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ABSTRACT

Teaching has been described by a number of educational researchers as a complex cognitive activity. In an effort to contribute to the knowledge base for elementary science teacher effectiveness, this study was undertaken to build upon the procedures and findings of previous intensive instruction research by providing a framework for the investigation of the effects of intensive instruction upon the thought processes of preservice elementary science education teachers engaged in inquiry skill tasks. Fourteen preservice teachers enrolled in education courses of a major mid-western university were randomly assigned to either a treatment or control group. Treatment subjects received intensive instruction in cue attendance. All subjects were assessed for their ability to observe details, ask questions and to generate hypotheses on inquiry skill tasks. Intensively instructed subjects performed better in inquiry skill tasks than those subjects receiving no intensive instruction. Intensive instruction appears to have enhanced the treatment subjects' ability to consider and report a greater number of alternative relevant cues while engaged in the observation of details. (YP)

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Research Paper
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Abstract

Teaching has been described by a number of educational researchers as a complex cognitive activity. In an effort to contribute to the knowledge base for elementary science teacher effectiveness, this study was undertaken to build upon the procedures and findings of previous intensive instruction research by providing a framework for the investigation of the effects of intensive instruction upon the thought processes of preservice elementary science education teachers engaged in inquiry skill tasks. Fourteen preservice teachers enrolled in education courses of a major mid-western university were randomly assigned to either a treatment or control group. Treatment subjects received intensive instruction in cue attendance. All subjects were assessed for their ability to observe details, ask questions and to generate hypotheses on inquiry skill tasks. From videotaped interviews, stimulus response procedures were utilized to obtain teachers' interactive thought process data provided by eight randomly selected subjects. Thought process data reflected the teachers' interactive thoughts when presented with a scientific phenomenon and asked to perform inquiry tasks (i.e., cue attendance, information search, and hypothesis generation). Intensively instructed subjects performed better in inquiry skill tasks than those subjects receiving no intensive instruction. Intensive

instruction appears to have enhanced the treatment subjects' ability to consider and report a greater number of alternative relevant cues while engaged in the observation of details. This suggests that intensive instruction treatment could improve an individual's ability to recognize additional relevant details when presented with a scientific phenomenon. Another way of interpreting the results is that intensive instruction training could improve an individual's ability to solve problems associated with scientific phenomena by allowing the subject's schema to recognize more factors, thus reducing the individual's reliance on pre-existing concepts and the individual's resistance to concept modification.

THE EFFECTS OF INTENSIVE INSTRUCTION IN CUE ATTENDANCE UPON ELEMENTARY SCIENCE EDUCATION PRESERVICE TEACHERS' INTERACTIVE INQUIRY THOUGHT PROCESSES: A PRELIMINARY QUALITATIVE STUDY

Purpose of the Study

Teaching has been described by a number of educational researchers as a complex activity. In the psychological context of teaching, teacher planning and decision making have been shown to strongly influence teacher behavior. In an effort to contribute to the knowledge base for teacher effectiveness, this study was undertaken to build on the procedures and findings of previous intensive instruction research (Wright, 1978, 1979; Pouler and Wright, 1980; Sunal, 1988) by providing a framework for the investigation of the effects of intensive instruction upon the thought processes of preservice elementary science education teachers engaged in inquiry skill tasks.

