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ABSTRACT

This ERIC Digest describes the parameters of misconception research as it relates to the learning of science and highlights some of its implications for the teaching of science in the elementary school. The document reviews terminology associated with misconception research, identifies common characteristics of misconceptions, and specifies strategies and directions for teachers and teacher educators of elementary school science. (ML)

SCIENCE MISCONCEPTIONS RESEARCH AND SOME IMPLICATIONS FOR THE TEACHING OF SCIENCE TO ELEMENTARY SCHOOL STUDENTS

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No. 1, 1987

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Introduction

In July, 1983, an international seminar on misconceptions in science and mathematics was held at Cornell University (Helm and Novak, 1983). Fifty-five papers were presented and 118 people registered for the seminar. The proceedings of this conference were published, with the papers grouped according to primary emphasis: theoretical and philosophical perspectives (8 papers), instructional issues (9 papers), research and methodological issues (12 papers), historical and epistemological perspectives (5 papers), elementary school science (2 papers), physics (11 papers), biology (6 papers), chemistry (1 paper), and mathematics (5 papers). A second international seminar is scheduled for the summer of 1987, also at Cornell.

Although elementary school science as a primary paper emphasis accounted for only two papers, the area of misconceptions research has relevance for the teaching of science to elementary school students. This digest has been produced in an effort to describe what this area of research encompasses, to highlight a few relevant studies, and to communicate some of the implications that the findings of misconceptions research has for the teaching of science in the elementary school.

A Variety of Terms

An article published in *Science Education* in April 1940 was entitled "An Evaluation of Certain Popular Science Misconceptions" (Hancock, 1940:208). This author defined a "misconception" as "... any unfounded belief that does not embody the element of fear, good luck, faith, or supernatural intervention." (1940:208) Hancock considered that misconceptions arose from faulty reasoning (1940:209). Current science education researchers would probably take issue with this assumption.

Science educators, in the United States and abroad, who are interested in conceptual development have used a variety of terms to describe the situation in which students' ideas differ from those of scientists about a concept. Some talk of students' misconceptions; others write of preconceptions; still others, of naive conceptions; some, of naive theories; some, of alternative conceptions, and some, of alternative frameworks.

Barrass (1984) wrote of "mistakes" or errors, "misconceptions" or misleading ideas, and "misunderstandings" or misinterpretations of facts (p.201), saying that teachers and brighter students can correct errors but what attention is paid to misconceptions and misunderstandings that are perpetuated by teachers and textbook authors?

Driver and Easley (1978:62) contend that semantics indicate the writer's philosophical position, saying that Ausubel talks of "preconceptions" which are ideas expressed that do not have the status of generalized understandings characteristic of conceptual knowledge. However, those who use the term "misconception" indicate an obvious connotation of a wrong idea or an incorrectly assimilated formal model or theory. And, those persons who use "alternative frameworks" indicate that pupils have developed autonomous frameworks for conceptualizing their experience of the physical world.

Helm and Novak, in the introduction to the proceedings of the 1983 seminar, stated that an issue which surfaced early in the meeting was that "misconceptions" as a term carried with it some connotations that are not appropriate (1983:1). This issue was not resolved although Novak suggested that researchers adopt the acronym LIPH, standing for "Limited or Inappropriate Propositional Hierarchies." However, seminar participants decided it was too early in the history of research programs to attach an explicit label (1983:4).

Findings Related to Elementary Science

What does all this mean in terms of teaching science in elementary schools? Frequently, when science is taught to elementary school pupils, it is taught as if the children had had no prior experiences relative to the topic being studied. Misconceptions research contains findings indicating that this is not a valid assumption. Children come to school already holding beliefs about how things happen, and have expectations - based on past experiences - which enable them to predict future events. They also possess clear meanings for words which are used both in everyday language and in a more specialized way in science. A child's view and understanding of word meanings are incorporated into conceptual structures which provide a sensible and coherent understanding of the world from the child's point of view (Osborne & Gilbert, 1980:376). Children hold ideas developed before and during their early school years. These ideas may be compounded by the teacher and/or the textbook. It is possible that children develop parallel but mutually inconsistent explanations of scientific concepts - one for use in school and one for use in the "real world" (Trowbridge & Mintzes, 1985:304).

Fisher contends that misconceptions serve the needs of the persons who hold them and that erroneous ideas may come from strong word association, confusion, conflict, or lack of knowledge (1985:59). According to Fisher, some alternative conceptions, judged to be erroneous ideas or misconceptions, have these characteristics in common:

1) They are at variance with conceptions held by experts in the field.
2) A single misconception, or a small number of misconceptions, tend to be pervasive (shared by many different individuals).
3) Many misconceptions are highly resistant to change or alteration, at least by traditional teaching methods.

