963, in answer to personal written inquiry.

39 Ibid., p. 366.

measured on the Winnetka Scale. Six texts had not been measured on the Winnetka Scale as the Scale does not attempt to measure a text with less than 1,000 running words. Three texts had been measured by the Spache readability formula. Two texts had an author's estimate of reading level stated in Spache's list of series books. The information on this First Book series was:

First Books. New York: Watts. Inexpensive, relatively simple introductions to an area of interest. Includes books on science, animals, occupations, etc.

R.L. 2-6 I.L. 4 up.

The letter designations of R.L. refers to reading level and I.L. refers to interest level.

Difficulty of first grade science texts. In December, 1963, a list of the current science texts for grade I indicated that the first grade science texts were: Birds In Your Backyard, Fall Is Here, Leaves, Spring Is Here, Summer Is Here, Toys, and Winter Is Here. There was no reading difficulty measurement available for these texts. One text, Science for Work and Play, had a reading difficulty level of 1.5 as determined by the Spache formula.


42 Spache, Good Reading for Poor Readers, p. 99.

Difficulty of second grade science texts. The second grade science texts and their reading difficulty as measured on the Winnetka Scale were as follows: *Animals and Their Young* with 2.1, *Animals Round the Year* with 3.3, *Animals That Live Together* with 1.9, *Birds In The Big Woods* with 2.1, *The Pet Show* with 3.2, and *Water Appears and Disappears* with 2.6. *Six-Legged Neighbors* had no measurement of difficulty as it had less than 1,000 running words. One text, *Science for Here and Now*, had a reading difficulty level of 1.7 as determined by the Spache readability formula.

Difficulty of third grade science texts. The third grade science texts and their reading difficulty as measured on the Winnetka Scale were as follows: *An Aquarium* with 2.7, *Doing Work* with 3.4, *How The Sun Helps Us* with 2.4, *Magnets* with 2.7, *Plants Round The Year* with 2.8, *The Insect Parade* with 3.1, and *Useful Plants and Animals* with 3.2. One text, *Science Far and Near*, had a reading difficulty level of 2.3 as determined by the Spache readability formula. The texts in the First Books series were entitled *The First Book of Dogs* and *The First Books of Birds*. The information on the First Book series indicated

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44"Grade Placement Rating by the Winnetka Scale. . ."


46"Grade Placement Rating by the Winnetka Scale. . ."

that the books in the series had a reading level of 2.6 and an interest
level of 4 up.  

Literature on the reading difficulty of the California state-
adopted science texts has revealed that two formulas of measuring were
used: the Spache readability formula and the Winnetka Scale.

The Winnetka formula, according to Russell and Fea, is one
formula that yields estimates which least approximate the librarians'
ratings. It averages over 1.5 grade deviations from the librarians'
mean rating of difficulty.

Russell and Fea's findings show that the Winnetka grade-levels
on books gave the fifth highest grade scores as compared with the Dale-
Chall, Flesch, Leverenz, Lorge and Yoakum formulas. While the Winnetka
and the Dale-Chall formula assign the same relative difficulty to the
book, the Winnetka formula, on the average, rates the books as about two
grades higher, or two grades more difficult, than does the Dale-Chall
formula.

Chall discussed the Winnetka and the Spache formulas, among others,
in the following manner:

Formulas with validity coefficients above .7 are the Winnetka,
Spache, Farr-Jenkins-Paterson, and Forbes. The validity of the
Winnetka (.86) is high probably because it is based on a criterion

48 Spache, Good Reading for Poor Readers, p. 99.

49 David H. Russell and Henry R. Fea, "Validity of Six Readability
Formulas as Measures of Juvenile Fiction," Elementary School Journal,
LI (November, 1951), 136-44.

50 Ibid., pp. 136-44.
of interest and reading difficulty. Spache's validity coefficient of .81 no doubt reflects the tendency of authors to control the vocabulary and sentence structure of primary-grade textbooks, especially basal reading books. The Spache formula and also the Dolch (1948) formula differ from most of the others in that the authors accept the present grading of schoolbooks as evidence of comprehension difficulty. These formulas do not estimate tested comprehension difficulty, but they are devices for determining the similarity of new books, in terms of sentence length and vocabulary, to the books commonly used in the elementary school at the time the formulas were devised.\textsuperscript{51}

Chall felt that:

If the formulas are used merely to judge the relative difficulty of a series of books, then one formula gives as good an estimate of difficulty as another. However, if the formula ratings are taken as indications of the appropriate grades in which the book may be read, the evidence of differences in grade-placement is needed.\textsuperscript{52}

Since the purpose of the study is to determine the reading difficulty of the California state-adopted science texts, grades I to III, then the formula ratings determined by the study should be taken as indications of the grades in which the book may be read.

**SUMMARY OF THE REVIEWED LITERATURE**

Summary. The literature reviewed in this chapter discussed the following points that are pertinent to the study:

1. There is a need for teachers to know the levels of the reading difficulty of the content texts in their classrooms so that the teacher can meet the individual needs of the child by matching the child's level of reading ability to the difficulty of the book that he is to read.\textsuperscript{53}


\textsuperscript{52}Ibid., p. 77.

