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TEACHING THE ESSENTIAL READING SKILLS IN SCIENCE.

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THE CURRENT DEBATE OVER THE READING SKILLS NECESSARY FOR SCIENCE LEARNING IS DISCUSSED. IN THE PAST, THE TEACHING OF READING WAS BASED ON THESE TWO MAJOR CONSIDERATIONS--THE RECOGNITION OF MEANINGS OF INDIVIDUAL WORDS AND THE ORGANIZATION OF THE WORD STIMULI RECEIVED FROM THE PRINTED PAGE INTO MEANINGFUL PATTERNS. THE RESURGENCE OF THE INVESTIGATION OF THE THEORY AND PRINCIPLES OF LEARNING IS CHARACTERIZED. SOME CURRENT PROBLEMS ARE THAT RESEARCH IN PERCEPTION RELATING TO READING HAS NOT DEALT ADEQUATELY WITH THE INFORMATION EXPLOSION, WITH THE POPULATION SIZE AND TYPE, OR WITH PROBLEMS ARISING FROM MODERN COMMUNICATION. CURRENT ASSUMPTIONS FOR TEACHING ARISING FROM PRIOR RESEARCH ARE PRESENTED. PREDICTIONS CONCERNING THE ROLE OF THE BOOK AND OF ELECTRONICS TECHNOLOGY AND SUGGESTIONS FOR RESEARCH AND STUDY ARE OUTLINED. THIS PAPER WAS PRESENTED AT THE INTERNATIONAL READING ASSOCIATION CONFERENCE (SEATTLE, MAY 4-6, 1967). (BK)

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Introduction

The topic of this paper, "Teaching the Essential Reading Skills in Science," is currently subject to much debate. That debate arises from progress that has taken place since World War II. One quarter century ago no one would have disputed the merits of teaching the essential reading skills in science, nor would there have been much argument concerning the premises on which the teaching might have been based. In general, it was agreed that reading represented the communication of ideas from the printed page via the processing of information through the visual mechanism and the transformation of that information into meaningful understandings. This general principle was translated into

a number of sub-principles and skills, all of which served as general objectives of the teaching of reading. Specialists in the content fields applied these general objectives to their fields and the literature contained many reports describing effective ways for teaching reading in the content areas. These ways were founded on the assumption that there were two major considerations in the teaching of reading:

1. The recognition of the meanings of individual words:

   Support for this assumption is evident in the numerous general vocabulary studies published by Thorndike, Horn, Buckingham-Dolch, and their colleagues. The literature in science teaching contained numerous reports of research concerning science vocabulary and other problems related to reading science materials. Practically all of the earlier major studies were summarized in the milestone report of Curtis[1] in 1938 in which the findings of more than 100 studies of science vocabulary were synthesized. Although this study proved to be the high-water mark of vocabulary studies in science, nevertheless, it proved to be the basis for many other minor studies, most of which have since been forgotten.

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[1]Curtis, Francis D., Investigations of Vocabulary in Textbooks of Science for Secondary Schools. Boston: Ginn and Company, 1938 Pp. viii + 127.

2. The organization of the word "stimuli" received from the printed page into meaningful patterns:

It has been generally accepted that reading is a perceptual task. Hence, many of the traditional views concerning the teaching of the essential reading skills have been closely allied with Gestalt findings. The influence of Gestalt theorists is evidenced by the studies involving reading difficulty of Flesch, Dale-Chall, and Lorge. Their studies emphasized the structure of the materials to be read rather than the characteristics of the individual words.

In the past decade, however, a number of findings have cast doubt on traditional reading instruction and have suggested that reading instruction may change greatly from that of the present time. Some of those findings seem related only indirectly to reading instruction but their influence is evident if they are studied carefully.

