AN ANALYSIS OF TEACHER-PUPIL INTERACTION IN FOURTH-GRADE MATHEMATICS CLASSROOMS

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PREFACE

This study is concerned with an analysis of teacher-pupil verbal interaction in the fourth-grade mathematics classroom and the effects of the interaction on student achievement. The method of research was direct observation using the Wright-Proctor Observation Instrument.

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CHAPTER I

INTRODUCTION

The Problem

Investigations into the question of what is effective teaching have occupied educators for many years. The reports of research into this area are almost too numerous to count. The investigations have been of several types - descriptive, experimental, correlational, and combinations of these. A major problem of investigators has been that of establishing criteria of "effective teaching." Criteria have been thought of as process and product. In recent years considerable attention has been directed to securing descriptions of the behaviors that are found in the classroom. The research reported in the following pages attempted to determine the relation of selected classes of verbal behaviors of teachers and pupils (process) to pupil gain scores in mathematics (product).

A systematic scheme for making direct observations of the classroom should provide information about the teaching process. Medley and Mitzel (16, p. 249) stated that the proper role of direct observation in research seemed to be as a means of learning something about the teaching process and its relationship to pupil learning. The establishing of such a relationship is the focus of the study reported below.

The Elementary Mathematics Classroom

This study included making a record of observable behaviors in fourth-grade mathematics classrooms. By using direct observation and recording verbal interaction behaviors between teacher and pupils, it was hoped that significant patterns would be identified.

In considering the use of direct observation in the mathematics classroom, attention had to be given to the different types of classroom situations that could have been encountered. Possible classroom situations were as follows:

1) The teacher-dominated classroom is one in which the teacher dominates all verbal behavior. Talk concerned with the subject being studied is limited to the teacher explaining, giving directions, and asking questions requiring simple, direct answers.

2) The textbook-dominated classroom is similar to the teacher-dominated. Talk concerned with the subject is taken directly from the textbook. The teacher or a student reads from the book for information and students answer the questions found in the book. Other verbal activity is usually limited to the teacher's giving directions.

3) The workbook classroom is a third type. In this classroom, the students read the exposition and write responses to the questions posed in the workbook. Students are allowed to work as fast or as slowly as they please. The teacher tries to visit each student, explaining and answering questions on an individual basis.

4) The discovery classroom is one in which the teacher asks open-end questions to help students "discover" the meaning in the subject being studied. The students are encouraged to ask questions of the teacher and each other. The teacher attempts to build on that which has happened in class and on physical surroundings of the students.

5) The laboratory-oriented classroom is characterized by students performing experiments and answering questions concerning the experiments. The teacher assumes a role of supervisor and helps the students perform their experiments as directed by lab cards. As a result of his experimenting and answering the questions found on the lab card, the student is helped to discover desired relationships.

The types of classrooms described could probably not be found in a pure form. Most elementary mathematics classrooms are a combination of two or more of the types described, and at different times during a school year a classroom may be as each type. Making records of observations in such a range of classrooms would be a monumental task. Yet, significant verbal behaviors have to be identified and enumerated.

Observation Instrument

The observation instrument selected for this study was developed by Wright and Proctor (23). The instrument is a multidimensional system and was used by Wright and Proctor (23) in high school and college mathematics classrooms. It was specially designed for direct observation of verbal interaction of teachers and pupils in mathematics classrooms. The Wright-Proctor instrument classifies verbal behaviors from three frames of reference: mathematic content, psychological process, and sociological attitudes. Verbal behaviors are classified in all three frames simultaneously. Each of the frames has several categories.

<u>Mathematic Content</u>

1. Fundamentals: Structure, Technique
2. Relations: Deductive, Inductive, Statement
3. Application: Mathematical, Other

<u>Psychological Process</u>

1. Syllogistic: Analyzing, Synthesizing
2. Classificatory: Specializing, Generalizing, Relevant

<u>Sociological Attitudes</u>

1. Curiosity
2. Independence
3. Receptivity

Verbal behaviors that are nonmathematical are classified as Neutral. Silent study in the mathematics classroom can also be classified as one of three categories. The complete instrument and the categories are described in detail in Chapter II.

This study, then, was an attempt to establish certain verbal behaviors as reflected in the categories of the Wright-Proctor (23) instrument as valid predictors of pupil gain scores in mathematics.

Previous Research

In the past quarter of a century, a number of researchers have focused their attentions on teacher-pupil behaviors in the classroom. Although the studies differed in scope and intent, they reflected a common research orientation. The manner in which behaviors were classified and the types of behaviors classified reflected the researcher's intended purpose. These studies of teacher-pupil interaction can be grouped according to their scheme of classification, as one of three categories: affective systems, cognitive systems, and multidimensional systems.

Affective systems are those that attempt to measure the classroom or psychological climate by observing the teacher-pupil interaction. Cognitive systems for observing teacher-pupil interaction involve categorizing various aspects of intellectual skills. Multidimensional systems are those that attempt to measure more than one dimension of the classroom through direct observation of teacher-pupil interaction

Anderson and Brewer (4) made one of the original studies of classroom climate. They identified the patterns of "dominative" and "socially integrative" teacher behaviors. They found that teachers whose predominant relations with the children were "integrative" in nature had classrooms in which children showed more initiative and spontaniety.

When the relations were "dominative" in nature, the children were less responsive to the classroom situation.

Withall (21) developed a set of seven categories into which teacher statements could be classified on the basis of transcripts of their teaching behavior. These categories were learner-supportive, acceptant, problem-structuring, neutral, directive, reproving, and teacher self-supporting. These categories comprised the Social Emotional Climate Index, and were seen by Withall as lying along a continuum from "learner-centeredness" to "teacher-centeredness." Withall concluded that "teacher-centered" patterns produced anxiety and reduced pupil's ability to recall the material studied. "Learner-centered" patterns produced the opposite student reactions.

Flanders (9) developed a scheme, which included ten categories, for observing behavior in the classroom. He conceptualized the categories as lying along a dimension of influence. The first four categories (accepts feeling, praises or encourages, uses student ideas, and asks questions) represent indirect influence by the teachers. The next three categories (lecturing, giving directions, and criticizing or justifying authority) represent increasing amounts of direct influence. Categories eight and nine represent different levels of teacher influence as inferred from pupil behavior. Category ten is used to record silence or confusion.

Flanders (9) found that the students in the indirect classes achieved more than students in direct classrooms in both mathematics and social studies. A third finding was that indirect teachers were more flexible. A fourth finding was that students who achieved most and had significantly higher scores on attitude tests were in classes exposed to flexible patterns of teaching. His study revealed that teachers of high achieving classes were found to differ from teachers of low achieving classes in a number of ways. The teachers of high achieving classes used five or six times as much acceptance of student ideas and encouraging of ideas and five to six times less direction and criticism of students. They talked 10 percent less and encouraged two to three times as much student-initiated talk.

Amidon and Giammatteo (2) conducted a study of 153 teachers using Flanders system of interaction analysis (10). Using administrators and supervisors, 33 teachers were identified as superior teachers, and 120 other teachers were selected at random from the eleven school districts used. The observer categorized the verbal behaviors of teachers and pupils during the language arts period. The results indicated that verbal behavior patterns of superior teachers differ substantially from those of average teachers. The superior teachers talked less, were more accepting of pupil-initiated ideas, tended to encourage these ideas more, and made a greater effort to build on these ideas. Superior teachers dominated their classrooms less, used indirect verbal behavior more, and used direction giving and criticism less.

Hughes (13) conducted a study using a system of categorization called the "Provo Code." The code categorizes 31 separate teacher or pupil functions. The instrument is divided into three broad classifications of "Positive Affectivity," "Negative Affectivity," and "Development of Content." The study included 41 teachers; six teachers used as a special pilot group, 25 teachers judged "good" by the county supervisory staff, and 10 teachers chosen to be representative of the teachers of a particular district. Hughes found that primary teachers were more controlling and more negative than middle or upper grade teachers. She also found that the most frequent function performed by the teacher was controlling. Another significant finding revealed that there was no significant difference between the group of teachers judged "good" and the representation group.

Gallagher (11) used an instrument developed with the help of Aschner (5) to study gifted children. The development of this instrument was greatly influenced by Guilford's concept of the "structure of intellect" (11). Four of five primary categories represent Guilford's theory of thinking operations: cognitive-memory, convergent thinking, divergent thinking, and evaluation thinking. The fifth category, routing, encompasses various interactions that occur in a classroom that are not directly related to the cognitive domain. Gallagher was particularly interested in developing the productive and creative aspects of intellectual activity. It was found that the greatest proportion of teacher responses and questions fell in the cognitive-memory category, and the second most utilized category was that of convergent thinking. Meaningful differences were also observed between teachers in terms of the types of questions asked and the types of statements made.

Smith and Meux (19) were the first investigators to consider the logical aspects of the teaching act. They developed thirteen categories to identify and describe the logical dimensions of teaching. The categories developed were defining, describing, designating, stating, reporting, substituting, evaluating, opining, classifying, comparing, contrasting, conditional inferring, explaining, directing, and managing. They studied the relative frequency of logical operations in teaching behaviors at various schools, grade levels, and content areas. They found that differences existed in the extent to which logical operations occured from teacher to teachers, and from content area to content area.