\textsuperscript{53}Yoakum, op. cit., p. 429.
2. This review revealed that the information of the reading difficulty of the California state-adopted science texts for grades I to III is based on the Winnetka Scale, the Spache formula and author’s estimates. Each text had a designated grade level, but there was no information available for all the texts as to the levels of reading difficulty when measured by the same formula.

3. A study by Mallinson and Herrington concluded that, "The readability formulas do measure grade level of reading difficulty of science materials more consistently than the estimates of reading experts." An objective measurement was chosen over subjective measurement to determine the reading difficulty levels of the science texts in this study.

4. Because the Spache formula can be used to evaluate trade books, school textbooks, readers and reference books, this formula was chosen to measure the material in the California science texts, grades I to III. This formula helps the teacher to determine the reading levels of these books in comparison with the common readers used in the classroom. The formulas readings should be taken as an indication of the grade in which the book may be read.

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Herrington and Mallinson, op. cit., p. 390.

Spache, Good Reading for Poor Readers, p. 119.

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CHAPTER III

PROCEDURES OF THE STUDY

The formula used. The Spache readability formula was used to determine the reading difficulty, or grade placement level, of each California state-adopted science text for grades I to III. The formula was applied to selected samples from each text.

The texts used. In December, 1963, a list of the twenty-six science texts currently used in grades I to III was compiled from the inventory list of the Horace Mann elementary school in Bakersfield, California. Three texts had been previously measured by the Spache formula and were eliminated from the study. The remaining twenty-three science texts were measured in this study.

Selection of the samples. Spache suggested that at least five to ten samples be used depending upon the length of the book. To determine the sampling pages in each text, the following steps were taken:

1. The total number of pages in the text was divided by ten which represented the maximum number of samples suggested by Spache.
2. After dividing, then the dividend was the number which indicated the first sampling page. The multiples of the dividends indicated the other sampling pages in the text. For example, a text with fifty pages, divided by ten, would have a dividend of five. The sampling would begin on page five and continue with pages ten, fifteen, twenty, etc.
3. When a page contained a full-page illustration, the page preceding it was taken as the sample.

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1 Horace Mann elementary school, Bakersfield City School District, 2710 Niles Street, Bakersfield, California
2 Spache, Good Reading for Poor Readers, p. 113.
4. When a text had only one sample that measured over 3.9, this was noted in the Table I on page 35, then another sample was chosen to be measured.

5. When a text had one-half or over one-half of the samples measuring over 3.9 then the text difficulty was recorded as over 3.9 and no other samples were chosen.

In four of the first grade texts, three samples were taken from every tenth page. The other first grade texts had five samples measured from every seventh page of the text. A sampling of every third page was taken from seven second and seven third grade texts. One third grade text had every fourth page sampled. One third grade text had every sixth page sampled. The samples included poems, running words, questions, exercises, and experiments.

Procedures in counting. The following procedures were used:

1. All samples were kept to exactly 100 words by ceasing to count words at that point. If the last word included half or more of the last sentence, that sentence was counted in determining the number of sentences.

2. The separate words in each sample were checked against Stone’s Revised Word List. The words not found in this list were considered hard words. These words were then counted and recorded.

3. All letters and numbers in figures were counted as familiar.

4. Proper nouns, or names of persons or places were counted as familiar.

5. Adjectival or adverbial endings such as ily, er, est, ly, were counted as unfamiliar unless on Stone’s List of Hard Words.

6. An unfamiliar word was counted only once even though it appeared again or with variable endings later on in the sample.

7. A group of words, consisting of the repetition of a single word or exclamation was counted as a single sentence regardless of punctuation.

\[3\] Ibid., p. 114.

\[4\] Ibid., pp. 115-117.
8. Hyphenated words were counted as unfamiliar unless on Stone's list.

9. Contractions were counted as unfamiliar unless on Stone's List.

10. Hyphenated words, compound words, and numbers in figures were each counted as one word.

Computations. The computations of the reading difficulty of each text were made as follows: 5

1. A worksheet was prepared for each text that was to be measured in the study.

2. Exactly 100 in the first chosen sample of the book was counted. The count was begun at the beginning of the first sentence and ended with the 100 word. If the last word included half or more of the last sentence, that sentence was counted in determining the number of sentences.

3. The number of words in the sample was written on line 1.

4. The number of sentences in the sample were counted. This number was written on line 2.

5. The separate words in the sample were checked against the Stone Revised Word List. A count and recording of the words not found on this list was made. These words were considered hard words.

6. The number of hard words was written on line 3.

7. The number of words in the sample was divided by the number of sentences to find the average sentence length. This number was written on line 4.

8. The Spache's computation table was entered with the number of hard words in the proper horizontal row. The table was entered with the number of sentences in the vertical column. Where these two met in the table, the estimate of reading difficulty or the grade placement level was found.

9. These steps 1-8 were repeated from three to ten times depending upon the number of samples taken from each text.

5Ibid., p. 113.
10. The averages of the grade placement level and of the reading difficulty factors were determined by adding the total number of estimates and dividing by the number of samples taken from the text. The figures were rounded off. In addition, the sums were rounded off to the same number of decimal places as the least precise of the addends. In division, the quotient was rounded off until it had the same number of significant figures as the given number with the lesser number of significant figures.