Review of the Literature

A primary goal of educational research into teachers' thought processes is to improve the effectiveness of teaching through a descriptive portrayal of those processes (Clark & Peterson, 1986; Marland, 1986). The same goal may be inferred from the research efforts aimed at teacher cognitive modification in inquiry skill tasks utilizing the intensive instruction procedure (Sunal, 1988). The majority of research efforts into interactive thought processes of teachers has been done in the past 20 years. Joyce (1978-1979) and Marland (1986) have commented on the status of research efforts in teachers' interactive thought processes as being at the fact-gathering stage. Early research by B. S. Bloom (1954) utilized a research procedure called "stimulated recall" to obtain information about student thought processes. Bloom found as high as 95 percent accurate recall of overt and checkable events. In the collection and treatment of data, Bloom reported a classification scheme utilized to break down the data into thought units centered on a single idea, activity, or thought. Bloom's scheme was found to be in agreement about 98 per cent of the time by two independent workers. Variations in the procedures for collecting and analyzing the stimulated-recall data exist (Clark & Peterson, 1986, p. 259), though most approaches appear to be developed, as did Bloom (1954) ad hoc with the intended application of the thought units in mind. Marland (1984, p. 225), in a report on the use of stimulus recall procedure, wrote that "...there is a generally held view among those who have used stimulus recall that the technique does offer a fruitful means of exploring the cognitive concomitants of human behavior in the classroom and other task settings, and of developing new insights into the nature of important enterprises like teaching." "To understand, predict, and influence what teachers do," argued panelists in the National Institute of Education's National Conference on Studies in Teaching (1975),"...researchers must study the psychological processes by which teachers perceive and define their professional responsibilities and situations" (p. 2).

Intensive instruction research in education since 1974 suggests that elementary, secondary and college level students can improve their ability to: 1) isolate and identify variables as critical questions and 2) generate hypotheses. Suchman (1961, 1966) developed and demonstrated a teaching method utilizing discrepant events which has shown to improve the ability of students to isolate variables of causality by questioning. A procedure for the evaluation of the quality of generated hypotheses was developed by Quinn (1971). Utilizing the Suchman teaching design, Quinn found that students were able to improve their hypothesis-forming ability. Wright (1978, 1979, 1981, 1988) and Pouler and Wright (1980) studied the effects of cue attendance intensive instruction. They found that secondary school students and preservice teachers improved their skills in identifying problem variables, questioning strategies and hypothesizing strategies following the intensive instruction procedure in both clinical and classroom settings. Studies by Klein, et al., (1969) Salomon (1970) and Koran (1972) have yielded similar results with college students.

Design and Procedure

Fourteen preservice teachers were randomly assigned to a treatment or control group. The treatment group received intensive instruction which followed the procedure established as reliable and valid in previous studies by Salomon and Sieber (1970) and Wright (1978). Three of six post-treatment measures consisted of short-term measures of cognitive skill tasks labeled Cue Attendance (CA; Figure 1), Information Search (IS; Figure 2), and Hypothesis Generation (HG; Figure 3). The cognitive skill task activity interviews were videotaped for transcription and later data analysis.

(Insert Figures 1,2 & 3 here)

The remaining three post-treatment measures were the assessments of preservice teachers' interactive thoughts while they were engaged in each inquiry skill task; Cue Attendance, Information Search, and Hypothesis Generation. Through the use of their videotaped interviews, eight of the fourteen preservice teachers were randomly selected for examination of their interactive thoughts (control, n=4; treatment, n=4). Stimulus response procedures utilized by Bloom (1954) and refined by Marland (1984) were employed in this study. Modifying a classification schema developed by Marland (1986), subject responses were subjected to qualitative analysis using a nine-category thought unit schema (Figure 4).

(Insert Figure 4 here)

All cognitive skill task data and interactive thought responses were analyzed by members of the research team. The procedure for analyzing subject responses was the independent viewing of subject interview videotapes and the examination of subject interview transcripts by each research team member. Following independent analysis, the researchers met in committee and responses were categorized according to the units which had been developed in previous studies and modified for this study.

Results

The subjects that were intensively instructed in cue attendance reported more cues in each category (events, objects, conditions, and properties) than did the control group (Table 1). Intensively instructed subjects also reported more diverse and numerous questions (Table 2), and more acceptable and a higher quality of hypotheses (Table 3) than did the control group.

With respect to subjects' interactive thoughts, the treatment group reported more perceptions (CA, Table 4; IS, Table 5; HG, Table 6), prospective tactical deliberations (CA), retrospective tactical deliberations (CA, HG), anticipations (CA, IS), goal statements (CA, IS), fantasy (HG), and feelings (CA, IS, HG) while engaged in the Cue Attendance, Information Search, and Hypothesis Generation Inquiry Tasks than did the control group. The treatment group reported fewer references to interpretation (CA, IS, HG), and reflection (CA, IS) while engaged in the Cue Attendance, Information Search, and Hypothesis Generation Inquiry Tasks than did the control group.