Taba (20) investigated the role of curriculum organization in the development of the thinking processes of children. The major hypothesis of the study was that if students were given a curriculum designed to develop their cognitive potential and if they were taught strategies to help them master cognitive skills, they would develop forms of symbolic thought earlier and more systematically. She found that the whole pattern of teacher behavior determined the level of response attained by learners.

Bellack (7) conducted an investigation into the linguistic behaviors of the classroom. He conceived of four basic verbal maneuvers that describe what teachers and pupils do while playing the game of teaching. These maneuvers are called "pedagogical moves" and are described as structuring, soliciting, responding, and reacting moves. Bellack found that the teaching roles of the classroom are clearly delineated for both teacher and pupil. Teachers are responsible for structuring the lesson, while the pupils' primary task is to respond to the teacher's solicitation. The teacher functions then are structuring, soliciting, and reacting. The corresponding pupil function is responding.

Medley and Mitzel (16) develop an instrument entitled the Observation Schedule and Record (OScAR). The OScAR is an instrument designed to provide measures of teacher behaviors, pupil behaviors, classroom grouping, educational material used, and subject taught. The OScAR provides a method for analyzing and summarzing fourteen variables into three categories called emotional climate, verbal emphasis, and social structure. A study using the OScAR was conducted in which the performances of beginning teachers were studied. It was concluded that relatively untrained observers using an instrument like the OScAR could develop reliable information about the differences in classrooms of different teachers. It was also concluded that the OScAR is sensitive to only three of the many dimensions of the classroom that probably exist, and that observations made with instruments of this type can contribute to the solution of many important problems having to do with the nature of effective teaching.

Medley and Hill (15) conducted a study using Flanders' Interaction Analysis Technique (10) and OScAR 4V (15). Two observers, one using OScAR 4V and the other using Flanders' Interaction Analysis Technique, recorded observation on 70 teachers. Each teacher was observed four times by each observer. The observers made all of their observations in pairs. The OScAR 4V (Observation Schedule and Record 4, Verbal) is one of a series of "OScARs," each a revision of the last. It was concluded that the Flanders' instrument appeared more sensitive to student behaviors and less able to discriminate teacher behaviors related to substantive content from behaviors related to procedure or management. OScAR 4V is less useful in examing student behavior, but provides more information about how a teacher divides his time between management and instruction, and the quality of both. They also concluded that the one that would be most useful in a given instance would depend on the type of problems that concerned the teacher in question.

Smith and his associates (18) extended their original research on the logic of teaching by developing a framework and a set of concepts to describe and analyze classroom discourse associated with achieving content objectives. The concepts of "venture" and "move," developed in previous research, were incorporated in the concepts of "verbal unit" and "strategy" to form a basis for identifying and clarifying the concept of "teaching strategy." A system for describing and analyzing classroom discourse associated with achieving content objectives was developed for this study. It also provided a means for conceptualizing the verbal maneuvers involved in this aspect of a teacher's behavior.

Wright (22) developed a classification system designed specifically for analyzing verbal behaviors in the secondary school mathematics classroom. The instrument was based on certain aims of teaching mathematics. The classification system consists of three frames of reference, each having several categories, ability to think - analyzing, synthesizing, specializing, and generalizing; appreciation of mathematics - methodology, subject matter, other fields, and historical significance; and attitudes of curiosity and initiative - enthusiasm for fresh knowledge, and independence. Using this instrument, Wright classified the teacher-pupil interaction in 12 high school algebra classes. Wright found that differences in specific subject matter or age of pupils did not affect significantly the patterns of behaviors. The study also revealed information on the emphasis of categories in each of the frames.

Wright's system was refined and modified in collaboration with Virginia Proctor (23). Wright and Proctor, in the revised instrument, considered the study of verbal behaviors from three viewpoints: mathematical content, psychological process, and sociological attitudes. In a major study, Wright and Proctor observed 12 classrooms selected from 20 high school and first-year university classrooms. The classrooms were characterized as high rigor-high participation, low rigor-high participation, low rigor-low participation, and high rigor-low participation. The purpose of the study was to analyze the differences and similarities of the teacher-pupil interaction in the 12 classrooms observed. Wright and Proctor found that an increase in rigor with participation constant produced a greater emphasis on structure without lack of attention to technical skills. In the same manner, an increase in participation with rigor constant produced the same results.

The research summarized above is but an extremely small sample of the literature on development and use of observation instruments in classrooms. The literature repeatedly supports the contention that verbal behaviors of teachers as they teach and pupils as they learn can be identified and classified. Also, the product of these verbal behaviors or patterns are reflected in the level of student achievement.

Theoretical Basis

The research conducted using observation instruments in recording classroom behavior has produced considerable information about the behaviors of teachers and pupils as they interact. Amidon and Simon, in a review of research on teacher-pupil interaction, concluded:

> Within school classrooms there appeared to be definite patterns of teacher-pupil interaction which could be objectively observed and categorized. These patterns were apparently related to achievement, perception, and classroom climate (3, p. 130).

Amidon also concluded:

> 1. Apparently there are certain identifiable teacher behaviors that inhibit and others that enhance pupil learning.
>
> 2. Patterns of teaching can be described objectively and then related to pupil outcomes. There may be particular patterns that are appropriate for teaching certain subject matters.
>
> 3. There appear to be certain behaviors that characterize good teachers (in terms of pupil achievement) regardless of the subject matter being taught (1, p. 96).

The teacher is the most influential person in the classroom, and the teacher's verbal behavior is the most influential tool. Flanders (1) reported a rule of two-thirds which stated that in the average classroom someone is talking two-thirds of the time: two-thirds of this is teacher talk; and two-thirds of teacher talk consists of direct influence.

It was the intent of this study to determine patterns of verbal behaviors in the elementary mathematics classroom that enhance learning. Since the Wright-Proctor Observation Instrument (23) was developed specifically for secondary mathematics classrooms, information was desired concerning its usefulness in the elementary classroom. The categories of the instrument were developed to describe the language of the secondary mathematics classroom. The originators hypothesized that the instrument should be able to describe the language of the elementary mathematics classroom.

A teacher employs patterns of teaching techniques as he instructs. He may use several different techniques of teaching any lesson, and these techniques do, in most cases, involve verbal expression. A teacher will present material on different cognitive levels throughout a lesson. At the same time, he will be using different affective levels. The teacher will also solicit different levels of sociological attitudes from the pupils in response to the lesson.

While the teacher is the most influential person in the classroom, the pupil is the most important. It is the pupil's behavior that the teacher in trying to change. Hopefully, the change will be a positive one, one in which learning will have taken place.

Pupils perceive the verbal behaviors of the teacher and usually react to these behaviors at the levels the teacher wants. If the teacher asks a simple question, the pupils will give a simple answer. If the teacher asks an open question, the pupils will answer in detail. If the teacher asks the pupils what they think about something, the pupils will answer with just the amount of freedom the teacher will give them.

In considering the categories of the Wright-Proctor Observation Instrument (23), inferences may be made concerning the levels of verbal behavior expected of teachers, and the level of verbal responses expected of pupils. Although verbal behaviors are recorded in all three frames during each recording interval, it is simpler to consider the types of verbal behavior classified in each frame than the 105 possible combinations of behaviors.

The Mathematical Content Frame is divided into categories by which the aspect of mathematics being dealt with can be classified. In a lesson, the material may be related to knowledge at the command of the pupils; the verbal behavior observed is classified as Structure or Technique. The material may be related to the development and statement of new relations; the verbal behavior is classified according to the method being used as Deductive, Inductive, or Statement. When the lesson deals with the use and significance of the mathematical system being studied, the verbal behavior is classified as Mathematical or Other.

In the presentation of material already at the command of the pupils, the teacher may solicit responses from the pupils that require them to use this knowledge in solving new, related problems or in some other way evaluate their understanding of the basic mathematical relation being studied. Verbal behaviors of this type are classified as Structure. At other times, the teacher may describe the mechanical process without considering the basic mathematical relation. This type of behavior is classified as Technique. Other verbal behaviors falling in this category are answers to homework problems, assignment of homework, and the use of a mechnical process.

In presenting new materials, the teacher may either develop it systematically or state it empirically. One method of systematically developing a new relation is to prove it deductively. Verbal behaviors of this type are classified as Deductive. Another approach would be by induction, where the teacher uses specific examples and statements to elicit a new relation from the students. This type of verbal behavior is classified as Inductive. A third method for introducing a new relation is to state it empirically. To support the statement of a new relation, examples of the relation and its uses are given to the pupils. These verbal behaviors are classified as Statement.

After a relation has been introduced and developed, the lesson enters the application stage. In verbal behaviors at this stage, the teacher may have the students find the solutions of mathematical problems. These verbal behaviors are classified as Mathematical. The teacher may wish to relate the study to other fields or make historical references. Verbal behaviors of this type are classified as Other.