Perception and Reading

Recently, there has been a great resurgence in the investigation of the theory and principles of learning. Many of the earlier ideas about learning behavior that emerged from the behaviorists and the Gestaltists have been questioned. Much of the questioning has come from reading specialists. One reason for the concern is that it has not been possible to apply the findings of perceptual research to the teaching of reading, either in terms of general reading ability or

reading in the content fields. This seems strange, indeed, if reading is a perceptual task. However, an examination of many of these studies concerning reading and perception indicate that the designs may have been faulty. In general, they have dealt with one factor of perception and its relationship to the teaching of reading, and have indicated that there is little relationship between this factor and reading success. Nevertheless, positive relationships might exist because perception is an extremely complicated process involving many different factors and the distillation of one factor from the total realm of perception could destroy the significance of that factor. Thus, the limited range of perceptual phenomena tested may have been responsible for the apparent lack of relationship. It is well known also that findings of many perceptual studies suggest that learning involves wholes rather than parts of situations. However, these studies have generally involved adults. Yet, some of the more recent studies with children indicate that frequently they learn by parts rather than by wholes. Thus, the general applicability of findings from adult-centered studies may be somewhat doubtful.

Many of the studies involving perception have dealt with the organization of <u>objects</u> into patterns. Yet, the teaching of reading, in which the findings of these studies have been applied, has been based on the word, phrase, sentence, or story methods, seldom on the use of objects. There is little evidence to indicate that an individual can mentally reconstruct words, phrases, sentences, and stories into analogous objects which, in turn, can be reconstructed into patterns.

The symbol for an object, as found in reading material, may not be reconstructable into the wholes into which the objects themselves can be reconstructed.

McLuhan's work, which has affected television advertising greatly, has indicated that many of the ideas concerning perception are not tenable, at least over television. It has been assumed traditionally that a carefully-organized, didactic presentation of material would develop appropriate patterns of ideas in the individual, thus exerting the desired influences on him. It has been found, however, that the individual does not necessarily develop the expected patterns. The factor of identification in many cases has more influence than the logical presentation of parts on idea development.

It may be, therefore, that the studies of perception themselves have been so atomistic as to destroy the possibilities of understanding the true role of perception.

The Information Explosion and Educational Communication

A major problem that besets educational communication, particularly in the sciences, is the knowledge explosion. Prior to 1940 it was believed that knowledge was doubling in volume every 50 years. If true, the volume of knowledge accumulated between the dawn of history and 1940 would be replicated in volume by 1990. However, the assumption proved to be incorrect. The development of computers in the middle of the 20th Century freed the scientist and researcher from lengthy periods

of analyzing data. Prior to that development the collection of data might have occupied 10 percent of the researcher's time, and the analysis of the data, 90 percent or more. However, with the development of the solid state computer, the analysis of data frequently takes less time than collection. Thus, findings on which future knowledge can be sought and revealed are immediately available to the scientist and researcher. Thus, by 1950 it was estimated that knowledge was doubling in volume every 10 years. In the early 1960's, withe the new generations of computers, the rate of accumulation of knowledge had accelerated to doubling every seven. With the third generation of computers now appearing, by 1970 scientific knowledge may be doubling every five years. Thus, the mass of information that appears only serves to complicate further the reading process.

The Population Explosion and Educational Communication

If you read at a rate of about 150 words per minute by the time you finish this sentence the earth's population will have increased by about 23. One hour from now it will have increased enough to populate a city of about 8,000. One year from now the increase would populate a nation the size of the United Kingdom and Sweden combined - countries with a total population of about 62,500,000 people. Recent, extensive investigations by UNESCO of the nocturnal habits of Homo sapiens suggest that the population increment is likely to increase in the years ahead. Many educational problems, particularly those

involved with the teaching of reading, arise from the characteristics of the population, as well as from its size.