Discussion

In keeping with the intent of this study, which was to qualify not quantify subject responses, no statistical analyses were conducted. Qualitative analysis procedures were utilized by the research team members, both independently and in collaboration, to identify patterns of responses by subjects.

The results for Cue Attendance, Information Search, and Hypothesis Generation in this study supports previous intensive instruction research (Wright, 1978; Pouler and Wright, 1980; Sunal, 1988). The enhanced cue attendance responses can be attributed as a direct result of the intensive instruction. The treatment group responded with more verification, experimentation, necessity and synthesis statements during the Information Search task than did the control group. This may indicate a tendency of intensively trained subjects to search for more than just facts when faced with a problem-solving dilemma. Intensively instructed subjects tended also to report more details and ask more questions of a diverse nature than did the control group subjects. This is to say that the intensively instructed subjects tended to report more details of and ask more questions about factors contributing to an observed phenomenon. The control group subjects tended to focus directly upon the featured apparatus of the discrepant event while the intensively instructed subjects noted these observations and, in addition, tended to report more information regarding the environment surrounding the apparatus being featured in the science discrepant event.

Subjects who were intensively instructed responded with higher level hypotheses than subjects who did not receive the intensive instruction. These results may indicate that intensive instruction not only increases the number of hypotheses which subjects may generate, but also improves the quality of those hypotheses.

In terms of interactive thought process, intensively instructed subjects reported nearly four times as many retrospective tactical deliberations for cue attendance (CA) than did the control group. The instructions for the Cue Attendance cognitive skill activity asked the subjects to report from memory all the observed details possible when each subject was presented with a science discrepant event. Subjects in the treatment group demonstrated a higher level of anticipation when searching for information (IS) and cues (CA) but showed a lower level of anticipation during generating hypotheses (HG). This pattern could indicate that subjects who received intensive instruction in cue attendance were more willing to accept multiple solutions to a problem when attempting to solve a problem. The intensively instructed subjects also relied more on reflection when solving hypothesis generation problems.

A recurring pattern occurred in analyzing the thought units in terms of perception and interpretations. The treatment group consistently reported more perceptions and less interpretations than did the control group. The emphasis on facts rather than inferences may be a direct result of the intensive instruction.

The treatment group also reported more responses in the feelings category. This may be due to the fact that, as part of their intensive instruction, treatment subjects were required to reach a criterion number of cues. This activity was reported as being frustrating for most intensively instructed subjects. Intensive instruction in cue attendance appears to cause subjects to identify and report additional details that under routine problem-solving tasks would not typically be considered as initially important or relevant to the problem. This is to say that intensively instructed subjects tended to report more details about items surrounding a featured discrepant event apparatus than did control subjects. Examples of details reported by intensively instructed subjects and not typically reported by the control subjects were, "the background was white" and "there were reflections of four lights on the jar." Both control and treatment subjects would not indicate a level of satisfaction until their need to reach a self-imposed criterion number of responses was accomplished. The self-imposed criterion number was, however, greater and the attention to cues in addition to those of the featured apparatus more diverse for the intensively instructed subjects than for the control subjects. The subjects receiving intensive instruction appeared to become more involved in the cognitive skill tasks and felt more comfortable exploring alternative details than did the control subjects.

Conclusions

Intensive instruction appears to have enhanced the treatment subjects' ability to consider and report a greater number of alternative relevant cues while engaged in the observation of details. This suggests treatment could improve an individual's ability to recognize additional relevant details when presented with a scientific phenomenon. Another way of interpreting the results is that intensive instruction training could improve an individual's ability to solve problems associated with scientific phenomena by allowing the subject's schema to recognize more factors, thus reducing the individual's reliance on pre-existing concepts and the individual's resistance to concept modification.