A teacher presenting a lesson on any mathematics topic may use any or all of the above verbal behaviors. It seems likely, though, that certain behaviors would be in greater evidence during certain periods in the development of a topic. It also seems unlikely that the verbal behaviors that would be classified as Deductive would be encountered in the elementary mathematics classroom. The sophistication of the material and the level of training of most elementary teachers would seem to eliminate the logical proof of a new relation.

In considering Flander's (9) results regarding the achievement of students under direct and indirect teacher influence, it might be possible to determine behaviors in the Content Frame that could be classified as direct or indirect. Teacher behaviors that might be classified as indirect teacher influences are subsumed under the categories of Structure, Deductive, Inductive, and Other. If these are, in fact, analogous to Flanders' constructs, then they should be highly correlated in a positive direction with pupil gain scores. The categories that might be classified as direct teacher influences are those of Technique, Statement, and Mathematical. If these are, in fact, analogous to Flanders' constructs, then they should demonstrate limited positive or even negative coefficients of correlation.

The Psychological Process Frame is divided into categories by which the aspects of mathematical thinking involved in the verbal interaction of the mathematic classroom can be classified. Because mathematical thinking consists largely of problem solving, the aspects of logic functional in problem solving are used to form the basis for classification of classroom verbal interaction. In a lesson, the teacher may require the logical operation of inference and verbal behaviors of this type are classified as Analyzing or Synthesizing. At other times, the teacher may desire the formulation of generalizations, applications, and problem dissection. Verbal behaviors of this type are classified as Specializing or Generalizing. Also, during the presentation of a lesson, mathematical information is presented that belongs to no apparent logical sequence. This type of verbal behavior is classified as Relevant.

In the presentation of a lesson using the process requiring the logical operation of inference, the teacher may solicit responses from the pupils requiring them to move from an assumption of a desired conclusion toward an accepted conclusion. The justification of a statement by asking the question "Why?" and the developing of a chain of backward implications are two teaching patterns employed. Verbal behaviors of this type are classified as Analyzing. Another technique employed is to solicit responses requiring the pupils to move from accepted principles toward a desired conclusion. This may be accomplished by developing a chain of forward implication or the consolidation of parts into a complete solution. This type of verbal behavior is classified as Synthesizing.

In developing the formulation of generalization, applications, and problem dissection, the teacher may require pupils to use the significant attributes of a given set in an analogous set or to apply a generalization. The recognition of a relationship among corresponding sets and the identification of necessary and sufficient conditions are also processes required of pupils. Verbal behaviors of this type are classified as Specializing. In the course of a lesson, the teacher may require the pupils to recognize the significant attributes of a given set and pass these considerations of the given set to that of a larger inclusive set. Verbal behaviors of this type are classified as Generalizing.

The verbal behaviors that are classified as Relevant are those that do not belong to any apparent logical sequence. The reading of problems, the reading of homework answers, and the presentation of historical information are examples verbal behaviors classified under this category.

In considering the Psychological Process Frame, the categories of Analyzing and Generalizing might be classified as indirect teacher influence categories. The categories of Synthesizing, Specializing, and Relevant might be classified as direct teacher influence. If these are, in fact, analogous to Flanders' constructs, then the former should be highly correlated in a positive direction with pupil gain scores and the latter comparisons demonstrating limited positive or even negative coefficients or correlation.

The Sociological Attitude Frame is divided into categories by which the amount of initiative is classified. The Curiosity category deals with verbal behaviors that encourage unusual problems or a new direction. Verbal behavior that excites and stimulates pupils to learn more are also classified in the Curiosity category. The Independence category is for open questions or responses to open questions. The teacher requires the pupils to take some of the responsibility for the development of the material. The Receptivity category is for verbal behaviors that require little to no initiative by the pupils.

In the Sociological Attitude Frame, the categories of Curiosity and Independence might be classified as indirect teacher influence and the category of Receptivity as a direct teacher influence. If these are analogous to Flanders' constructs, then the categories of Curiosity and Independence should be highly correlated in a positive direction with pupil gain scores, and the category of Receptivity should demonstrate limited positive or even negative coefficients of correlation.

In considering the above, the following statements are postulated.

1. If there are definite patterns of teacher-pupil interaction in the elementary mathematics classroom, then these patterns have a direct relationship to student achievement in mathematics.

2. If there are definite patterns of teacher-pupil interaction in the elementary mathematics classroom, then these patterns can be identified and classified.

Hypotheses

The study was conducted in eight fourth grade classrooms from four Tulsa elementary schools. Two observers visited each of the teachers a total of ten times. Each visit lasted thirty minutes, during which the observers recorded the teacher-pupil verbal interaction using the Wright-Proctor Observation Instrument (23). Each minute of the observation period was divided into four fifteen-second intervals. During the first and third intervals, the observers observed the verbal interaction, and during the second and fourth intervals, their observations were recorded. This gave a total of sixty recorded observations per class period. A total of six hundred recorded observations were collected per teacher.

The average pupil gain scores used as a measure of student achievement were secured from subtests of the Stanford Achievement Test (14). During their third-grade year in the Tulsa Public Schools all students take the Stanford Achievement Test (14). This test has two subtests related to mathematics: computation and concepts. During their fourth-grade year, another level of the Stanford Achievement Test (14) is taken. It also has subtests of computation and concepts.

The variables of the study were as follows: (1) the categories of the Wright-Proctor Observation Instrument (23), and (2) the arithmetic achievement gain scores.

The following research hypotheses were formulated:

1. a) There is a significant positive correlation between the fourth grade mean pupil gain scores on the arithmetic computation subtest of the Stanford Achievement Test (14) and the frequency of teacher behaviors classified as Structure, Deductive, Inductive, Other, Analyzing, Generalizing, Curiosity, and Independence on the Wright-Proctor Observation Instrument (23).

   b) There is limited positive or even negative correlation between the fourth-grade mean pupil gain scores on the arithmetic computation subtest of the Stanford Achievement Test (14) and the frequency of teacher behaviors classified as Technique, Statement, Mathematical, Synthesizing, Specializing, Relevant, and Receptivity on the Wright-Proctor Observation Instrument (23).

   c) There is a significant positive correlation between the fourth-grade mean pupil gain scores on the arithmetic computation subtest of the Stanford Achievement Test (14) and the frequency of pupil behaviors classified as Structure, Deductive, Inductive, Other, Analyzing, Generalizing, Curiosity, and Independence on the Wright-Proctor Observation Instrument (23).

   d) There is limited positive or even negative correlation between the fourth-grade mean pupil gain scores on the arithmetic computation subtest of the Stanford Achievement Test (14) and the frequency of pupil behaviors classified as Technique, Statement, Mathematical, Synthesizing, Specializing, Relevant, and Receptivity on the Wright-Proctor Observation Instrument (23).

2. a) There is a significant positive correlation between the fourth-grade mean pupil gain scores on the arithmetic concepts

subtest of the Stanford Achievement Test (14) and the frequency of teacher behaviors classified as Structure, Deductive, Inductive, Other, Analyzing, Generalizing, Curiosity, and Independence on the Wright-Proctor Observation Instrument (23).

b) There is limited positive or even negative correlation between the fourth grade mean pupil gain scores on the arithmetic concepts subtest of the Standord Achievement Test (14) and the frequency of teacher behaviors classified as Technique, Statement, Mathematical, Synthesizing, Specializing, Relevant, and Receptivity on the Wright-Proctor Observation Instrument (23).

c) There is a significant positive correlation between the fourth-grade mean pupil gain socres on the arithmetic concepts subtests of the Stanford Achievement Test (14) and the frequency of pupil behaviors classified as Structure, Deductive, Inductive, Other, Analyzing, Generalizing, Curiosity, and Independence on the Wright-Proctor Observation Instrument (23).

d) There is limited positive or even negative correlation between the fourth-grade mean gain scores on the arithmetic concepts subtest of the Stanford Achievement Test (14) and the total frequency of pupil behaviors classified as Technique, Statement, Mathematical, Synthesizing, Specializing, Relevant, and Receptivity on the Wright-Proctor Observation Instrument (23).

The above research hypotheses were tested for statistical significance using their null statements.

CHAPTER II

PROCEDURE

Instrumentation of the Study

The purpose of this study was to identify characteristics of teacher-pupil interaction in the classroom that demonstrated a high degree of relationship with average pupil gain scores. The _Wright-Proctor Observation Instrument_ (23) was selected to measure the characteristics of the teacher-pupil interaction. The average pupil gain scores were measured by the arithmetic subtests of the _Stanford Achievement Test_ (14). This purpose was accomplished by correlating data gathered from the observations of teachers and pupils at the fourth-grade level and pupil gain scores determined from data secured from the research department of the Tulsa Public Schools.