Interpretation of the formula. The Speche formula was standardized by the analysis of primary reading materials. It is applicable only to materials which are appropriate for those levels. In this study, a short method of computation using a computation table was used in determining the reading difficulty of each sample. This short method does not distort the grade level estimates according to the conclusions of previous result with this method. At the most, it tends to change the estimate from 0 to three months. Most of the larger distortions are concentrated in the upper half of the third grade.

In addition to a final estimate of the reading difficulty of a text, other kinds of information may be derived from the application of the formula. It shows the range of difficulty within the book and the difficulty of the hardest sample. It shows the vocabulary burden and the sentence length of each sample.

In Speche's opinion, the formula can certainly be used to evaluate trade books, school textbooks, readers of all types and reference books offered for primary children. Even picture books with a relatively small number of sentences can be analyzed in this way.

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6 Ibid., p. 119

7 Ibid.

8 Ibid.
In effect, the formula helps the teacher determine the reading level of any book in comparison with the common readers used in the classroom. The formula also evaluates these books in terms of the reading ability needed to comprehend them.  

A study of Table I shows that a consistent progression of difficulty is not found among the science texts from grade to grade.  

**Difficulty of First Grade Science Texts.** There is a range of 1.9 to 2.7 among the average estimates of reading difficulty in the first grade texts. Text 1 (b) has the lowest average reading difficulty of 1.9 and has a range of difficulty within the text of .3 or three months. The highest average estimate of reading difficulty was 2.7 in text 1 (c) and 1 (f). These texts have a range of difficulty of .9 and 1.1 respectively. If the first grade texts were studies in order of the author's designation, a first grade child would begin this science series with text 1 (b) which was a difficulty of 1.9. The child would continue with text 1 (c) with 2.0 and then text 1 (d) with 2.3. The child would finish his study of the season with text 1 (e) with a difficulty of 2.5. To study a text in biological science, the first grader would read text 1 (c) which has a difficulty of 2.6 or text 1 (a).  

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CHAPTER IV

ANALYSES OF THE DATA

In applying the Spache readability formula to the selected samples from the California state-adopted science texts for grades I to III, a final estimate of reading difficulty or grade placement was acquired for each text. Table I on page 35 shows the texts measured in each grade and the average estimate of reading difficulty for each text.

A study of Table I shows that a consistent progression of difficulty is not found among the science texts from grade to grade.

**Difficulty of first grade science texts.** There is a range of 1.9 to 2.7 among the average estimates of reading difficulty in the first grade texts. Text I (b) has the lowest average reading difficulty of 1.9 and has a range of difficulty within the text of .3 or three months. The highest average estimate of reading difficulty was 2.7 in texts 1 (c) and 1 (f). These texts have a range of difficulty of .9 and 1.1 respectively. If the first grade texts were studies in order of the author's designation, a first grade child would begin this science series with text 1 (b) which was a difficulty of 1.9. The child would continue with text 1 (g) with 2.0 and then text 1 (d) with 2.3. The child would finish his study of the seasons with text 1 (e) with a difficulty of 2.4. To study a text in biological science, the first grader would read text 1 (a) which has a difficulty of 2.6 or text 1 (c)