Distinct subject response patterns were identified in this preliminary study. Further studies will be necessary to determine whether these patterns truly occur or whether they were coincidental in this study. A larger sample size would be required to validate these patterns.

The results of this study must be considered inconclusive while also being considered indicative of possible effects of intensive instruction on college subjects. Further research in this area of cognitive study is necessary prior to any definitive statement concerning the effects of intensive instruction upon the quality of subjects' responses.

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Cue Attendance Criteria

D· fined: The gathering of data by identification of ꞔ)ecific details occurring in a natural phenomenon, falling within one of the following categories:

A. **Events** (e) are any happenings, apart from the analysis of them. Water being poured into a glass, a balloon expanding or substance burning are all examples of an event.

B. **Objects** (o) are slightly more abstract than events. An object represents a separate part of a whole happening. Events occur within the time dimension. They have a beginning, end, and duration. Objects are timeless. Though they exist in time, they can be discussed and analyzed without any reference to time. Objects can be simple substances like water and air, or complex systems like a human hand or a wristwatch.

C. **Conditions** (c) are the states of objects. Temperature is a condition. So are position, shape, speed and weight. The condition of an object can change without the identify of the object changing... Conditions vary with time. Water can be hot or cold, can have high or low pressure, at various times during a single event. Position, shape, speed, or weight might also change with time.

D. **Propert'.es** (p) are characteristics of objects that do not change with time. Objects are known and identified by their properties. For example, water is a clear, odorless liquid that at ea level boils at 212 F. Any liquid that exhibits these characteristics is probably water.

Figure 1. Cue Attendance Criteria. Adapted from Wright (1978).

Information Search Criteria

Defined: The number and diversity of questions asked by each subject in developing a theory or hypothesis about an observed phenomenon. The question must be structured so as to only ask for facts (not inferences, conclusions, etc.) and so that the instructor can answer with either "yes" or "no." Questions are classified as follows:

A. **Verification** (V). This class includes all questions that seek to identify or verify some aspect of the given phenomenon. Verification questions are always factual. Example: "Was that an ice cube?"

B. **Experimentation** (E). In this class are all questions that attempt to ascertain the consequences of some change in the given experiment. Experimental questions are always hypothetical. Example: "If the liquid in the right hand glass had been milk, would the cube have floated?"

C. **Necessity** (N). All questions that seek to determine whether a particular aspect of a phenomenon was necessary for the outcome are in this class. Example: "Was it necessary to have the liquid in glass rather than metal containers?"

D. **Synthesis** (S). This class includes all questions that seek to determine whether a particular idea about causation is valid. Actually, such questions are theories for which the subject is seeking approval through authority, rather than attempting to verify them himself by gathering data. Example: "Does the fact that the liquids were not the same weight explain why the cubes behaved differently?"

The four categories of questions (information search) can be asked about each of the four kinds of data (events, objects, conditions and properties).

Figure 2. Information Search Criteria. Adapted from Wright (1978).

Hypothesis Generation Criteria

Defined: An informed guess about the solution to a problem or about a general rule which describes the common elements characterizing a series of instances.

To be an acceptable hypothesis the hypothesis must satisfy at least one of the following criteria:

A. **It makes sense,** it is not a statement of contraries.

B. **It is empirically based,** it can be empirically tested, it is not contrary to the laws of nature in its content.

C. **It is adequate,** it relates at least two of the total number of variables and/or events presented in the problem.

D. **It is precise,** it relates at least two of the total number of variables and/or events presented in the problem situation in a more specific way than the mere stating of a relationship among variables.

E. **It explicitly states a test of its validity,** it makes a prediction or in some other way indicates how the hypothesis may be verified.

Note: This classification scheme reflects a scale of hypothesis quality. A score of "0" was assigned to a statement if the statement was not a hypothesis. Scores 1 to 5 corresponded to letters A through E.

Figure 3. Hypothesis Generation Criteia. Adapted from Quinn (1971).

