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A qualitative analysis of preservice elementary teachers' conceptions of heat transfer and temperature

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A QUALITATIVE ANALYSIS OF PRESERVICE ELEMENTARY TEACHERS' CONCEPTIONS OF HEAT TRANSFER AND TEMPERATURE

by

Peggy J. Tilgner

A DISSERTATION

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For the Doctor of Education Degree

Major: Interdepartmental Area of Administration, Curriculum and Instruction

Under the Supervision of Professor Donald W. McCurdy

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DISSERTATION TITLE

A QUALITATIVE ANALYSIS OF PRESERVICE ELEMENTARY TEACHERS'

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GRADUATE COLLEGE
UNIVERSITY OF NEBRASKA

A QUALITATIVE ANALYSIS OF
PRESERVICE ELEMENTARY TEACHERS' CONCEPTIONS
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Peggy Jane Tilgner, EdD

University of Nebraska, 1990

Advisor: Donald W. McCurdy

The purpose of this study was to determine the level of understanding concerning heat transfer and temperature held by preservice elementary teachers. Three questions were identified: (1) What did preservice elementary teachers know about everyday phenomena that involved heat transfer and temperature? (2) How did their answers compare with answers accepted by most experts as being correct? (3) How did their answers compare with answers given by elementary students as reported in the literature?

Eleven elementary education majors from a midwestern university elementary science methods class were interviewed using an interview-about-instances technique. Interview transcripts were analyzed using a variety of matrices. Frequent peer reviews and member checks were made to insure the validity and consistency of the findings. Detailed description of the setting, methods,

and the findings were provided to accurately represent the multiple realities.

The following conclusions were made based on the results: (1) The conceptual model of heat transfer and temperature used by the subjects in the study more closely resembled the caloric theory than modern thermodynamics. (2) The problem-solving method employed by the subjects consisted largely of recalled facts and personal experiences. The subjects were unable to deal successfully with interactions between two or more variables. (3) The idea of temperature as a relative measure is well-developed in the subjects but does not appear to be grounded in the kinetic theory of matter. (4) The conceptions held by the subjects matches closely with those reported being held by older elementary children.

The findings of this study suggest that alternative methods should be employed in teaching science to future elementary teachers. The methods might include making them aware of their current conceptions before providing them with activities to change any incorrect conceptions they may have.

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CHAPTER 1

The Problem

Setting the Stage

I walked into the elementary classroom looking for the student teacher. "She's outside on the playground watching recess, but she'll be back inside in about five minutes. Just make yourself at home," said the cooperating teacher. As I settled into the corner from where I would do my observing, I took a look at the things around the room. There were brightly colored animal posters, the "mandatory" penmanship train, and samples of student work covering the available wall space. On the table in the back was an aquarium. A variety of common house plants filled the window sills. I thought to myself, "Here's a room where the kids have some real fun in science class."

After I finished observing and debriefing the student teacher, I visited with the cooperating teacher and student teacher about the various subjects the student teacher would be teaching that term. When I mentioned science, the cooperating teacher hesitated and then said quietly, almost apologetically, "We try to squeeze science in on Fridays. With all the extra classes like art, music, and PE, it's really hard to cover the things we are supposed to and have time left over for science."

"What about the plants and the aquarium?" I inquired. "Seems to me you have some potential science activities right there."

"Oh those," the cooperating teacher replied. "They are things I have every student teacher set up because the principal likes to see lots of things to stimulate the kids' curiosity. We never do much with them."

<u>The Magnitude of the Problem</u>

Such a scenario is all too common in this nation's elementary schools. A subject that excites students and has the possibility to be integrated with the core curriculum is virtually neglected by 85% of teachers (Manning et al., 1980).

Research concerning the lack of elementary science has revealed a number of causes. Lack of academic preparation in science is cited by three-fourths of surveyed teachers (Gerlovich et al., 1981). Lack of administrative support, insufficient materials and space, difficult textbooks, and inadequate time are other frequently mentioned obstacles (Mechling & Oliver, 1981). All of the aforementioned items need to be dealt with to increase the amount of science taught in our elementary schools. A clue to a good place to begin dealing with the problem may be the fact that 75% of elementary teachers feel unprepared to teach science.