---

<table>
<thead>
<tr>
<th>GRADE</th>
<th>TEXT TITLE</th>
<th>LEAST DIFFICULT SAMPLE</th>
<th>MOST DIFFICULT SAMPLE</th>
<th>VARIANCE OF SAMPLES</th>
<th>AVERAGE READING DIFFICULTY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (a)</td>
<td>Birds In Your Backyard</td>
<td>2.5</td>
<td>2.8</td>
<td>.3</td>
<td>2.6</td>
</tr>
<tr>
<td>1 (b)</td>
<td>Fall Is Here</td>
<td>1.7</td>
<td>2.0</td>
<td>.3</td>
<td>1.9</td>
</tr>
<tr>
<td>1 (c)</td>
<td>Leaves</td>
<td>2.3</td>
<td>3.2</td>
<td>.9</td>
<td>2.7</td>
</tr>
<tr>
<td>1 (d)</td>
<td>Spring Is Here</td>
<td>2.2</td>
<td>2.4</td>
<td>.2</td>
<td>2.3</td>
</tr>
<tr>
<td>1 (e)</td>
<td>Summer Is Here</td>
<td>2.3</td>
<td>2.5</td>
<td>.2</td>
<td>2.4</td>
</tr>
<tr>
<td>1 (f)</td>
<td>Toys</td>
<td>2.3</td>
<td>3.4</td>
<td>1.1</td>
<td>2.7</td>
</tr>
<tr>
<td>1 (g)</td>
<td>Winter Is Here</td>
<td>1.8</td>
<td>2.2</td>
<td>.4</td>
<td>2.0</td>
</tr>
<tr>
<td>2 (a)</td>
<td>Animals and Their Young</td>
<td>2.2</td>
<td>3.5</td>
<td>1.2</td>
<td>2.8</td>
</tr>
<tr>
<td>2 (b)</td>
<td>Animals Round The Year</td>
<td>2.3</td>
<td>3.3*</td>
<td>1.0</td>
<td>2.8</td>
</tr>
<tr>
<td>2 (c)</td>
<td>Animals That Live Together</td>
<td>2.6</td>
<td>3.3</td>
<td>.7</td>
<td>2.9</td>
</tr>
<tr>
<td>2 (d)</td>
<td>Birds In The Big Woods</td>
<td>2.5</td>
<td>3.5</td>
<td>1.0</td>
<td>3.0</td>
</tr>
<tr>
<td>2 (e)</td>
<td>Six-Legged Neighbors</td>
<td>2.5</td>
<td>3.1</td>
<td>.6</td>
<td>2.8</td>
</tr>
<tr>
<td>2 (f)</td>
<td>The Pet Show</td>
<td>2.2</td>
<td>3.1</td>
<td>.9</td>
<td>2.6</td>
</tr>
<tr>
<td>2 (g)</td>
<td>Water Appears and Disappears</td>
<td>2.6</td>
<td>3.6</td>
<td>1.0</td>
<td>3.1</td>
</tr>
<tr>
<td>3 (a)</td>
<td>An Aquarium</td>
<td>2.8</td>
<td>3.7</td>
<td>.9</td>
<td>3.1</td>
</tr>
<tr>
<td>3 (b)</td>
<td>Doing Work</td>
<td>3.0</td>
<td>3.4</td>
<td>.4</td>
<td>3.2</td>
</tr>
<tr>
<td>3 (c)</td>
<td>How The Sun Helps Us</td>
<td>2.3</td>
<td>3.6</td>
<td>1.3</td>
<td>3.1</td>
</tr>
<tr>
<td>3 (d)</td>
<td>Magnets</td>
<td>2.4</td>
<td>3.8</td>
<td>1.4</td>
<td>3.2</td>
</tr>
<tr>
<td>3 (e)</td>
<td>Plants Round The Year</td>
<td>2.8</td>
<td>3.7</td>
<td>.9</td>
<td>3.1</td>
</tr>
<tr>
<td>3 (f)</td>
<td>The Insect Parade</td>
<td>2.4</td>
<td>3.7</td>
<td>1.3</td>
<td>3.1</td>
</tr>
<tr>
<td>3 (g)</td>
<td>Useful Plants and Animals</td>
<td>2.2</td>
<td>3.8</td>
<td>1.6</td>
<td>3.1</td>
</tr>
<tr>
<td>3 (h)</td>
<td>The First Book of Dogs</td>
<td>3.9*</td>
<td>3.9**</td>
<td>.0</td>
<td>3.9**</td>
</tr>
<tr>
<td>3 (i)</td>
<td>The First Book of Birds</td>
<td>3.3</td>
<td>3.9**</td>
<td>.6</td>
<td>3.8**</td>
</tr>
</tbody>
</table>

* Indicates that the most difficult samples in this text was over 3.9 and was not used to determine the averages.
** Indicates that over one-half of the samples were over 3.9 and were used to determine the averages; indicates text should be re-evaluated with another formula other than the Spache formula.
with 2.7. The first grade physical science text is 1 (f) and has a difficulty of 2.7. The first grade teacher's manual designates that text 1 (b), 1 (c), and 1 (f) could be read by a "superior group in the fall." The average estimates of reading difficulty of these texts are 1.9, 2.7, and 2.7 respectively. The first graders would need a reading ability to match the text in order to adequately read these books in the fall.

The first grade texts with samples that varied more than six months are 1 (c) with .9 and 1 (f) with 1.1. The large variance in text 1 (f) occurred within seven pages of running words. Page three of 1 (f) measured 2.3 and page ten measured 3.4. This is a large span of reading difficulty to be successfully hurdled by a beginning reader in first grade. The wide range of difficulty measured in 1 (c) and 1 (f) indicated that these texts are too difficult to be read by most pupils in grade one. The average estimates of reading difficulty of the first grade texts indicated that the texts are not perfectly adapted to grade one and that all of the texts would be difficult for most of the pupils in the grade.

**Difficulty of second grade science texts.** There is a range of 2.6 to 3.1 among the average estimates of reading difficulty in the second grade texts. Text 2 (f) which has the lowest average reading difficulty has a range among its samples of .9 or nine months. The text 2 (g) which has the highest reading difficulty has a range among its samples of 1.0

\[2\] Ibid., pp. 5, 60, and 73.
The text 2 (b) had a sample with a difficulty over 3.9, which could not be measured accurately by the formula. In determining the averages of the samples of text 2 (b), the sample measuring above 3.9 was not used. The range of difficulty in text 2 (b) was 1.0.

There is no designated order in which these texts should be studied. Blough suggested that the local course of study or curriculum plan indicate the order of study for the texts. If the texts are studied in order of their reading difficulty, the texts would be read in the following sequence: text 2 (f) with a difficulty of 2.6, then 2 (a), 2 (b) and 2 (e) with 2.8, then text 2 (c) with 2.9, then 2 (d) with 3.0, and finally 2 (g) with a difficulty of 3.1.

The second grade with samples that varied eight months or more were 2 (a), 2 (b), 2 (d), 2 (f), and 2 (g).

There is no consistent progression of reading difficulty found in the samples of any one text. An example of this is seen in text 2 (g) which begins with a difficulty of 3.3 and goes to 2.6 in the middle and ends with a difficulty of 3.1. The wide and inconsistent range of difficulty found in the second grade texts indicates that they are not perfectly adapted for the second grade.