Wright-Proctor Observation Instrument

The _Wright-Proctor Observation Instrument_ (23) is the product of several years' work first by Wright and later aided by Proctor. Wright (22) made the initial attempt to develop a multi-criterion approach to classifying the language used in the mathematics classroom in 1956. In 1959 Wright (22) modified and refined her original instrument in an attempt to develop an instrument to study verbal behavior in the secondary school mathematics classroom. Fundamental to the development of her instrument was the desire to consider the subject matter taught and the method of its development simultaneously. Considering general education objectives for the teaching of mathematics, Wright developed the categories for the instrument. These categories were classified into three frames of reference: ability to think, appreciation of mathematics, and attitudes of curiosity and initiative. In order to validate the categories and develop an observation technique, several investigations were made in mathematics classrooms.

In 1961, working in collaboration with Virginia Proctor, Wright (23) again redefined and modified her instrument. Using their belief that the key aspect of the classroom is the mastery of particular subject matter, the categories and their definitions from the species of mathematical language in the classroom were developed. It appeared to them that (23, p. 4):

> ...language involving mathematical argument was based on content which had to be carried in the broad vehicle of psychological process and together these were effected in the broader framework of sociological attitude. The cognitive aspects, then, resulted from impetus of the general or particular environment of the speaker.

Thus, the three frames of reference for classifying verbal behavior were established as mathematical content, psychological process, and sociological attitude.

<u>Mathematical Content Frame</u>

Wright and Proctor (23) developed the mathematical content frame for the classification of behaviors that answered the question, "What aspect of mathematics is being worked on?" The categories were selected to correspond to aspects of mathematical systems in a functional classroom. The content frame was broken down into three major areas of fundamentals, relations, and applications to facilitate the development of the categories. The following categories were selected: 1) fundamentals--structure, technique; 2) relations--deductive, inductive statement; and 3) applications--mathematical, other.

Psychological Process Frame

The categories of the process frame were developed on the basis of the tool of mathematical thinking, logic. Wright and Proctor (23) felt that logic was the vehicle of the verbalized interaction occurring in the mathematics classroom and was, therefore, the basis for classification of classroom verbal interaction. The process frame was divided into the major areas of syllogistic, classificatory, and relevant. Categories were developed for each of these areas. The syllogistic categories were analyzing and synthesizing. The classificatory categories were specializing and generalizing. The relevant area had only the category of relevant.

Sociological Attitude Frame

The categories of the attitude frame were developed by Wright and Proctor (23) to answer the question, "How much initiative are the pupils asked to show, and how much do they demonstrate?" Wright and Proctor were particularly interested in the situation where the learner was moved from receptivity to independence. The attitude frame consists of the categories of curiosity, independence, and receptivity.

Classification of Other Behaviors

In addition to the categories already described, categories were developed to classify non-mathematical behaviors and silence in the classroom. Non-mathematical verbal behaviors were classified as neutral. Four silent study categories were developed to classify different types of mathematical study that occur in the classroom.

The Observation Process

The observation process consists of an observer viewing the classroom interaction and classifying the verbal and nonverbal behaviors. By using a stop watch or sweep second hand of a watch, each minute of observation is divided into four 15 second intervals. The first and third intervals are used to observe the verbal interaction of the classroom and the second and fourth intervals are used to record the classification of the observed verbal interaction. Each recorded verbal interaction is either classified simultaneously under each frame of the instrument, or is classified as neutral. Thus, each minute gives two recorded observations. Classroom silence, if non-mathematical, is classified as neutral, while silence which is mathematical is classified as one of the categories of silent study.

A schema of classification of behaviors and the definition and description of the categories of the Wright-Proctor Observation Instrument (23) is given in detail in Appendix A.

Stanford Achievement Test

The achievement data for the study were the scores of 222 fourth-grade students on the arithmetic subtest of the Stanford Achievement Test (14). The test scores were obtained from the research department of the Tulsa Public Schools. The Stanford Achievement Test (14), Primary 2 Battery, Forms W and X, was administered to the third-grade students in April 1967. The Intermediate I Battery, Form X, of the SAT was administered to the same students as fourth graders during April of 1968. Of the 222 fourth-grade students, companion scores from their third grade tests were found for 175. These 175 scores were used to compute the average pupil gain for each of the eight classrooms on each of the two arithmetic subtests.

The Primary 2 Battery of the <u>Stanford Achievement Test</u> (14) is designed for use from the middle of grade 2 to the end of grade 3. The Primary 2 Battery includes two arithmetic subtests: Arithmetic Computation and Arithmetic Concepts. The Arithmetic Computation Test is designed to measure proficiency in the operations of addition, subtraction, multiplication, and division. The Arithmetic Concepts Test is designed to measure the understanding of basic mathematical concepts.

The Intermediate I Battery of the <u>Stanford Achievement Test</u> (14) is designed for use from the beginning of the fourth grade to the middle of the fifth grade. This Battery includes three arithmetic subtests: Arithmetic Computation, Arithmetic Concepts, and Arithmetic Application. The primary purpose of the Arithmetic Computation Test and the Arithmetic Concepts Test is basically the same as for the Primary 2 Battery. The Arithmetic Application Test requires the student to apply his mathematical knowledge and ability to practical problems taken from life experiences.

In calculating the pupil gain scores, only the comparable scores from the two test batteries were used. Thus, no pupil gain scores could be computed for the Arithmetic Application Test of the Intermediate I Battery since no similar test existed for the Primary 2 Battery. Pupil gain scores were computed for each of the Arithmetic Computation Test and the Arithmetic Concepts Test. The mean gain scores for pupils under each teacher were then calculated.

Design of Study

The study was conducted in four elementary schools in the Tulsa Public School District during the 1967-1968 school year. The investigation was conducted and data were gathered during the time ordinarily alloted to arithmetic. Eighty teaching periods of eight fourth-grade teachers in four elementary schools were observed.

Selection of the schools was on the basis of mean I.Q. scores and the number of fourth-grade teachers in a school. Twelve elementary schools were selected that had a mean I.Q. of 104$\pm$2 on the Kuhlman-Anderson Intelligence Test the previous year and had two or more fourth-grade teachers. The mean and median I.Q. for the Tulsa elementary schools is 104. Elementary schools having a specialized arithmetic teacher or having fourth-grade classes combined with another grade were not considered. From the nine remaining schools, four schools were selected on the basis of stability of the surrounding neighborhood and the location of the school in relation to the other schools. Two schools were selected in the center of the city and two schools were selected in the suburban part of the city. An attempt was made to select schools that were located in fairly stable neighborhoods to insure that achievement scores would be available for a majority of the pupils. This was partially achieved since it was possible to find both third and fourth grade scores for 175 of 222 students in the study. This is approximately 79 percent of the student population. The schools were selected fairly close together to facilitate the observation by reducing the time involved in traveling from one school to another. The fourth-grade teachers and pupils in the four selected schools were the sample for this investigation.

Collection of Data

After the schools were selected, a meeting was held in each school with the principal and the fourth-grade teachers explaining the study and asking for their cooperation. During the meeting, the Wright-Proctor Observation Instrument (23) was explained to the teachers and the aims of the study were discussed. The teachers were assured that the information gathered would be used only by the writer and any further use of the data would not make any reference to the teachers by name. It was explained that participation was voluntary and the observer or observers could be asked to leave at any time.

Upon receiving assurance of cooperation from the teachers, the time each teacher normally taught arithmetic each day was obtained. This information was used to schedule two periods of familiarization and to plan additional observation periods. The familiarization periods were scheduled so that the teachers and pupils could become somewhat accustomed to having an observer in the classroom. After the familiarization periods were completed, the teachers were informed that they would be observed ten times during the semester but no specific dates were arranged.

Restrictions were placed on when a class could not be observed. Classes were not observed during a testing session or immediately prior to or following a school holiday, all school activity, or school assembly.

Classes were not observed when a substitute teacher or student teacher was teaching. During the observational periods, the observer of observers sat in the rear of the classroom with a coding sheet and a watch with a sweep second hand to determine time intervals. The data gathered by observing eight fourth-grade teachers instructing 222 fourth-grade students in arithmetic for 30-minute periods were transferred to a summary sheet. A copy of the summary sheet may be found in Appendix B.

Training of Observers

Two observers were used to collect the data for the study. One observer was the writer and the other was conducting a similar study using the Wright-Proctor Observation Instrument (23) in fifth-grade mathematics classrooms.

Training in the use of the instrument began with the observers working in a manual written by Wright and Proctor (23) for the training of observers. The manual contained several transcripts of secondary school mathematics classes. These transcripts were divided into fifteen second intervals. Correct classifications of the verbal behaviors reported in the transcripts were in an index. The observers worked through each of the transcripts and compared their classifications with those given in the index. This practice was continued until an almost perfect agreement between the classifications by the observers and the index was reached.

Since the manual contained only transcripts of secondary school mathematics classes, the observers discussed the possible differences that might be encountered in the elementary school mathematics classroom. Each category of the instrument was discussed in detail until the observers agreed on the exact meaning of each category. Situations were also discussed concerning the use of each category of the instrument.

The third stage of the training was the use of the instrument in elementary classrooms. Several elementary school mathematics classrooms were visited and the verbal interactions were classified. These observations lasted from ten to thirty minutes. As soon as possible after each observation, the observers compared their recordings and discussed the classifications that were different. These trial observations were continued until the observers were familiar with the fifteen second intervals for observing and classifying, and they had achieved agreement on the observations over ninety percent of the time.