When researching anxiety in preservice elementary science teachers, Duschl (1983) found the knowledge component to be the most threatening factor and a significant contributor to apprehension about teaching science. Elementary teachers simply did not feel they knew enough science to teach it. A search of

the literature revealed that few attempts had been made to ascertain what elementary teachers knew about science. Science is not a component of the Pre-Professional Skills Test (PPST); it is not part of most state teaching exams. In fact, college-level science is not a requirement for elementary certification in some states (Manning et al., 1981).

It would seem that a logical starting point for solving the problems listed above would be to determine how much science elementary teachers know. One could administer a standardized, multiple-choice exam and obtain scores that could be compared with a norm. Too often the standardized tests only measure knowledge at the recall and comprehension levels but reveal little about the level of understanding of any particular concept.

A number of researchers have conducted in-depth interviews with children in both elementary and secondary schools to determine the level of understanding of concepts in earth science, astronomy, biology, physics, and chemistry (Arons, 1981; Bishop & Anderson, 1986; Brumby, 1982; Eaton, 1983; Erickson, 1979, 1980; Minstrell & Smith, 1983; Wandersee, 1985; and Za'Rour, 1975). To date, there have been no similar attempts reported concerning elementary teachers' understanding of these same concepts. Although a time-consuming process, such interviews allow probing that can reveal how much or how little a person actually knows about a concept.

Research Focus

It was beyond the scope of this research to determine what level of understanding even a single teacher had of all the scientific concepts he/she might teach in an elementary classroom. A more manageable problem was to select a single concept and try to gain a more complete picture of the understanding of that concept. The concept chosen was heat transfer--a concept that is found at nearly every grade level in all the major publishers' science texts.

Children's understanding of heat transfer phenomena has been documented by Erickson (1979, 1980), Erickson & Tiberghien (1985), Osborne & Colgrove (1983), and Osborne & Freyberg (1985). By using similar tasks and techniques, the investigator was able to uncover preservice elementary teachers' ideas about heat transfer. The subjects chosen for the research were preservice elementary teachers in a science methods class. They were selected for their accessibility for the researcher as well as for the fact they would soon be responsible for teaching these concepts in their own classrooms.

Some specific questions that were explored in this study were: (1) What did elementary teachers know about everyday phenomena that involve heat transfer? (2) How did their answers compare with the answers accepted by experts as being correct? (3) How did their answers compare to those given by students as

reported in the literature? (4) What recommendations can be made for improving an elementary teacher's knowledge about scientific concepts such as heat transfer?

Philosophical Background

How one ascertains another person's knowledge about certain phenomena is a perplexing question. Truth in nature is not waiting to declare itself. Scientists do not know in advance what observations or data will be important, but they usually have an imagined preconception of what the truth might be that arises out of their view of the world (Medawar, 1979). This viewpoint is the basis for the questions asked, the methods employed to research the question, and serves as the standard against which the results are evaluated.

Positivist Viewpoint

Traditional research is based on the assumption that there is a single objective reality that we can observe, know, and measure. The nature of that reality is held to be constant (Merriam, 1988). Logical positivism, the contemporary form of the traditional viewpoint, brings together two very powerful bases for knowledge. Logic serves as the scaffolding on which one models the world while observational experiences constrain the model. The main concern of such a viewpoint is to develop clear criteria for what are meaningful explanations. Analytic or synthetic statements are the only meaningful statements since their truth can be

established by definition or experience. All other statements are outside of the realm of verification since their truth cannot be established by definition or experience. The end results are explanations that show how particular events are examples of an established pattern (Bredo & Feinberg, 1982).

The use of logic and constraint serves as a convincing argument for the veracity of traditional research. However, universal laws are difficult if not impossible to find when dealing with the social sciences. There are exceptions to every rule, so a strict deductive-nomological model of explanation is not useful.

In order to overcome this problem and yet maintain some standards against which one can judge veracity of claims, researchers have adopted the inductive-statistical model of explanation. Rather than strict adherence to universal laws, the researcher tries to find general probabilistic relationships to explain the data. These generalizations in turn can be used to predict other events in a statistical rather than in a deterministic sense.