Difficulty of third grade science texts. There is a range of 3.1 to over 3.9 among the average estimates of reading difficulty in the third grade texts. Five of the texts have a difficulty of 3.1 and two have a difficulty of 3.2. Texts 3 (a), 3 (c), 3 (e), 3 (f), and 3 (g) have the same average of reading difficulty of 3.1, but there

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is considerable difference in the range of difficulty among the samples within each text. Texts 3 (a) and 3 (e) have a variance of .9 and text 3 (f) has a range of 1.3, while 3 (g) shows an even wider range of difficulty with 1.6.

Both 3 (c) and 3 (d) had samples with a difficulty over 3.9. These samples could not be measured accurately by the Spache formula and were eliminated from determining the averages of the texts. In determining the averages of texts 3 (c) and 3 (d) with samples that were measured by the Spache formula, the range of difficulty within each text was 1.3 and 1.4 respectively. Text 3 (h) had eighty per cent of its samples measuring over 3.9. Text 3 (i) had seventy per cent of its samples measuring over 3.9.

There is no designated order in which these texts should be studied. Blough suggested that the local courses of study or curriculum plan indicate the order of study for these texts. If the third grade texts were studied in order of the average estimate of reading difficulty, the texts would be read in the following sequence: 3 (a), 3 (c), 3 (e), 3 (f), and 3 (g) with a difficulty of 3.1; texts 3 (b) and 3 (d) with a difficulty of 3.2; text 3 (i) with 3.8; and text 3 (h) with a difficulty of over 3.9.

The third grade texts with samples that varied more than eight months were 3 (e), 3 (c), 3 (e), 3 (f), and 3 (g). These five texts seem adapted to the assigned grade from the standpoint of the average estimate of reading difficulty. The large variance of eight months among
the samples may indicate a difficulty too large for pupils of that grade to master.

Text 3 (b) seems adapted to the assigned grade because of its small range of difficulty and because of the average estimate of reading difficulty of 3.2 that is well within the range of third grade reading abilities. Two texts 3 (h) and 3 (i) do not seem adaptable for the assigned grade because both texts had seventy per cent of the samples measuring over 3.9.

Reading difficulty factors. The following reading difficulty factors were studied:

1. The number of sentences in each one-hundred word sample that was measured by the Spache formula.

2. The number of hard words outside Stone's Revised Word List in each one-hundred word sample measured by the Spache formula.

3. The average sentence length found in each one-hundred word sample.

A study of Table II on page forty shows the averages of the reading difficulty factors from the science texts that were measured by the Spache readability formula. The first column in Table II shows that the largest per cents of hard words were found in the third grade texts. Text 3 (h) had an average of 15.3 per cent hard words in the samples. Text 3 (i) had an average of 15.2 per cent hard words in the samples. Text 3 (f) had 10.7 per cent hard words in the samples. The smallest per cent of hard words in the third grade was text 3 (c) with 7.5.

The largest per cent of hard words in the second grade texts was texts 2 (d) and 2 (e) with 9.3. The smallest per cent of hard words in the second grade was text 2 (f) with 5.9.
### TABLE II

**AVERAGES OF THE READING DIFFICULTY FACTORS OF THE CALIFORNIA STATE-ADOPTED SCIENCE TEXTS, GRADES I TO III, AS MEASURED BY THE SPACHE READABILITY FORMULA**