During the study, the observers discussed the classroom situations they were observing and how they were classifying different situations. At least once for each teacher, the two observers would both observe the same teacher. These concurrent observation periods were scheduled throughout the series of regular observation periods. These simultaneous observations were used as the data for testing observer reliability.

Observer reliability was determined in two ways. Scott's index of inter-coder agreement was calculated for each of the three frames of the instrument, and the totals of the single categories across an entire frame were compared by applying chi square to the frequency totals of each category. The formulas and the results of their application are to be found in Cahpter III.

Treatment of Data

The statistical analysis of the data resulting from the use of the <u>Wright-Proctor Observation Instrument</u> (23) involved the determination of coefficients of correlation between the variables. The statistical technique used was the Spearman method of rank-difference correlation (12, p. 306). The frequency totals of each category of the Wright-Proctor Observation Instrument (23) for the eight teachers were ranked in order of decreasing frequency. The mean pupil gain scores computed from the computation and concepts subtests of the Stanford Achievement Test (14) were also ranked for the eight teachers. The Spearman method of rank-difference coefficient of correlation was then applied to the ranks. The level of confidence was set at the .05 level. The following formula was used to compute the coefficient ρ (Greek letter rho)

$$\rho = \frac{1 - 6\Sigma D^2}{N(N^2-1)}$$

where N is the number of pairs of measurements and ΣD^2 is the sum of the squared differences between ranks. Discussions of the calculation of the rho and of the results are to be found in Chapter III.

Assumptions

The research reported here was an attempt to determine the relation of selected classes of verbal behaviors of teachers and pupils (process) to pupil gain scores in mathematics (product). The method of research used was direct observation and classification of the verbal interaction as found in selected fourth grade mathematics classes. It is upon the premise of a relation and the method of research that certain assumptions were made.

The following assumptions were applied in the study:

1. The Wright-Proctor Observation Instrument (23) provides distinct categories for classifying teacher-pupil interaction in the elementary mathematics classroom.

2. The presence of the observers in the classroom does not influence the patterns of teacher-pupil interaction during the observation periods.

3. The basic acts of influence by the teacher are verbal.

4. The teacher, by her actions and behaviors, controls the verbal participation of the students.

5. The amount and type of teacher talk influence the verbal behavior of the students.

Limitations

The conduct of a research study dictates that certain limitations be placed on the study. The premise, the design, and the method of the study all introduce limitations to the results of the study. The following are limitations that apply to this study.

1. The results of this study are limited to the eight fourth grade teachers, their elementary mathematics classrooms, and the four Tulsa elementary schools in the spring of 1968.

2. The use of direct observation and classification of verbal interaction considers only a few of the many variables of the classroom.

3. Pupil gain scores as a measure of pupil achievement are notoriously unstable in that errors of measurement do not cancel.

CHAPTER III

ANALYSES OF DATA

Introduction

The data of the study consisted of 600 recorded observations for each of the eight classrooms. The data were collected by two observers who made a total of ten observation visits to each of the eight classrooms. Verbal interaction of pupils and teachers were recorded using the classification scheme of the <u>Wright-Proctor Observation Instrument</u> (23). The recorded observations were then transferred to a summary sheet (Appendix B). The total frequency for each category for each classroom was recorded. Additionally, total frequencies for each category were noted as being teacher behaviors or pupil behaviors. Frequencies were also totaled over the categories of each frame of the instrument that were identified as being analogous to Flanders' constructs identifying direct and indirect teacher influence.

From the summary sheet, the data were converted into ranks. The procedure consisted of first taking the total frequency of a given category for each teacher and ranking the frequencies from highest to lowest. The total frequency of pupil behaviors for each category were ranked in the same manner, from highest to lowest. In case of ties, the average of rank positions was taken and that average was assigned to each of the tied individuals. The next rank position assigned was the one following those used for the tied ranks.

The mean pupil gain scores were computed for each of the eight classrooms. This was accomplished by finding student scores on the Stanford Achievement Test (23) taken in the third grade and the corresponding subtests of computation and concepts. The average pupil gain scores were computed for both subtests for all eight classrooms. The average pupil gain scores for the computation subtest were then ranked from highest to lowest, as were the average pupil gain scores for the concepts subtest.

A comparison of the ranks of frequency of use of a category of the Wright-Proctor Observation Instrument (23) with the ranks of mean pupil gain scores were made using Spearman's rank-difference correlation method (12). The results of these comparisons will be reported below.

Observer Reliability

The data for determining observer agreement were secured by having the two observers independently observe the same teacher during the same arithmetic class period. Data were secured in each of the eight classrooms using this method. These concurrent observation periods were conducted throughout the sequence of scheduled observation periods.

The observer agreement was determined by two different methods: Scott's index of intercoder agreement (17) and the chi-square test. Scott's index of intercoder agreement, "pi," is interpreted as the extent two observers exceed chance agreement divided by the amount perfect agreement exceeds chance. The chi-square test was used to make a comparison of the frequency totals of each category across an entire frame. The use of the chi-square is possible since Wright and Proctor (23) established the independence of the single categories from each other.

Scott's coefficient, "pi," is determined by the two formulas (17, p. 323)

$$\pi = \frac{P_o - P_e}{1 - P_e} \qquad (1)$$

where P_o is the observed percent agreement and P_e is the percent agreement to be expected on the basis of chance.

$$P_e = \sum_{i=1}^{k} P_i^2 \qquad (2)$$

where k is the total number of categories and P_i is the percent of the entire sample which falls into each category. The results from the calculation of π are given in Table I.

TABLE I

THE LEVELS OF AGREEMENT BETWEEN OBSERVER 1 AND OBSERVER 2 USING SCOTT'S INDEX OF INTERCODER AGREEMENT COEFFICIENT

Frame	π
Content	.96
Process	.95
Attitude	.96

Scott's index corrects for the number of categories in the code, and the frequency with which each is used. Scott's index varies from 0.00 to 1.00, regardless of the number of categories and is not affected by low frequencies. The calculations of 0.96, 0.95, and 0.96 over the three frames of the instrument show very close agreement between the observers. This would seem to indicate the two observers were in agreement as to how the categories were defined and how they were to be used in classifying the verbal behavior.

Wright and Proctor (23) suggest that observer reliability be tested by comparing the totals of the single categories across an entire frame. This comparison is made by applying chi-square to the frequency totals of each category. A chi-square value for each frame of the instrument (23, p. 331) was secured by applying the formula

$$X^2 = \sum_{i=1}^{r} \sum_{j=1}^{k} \frac{(N_{ij} - N_{ij}')^2}{N_{ij}'}$$

where r is the number of rows and k is the number of columns. N_{ij} is the total in the i row and the j column. N_{ij}' is the expected total for the i row and the j column. The number of degrees of freedom for chi-square is k(r-1). Since the observers viewed the same number of behaviors during the concurrent observation periods, the columns are fixed and equal. The results of the chi-square comparisons are given in Table II.

TABLE II

CHI-SQUARE COMPARISONS OF TOTAL OF BEHAVIORS CLASSIFIED BY OBSERVERS 1 AND 2 IN EACH FRAME

Frame	Computed X^2	df	Tabulated $X^2_{(0.05)}$
Content	2.565	12	21.026
Process	1.172	8	15.505
Attitude	0.004	2	5.991

Since none of these values provide evidence for rejecting a null hypothesis of no significant differences between the records of the two observers at the 0.05 level of confidence, the frequency totals for the observers are accepted as being related.

Significance of the Variables

The results to the statistical tests of the hypotheses relating to the variables are presented below. The Spearman coefficient of correlation, "rho," was calculated for each of the variables using the rankings of total frequency of a given category over the ten observation periods for each teacher and the average pupil gain scores for each of the two arithmetic subtests of the _Stanford Achievement Test_ (14). The coefficients that were secured are reported in Table III.

A Spearman coefficient of correlation of 0.643 is required for significance at the 0.05 level of confidence.

Another analysis will consider groupings of these variables in terms of direct and indirect influence. Several observations based on the variables are pertinent to that consideration. Of the categories classified as indirect influences (Structure, Deductive, Inductive, Other, Analyzing, Generalizing, Curiosity, and Independence) only Analyzing was statistically significant for both subtests. Independence was statistically significant for one subtest. Two categories, Deductive and Curiosity, were not used enough for a coefficient to be computed. Two additional categories, Structure for the computation subtest and Inductive for the concepts subtest, had high coefficients of correlation (0.595) though not significant. Of the categories classified as direct (Technique, Statement, Mathematical, Synthesizing, Specializing, Relevant, and Receptivity) none was statistically significant. The highest coefficients was 0.459 for the category of Synthesizing for the computation subtest. Two of the categories, Relevant and Receptivity for the computation subtest, had negative coefficients of -0.351 and -0.381 respectively.