Thought Unit (Adapted)	Description (Adapted)	Example (Characteristic response from intensive instruction study subjects)
1. Perception	Unit in which teacher reports a sensory experience	I observed that there were five balls.
2. Interpretation	Unit in which teacher attaches subjective meaning to perception	It just makes sense...when there isn't enough wind the boat won't move.
3. Prospective tactical deliberation	Unit in which teacher reports thinking about a tactic to be used later in the inquiry skill task	I was thinking that I was going to try to start from the back and move forward...go from first, to second, to third, to forth, in a pattern.
4. Retrospective tactical deliberation	Unit in which teacher contemplates tactic or course of action already used in the skill task activity	After I saw it the second time I realized that it might not have been a good idea to focus on the man in the experiment.
5. Reflection	Unit in which teacher ponders past aspect of, event in, the skill task activity other than tactic	It reminded me of when I went sailing once. When the wind didn't hit the sail just right, I didn't move.
6. Anticipation	Speculation or prediction about what could, or is likely to, occur later in the skill task activity	I thought it was going to stop, but it didn't.
7. Goal statement	Unit in which teacher is thinking about intended skill task activity outcomes	I wanted to look and see which ball slowed down first.
8. Fantasy	Unit in which teacher expresses fanciful bizarre comments	I was thinking that I wished I were on a sailboat to Hawaii!
9. Feeling	Unit in which teacher reports an affective state personally experienced during the skill task activity	I felt kind of foolish right there. At that point I was starting to feel like I couldn't come up with any more questions.

Figure 4. Categories of Skill Task Activity Thought Units (Adapted from "Categories of Thought Units;" Marland, 1986)

Table 1

Cognitive Skill Tasks Response - Average Frequency
Cue Attendance

	Events	Objects	Conditions	Properties	Total
Control (n=6)					
	5.60	6.00	7.16	5.16	24.00
Treatment (n=7)					
	5.00	16.00	23.00	16.00	60.00

Table 2

Cognitive Skill Tasks Response - Average Frequency
Information Search

	Verification	Experimentation	Necessity	Synthesis	Total
Control (n=6)					
	13.30	0.16	1.16	0.00	14.60
Treatment (n=7)					
	18.50	0.33	2.67	0.16	19.80

Table 3

Cognitive Skill Tasks Response - Average Frequency
Hypothesis Generation

(Quinn Hypothesis Quality Scale)

	0	1	2	3	4	5	Total
Control (n=6)	0.16	1.16	2.30	0.30	0.16	0.00	4.16
Treatment (n=7)	0.33	0.33	3.83	1.00	0.00	0.00	5.50

Table 4

Average Frequency of Response by Category of Thought Unit
Cue Attendance

	Thought Unit								
	Perception	Interpretation	Prospective tactical deliberation	Retrospective tactical deliberation	Reflection	Anticipation	Goal Statement	Fantasy	Feeling
Control (n=4)	3.75	2.75	4.50	0.50	3.50	0.75	0.50	0.00	1.50
Treatment (n=4)	4.00	2.00	4.75	2.25	3.00	1.75	0.75	0.00	3.50

Table 5

Average Frequency of Response by Category of Thought Unit
Information Search

	Thought Unit								
	Perception	Interpretation	Prospective tactical deliberation	Retrospective tactical deliberation	Reflection	Anticipation	Goal Statement	Fantasy	Feeling
Control (n=4)	2.75	4.75	5.25	2.75	3.50	0.50	0.50	0.00	3.25
Treatment (n=4)	5.25	2.00	5.25	1.00	3.25	1.00	2.25	0.00	6.00

Table 6

Average Frequency of Response by Category of Thought Unit
Hypothesis Generation

	Thought Unit								
	Perception	Interpretation	Prospective tactical deliberation	Retrospective tactical deliberation	Reflection	Anticipation	Goal Statement	Fantasy	Feeling
Control (n=4)	3.00	5.50	7.00	1.75	1.50	1.75	0.75	0.25	2.75
Treatment (n=4)	3.50	3.75	4.50	2.25	2.75	1.25	0.50	0.75	4.50