<table>
<thead>
<tr>
<th>GRADE</th>
<th>TEXT TITLE</th>
<th>AVERAGE PER CENT HARD WORDS</th>
<th>AVERAGE NUMBER SENTENCES</th>
<th>AVERAGE SENTENCE LENGTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (a)</td>
<td>Birds In Your Backyard</td>
<td>6.6</td>
<td>12.8</td>
<td>6.7</td>
</tr>
<tr>
<td>1 (b)</td>
<td>Fall Is Here</td>
<td>4.8</td>
<td>19.3</td>
<td>4.9</td>
</tr>
<tr>
<td>1 (c)</td>
<td>Leaves</td>
<td>8.8</td>
<td>13.0</td>
<td>7.4</td>
</tr>
<tr>
<td>1 (d)</td>
<td>Spring Is Here</td>
<td>5.6</td>
<td>14.6</td>
<td>6.8</td>
</tr>
<tr>
<td>1 (e)</td>
<td>Summer Is Here</td>
<td>7.3</td>
<td>13.6</td>
<td>6.8</td>
</tr>
<tr>
<td>1 (f)</td>
<td>Toys</td>
<td>6.2</td>
<td>11.4</td>
<td>9.3</td>
</tr>
<tr>
<td>1 (g)</td>
<td>Winter Is Here</td>
<td>5.9</td>
<td>19.3</td>
<td>5.2</td>
</tr>
<tr>
<td>2 (a)</td>
<td>Animals and Their Young</td>
<td>7.6</td>
<td>10.4</td>
<td>9.8</td>
</tr>
<tr>
<td>2 (b)</td>
<td>Animals Round The Year</td>
<td>6.5</td>
<td>10.8</td>
<td>9.6</td>
</tr>
<tr>
<td>2 (c)</td>
<td>Animals That Live Together</td>
<td>9.1</td>
<td>10.5</td>
<td>9.6</td>
</tr>
<tr>
<td>2 (d)</td>
<td>Birds In The Big Woods</td>
<td>9.2</td>
<td>10.5</td>
<td>9.8</td>
</tr>
<tr>
<td>2 (e)</td>
<td>Six-Legged Neighbors</td>
<td>9.3</td>
<td>12.4</td>
<td>8.2</td>
</tr>
<tr>
<td>2 (f)</td>
<td>The Pet Show</td>
<td>5.9</td>
<td>11.3</td>
<td>9.9</td>
</tr>
<tr>
<td>2 (g)</td>
<td>Water Appears and Disappears</td>
<td>9.1</td>
<td>9.9</td>
<td>10.3</td>
</tr>
<tr>
<td>3 (a)</td>
<td>An Aquarium</td>
<td>10.0</td>
<td>10.3</td>
<td>9.8</td>
</tr>
<tr>
<td>3 (b)</td>
<td>Doing Work</td>
<td>9.5</td>
<td>10.0</td>
<td>10.3</td>
</tr>
<tr>
<td>3 (c)</td>
<td>How The Sun Helps Us</td>
<td>7.5</td>
<td>9.4</td>
<td>10.9</td>
</tr>
<tr>
<td>3 (d)</td>
<td>Magnets</td>
<td>9.4</td>
<td>9.5</td>
<td>10.9</td>
</tr>
<tr>
<td>3 (e)</td>
<td>Plants Round The Year</td>
<td>8.7</td>
<td>10.1</td>
<td>10.1</td>
</tr>
<tr>
<td>3 (f)</td>
<td>The Insect Parade</td>
<td>10.7</td>
<td>11.2</td>
<td>9.3</td>
</tr>
<tr>
<td>3 (g)</td>
<td>Useful Plants and Animals</td>
<td>9.2</td>
<td>9.2</td>
<td>9.2</td>
</tr>
<tr>
<td>3 (h)</td>
<td>The First Book of Dogs</td>
<td>15.3</td>
<td>5.8</td>
<td>18.1</td>
</tr>
<tr>
<td>3 (i)</td>
<td>The First Book of Birds</td>
<td>15.2</td>
<td>7.2</td>
<td>14.7</td>
</tr>
</tbody>
</table>
The largest per cent of hard words in the first grade texts was text 1 (c) with 8.8. The first column in Table II shows that the smallest per cent of hard words was found in the first grade texts. Text 1 (b) had an average of 4.0 per cent hard words in the samples. Text 1 (g) had an average of 5.0 per cent hard words in the samples. Text 1 (d) had an average of 5.6 per cent hard words in the samples.

The increase in hard words in the first grade texts was from 4.0 per cent to 8.8 per cent. The increase of difficult words was from 5.9 to 9.3 per cent in the second grade texts. The increase of difficult words in the third grade texts was from 7.5 to 15.3 per cent.

The first grade text 1 (c) had an average of 8.8 per cent hard words in its samples. This average was more difficult than the three second grade texts 2 (a), 2 (b), and 2 (f). This average was more difficult than two third grade texts 3 (c) and 3 (e).

Two second grade texts 2 (d) and 2 (e) had an average of 9.3 per cent hard words in their samples. This average was more difficult than the averages of three third grade texts 3 (c), 3 (e) and 3 (g).

The second column on Table II on page forty-six shows the average number of sentences found in the one-hundred word samples from each text. The least number of sentences was found in text 3 (h) with an average of 5.8. The largest number of sentences was found in texts 1 (b) and 1 (g) with an average of 19.3 sentences per one-hundred word sample.

The third column on Table II shows the average sentence length found in the samples of each text. The greatest increase in sentence length in the first grade was from text 1 (b) with 4.9 words to text
1 (f) with 9.3 words. The averages of sentence length in the second grade texts were more uniform than the first grade texts and increased from 8.2 words in text 2 (e) to 10.3 words in text 2 (g). The increase of sentence length in the third grade was from 9.2 words in text 3 (g) to 18.1 words in text 3 (h).

A review of the reading difficulty factors shows that the greatest increase of difficult words was in the third grade texts. The greatest increase in sentence length occurred in the third grade texts. There is very little increase in the sentence length and the average number of sentences per the one-hundred word samples in the second grade texts. A significant increase, from 4.0 to 8.8 per cent of the hard words found in one-hundred word samples, was found among the first grade texts. The increase of the average sentence length in the first grade texts almost doubled when it ranged from 4.9 words to 9.3 words per sentence.

The greatest increase of difficulty would be expected to appear in the third grade texts since the third grade readers, by comparison with the first and second grade readers, would be more skilled in the mechanics of reading and thus able to handle increases of difficulty more aptly.
SUMMARY AND CONCLUSIONS

Summary. In applying the Spache readability formula to the California state-adopted science texts for grades I to III, an estimate of the reading difficulty of each text was acquired. This estimate indicates the average reading ability needed for adequate comprehension of the text. This estimate is shown by a number which represents a grade placement level. This estimate determines the reading levels of these books in comparison with the common readers used in the classroom. Thus a science text with a reading difficulty of 1.2 would be a book on pre-primer level; with a difficulty of 1.5 would be on primer level and, with 1.8 would have a difficulty of a first reader.