TABLE III

COEFFICIENTS OF CORRELATION BETWEEN AVERAGE PUPIL GAIN SCORES AND FREQUENCY OF TEACHERS BEHAVIORS

Category	Computation	Concepts
Structure	0.595	-0.048
Technique	-0.190	0.095
Deductive	**	**
Inductive	0.488	0.595
Statement	0.357	-0.024
Mathematical	0.310	0.155
Other	-0.018	0.292
Analyzing	0.881*	0.643*
Synthesizing	0.459	0.221
Specializing	0.280	0.101
Generalizing	0.018	-0.054
Relevant	-0.351	0.042
Curiosity	**	**
Independence	0.744	0.339
Receptivity	-0.381	0.167

* Significant at the 0.05 level of confidence.
** Not enough data available to compute rho.

Table IV contains the results of the computations of the coefficients of correlation between average pupil gain scores and frequency of pupil behaviors. There were no coefficients reported in Table IV that were statistically significant. Synthesizing for the computation subtest approached the significant level with a coefficient of 0.620. The categories of Deductive and Curiosity again did not contain enough data to compute rho. The range of coefficients for the indirect categories was from 0.518 to -0.214. The range of coefficients for the direct categories was from 0.620 to -0.333.

TABLE IV

COEFFICIENTS OF CORRELATION BETWEEN AVERAGE PUPIL GAIN SCORES AND FREQUENCY OF PUPIL BEHAVIORS

Category	Computation	Concepts
Structure	0.054	0.161
Technique	0.024	-0.333
Deductive	**	**
Inductive	0.518	0.458
Statement	0.477	0.381
Mathematical	0.167	0.167
Other	-0.214	0.393
Analyzing	0.316	0.315
Synthesizing	0.620	0.405
Specializing	0.310	0.310
Generalizing	0.173	-0.017
Relevant	-0.023	-0.333
Curiosity	**	**
Independence	0.048	-0.071
Receptivity	-0.143	-0.214

** Not enough data available to compute rho.

Table V contains the values of the rho for the Neutral and Silent categories. Category S3 Dealt with silent study after the lesson had been presented. The coefficient of 0.620 for S3 approaches the significant level. The Neutral category dealt with verbal behaviors that were non-mathematical in nature. This category had extremely low negative coefficients of correlation and was negatively significant for the concepts subtest.

TABLE V

COEFFICIENTS OF CORRELATION BETWEEN AVERAGE PUPIL GAIN SCORES AND FREQUENCY OF BEHAVIORS OCCURING IN THE NEUTRAL OF NONVERBAL CATEGORIES

Category	Computation	Concepts
Neutral	-0.625	-0.672*
S1	0.191	-0.059
S2	-0.452	-0.071
S3	0.620	0.120
S4	**	**

* Significant at the 0.05 level of confidence.
** Not enough data available to compute rho.

Table VI contains the computations of rho for the grouping of categories of teacher behavior that were felt to be indirect or direct influences. The indirect categories of the Process Frame--Analyzing and Generalizing, when combined, had a coefficient of correlation that was statistically significant. None of the coefficients for the direct frames were significant or very high.

TABLE VI

COEFFICIENTS OF CORRELATION BETWEEN AVERAGE PUPIL GAIN SCORES AND FREQUENCY OF TEACHER BEHAVIORS CLASSIFIED AS DIRECT OR INDIRECT

Frame	Computation	Concepts
Content Indirect	0.477	0.214
Process Indirect	0.935*	0.518
Content Direct	-0.024	0.286
Process Direct	0.000	0.048

* Significant at the 0.05 level of confidence.

TABLE VII

COEFFICIENTS OF CORRELATION BETWEEN AVERAGE PUPIL GAIN SCORES AND FREQUENCY OF PUPIL BEHAVIORS CLASSIFIED AS DIRECT OR INDIRECT

Frame	Computation	Concepts
Content Indirect	0.214	0.429
Process Indirect	0.316	0.316
Content Direct	-0.048	-0.309
Process Direct	-0.048	-0.214

Table VII contains the computation of rho for the grouping of categories of pupil behaviors felt to be direct or indirect. None of the coefficients was significant. All of the coefficients for the direct frames were negative.

TABLE VIII

COEFFICIENTS OF CORRELATION BETWEEN AVERAGE PUPIL GAIN SCORES AND FREQUENCY OF BEHAVIORS CLASSIFIED AS TEACHER OR PUPIL

Behaviors	Computation	Concepts
Teacher	0.620	0.333
Pupil	0.000	-0.143

Table VIII contains the computed rhos for the behaviors classified as Teacher or Pupil. None was significant, but the coefficient of 0.620 for Teacher for the computation subtest is near the value for significance. In considering the above, it was found that of all behaviors classified as either Teacher or Pupil; 75 percent were classified as Teacher. This figure is a little above Flanders' rule of two-thirds (9).

Summary

In the majority of the tests, the null hypothesis that no correlation existed between the variables was not rejected. The results indicate, however, that hypothesis 1a was rejected for the categories of Analyzing and Independence. Also, hypothesis 2a was rejected for the category of Analyzing. The null hypothesis of no correlation for Teacher behaviors classified as indirect influence in the Process Frame was also rejected.

CHAPTER IV

SUMMARY AND CONCLUSIONS

Purpose of the Study

This research sought to determine the value of an observation instrument designed for use in mathematics classes by establishing the relation between selected classes of verbal behaviors of teachers and pupils (process) to pupil gain scores in mathematics (product). The review of research supported the hypothesis that such a relationship does exist and can be described by the use of an observation instrument. Medley and Mitzel (16, p. 249) stated that the proper role of direct observation in research seemed to be as a means of learning something about the teaching process and its relationship to pupil learning.

The _Wright-Proctor Observation Instrument_ (23) was chosen for use in this study because it was developed for use in high school and college mathematics classrooms. The value of the _Wright-Proctor Observation Instrument_ in the study of such mathematics classrooms was established by the research of Wright and Proctor (23), its developers. The research reported here sought informationconcerning the value of the _Wright-Proctor Observation Instrument_ in elementary mathematics classrooms.

Sources of Data

The categories of the _Wright-Proctor Observation Instrument_ (23) were used to record occurrences of classes of verbal behavior that were observed in fourth-grade mathematics classes. These classes of verbal behaviors were the process data for the study. The process data were secured by observing eight fourth-grade mathematics classes for thirty minute periods. The eight classrooms were observed a total of ten times each. During each of the thirty minute periods, the observer made two recorded observations per minute. This procedure yielded 60 recorded observations per observation period and a total of 600 recorded observations per teacher.

The Wright-Proctor Observation Instrument (23) uses the following scheme for making a recorded observation. The observer views for fifteen seconds and then records for fifteen seconds, repeating this cycle throughout the entire observation period. For each recorded observation, the observer classifies the verbal interaction as either teacher or pupil and then classifies it in each of the three frames of the Wright-Proctor Observation Instrument.

The product data were made available by the Research Department of the Tulsa Public Schools. The third and fourth grade tests scores from the Stanford Achievement Test (14) were secured for the students in the eight classrooms used in the study. Average pupil gain scores on each of two subtests were calculated for each class of fourth graders.

The data for determining observer agreement were secured from two observers, who independently observed the same teacher during the same arithmetic class periods. Data were secured in each of the eight classrooms using this method. These concurrent observation periods were maintained throughout the sequence of scheduled observation periods.

Analyses of Data

The relationship between process variables and product variables were expressed as Spearman coefficients of correlation (12, p. 306). The following relationships were studied:

A. Separate categories of verbal behaviors (4 comparisons)

1. Teacher behavior - arithmetic computation
2. Teacher behavior - arithmetic concepts
3. Pupil behavior - arithmetic computation
4. Pupil behavior - arithmetic concepts

B. Combined categories of verbal behaviors (8 comparisons)

1. Teacher behaviors considered direct - arithmetic computation
2. Teacher behaviors considered direct - arithmetic concepts
3. Teacher behaviors considered indirect - arithmetic computation
4. Teacher behaviors considered indirect - arithmetic concepts
5. Pupil behaviors considered direct - arithmetic computation
6. Pupil behaviors considered direct - arithmetic concepts
7. Pupil behaviors considered indirect - arithmetic computation
8. Pupil behaviors considered indirect - arithmetic concepts

C. Total verbal behaviors (4 comparisons)

1. Teacher behaviors - arithmetic computation
2. Teacher behaviors - arithmetic concepts
3. Pupil behaviors - arithmetic computation
4. Pupil behaviors - arithmetic concepts

D. Neutral or nonverbal (2 comparisons)

1. Neutral or nonverbal - arithmetic computation
2. Neutral or nonverbal - arithmetic concepts

The statistical significance of each coefficient was determined. The .05 level or point of confidence was used in rejecting or not rejecting the null hypotheses.

Results of the Study

In the analysis of the relationship of the separate categories of verbal behavior, the following results to the statistical tests were secured. The comparison of teacher behavior to arithmetic computation were significant for the categories of Analyzing and Independence. The comparison of teacher behavior to arithmetic concepts was significant for the category of Analyzing. Two additional categories, Structure for the computation subtest and Inductive for the concepts subtest, had high coefficients of correlation (0.595) though not significant. Negative coefficients of correlation were computated for the categories of Technique, Other, Relevant, and Receptivity for the computation subtest and for the categories of Structure, Statement, and Generalizing for the concepts subtest. Of interest, is the fact that all of the significant categories and those with high coefficients were considered to be among those grouped as indirect influence.

