DOCUMENT RESUME

ED 269 243 SE 046 559

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TITLE What Research Says about Science Textbooks, Science Reading and Science Reading Instruction: A Research Agenda.
PUB DATE [86]
NOTE 10p.; Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (59th, San Francisco, CA, March 28-April 1, 1986).
PUB TYPE Speeches/Conference Papers (150) -- Reports - Descriptive (141)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Elementary Secondary Education; Material Development; *Reading Instruction; *Research Needs; *Science Education; Science Materials; *Textbooks
IDENTIFIERS *Science Education Research

ABSTRACT

A survey of the literature on science and reading research supports the identification of six potential foci and numerous interactions for future research related to science and reading. These six areas are: (1) nature of science and science education; (2) nature of the reading process (outlining Holliday's 10 rules for designing effective science texts); (3) nature of science text; (4) nature of the reader; (5) teachers' attitudes toward and knowledge about science reading; and (6) instructional uses and strategies related to science reading. Research needs related to each of these areas are addressed. For example, it is noted that research is needed to more clearly describe the nature of science, its influences on science education, and the role textual materials and print processing play in science and science education. Other research needs to focus on new assessment techniques that more closely reflect the interactive-constructive reading process that critically involves both the text and the reader, on the teacher's personal attitudes toward and knowledge about science reading, and on whether the science textbook is used as the initial source of data or if it is used as an instructional supplement to reinforce and enrich concepts initiated by concrete experience, demonstration, or lecture. (JN)

What Research Says About Science Textbooks, Science Reading and Science Reading Instruction: A Research Agenda

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Introduction

The survey of the literature on science and reading research (Yore & Shymansky, 1985) supports the identification of six potential foci and numerous interactions for future research in science reading (Figure 1).

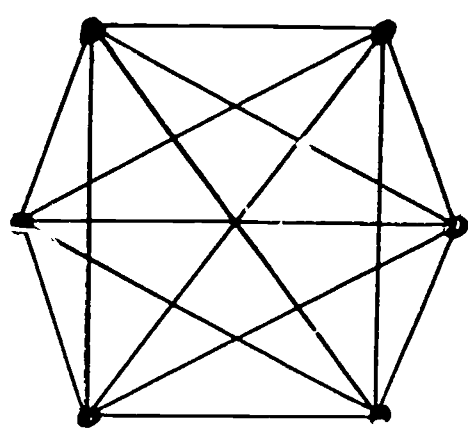

Figure 1: Research Foci of Science and Reading

*Presentation at the National Association for Research in Science Teaching Annual Meeting, San Francisco, March 28-31, 1986.

Nature of Science and Science Education

The nature of science and science education are unique factors influencing the science reading process. The science enterprise and teaching/learning science both emphasize the importance of experience, primary data sources, and commonly accepted personal interpretations. The records of previous science experience are valuable resources for initiating further exploration, formulating new hypotheses and interpreting results, but they seldom replace the concrete-intellectual experience phase of science. Science is people's attempts to search out, describe and explain patterns of events in the natural universe. Science is a cyclic, self-verifying, dynamic process that produces temporary truths. The perception and processing of data are critical to successful sciencing. The processes, attitudes, logic, and thinking related to science are equally important as the end-products of science: facts, concepts, principles and theories. Embed these dynamic attributes of science in a technological and societal context, while attempting to educate a variety of learners one can easily accept that the nature of the science and science education enterprises have critical influence on their relationship to science prose, science reading, and science reading instruction. Research is needed to more clearly describe the nature of science, its influences on science education, and the role textual materials and print processing play in science and science education.

Nature of Science Text

Science and mathematics' textual materials are uniquely different from any other type of written material. Science prose generally attempts to convey information and abstract ideas without the aid of a common story grammar. Intricate use of traditional syntax, vocabulary and development in conjunction with specific content, uncommon concepts, unique lexicon, non-traditional symbols, adjuncts, connectives, logic and purpose forces one to realize that much comparative analysis is needed between science, technical and mathematics prose, and traditional written text such as fiction and non-fiction novels. Furthermore, a comprehensive analysis within the various science disciplines is needed to determine if a significantly different style is found in the biological, earth or physical sciences. Holliday (1986) identified rules for designing effective science text, specifically:

1. The organization and contents of a text should reflect the author's concept of science, and inspire the student to learn.
2. Headings and pointer words should be reliable signals of a science text's "predictable" organization.
3. Selected words and sentences representing new science information and requiring special study should be highlighted using bold-type, italics, color, underlining, or some other graphic technique.
4. A science text should be coherent and void of clutter -- including unnecessary modifiers, jargon, and vaguely

referenced words and phrases.

5. New science information should be explained and connected to old information.
6. Extraneous, distracting information should be placed in tables, figures, boxes or simply deleted.
7. Visuals and other graphic devices should be referenced in the prose, be appealing, highlight important science information, and clarify "semantic positions" among science concepts in layout.
8. Study questions and problems should encourage comprehension of important science information and clarification of the author's purpose, rather than verbatim and rote processing of information.
9. The author should describe how to study a science text by providing direct instruction with examples and practice exercises on how to learn.