The averages of the reading difficulty or the grade placement levels of the texts show an increase of difficulty from first to second grade and from second to third grade, but this difficulty is not consistent. One first grade text had the same reading difficulty as one second grade text. One second grade text had the same reading difficulty as five third grade texts. From the standpoint of the average reading difficulty scores, six of the first grade texts would be difficult for most pupils in that grade. Two of the second grade texts would be difficult for pupils to read at that grade. Two of the third grade texts would be difficult for most pupils in that grade.

On the basis of grade placement levels, one first grade text could be considered adapted to first grade. Four second grade texts could be considered as adaptable to the assigned grade. Seven third
grade texts could be considered as well-adapted for the assigned grade.

In Spache's opinion, books of first grade level in which the samples vary more than six months and those of second and third grade that vary eight months or more, tend to be laid aside unfinished and judged uninteresting by the reader. Though there is no data to support this view, Spache felt that these books were unsuitable at the level of the average estimate of reading difficulty. Two first grade texts varied more than six months in the samples measured. Five of the second grade texts varied eight months or more in the samples measured. Six third grade texts had samples that varied eight months or more. From Spache's viewpoint then, these thirteen books might be considered unsuitable and not adapted for the assigned grade.

One second-grade text and four third-grade texts had samples with a difficulty of over 3.9. Spache suggested that any materials measuring higher than 3.9 be re-evaluated using the Dale-Chall formula.

A study of the reading difficulty factors showed that the largest increase in difficult words and in average sentence length occurred in the third grade texts. A significant increase in difficult words and in the sentence length also occurred in the first grade texts. The increases in the reading difficulty factors found in the first grade texts could present significant hurdles for the beginning reader.

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1 Spache, Good Reading for Poor Readers, p. 120.
2 Ibid., p. 119.
Conclusions. The following statements present the important points:

1. The California state-adopted science texts for grade one do not conform highly to the grade to which they are assigned. Two second grade texts would be difficult for most pupils at that grade. Two third grade texts would be difficult for the assigned grade.

2. On the basis of the grade placement level, one first grade text, four second grade texts, and seven third grade texts seem adaptable for the assigned grade.

3. The wide range of difficulty in thirteen of the texts may indicate that they are unsuitable for the assigned grade even though the average of the estimate of reading difficulty shows that the texts are suited for the grade.

4. Five texts need to be re-evaluated with another formula since each had samples which measured higher than 3.9.

5. The increase of difficulty of the texts is not consistent from grade to grade.

6. The increase in difficulty from the most difficult first grade text to the most difficult second grade text is less than one grade level.

7. The increase in difficulty from the most difficult second grade text to the most difficult third grade text is .8, indicating a range from 3.1 to over 3.9.

8. The increase in difficulty from the least difficult first grade text to the least difficult second grade text is .7, indicating a range from 1.9 to 2.6.

9. The increase in difficulty from the least difficult second grade text to the least difficult third grade text is .5, which is less than one grade level.

10. The per cent of hard word increases between grades with the least per cent occurring in the first grade text and the highest per cent occurring in a third grade text.

11. The per cent of hard word increases within a grade was largest in the third grade and the first grade.

12. The average sentence length increases between grades with the shortest sentence occurring in a first grade text and the longest occurring in a third grade text.

13. The average number of sentences in a sample was largest in a first grade text and smallest in a third grade text.
Recommendations. The following recommendations are made:

1. It is recommended that the reading difficulty of these texts and any future California state-adopted science texts for grades I to III be made available to the classroom teacher to aid her in meeting the reading abilities of the children more adequately.

2. It is recommended that the vocabulary burden and the sentence length of each science text be made available to the classroom teacher to aid her in presenting the science material of these texts.

3. It is recommended that five texts, because of samples measuring a difficulty of over 3.9, be re-evaluated for reading difficulty by the Dale-Chall formula.

4. It is recommended that the vocabulary lists presented in this study be used as an aid in teaching the science vocabulary of the texts.

5. It is recommended that a study be done to determine if the first grade texts in which samples varied more than six months are suitable at the level of the average estimate of reading difficulty.

6. It is recommended that a study be done to determine if the second and third grade texts in which samples varied eight months or more are suitable at the level of the average estimate of reading difficulty.

7. It is recommended that teachers acquaint themselves with the use and the limitations of readability techniques, and when necessary, re-write science materials for their pupils' reading levels.

8. It is recommended that the in-service training programs for teachers present the use of readability techniques. A workshop could be used for re-writing materials found too difficult for pupils during the school year.
A. HOME


Bleau, Glenn O. Grade Four Teaching Manual for the Basic Science Education Series. Hinsdale, Illinois: Scott, Foresman and Company, 1959. 95 pp. This manual contains suggestions for introducing science units and lists activities and science concepts for each unit.


A. BOOKS

The readability of children's books in the content areas is discussed on pp. 119-20.

This manual contains suggestions for introducing science units and lists activities and science concepts for each unit.

This manual contains suggestions for introducing the science units and lists activities and science concepts for each unit.

Burnett discusses readability as a function of interest in the area of science on pp. 85-6.

The limitations of reading difficulty formulas are discussed on p. 386.

A comprehensive review of readability formulas and their applications to the areas of education, journalism, industry and government. The Spache formula is discussed on pp. 39, 53, 44, 64, and 71.

Cleary discusses the readability factors of books on p. 61.