The primary argument against either positivistic approach is the absolute logical distinction made between theory and observation. If theories are based on paradigms, then observations are always constructed according to the patterns involved in the paradigm. The observer is never neutral nor

objective, but makes observations rooted in prior experiences and beliefs. The positivistic focus on single, tangible fragments of reality in which the knower is completely independent of the known can result in research which ignores the humanness of human respondents.

Interpretavist Viewpoint

To more adequately deal with human nature, a different view of the world is called for; a point of view in which we think of the nature of reality as holistic with a complex interrelationship between the knower and the known. Such a world view might argue that we cannot find out much about the way the world is by asking about the best or most faithful or most realistic way of seeing or picturing it. The ways of seeing and picturing are many and varied and are dependent on past and present experiences. Instead one must be willing to accept the idea that there are multiple realities that are context-bound and value-bound (Lincoln & Guba, 1985).

If one adopts this interpretive point of view, he/she must employ different research methods. These methods are qualitative rather than quantitative because the interpretavist assumes that the world is not an objective thing, but a function of personal interaction and perception. Beliefs rather than facts form the basis of perception. The research is exploratory, inductive and emphasizes processes rather than products (Merriam, 1988).

Although the methods may be qualitative, the purpose of the research remains the same--to add to the body of knowledge. For that to occur, the findings must match reality, including concern for reconstructing multiple realities that are valid and reliable.

Qualitative Methodology

The first assumption underlying the chosen methodology is that individuals' experiences are mediated by their own interpretations of experience. Experiences are created by individuals through an interaction with others and are used by individuals to achieve specific goals. The researcher therefore is concerned with covert behavior--the participants' point of view. The intent is to try and discover and understand the processes by which the points of view have developed (Jacob, 1987).

Something is known conceptually about how the points of view may have developed, but not enough to house a theory. However, theory is important to this type of exploration in that it aids in formulating propositions about relationships among categories of data. These propositions can be woven into a theoretical scheme which is further tested by additional examination of the empirical world.

Propositions are the result of collecting descriptive data. Descriptive data can include information gathered in interviews, observations, and examination of written documents. Even though

the investigator does not have a theory to operate from, he/she usually has a fairly good idea of where to look for the necessary information--in which setting, among which actors, within which processes he/she is likely to find useful data.

The descriptive data is then used to develop conceptual categories that illustrate, support, or challenge the researcher's conclusions. These categories should be exhaustive, mutually exclusive, independent, and derive from a single classification principle. Schemes can be borrowed from outside sources as long as they contribute to making the results plausible and reasonable (Merriam, 1988).

The primary research instrument for data gathering becomes the human inquirer. Human instruments are fallible, as are other research instruments. Mistakes will be made, opportunities will be missed, personal biases may interfere. This is no different from the researcher using positivistic methods. To control for these factors, the researcher must take precautions to include a variety of respondents and to continually involve others in examining the data and subsequent conclusions.

The qualitative researcher must also be constantly aware of the extent to which her/his presence is changing what is observed. He/she must have a sensitivity for the context and the variables within it, including the setting, the people, and the nonverbal behavior. The researcher must be a good communicator, be able to

empathize with respondents, be able to ask good questions, and above all to listen intently in order to reconstruct reasonable multiple realities.

The human instrument has an invaluable capability--the capability of summarizing data on the spot and feeding them back to a respondent for clarification, correction, and amplification. The researcher may also interpret and reinterpret the data during the process. This allows the inquirer to move beyond the level of tacit knowledge. Tacit knowledge must be converted to propositional knowledge so that the inquirer can both think about the knowledge explicitly and communicate it to others.

A second assumption made in adopting a qualitative method for this study was that the goal of the research was to discover, understand, and gain insight. In order to do that the researcher selected the sample from which he/she could learn the most. Members of any group that occupy a particular position in the social structure (i.e., elementary teachers) develop common mental frameworks and patterns of behavior for dealing with the situations they encounter. In order to understand the behavior in certain situations, one must select people from that context that are likely to provide the rich description necessary for understanding complex thought processes. This sample should be nonrandomly selected precisely for its potential to provide the greatest insight. Respondents may include dissidents, isolates,