The comparison of pupil behaviors to the two arithmetic subtests yielded no significant correlations. The categories of Inductive (0.518), Statement (0.477), and Synthesizing (0.620) for the computation subtest yielded the highest coefficients of correlation. Negative coefficients were recorded for the categories of Other, Relevant, and Receptivity for the computation subtest and for Technique, Generalizing, Relevant, Independence, and Receptivity for the concepts subtest.

It is interesting to note that for neither the teacher behaviors nor the pupil behaviors were there enough data available to compute the coefficient of correlation for the categories of Deduction and Curiosity. Of the total of 6,000 recorded observations made, there were no observations recorded for Deductive and only one for Curiosity.

In the analysis of the relationship of the combined categories of verbal behaviors, the following results were secured. The comparison of teacher behaviors to arithmetic computation was significant for the Process Indirect categories. Also, high coefficients of correlation were recorded for Content Indirect (0.477) for the computation subtest and Process Indirect (0.518) for the concepts subtest. The Content Direct (-0.024) for the computation subtest was negative and the Process Direct for the same subtest yielded a zero coefficient. The comparison of pupil behaviors to the combined categories yielded no significant coefficients. The highest coefficient was for Content Indirect (0.429) for the concepts subtest. It is interesting to note that both Content Direct and Process Direct yielded negative coefficients.

The comparison of behaviors classified as Teacher or Pupil to the subtests yielded no significant results, although the Teacher behavior for the computation subtest yielded a coefficient of 0.620. The comparison of Pupil behaviors yielded a zero coefficient for the computation subtest and a negative coefficient for the concepts subtest.

The comparison of the Neutral and Nonverbal categories to the subtests yield some interesting results. The Neutral category which dealt with verbal behaviors that were non-mathematical was negatively significant (-0.672) for the concepts subtest and had a negative coefficient of _0.620 for the computation subtest. The S3 category, which dealt with silent study after the lesson had been presented, had a high though not significant coefficient of 0.620.

Conclusions

The analysis of the research data reported here yielded four positive significant correlations out of the 70 statistical correlations computated. This is about the number of significant results that would occur by chance. Of importance is where they occur and where they do not occur.

All four of the positive significant results are associated with teacher verbal behaviors and none with pupil verbal behaviors. Most of the verbal interaction taking place in the fourth-grade classes observed was teacher initiated and usually required only a short answer from the student. It was found that about three-fourths of the recorded observations were teacher initiated. This might explain the fact that all of the positive significant correlations are associated with teacher behaviors. Also, a factor might have been the length of the observation period and length of recording period. The scheme of observing 15 seconds and then recording for 15 seconds which was used by the observers left a great amount of verbal interaction unrecorded. In fact, the verbal interaction of the elementary classroom required the observers to decide which segment would be recorded.

Of the categories classified as indirect influence (Structure, Deductive, Inductive, Other, Analyzing, Generalizing, Curiosity, and Independence), Analyzing was significant for both subtests and Independence for the computation subtest. Structure for the computation subtest and Inductive for the concepts subtest had high, though not significant, coefficients of 0.595. These were the highest coefficients that were not significant. Two categories, Other (-0.018 and 0.292) and Generalizing (0.018 and -0.054) had low coefficients of correlation and it would seem that they might not belong in this grouping. The Deductive and Curiosity categories are not appropriate for observations of elementary classrooms in that they are used infrequently.

Of the categories classified as direct influence (Technique, Statement, Mathematical, Synthesizing, Specializing, Relevant, and Receptivity) none was statistically significant. The highest coefficient was 0.459 for the Synthesizing category. This category might have been better placed with the indirect influence group. Without it, the range of coefficients for the direct group was from 0.357 to -0.381.

For the pupil verbal behaviors, the indirect and direct grouping did not seem to have much meaning. The range of coefficients for the indirect group was from 0.518 to -0.214. The range for the direct group was from 0.620 to -0.333. A possible explanation might be that the comments of elementary pupils has little effect on the achievement of their classmates.

For the combined categories of direct and indirect influence for teacher behaviors, the Process Indirect was significant for the subtest of computation. The Process Indirect for the concepts subtest was 0.518 and Content Indirect for computation was 0.477 and for concepts was 0.214. The range of scores for the Content Direct and Process Direct was from 0.286 to -0.024. This seems to imply that the Indirect influence has a positive influence on learning.

For the combined categories of direct and indirect influence for pupil behaviors, none was significant. The range for indirect categories was from 0.429 to 0.214. The range for direct categories was from -0.048 to -0.309. It is interesting that all four coefficients for the direct categories were negative.

Also of interest are the coefficients for the total Teacher behaviors and Pupil behaviors. The Teacher coefficients were 0.620 on the computation subtest and 0.333 on the concepts subtest. The 0.620

coefficient is very close to being significant. The Pupil coefficients were 0.000 on the computation subtest and -0.143 on the concepts subtest. This seems to support the conclusion that pupil comments have little effect on pupil achievement.

The results do seem to show that the Wright-Proctor Observation Instrument is a valuable tool in the study of the elementary mathematics classroom. It is felt that some of the categories might be redefined to be more easily used in the elementary classroom. Also, two recorded observations a minute is not enough. It is felt that four observations per minute would be better.

Suggestions for Further Study

It is suggested that the categories of the Wright-Proctor Observation Instrument be studied and if necessary redefined, and then used to study different types of elementary mathematics classrooms. Knowledge is needed concerning what is happening in the classroom, and the Wright-Proctor Observation Instrument is a valuable tool for finding out what is happening.

It is suggested that student teachers be taught to use the Wright-Proctor Observation Instrument to be used by them in their observation of classrooms. To gain valuable experience from classroom observation, a scheme or system of observation is needed. It is felt that the Wright-Proctor Observation Instrument would be a valuable tool for them.

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APPENDIXES

APPENDIX A

APPENDIX A

THE WRIGHT-PROCTOR OBSERVATIONAL INSTRUMENT

Definition of Categories: Content Frame

The categories of the Content Frame were selected to correspond to aspects of mathematical systems and functional classroom. Classification of behavior into the Content categories answers the question, "What aspect of mathematics is being worked on?"

Fundamentals: The body of mathematical knowledge at the command of the pupils; 'old' knowledge up to arbitrary cut off point such as last chapter or topic.

1. Structure
    - 1.1 Fundamental elements, operations, postulates
    - 1.2 Well established theory when understanding is apparent, e.g. definitions, suitable notation, theorems
    - 1.3 Logical principles, e.g. consistency, inference, equivalence, proof
    - 1.4 Strategies of problem solving, e.g. verification of facts, varying of conditions, testing hypotheses, inventing analogous problems, estimation of plausible answers, analysis of a method of problem solving
2. Techniques
    - 2.1 Description and use of mechanical processes or rules where basic mathematical relation is not made apparent
    - 2.2 Reading of mathematical materials already developed, e.g. answers to homework problems, assignment of homework, first reading of a problem with no emphasis of specific conditions

Relations: The development and statement of 'new' relations

3. Deductive
    - 3.1 Logical proof of new theory
4. Inductive
    - 4.1 Use of specific examples selected to elicit new generalization or relation, e.g. problems used for this purpose usually begin quite simply and increase in technical complexity until pupils begin to look beyond the old method for a new solution or for a general relationship
    - 4.2 Use of graphs, diagrams, to make a relation clear
    - 4.3 Intuitive approach to a relation, e.g. "What seems to be true?"

5. Statement
    5.1 Statements of new relations; may or may not be developed deductively or inductively; may be used in seeking method of problem solution in recent application, e.g. the statement may be right or wrong, may be pulled out for examination, and subsequently proved or disproved
    5.2 Definitions, notation, terminology; mathematical conventions e.g. selection of means of describing empirical data such as means, mode, median, measures of dispersion, type of graphs in statistics

Applications: The use, place of the mathematical system in specific problems and in historical context

6. Mathematical
    6.1 Solution of mathematical problems
7. Other
    7.1 Brief statement of problem in other field before abstraction essentials
    7.2 Examination of problems in terms of the concepts of the other field
    7.3 References from mathematical history
    7.4 Reference to new topics or different treatment to be met in later courses
    7.5 Humor--when pertinent to mathematical activities

Definition of Categories: Process Frame

Logic is the tool of mathematical thinking and as such is the vehicle of the verbalized interaction occurring in the mathematics classroom where the teacher instructs and pupils attend. Because mathematical thinking consists so largely of problem solving, both in building and in applying a system, the aspects of logic functional in problem-solving may usefully be identified to form the basis for classification of classroom verbal interaction.

Syllogistic: The syllogistic categories of analyzing and synthesizing require the logical operation of inference. Although synthesizing is often mechanical it may also be the method of highly creative divergent thinking.