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4) Misconceptions sometimes involve alternative belief systems comprised of logically linked sets of propositions that are used by students in systematic ways.

5) Some misconceptions have historical precedence; that is, some erroneous ideas put forth by students today mirror ideas espoused by early leaders in the field.

6) Misconceptions may arise as the result of:
   a) the neurological "hardware" or genetic programming (as in the case of automatic language-processing structures, which may be invoked when "reading" an equation);
   b) certain experiences that are commonly shared by many individuals (as with moving objects); or
   c) instruction in school or other settings. (1985:53)

Several reports have been produced as a result of a project carried out at the Institute for Research on Teaching at Michigan State University (Roth, 1985; Smith and Anderson, 1984a; Smith and Anderson, 1984b; Smith, 1983). This representative (not exhaustive) list relates to using activities from the Science Curriculum Improvement Study (SCIS) with elementary school pupils. SCIS activities were not sufficient to help students exchange their previous conceptions so curriculum materials, a text, and a teacher's guide were developed for use in the project. Even when these especially-developed instructional materials were used, misconceptions held by children proved difficult to change, although the modified materials were more effective than SCIS (Roth, 1985).

Operating on the assumption that if science in the schools is to improve, elementary school science teaching has to improve, Lawrenz (1986) investigated in-service elementary school teachers' understanding of some elementary physical science concepts. She developed a questionnaire using items from the physical science test questions given to 17-year-old students as part of the National Assessment of Educational Progress science studies and found that 11 of the 31 items were answered correctly by 50% or fewer of the 333 teachers surveyed. Lawrenz concluded that some of the errors were due to lack of content knowledge but that others were indicative of serious misconceptions (1986:658). If teachers do not understand elementary physical science concepts, how can they teach their students?

Implications for Teaching, Teacher Education

Lawrenz (1986) advocated in-service education, beginning with very basic science concepts so that in-service teachers could have experiences with concrete examples that conflict with misconceptions they hold. Then, teachers should be shown and given numerous examples of how to identify misconceptions of the pupils in their own classrooms.

Smith and Anderson (1984b) suggested that, in teacher education programs, preservice teachers should be helped to develop ideas about conceptual change in learning. Teacher educators must realize that their students have conceptions about teaching and learning that are different from those the teacher educators hold - and that the teacher educators should work to change these student misconceptions (p.696). They wrote:

> Among the important learning outcomes teacher education should address are the following:
> (1) a conceptual change view of learning,
> (2) knowledge of generic strategies useful in achieving conceptual change,
> (3) knowledge of common misconceptions for several important topics and specific strategies for changing them,
> (4) skill in selecting and adapting curriculum materials based on common preconceptions held by students,
> (5) skill in diagnosing student conceptions and recognizing them from student responses, and
> (6) a view of theory as invented to account for observations rather than deriving objectively and reliably from them.
> (1984:697)

Engel Clough and Wood-Robinson (1985) have suggested several things teachers may try although they admit that these ideas have not been tested: (1) start with students' ideas and devise teaching strategies to take some account of them; (2) provide more structured opportunities for students to talk through ideas at length, both in small group and whole class discussions; (3) begin with known and familiar examples; (4) introduce some science topics into the curriculum at earlier grade levels, drawing on out-of-school knowledge (p. 129).

Several researchers have emphasized the importance of allowing pupils to explore their own ideas in a non-threatening atmosphere. Teachers need to devise strategies for encouraging this exploration and for creating the necessary classroom climate.

Teachers also need to consider the extent to which misconceptions may be language difficulties. Teachers and students may fail to share the meaning of the terms they use or the questions they ask.

Hopps, in discussing cognitive learning theory and classroom complexity, has provided some suggestions that are relevant to structuring elementary school science lessons to deal with misconceptions:

> We cannot expect learners to identify and select key stimuli without specific advice from teachers . . .
>
> We cannot expect that all pupils will focus attention on key aspects of the learning activity without deliberate action on the teacher's part . . .
>
> . . . Models of conceptual change imply that the learner's ability to forge links between prior knowledge and sensory input is likely to be of critical importance in learning . . .
>
> Teachers can assist learners by providing the kinds of information and experiences which will enable them to bridge the gaps between sensory input and prior knowledge . . . ideas to be taught should always be related to the relevant frameworks held by the learner and revision of the key parts of such frameworks should not be undertaken lightly.
>
> Explanations of any links between new information and prior knowledge should be made in a variety of ways such that learners are presented with visual, verbal and/or a diagrammatic format of the principles to be taught.
>
> Whenever concepts or definitions are to be introduced, teachers should provide significant numbers of examples and non-examples . . .
>
> (1985:171-172)

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