Nearly 50 percent of the world's population is below the age of 25. Altogether, more than 80 million persons in the United States are in some type of organized educational program supported by local, state, or federal funds, or by private sources. Thus, education, at least in terms of student involvement, is an enormous business. It is expected that more than $1 trillion dollars will be spent on education in the United States from all sources before the end of the next decade. This is based on the assumption that 15 to 20 percent of the national income will be funneled into educational programs of various types. Currently in the United States, nearly 40 percent of public monies, other than for defense, are spent on some form of education. This has led to the development of new combines among publishers, computer manufacturers, and the electronics industry to exploit the potential market. Some of these combines are International Business Machines Corporation and Science Research Associates; Raytheon and D.C. Heath Company; and the Silver Burdett Company, Time, Inc., and the General Electric Company. Because of the information and population explosions and the continued growth of education, there is every reason to expect that the methods of education, particularly those in the sciences, will change and will be supplemented with media other than the textbook and traditional materials. This spawns a number of important problems. An investigation of the literature of science education indicates decreasing interest in the research in reading related to science education,

and more and more research on the use of outside objects, kits, and other multimedia for education. No doubt, this trend will continue, particularly with the sophisticated advertising and sales agencies in the newly-formed combines. Thus, there needs to be a complete review as to what constitutes the essential basic skills of reading in science in the years ahead and the most effective ways of teaching them. This, perhaps, can be done only by surveying the role of technology and education in the years ahead.

Television and Vocabulary Load

The studies undertaken many years ago concerning the optimal number of scientific terms that a student could learn at any grade level are so outdated as to be useless. The impact of modern communication media, particularly television, now provides an entirely new environment in which youngsters are stimulated by vocabulary and, in turn, against which they learn this new vocabulary. Television viewing, which has become common, provides great reinforcement for the presentation of words. Thus, students currently in the early elementary school might learn scientific vocabulary far more readily than students at the seventh-grade level formerly did. One only has to talk with elementary-school children and examine the kinds of books they read to ascertain quickly that their comprehension of vocabulary is far beyond that of their parents at a similar stage. However, many of the vocabulary terms with which they now become familiar are not those found in the learning materials ordinarily used in the school. There is, of course, some overlap but many of the terms found in the

traditional teaching materials are not presented in the same stimulating environment as scientific terms presented through modern communication media. The teacher may frequently be found in the embarrassing position of teaching terms, many of which are easier than those that appear on television, in an environment considerably less conducive to learning.

Technology and Education in the Next 100 Years

No one in his right mind would attempt to predict specifically what is likely to happen in the technology of education during the next 100 years. However, by reviewing the last 100 and extrapolating, with due consideration for an acceleration of developments, some ideas may be postulated. The postulates are based on these assumptions:

1. There will continue to be a shortage of qualified teachers to man the massive educational effort that lies ahead. Even if the anticipated supply were to expand greatly, one may expect that teachers will spend more time in updating their backgrounds and somewhat less in teaching. Also, the information explosion will require more teachers for science at the post-high-school and post-baccalaureate levels.
2. In order to disseminate the ever-accumulating mass of knowledge, new methods will be needed to complement the teacher effort in accelerating its dissemination.

3. The role of education will increasingly change from teaching persons to store information in, and retrieving it from, their heads to that of acquiring new information. This means new directions for teaching methods of inquiry.

The Role of the Book

As has been stated, "We would not think of advising friends to use new drugs as uncritically as we often recommend new learning devices." But, there is little doubt that the recommendations will continue, perhaps at an accelerated rate. Some devices will be useful and some will not. But, in all of these developments the book will continue to be an important teaching aid. However, the role and format of the basic textbook will change radically in the years to come. Some of the changes are likely to be these:

1. Textbooks in the natural sciences will increasingly de-emphasize the didactic presentation of information and will present more information in terms of problem and inquiry approaches. They will become more like textbooks of mathematics. Although many publishers have paid lip service to these approaches, there is little evidence yet of accomplishment. In general, the activities related to inquiry are found in the ancillary materials. One may expect that the textbooks of the future will contain mainly foundational problems and the ancillary materials will

contain problem-solving situations related closely to the student's everyday experiences. The latter will provide for cultural, geographical, and other differences among the students.