1. Analyzing--from assumption of desired conclusion toward accepted principles
    1.1 Chain of backward implication--"is implied by"
    1.2 Less systematic moving backward from goal seeking connection with known premises to establish approach to proof
    1.3 Justification of a statement, e.g. Why? Because...; plausibility
    1.4 Moving backward over an argument to discover mistake or clarify meaning
2. Synthesizing--from accepted principles toward desired conclusion
    2.1 Chain of forward implication--"implies," e.g. when moving forward from known premises to goal, synthesizing may be mechanical when method is a familiar one; formal development

or proof of theory or specific problem; reading entire proof already developed carefully step by step

2.2 Consolidation of parts into a complete solution

Classificatory: The classificatory categories of generalizing and specializing include the formulation of generalizations, applications, and the less formal but necessary heuristic process of problem dissection and focusing on goal.

3. Specializing--the use of significant attributes of a given set in an analogous set, or the application of a given set in a smaller included set

3.1 Selection of significant parts of a problem--dissection, abstraction, e.g. verification of facts of problem, identification of necessary and sufficient conditions; identification of true and false statements

3.2 Application of a generalization, e.g. substitution in a formula, use of theorem, definition

3.3 Recognition of relation of corresponding sets, e.g. analogous problems

3.4 Focusing on goal, e.g. recentering on goal at successive phases of solution

4. Generalizing--the recognition of significant attributes of a given set and the passing from the consideration of the given set to that of a larger inclusive set

4.1 Recognizing significant attributes and passing to a larger set, e.g. moving from particular examples to a common characteristic, a good guess, a hypothesis, the formulation of a problem, of a definition

4.2 Statement of a formula, law, relation, definition to be proved or arising from development or to examine for meaning

Relevant: A more static category, the statement of relevant information occurs when mathematical information is presented but belongs to no apparent logical sequence.

5. Relevant

5.1 Information about specific mathematics, e.g. reading problems, reading of homework answers when no solution meaning is given

5.2 Information about more general aspects of mathematics, e.g. historical, biographical without logical analysis of the mathematical ideas that may thus be referred to

Definition of Categories: Attitude Frame

The categories of the Attitude Frame answer the question, "How much initiative are the pupils asked to show, and how much do they demonstrate?"

Teacher or Pupil: The teacher demonstrates or encourages pupils behaviors in each category; the pupils demonstrate the behavior in each category.

1. Curiosity--fresh unusual material; a new direction
    1.1 Teacher statements relating present topic to other areas of mathematics or to other fields, or to more fundamental mathematics concepts or to historical context
    1.2 Teacher encouragement of unusual problem or new direction including positive support of pupil expression of unusual interest
    1.3 Pupils make statements as in 1.1
    1.4 Pupils ask questions about 1.1
2. Independence
    2.1 Teacher open questions or suggestions demanding pupil thinking beyond one carefully structured step, e.g. asking pupils to solve problems, asking pupils to discuss homework answers, asking pupil suggestion for relation apparent in a series of specific examples, requiring pupil development of proof of a relation, eliciting pupil criticism of his own work
    2.2 Turning of pupil-raised questions back to same pupil or to the class
    2.3 Assignment of pupil topics for class demonstration including regular homework questions developed on blackboard by pupil
    2.4 Pupil initiates discussion by asking a question and noting aspects he has considered
    2.5 Responsibility for development taken by pupil sometimes indicated by several steps forward or merely by one powerful step forward in a single interval
    2.6 Pupil statements moving problem solution forward more than one step during the interval
3. Receptivity
    3.1 Teacher tells, states, solves problems
    3.2 Teacher asks rhetorical questions or questions limited to one-step often trivial or merely yes-no answers
    3.3 Teacher is responsive to signals that pupils understand, follow the discussion, are interested in the presentation
    3.4 Pupils respond appropriately when called on, but answer is limited to one relatively small step, e.g. I don't know; The square of 7 is 49; Yes; the answer to that homework question was x plus 2
    3.5 Pupils ask questions without indicating readiness to treat it themselves with teacher's assistance, e.g. How do you do this problem; I couldn't solve number 37

Classification of Other Behaviors: Neutral and Non-Verbal

Neutral

Verbal behaviors which concern non-mathematical matters are classified as Neutral. Examples of these are classroom organization behaviors, disciplinary comments, interruptions by school administration such as announcements over the public address system.

Silent Study

Mathematical study occurs in the classroom silently in several ways.

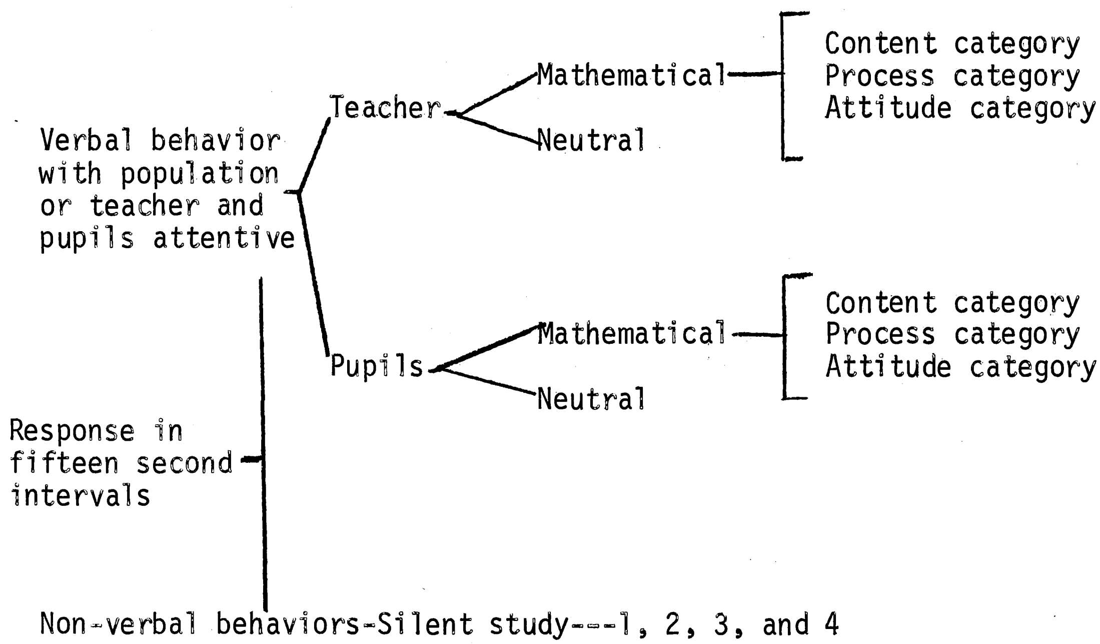
S1--Short periods of silence may comprise a complete interval set aside for classification of class interaction

S2--Within the general discussion period, the teacher may direct that all pupils individually, at their seats or with some at the blackboard, should develop a point for immediate use in class discussion

S3--Preceding or following the general class discussion the pupils may have a work period in which they may be doing assignments with individual pupils conferring with the teacher

S4--Tests of short duration over the course, say, of ten minutes--may occur. Where tests require the entire class period no observation would be made.

Schema of Classification of Behaviors



APPENDIX B

APPENDIX B

Frequency Totals

Teacher	1		2		3		4		5		6		7		8	
	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P
Structure	79	18	50	19	120	33	78	6	20	11	70	14	59	7	77	18
Technique	86	17	102	1	103	21	104	13	146	12	109	79	132	39	44	119
Deductive	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Inductive	6	1	2	--	1	--	--	--	--	--	7	3	--	--	--	--
Statement	8	--	1	--	1	2	21	--	3	--	2	--	--	--	21	--
Mathematical	102	55	160	42	142	51	146	29	88	36	99	91	91	32	190	67
Other	17	1	30	4	6	--	2	--	10	7	5	4	1	1	5	1
Analyzing	78	13	82	18	98	20	100	5	21	5	84	32	66	3	79	35
Synthesizing	2	1	--	--	4	--	--	--	--	--	3	1	--	--	2	--
Specializing	118	61	162	47	186	66	151	30	108	44	108	79	92	35	221	50
Generalizing	6	--	1	--	--	1	--	--	--	--	--	--	--	--	1	3
Relevant	94	17	100	1	85	20	100	13	138	12	97	79	123	41	34	117
Curiosity	--	--	--	--	--	--	-	--	--	--	1	--	--	--	--	--
Independence	146	65	123	51	207	76	152	29	46	33	120	74	94	38	120	91
Receptivity	152	27	222	15	166	31	199	19	221	28	171	117	189	41	217	114
Neutral	39		31		24		34		56		13		61		31	
S1	8		--		2		1		7		--		--		--	
S2	107		158		80		128		209		104		177		27	
S3	56		--		14		38		--		--		--		--	
S4	--		--		--		--		--		--		--		--	

APPENDIX B_2

AVERAGE PUPIL GAIN SCORES

Teacher	Computation	Concepts
1	11.3	16.7
2	11.2	19.3
3	17.8	18.7
4	20.1	18.9
5	9.1	16.8
6	19.4	19.6
7	8.2	14.4
8	9.5	13.7

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