Holliday implies that an accurate description of the nature of science, a consistent predictable structure, and an embedded study strategy must be imposed on science prose used for educating nonscientists. It seems reasonable that authors must have and convey an accurate, exciting model of science. Unfortunately few science writers have taken time to explore the nature and history of science. The work coming from the University of Keil, West Germany, appears to be a bright spot in this area. Holliday's points 2-7 appear to recommend a stripped-down lean version that provides consistent, perceptual clues regarding meaning and importance. The remaining ideas appear to provide hints that influence the information processing part of reading. Holliday's rules are worth further consideration and application, but if they are used, will readers be able to read science materials not designed for the educating process?

Nature of Reading Process

The nature of the science reading process appears to be most appropriately described by the constructive-interactive model. Reading science and mathematics involves much more than what is on the page and/or what the readers bring to the process. The effective science reading experience must involve both text-driven and reader-driven components and an invention or construction component that occurs at the time that text and reader are interacting. Written science materials must be logically developed, considerate and contain worthwhile science concepts clearly illustrated and accurately described. The reader must bring a variety of cognitive and meta-cognitive attributes to the print material. Foremost the reader must be flexible and interactive allowing readily available prior knowledge and skills to mediate the print processing in terms of an identified purpose. As the reading process continues the purpose may be refined or modified, less-available knowledge will be accessed and new meaning and understanding will be invented or constructed by the reader. Often the invention will occur in a post-reading activity in science classroom. The post-reading activity should provide a supportive scaffolding that aids the reader in organizing, analyzing, synthesizing and verifying the new inventions attained from the reading process.

Naturalistic research is needed to more accurately describe these components and the glue that integrate them. Few inferences from content reading research utilizing social studies or language arts can be comfortably applied to science and mathematics reading. Many research studies related to reading comprehension need to be replicated using science and mathematics textual materials before valid inferences or generalizations can be produced regarding text processing and comprehension of science.

Nature of Reader

The nature of the reader has been sparsely explored especially when science text is being read. Popular attributes in science education research, such as learning styles, hemispherical dominance, cognitive preference, cognitive style and cognitive development, have not been applied to the science reading issue. Furthermore, learner characteristics such as reading comprehension ability, reading vocabulary, content reading skills, metacognitive abilities and prior knowledge, need systematic exploration. It may be that learner specific text and processing is needed by a reader.

New assessment techniques are needed that more closely reflect the interactive-constructive reading process that critically involves both the text and the reader. The Cloze procedure was an advancement over the reading formuli, but it still is not the ideal state. A pretest-posttest strategy allowing free response on a specific science topic before and after reading may have promise. The pretest would allow the assessment of the reader's prior knowledge, while the posttest would allow the assessment of post-reading knowledge. The difference would be an indication of new knowledge comprehended during the reading process. The new knowledge could be partitioned into 1) knowledge provided directly from the text, 2) deep knowledge accessed during reading, and 3) new knowledge invented or constructed during the reading process.

The pretest-posttest strategy would allow researchers to describe the reader's attributes and to manipulate the textual material read. A variety of established instruments could be used to describe the reader's cognitive, affective, motor skills, physical and personality attributes. The textual material could have varying degrees of informaiton, clarity, logical development, adjuncts and comprehension aids. Such combinations of reader information and textual materials should allow more concise inferences to be generated about the science reading problem.

Teacher Attitudes and Knowledge

Little is known about the teacher's personal attitudes toward and knowledge about science reading. It has always been assumed that science textbooks were very important to most science teachers and teachers understood the major ideas regarding science prose and science reading. Students suggest that teachers do little to indicate the importance of science reading and science reading assignments. Students report that they do not see science teachers as readers, experience little pre-reading instruction as to purpose and appropriate skills and recall little follow-up on reading assignment other than the chapter problems. Surveys have indicated that students do little reading in school. Does this factor indicate that teachers have given up on reading as a worthwhile learning experience in science or does it indicate that science teachers do not understand the science reading issue?

A recent pilot study indicated that new science teachers graduating from the University of Victoria's teacher education program were knowledgeable about science reading and had positive attitudes toward science reading. Since a significant number of science teacher education programs do not provide course work in content reading and few content reading instructors have a science background, it may be reasonable to assume that most science teachers lack knowledge about science reading and may have less than positive attitudes. A more complete description of teacher attitude and knowledge could be attained by a large scale survey.

Instructional Uses and Strategies

What uses of and support strategies for science reading science teachers utilize are not well understood. The fact that teachers commonly request new science texts, along with little evidence of in-class use, emphasizes the importance of this research issue. Science teachers may be relying on content reading skills developed in traditional language arts courses that no longer exist. Researchers must establish the intended use and instructional supplements common in science classrooms before embarking upon redesigning science textbooks. Is the science textbook used as the initial source of data or is it used as an instructional supplement to reinforce and enrich concepts initiated by concrete experience, demonstration or lecture? Do science teachers introduce reading assignments in such a manner to establish purpose, access prior knowledge, and provide insights into new and difficult vocabulary? Do science teachers use direct instruction to develop content reading skills, such as defining from context, use of signal words, meaning of logical connectives, inferring meaning, developing graphic overview, concept maps and word webs and general comprehension strategies that encourage surveying, questioning, reading and summarizing?

Such research questions require a combination of questionnaires, personal interviews and classroom observations. This would allow precise descriptions of a small sample of science teachers, validation of self-report data and possible generalization to a larger sample.

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