Dolch discusses matching the difficulty of the book to the child's reading ability on pp. 54-5.

Dolch discusses the adaption of the material to the child's ability of p. 253.
The authors discuss matching reading difficulty of material to child's ability to read on p. 50.

Frank discusses matching the book to the child's ability on p. 57.

Harris is the director of the Educational Clinic at Queens College in New York and he discusses the levels of reading competence and the need to match the difficulty of the book with the child's ability on pp. 153-4.

Hildreth includes bibliographies and references. She discusses reading difficulty formulas on pp. 372-5.

Hubler gives suggestions for teaching science to children. He also stresses the need for a variety of science books to meet the range of reading abilities in a classroom.

A summary of educational research studies in reading, writing, spelling and arithmetic. The summary of the Spache formula is on pp. 177-183.

The authors discuss the basis for selecting science texts of p. 65.

Parker suggests the order of study for part of this series. There are suggested procedures for introducing the units, and study ideas and science concepts are listed for each unit.

A guide for procedures for developing science units. There are lists of inexpensive science materials, audio and visual aids and science bibliographies for children and teachers. The readability analysis by the Spache formula is on p. 152.
A guide for procedures for developing science units. There are lists of inexpensive science materials, audio and visual aids and science bibliographies for children and teachers. The readability analysis by the Spache formula is on p. 214.

A guide for procedures for developing science units. There are lists of inexpensive science materials, audio and visual aids and science bibliographies for children and teachers. The readability analysis by the Spache formula is on p. 280.

Spache suggests studies and lists other resources for teaching reading.

Spache lists books, workbooks, and magazines of particular value in stimulating interest for poor readers. The Spache formula is presented and instructions are given for its application and the interpretation when applied to written primary materials.

Graded lists of books for pre-primer to high school levels are given in this book.

B. PUBLICATIONS OF THE GOVERNMENT, LEARNED SOCIETIES, AND OTHER ORGANIZATIONS

An aid for teaching science in the elementary schools. Reading as an important aspect of science is discussed on pp. 16-7.

The authors discuss the importance of selecting science materials on varying levels of reading difficulty on p. 11.

A report of the speech given by the editor of Laidlaw Brothers regarding reading difficulties and what can be done in coping with these problems from the viewpoint of the author, editor and the teacher.
Mallinson discusses two views concerning the level of reading difficulty on which science texts should be written for students.

This index lists titles of books for children on various primary levels.


Yoakum discusses the importance of knowing the readability level of the material and matching the book to the child's reading ability.

Zim discusses the use of textbooks to further the aims of science on p. 27.

C. PERIODICALS

Arnsdorf points out that formulas do not take into account the nature and frequency of terms used in special context. This limitation of formulas could apply to the terms in science texts.

These authors recommend that reading achievement scores be used as a basis for determining what text should be used, and that readability ratings be a part of textbook selection.

This article deals with the readability measures and their limitations.

Chinnis studied the number and nature of scientific principles found in elementary science texts. This concept difficulty is one factor that is not measured by the various formulas.


Davis discusses readability and the correct use of materials.


Denslow studied the science texts in use from 1957-61. She lists 61 words from the texts as a first grade science vocabulary. The texts studied were from Scott Foresmen, Heath, Singer, Macmillan, Winston, Scribner, Ginn, and Lyons, and Carnahan.


Grace discusses programming as another use for readability formulas.


Groff measured the readability of children's magazines other than comic books. It would be interesting to know the difficulty of the science portions of these magazines, but the study does not give a difficulty by area division.


This is one of the earliest studies of the difficulty of the diverse vocabulary in textbooks.


Lockwood lists the conclusion from the results of studies concerned with the difficulty of science texts.


Mallinson recommends textbook evaluation by objective measurement.


This study compares the evaluation consistency of text difficulty as determined by "experts" and as determined by an objective measurement.
Mallinson and associates applied the Flesch formula to the elementary school texts in science and found none of the books sampled could be called easy reading material.

Mallinson and associates lists conclusions concerning the difficulty of texts as determined from the various studies done in this area of science.

A study of the reading difficulty of the elementary texts.

Mallinson and associates relate that the recent textbooks are as variable and are as likely to cause as much difficulty as the earlier texts analyzed in his previous studies.

This study presented the readability of certain United Nations publications by three readability formulas.

The focal point of this study was the incompatibility of the readability of certain text materials with the reading level of the students.

A study to determine the various means that the publishers determined the grade placement level for the texts that they published.

A study of the diversity of reading ability found among students which suggests that books of varied reading levels be considered for the science class.
Pressey, L. C. "The Determination of the Technical Vocabulary of the School Subjects," School and Society, XX (1924), 91-96. An extensive study of the science vocabulary found in widely used textbooks. This is one of the earliest studies in this area.

Rammel, Joseph A. "An Objective Study for the Bases of Selecting an Eighth Grade General Science Textbook," Science Education, XLVII (April, 1963), 258-64. Rammel lists interesting bases which could be adaptable for the selection of any level science text.


D. UNPUBLISHED MATERIALS

California State Department of Education. A letter dated November 13, 1963 and received in answer to written inquiry on December 11, 1963.


This is a one-page information sheet received November 22, 1963 from the publishers in answer to an inquiry regarding the grade placements of the Basic Science Education Series.