2. Modern printing developments will make it possible to increase greatly the numbers and types of illustrations in textbooks. This will mean more four-color illustrations and the possible use of three-dimensional photography. Many of the problems in the textbooks will be focused on the analysis of these photographs.
3. There will be greater integration between the ancillary materials and the textbooks. Students will be expected to move from the textbook to filmloops and to other types of hardware, including science kits, and then back to the textbooks. A single problem involving the use of ancillary materials will occupy far more than the usual class period, or even a day.

The Role of Electronics Technology

The greatest change in sources of information input in the sciences will be in periodicals and serial literature to which the student is directed. These are the "monsters" that are placing overwhelming burdens on shelving and cataloging capabilities in libraries. They will be replaced by vast electronic banks of information in which

this literature will be stored and to which students will direct questions. Such library systems will encompass these elements:

1. The purchase of subscriptions for periodical and serial literature in the form of a computer input device.
2. The storage of the "subscriptions" in toto in a ferro-magnetic, or other domain, in a computer in a form suitable for extremely rapid examination, manipulation, and printout.
3. The availability of some type of index or bibliography which a student can scan to determine which elements of the periodical or serial literature may be useful.
4. The issuance to a student, on receipt of a proper code number on one hand or a request based on diverse, custom, or subject specification on the other, a reproduced copy, or copies, of the periodical literature that he may keep.

The environments in which students gain information will be decentralized. Libraries may no longer be used for study, since the output mechanisms for the electronic banks can be placed in residence halls and homes. Much of the output may be on a television monitor rather than in the form of a printout.

Some Suggestions

In the previous discussions the writer has attempted to list some of the major cultural pressures that affect vocabulary and hence the teaching of reading, and also to make some predictions as to what may happen in the future with respect to learning materials. However, he has studiously avoided making any specific recommendations as to how to teach basic reading skills in science. To him the reason is obvious. Except for reviewing recommendations made in earlier reports, all of which would be redundant to those reading this report, he could do little. He firmly believes that extensive research must be undertaken to ascertain what needs to be done in a modern environment to teach basic reading skills of science before suggestions for implementation can be made. This may be construed as an evasion but it seems to be the only outlet. Thus, the following suggestions for research and study are made:

1. The extensive vocabulary studies in science undertaken by Curtis and Mallinson and their colleagues are hopelessly outdated. Although they may have been salutary and useful during the period when printed materials represented the primary learning sources, they are no longer significant contributions in view of the modern devices which are available for teaching science. Thus, it is suggested that a series of research studies be undertaken to

ascertain the type of vocabulary youngsters use as a result of the total environmental impact upon them.

2. Studies need to be undertaken to determine how well youngsters can read terms and concepts with which they have been stimulated over different types of multimedia, including television and filmloops, as well as other devices. It is obvious that these new multimedia offer entirely new patterns of perceptual stimuli which have not yet been investigated in this context.

3. Studies need to be undertaken to determine how familiarity with using these scientific terms in conversation and in being stimulated by them through the new multimedia is accompanied with understanding. The findings of the older studies in which word recognition was considered tantamount to understanding are no longer tenable.

4. Studies need to be undertaken to determine the ways in which modern graphic arts techniques can be incorporated into books and other printed materials so as to present science readings in a quasi-visual environment rather than remonstrances in print. Little has been done to determine how techniques such as three-dimensional printing may be used more effectively so

as to complement verbal concepts. Textbooks, unfortunately, still rely on outdated formats rather than making use of those that appear in modern media such as Life, Time, and Fortune. The picture essay technique has hardly been explored for providing a better visual environment in which to develop science concepts.

5. Studies should be undertaken to review critically the literature involved with the teaching of the blind and making use of stimuli other than visual to develop science understandings. Generally, as indicated in the earlier part of this paper, reading was essentially visual communication through the medium of print. However, many techniques involving tactual and auditory stimulations may be combined with those from other sources to teach reading. Little has been done to explore this broader concept of perception.

Summary

In brief, this paper has said little about "how to do it." Should any of the readers be interested in ways for teaching the essential reading skills of two decades ago effectively through science materials, they may be found by reading several sources already mentioned. However, it seems that entirely new directions of research are needed if recommendations for techniques are not to be dinosaurian.